Kern County Water Agency

Water Supply Report

1991

December 1992
Kern County Water Agency
WATER SUPPLY REPORT
1991

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General Manager

December 1992

Indian Wells Valley
Water District
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Definitions

Acre-Foot (AF) The quantity of water required to cover one acre of land to a depth of one foot (325,872 gallons). This amount of water is normally used by a family of 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 sufficient 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 Groundwater Storage The change in volume of water retained by subsurface aquifers within the groundwater basin. A negative change reflects the fact that extractions have exceeded recharge.

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

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

CVC The Cross Valley Canal.

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

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

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

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

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

In-lieu Recharge The process of recharging groundwater supplies by substituting surface water for groundwater.

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 groundwater extractions exceed groundwater recharge.

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

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

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

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

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

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

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

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

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

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

Figure 1. The Hydrologic Cycle

1991: The Drought Gets Worse

The year 1991 was conspicuous by the fact that the impacts of the present, lingering drought got worse. On the heels of a critically dry 1990 (when Kern County was strapped with a 50 percent reduction in State Water Project agricultural entitlement, and local Kern River supplies were 29 percent of average) the year 1991 proved also to be even more critically dry than the previous year. The resultant impacts of the ongoing drought during 1991 were substantial, caused primarily by a 100 percent reduction in SWP agricultural supplies and a 70 percent cut in SWP urban supplies. Since the SWPs inception, 1991 is the only year that a 100 percent reduction in SWP supplies was necessary, and the second time that urban SWP supplies have suffered a reduction. This is an event that seemed extremely unlikely when the State Water Project was approved by voters in 1960.

Curiously, there seems to be a persistence effect in the weather. The last drought cycle spanned the years 1976-77. The 1978-83 period was the wettest on record. Conversely, the year 1991 marks the fifth (and worst) year in the present, persistent drought, as shown below:

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<th>Year</th>
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<td>1991</td>
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The Sacramento River Index is routinely used to reflect statewide water supply conditions. The average index over 86 years of record is 17.8. Any year with an index less than 10.2 is classified as critically dry. Thus, four out of the last five years were critically dry, a period unmatched over the 86 years of historical record, dating back to 1906. Indeed, since 1906, never before has four critically dry years occurred back-to-back. One bright anomaly in the dismal year was the month of March, 1991. Going into March, precipitation was only 35 percent of normal in the Sierra watershed. Some cities were poised to impose near-draconian, water rationing due to the severe water shortage. Marin County residents were faced with rationing cutbacks of 50 percent. Los Angeles residents were faced with up to a 30 percent water conservation target. Three times normal precipitation during March provided a much-needed boost to the State’s water supply picture, but not enough to overcome the effects of six consecutive years of drought. Overall precipitation in the Sierra watershed was boosted to 75 percent of normal as a result of the March rains. Many areas of the state, including San Diego, Ventura and Fresno, surpassed their normal rainfall amounts for the year during March alone. Most urban areas were able to scale back their water rationing and conservation programs. While the month came to be called Miracle March, the rains came too late to be of much help to agricultural water users. Storage in the states reservoirs was too severely depleted from the previous years of drought.

In response to the serious water supply shortage, the state developed the State Emergency Bank. The Bank bought water from Delta and northern California water right holders, as well as paid farmers to fallow lands in return for the water that would have been used to irrigate the crop. A total of 820,000 acre-feet of water was made available by the Bank, from the following sources:

<table>
<thead>
<tr>
<th>Source</th>
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<tr>
<td>Land fallowing</td>
<td>414,000</td>
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<td>Groundwater purchases</td>
<td>276,000</td>
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<td>Surface water purchases</td>
<td>142,000</td>
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<tr>
<td><strong>Subtotal</strong></td>
<td><strong>832,000</strong></td>
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<tr>
<td>Less carriage losses</td>
<td>(168,000)</td>
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<tr>
<td><strong>Total available for sale</strong></td>
<td><strong>664,000</strong></td>
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The cost for water from the Bank was about $175 per acre-foot at the Delta pumps. Power costs to convey the water to Kern County was an additional $20 per acre-foot. Urban interests accounted for the bulk of State Bank purchases, about 307,000 acre-feet. The water was simply too expensive for most agricultural interests to afford, when added to their already large fixed costs for SWP water. Statewide, agricultural interests purchased about 83,000 acre-feet from the Bank. Of this amount, about 54,000 acre-feet was purchased by Kern County agricultural interests, and was used to sustain high-value permanent crops on the west side of the County. These west side areas were especially hard-hit by the zero allocation, since they have no usable groundwater to turn to when surface supplies are scarce.
Two important studies of drought impacts have been completed by Northwest Economics Associates (Economic Impacts of the 1991 Drought on Kern County Agriculture, Economic Impacts of the 1991 California Drought on San Joaquin Valley Agriculture and Related Industries). The worst impacts on San Joaquin Valley and Kern County agriculture were:

A) Severely reduced surface supplies resulted in idling of about 237,000 acres in the San Joaquin Valley, with about 101,400 acres idled in Kern County as a result of the drought. An additional 16,200 acres were abandoned after planting due to lack of water, with about 9,700 acres abandoned in Kern County. Another 124,900 acres suffered reduced yields, with about 110,700 acres in Kern County. Loss of farm revenue due to reduced acreage or reduced yields amounted to about $281.5 million, with about $170.8 million occurring in Kern County. When considering the impacts upon related businesses and industries, the total revenue losses were estimated to be $545.8 million, with $332.6 million occurring in Kern County. A total of about 5,000 direct jobs were lost in agriculture (about 3,800 in Kern County), with an additional 4,000 jobs lost in related agricultural support industries (about 3,100 in Kern County). In terms of economic impacts, the drought impacted Kern County the worst.

B) Repayment of fixed costs for State Water Project storage and delivery facilities, payable regardless of water deliveries. For Kern County, these fixed costs for agricultural water users were $34.5 million in 1991. Such a repayment without receiving any water placed a tremendous financial burden upon the farming industry. Higher water costs related to the present drought have had a severe impact on San Joaquin Valley farmers' net income and financial reserves. In some areas, unit water costs have more than doubled since 1987 due to price increases for both surface and groundwater.

C) Cost of purchasing alternative water supplies, such as from the State Emergency Bank, drilling new groundwater wells or rehabilitating existing wells. For the San Joaquin Valley, costs for these activities amounted to nearly $230 million in 1991. Notably, about 2,400 new groundwater wells were drilled from 1989-91 in the San Joaquin Valley, with about 1,300 new wells being drilled in 1991 alone. With average construction costs of $95,000 per well, some $228 million has been spent to drill new wells since 1989; about $124 million was spent in 1991 alone.

D) Increased groundwater pumping lifts due to groundwater level increases. More energy is required to pump from greater depths. The average increase in groundwater depth in the San Joaquin Valley from 1985 (pre-drought) to 1991 was about 54 feet. For Kern County, the average increase was 57 feet. The combination of increased pumping lifts and greater use of groundwater increased San Joaquin Valley farmers pumping costs by $219 million in 1991 alone, with $62.3 million in Kern County. Some of these cost increases will continue into future years, creating a long-term increase in farm production costs.

The seriousness of the water supply situation is reflected by the fact that a total of only 34,865 acre-feet of SWP water was imported into Kern County. Total deliveries through the SWP facilities were 34,865 acre-feet of SWP entitlement water, 47,670 acre-feet of State Bank water, 7,000 acre-feet of water delivered via an inter-county exchange by a landowner. An additional 143,310 acre-feet of local groundwater supplies were delivered via SWP facilities as part of the 1991 emergency programs. Kern River supplies were only 335,913 acre-feet, or 45 percent of average. Central Valley Project deliveries were 204,400, or 54 percent of the 1975-91 average. Overall, surface water supplies were only about 655,000 acre-feet during 1991. Total irrigated acreage was 767,600 acres. As a result of the reduction in irrigated acreage, total agricultural water use was correspondingly reduced, with a total gross water requirement of about 2,489,400 acre-feet. Total groundwater pumping was sharply increased during 1991 to 2,002,400 acre-feet, about 205,400 acre-feet more than 1990 and 414,000 acre-feet more than 1989. The change in groundwater storage in 1991 was a withdrawal of about 1,484,400 acre-feet, the ninth 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 groundwater basin) have been about 10,871,000 acre-feet. The total additions to storage over the same period have been about 4,614,000 acre-feet. Hence, the net change in storage since 1970 has been a reduction of about 6,257,000 acre-feet, or about 285,000 acre-feet per year. In terms of volume of water stored, the groundwater basin is now at 1977 levels, erasing the gains made since the 1976-77 drought. During the last five years of drought, about 4,258,000 acre-feet has been mined, or about 852,000 acre-feet per year.
Water Supplies

State Water Project

The drought patterns which have persisted since 1987 continued through 1991. The Sacramento River Index, used to reflect statewide water supply conditions, was 8.4, the lowest since the drought began. The average index over 86 years of record is 17.8. 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. Any year with an index less than 10.2 is classified as “critically dry”. Table 1 shows the historic record of the Sacramento River Index (SRI), both in natural order and sorted by size. Figure 2 is a histogram of the historic index.

Kern County Water Agency’s initial 1991 allocations of State Water Project entitlement (made in December, 1990) provided only 356,600 acre-feet for agricultural use (a 75 percent reduction) and 106,900 acre-feet for urban or M&I uses (a 20 percent reduction). As the year progressed, it became obvious that the drought weather pattern was still with us, and even worse than expected. Final allocations of SWP agricultural water resulted in NO water being available for agricultural uses (a 100 percent reduction), and only 35,900 acre-feet for M&I uses (a 70 percent reduction). This marked the first time ever that a zero allocation was declared. Following on the heels of a 50 percent agricultural entitlement reduction received in 1990, the potential impacts of such a water supply shortage were nothing short of catastrophic. KCWA recognized the catastrophic nature of the drought early on, and took a number of important drought-related actions early in the year:

A) Staff developed a 1991 Emergency Drought Relief Plan, which outlined many possible actions, both structural and administrative, which could be taken to lessen the local impacts of the drought.

B) KCWA’s Board of Directors declared a drought emergency in February, 1992. The intent of a drought emergency declaration is to facilitate emergency financing for drought relief and to allow KCWA to undertake other emergency measures.

C) KCWA petitioned the state Department of Water Resources to allow carryover of unused 1990 entitlement. This was done to maximize the amount of surface water available during 1991.

D) Approval was given KCWA’s General Manager to approve inter-or intra-district water transfers, subject to appropriate conditions.

E) KCWA petitioned the DWR to apply about $14 million in prior-year overcharges to the Agency’s 1991 bill, in order to minimize the financial impacts of paying for the SWP supply without receiving any water. (KCWA requested these funds to be returned earlier than provided by contract). Additionally, a five-year deferment of $21.4 million of KCWA’s fixed charges for 1991 SWP agricultural entitlement was approved.

The centerpiece of KCWA’s efforts to combat the drought was the 1991 Emergency Groundwater Recovery Program. This program was designed to extract 100,000 acre-feet of previously banked water from groundwater storage and deliver it via local canals to the California Aqueduct. From there it could be distributed to four west side water districts that were entirely without an alternative supply. While simple in principle, implementation of the program required construction of 14 new groundwater wells, in addition to the use of five wells already in place, and leasing of 25 other wells from private landowners. This effort required execution of numerous agreements between Kern County Water Agency and the Department of Water Resources, City of Bakersfield, local water districts and private landowners. The maximum extraction capacity of all the wells was about 6,800 acre-feet per month, which was insufficient to provide for peak irrigation needs. To overcome such pumping limitations, agreements with DWR provided for regulation of the local groundwater supply using SWP facilities. These agreements provided for advance delivery of water from SWP reservoir storage via the California Aqueduct on an agricultural demand schedule, with the bulk of the deliveries made during the peak summer months. KCWA would pump a steady stream of water into the California Aqueduct until the water was repaid to DWR. KCWA began groundwater production to repay the regulated water to DWR in January, 1991 and
Table 1
Historic Sacramento River Indexes *
(in million acre-feet)

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<td>1991</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1949</td>
<td>12.0</td>
<td>1991</td>
</tr>
<tr>
<td></td>
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<td>1991</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1947</td>
<td>10.4</td>
<td>1991</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1946</td>
<td>17.6</td>
<td>1991</td>
</tr>
</tbody>
</table>

* An index used by the California Department of Water Resources to forecast available water supplies and SWP delivery capabilities. The index consists of the forecasted or computed unimpaired flows of the Sacramento River near Red Bluff, Feather River at Oroville Reservoir, Yuba River at Smartville and American River at Folsom Reservoir. Formerly called Four-basin Index.
continued until mid-1992. Total cost of the program was about $12 million, which was entirely paid during 1991 by the west side participants in the program. Total water delivered to these participants during 1991 was 97,013 acre-feet; the remaining 2,987 acre-feet was delivered during January-February, 1992.

***

In addition to KCWA's program, local water districts developed their own programs to cope with the drought. Numerous water exchanges and purchases were made under these district programs. (As a regional body, KCWA serves as an administrator for the transfer of local SWP water). Also, local landowners without alternative groundwater supplies developed their own individual emergency programs. (See Table 4 for a list of these programs and their deliveries). These programs allowed west side permanent crops to avoid disaster — dying from lack of water. Had such an occurrence happened, the impacts on the local economy would have been catastrophic. The major local programs were developed by Wheeler Ridge-Maricopa Water Storage District, Belridge Water Storage District, Berrenda Mesa Water District, Lost Hills Water District, Buena Vista Water Storage District and Henry Miller Water District. Crucial to the success of these district's programs was an agreement between KCWA and the State Department of Water Resources to make use of San Luis Reservoir storage for regulation of local water on an irrigation demand schedule.

Belridge Water Storage District

Several industrial water users within Belridge WSD entered into an agreement with West Kern WD to purchase banked water belonging to West Kern. A pipeline was constructed by these industrial users to convey the extracted groundwater from West Kern's well field to the California Aqueduct. Belridge WSD then diverted a like amount of water into their distribution system from further north on the California Aqueduct for these industrial users. A total of 6,580 acre-feet was delivered under this program, at a cost of about $2.5 million.

Berrenda Mesa Water District

Berrenda Mesa WD owns about 400 acres of land adjacent to the Kern River, which has been developed into a groundwater recharge area. The District owns two groundwater wells which are on the property. As part of its program to survive the drought, Berrenda Mesa pumped 4,000 acre-feet of groundwater, transferred from KCWA, which had previously been recharged into the Berrenda Mesa Spreading Grounds. This water was extracted via the two district-owned wells and discharged into the Cross Valley Canal (CVC). The CVC was used to convey the well water into the California Aqueduct, and the District simultaneously diverted a like amount of water into its delivery system from further north on the California Aqueduct.

Additionally, Berrenda Mesa entered into an agreement with a landowner in the Devils Den WD and Green Valley WD to buy groundwater and import it into Berrenda Mesa. The landowner farmed in both the Devils Den and Green Valley WDs. This agreement called for the landowner to pump groundwater into the California Aqueduct during times when his wells weren't being used to irrigate his own crops. The water was then diverted into Berrenda Mesa's facilities via the Coastal Branch of the California Aqueduct. A total of 1,500 acre-feet was delivered as part of this agreement.

Total costs for Berrenda Mesa WD's programs were between $500,000 and $600,000.
Lost Hills Water District

Lost Hills WD facilitated the maximum use of water in-district by simplifying rules and regulations regarding water transfers. Lost Hills WD landowners with water allocations in other districts were allowed to transfer such water into Lost Hills WD for use on lands within the District. About 10,000 acre-feet of water was transferred into Lost Hills WD during 1991. These emergency transfers were necessary for the protection of permanent crops within Lost Hills WD.

Also, some landowners in Lost Hills WD drilled shallow groundwater wells and blended the poorer-quality groundwater with the district’s higher-quality canal water.

Henry Miller Water District/Buena Vista Water Storage District

Buena Vista WSD and Henry Miller WD operated a joint program to help both districts meet peak summer irrigation demands. Buena Vista WSD delivered pumped groundwater and Lake Isabella power flows (Kern River water which must be released from Lake Isabella for power generation) into the California Aqueduct on an as-available basis. In return, Buena Vista delivered California Aqueduct water on an agricultural irrigation demand schedule.

Henry Miller WD faced a similar problem as Buena Vista WD. Henry Miller has insufficient well pumping capacity to meet its full irrigation demands. The District normally uses a combination of surface and groundwater together to meet its peak needs. With no surface water available in 1991, 5,000 acres of land was fallowed in the district. To cope with the lack of surface water and limited well pumping capacity, Henry Miller used District-owned wells to pump groundwater into surface storage when irrigation demand were low. Water from seven District wells was discharged into Lake Webb (Buena Vista Aquatic Recreation Area) and into the California Aqueduct via a pump station at the Outlet Channel of the lake. The District then delivered California Aqueduct water on an irrigation demand schedule. The success of Henry Miller’s program is evidenced by the fact that about 3,000 acres were kept in production that would otherwise have been fallowed, due to inability of the

District to meet peak irrigation demands via groundwater alone.

It should be noted that these programs and their costs were in addition to normal district costs for water supplies. The critical situation created by the drought required extreme emergency measures. The local programs developed by the districts to cope with the drought emergency are a tribute to the ingenuity of local water managers.

The potential economic impacts of the drought could have been devastating to the local economy. Northwest Economics Associates (NEA) was engaged to analyze the economic impacts of the drought on Kern County. NEA’s studies show that the potential drought impacts could have reached $8.4 billion had west side permanent crops died from lack of water. The emergency programs reduced the economic impacts to about $800 million. While this may seem to be a much smaller economic impact compared to a potential $8.4 billion impact, it still represents a substantial negative effect upon the local economy. With less farmed acreage and less water, there is an associated reduction in farm labor requirements. NEA estimated that about 3,800 farm jobs were lost as a direct result of the drought. Perhaps another 3,100 jobs were lost in support and related industries, for a total job loss of 6,900. Total revenue losses from all sectors as a result of the drought were estimated to be about $384 million. This money was not circulated through the local economy. Also, one must not lose sight of the suffering endured by nearly 7,000 people, and their families, who lost their means of livelihood because of the drought. The human aspects of these drought impacts must not be lost in a focus upon merely economic values.

On a state level, Governor Pete Wilson set up a drought team to assess and cope with the situation. Mother nature provided some respite by granting a very rainy March, but the long drought was too entrenched for the precipitation to make a major difference in SWP allocations. At the recommendation of the drought team, a State Emergency Bank was set up by the Department of Water Resources early in 1991. In northern California, the DWR paid growers to pump groundwater and release their surface water to DWR’s drought pool. DWR also purchased stored surface water from some districts, and paid landown-
ers to fallow their land and thereby release their surface water rights for resale in the Bank. Potential buyers were required to demonstrate a critical need for the water. Kern County purchased 47,670 acre-feet from the Bank, for use on west side, high-value permanent crops.

The year 1991 was indeed a complicated year, with many water management programs not anticipated by the master water supply contracts for SWP water. Table 4 shows SWP water deliveries to each member unit in 1991, and reflects this complexity.

Article 12(d) of the master contract between DWR and KCWA provides for future repayment of entitlement water which DWR is unable to deliver as a result of causes beyond its control. Such 12(d) water is delivered on an as-available basis. (By design, 12(d) water is unreliable, and when it is available, it can only be delivered after entitlement deliveries). The 50 percent agricultural entitlement reduction in 1990 caused Article 12(d) to apply. At the end of 1990, KCWA had a 12(d) account of 516,900 acre-feet. The 100 percent agricultural entitlement cut in 1991, combined with the 75 percent M&I entitlement cut, added another 1,117,520 acre-feet to the account, for a total 12(d) account of 1,634,420 acre-feet. A breakdown of 12(d) water by Agency member unit is shown in Table 2a.

The Agency’s annual entitlement to SWP water is according to a build-up schedule in the master contract. The build-up provides for increasing amounts of water beginning in 1968, which reached a maximum in 1990. Contracts between the Agency and its member units provided for additional decreasing amounts of surplus water, reaching a minimum of 100,000 acre-feet in 1990. The surplus water would be delivered on an as-available basis. Agency member units’ contract entitlements for 1990 and thereafter are shown on Table 2b. The Agency’s actual contracted entitlement with DWR is the total firm entitlement shown on Table 2b. The table also breaks down entitlement between M&I and agricultural uses. While the M&I entitlement is relatively small compared to the agricultural, KCWA is the third-largest M&I contractor with the SWP, and is the largest agricultural contractor.

Since the first deliveries in 1968, a total of over 17 million acre-feet of SWP water has been imported into the San Joaquin Valley portion of Kern County. A histogram of historic SWP deliveries is provided in Figure 3. Table 3 provides a history of SWP deliveries, with annual and cumulative deliveries and imports shown. Table 4 shows 1991 SWP deliveries by contract type.

Kern River

Total Kern River flows contributed 335,913 acre-feet to the valley portion of Kern County in 1991, consisting of First Point Regulated flows of 333,494 acre-feet and 2,419 acre-feet diverted above First Point. The total was about 46 percent of the 98-year mean flow of 724,627 acre-feet, and about 45 percent of the mean regulated flow (1954 to present) of 749,397 acre-feet. Kern River runoff during the 1991 April-July snow melt period was 55 percent of the 98-year average flow. During the rainy season from October, 1990 through February, 1991 the Kern River watersheds rainfall was only 28 percent of normal. Early predictions were for the driest water year of the century on the Kern River. Then the March Miracle occurred, and record-breaking precipitation fell. The town of Isabella at the north end of Lake Isabella received 6.43 inches of rain in March, the greatest amount for that month ever recorded. Then the precipitation window slammed shut and the drought resumed, with the remainder of the season producing less than 10 percent of normal.

A comparison of the April 1 snowpack for the snow sensors in the Kern River watershed during 1991 with the historic average is shown as follows (inches of water content):

<table>
<thead>
<tr>
<th>April 1</th>
<th>April 1</th>
<th>April 1</th>
<th>1991 % of Avg.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper Tyndall Creek</td>
<td>12.7</td>
<td>16.0</td>
<td>27.7</td>
</tr>
<tr>
<td>Crabtree Meadow</td>
<td>7.1</td>
<td>13.1</td>
<td>19.8</td>
</tr>
<tr>
<td>Chagoopa</td>
<td>11.3</td>
<td>21.6</td>
<td>21.8</td>
</tr>
<tr>
<td>Pascoe</td>
<td>12.0</td>
<td>27.7</td>
<td>24.9</td>
</tr>
<tr>
<td>Wet Meadow</td>
<td>6.6</td>
<td>23.2</td>
<td>30.3</td>
</tr>
<tr>
<td>Tunnel Guard</td>
<td>0.0</td>
<td>13.2</td>
<td>15.6</td>
</tr>
<tr>
<td>Casa Vieja Meadows</td>
<td>10.5</td>
<td>19.0</td>
<td>20.9</td>
</tr>
<tr>
<td>Beach Meadows</td>
<td>0.0</td>
<td>9.0</td>
<td>11.0</td>
</tr>
</tbody>
</table>

Table 5 gives historic Kern River First Point runoff and cumulative runoff for the 98 years of complete record. During the last 98 years, over 71 million acre-feet of Kern River runoff have occurred. Since Isabella Dam began regulating flows in 1954, nearly 28.5 million acre-feet of Kern River runoff has occurred.
<table>
<thead>
<tr>
<th>Member Unit</th>
<th>Article 12(d) Acquired</th>
<th>Article 12(d) Delivered</th>
<th>Available Balance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1990</td>
<td>1991</td>
<td>Total</td>
</tr>
<tr>
<td>Berrenda Mesa WD</td>
<td>77,505</td>
<td>155,073</td>
<td>232,578</td>
</tr>
<tr>
<td>Lost Hills WD</td>
<td>70,159</td>
<td>140,376</td>
<td>210,535</td>
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<tr>
<td>Belridge WSD</td>
<td>81,453</td>
<td>162,972</td>
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<td>82,986</td>
<td>124,462</td>
</tr>
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<td>Pond Poso ID</td>
<td>33,480</td>
<td>66,988</td>
<td>100,468</td>
</tr>
<tr>
<td>Semitropic WSD</td>
<td>3,998</td>
<td>7,999</td>
<td>11,997</td>
</tr>
<tr>
<td>Cawelo WD</td>
<td>19,089</td>
<td>38,193</td>
<td>57,282</td>
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<td>Improvement District No. 4 (Ag)</td>
<td>5,135</td>
<td>10,274</td>
<td>15,409</td>
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<td>Improvement District No. 4 (M&amp;I)</td>
<td>0</td>
<td>53,900</td>
<td>53,900</td>
</tr>
<tr>
<td>Rosedale-Rio Bravo WSD</td>
<td>14,941</td>
<td>29,895</td>
<td>44,836</td>
</tr>
<tr>
<td>Buena Vista WSD</td>
<td>10,644</td>
<td>21,296</td>
<td>31,940</td>
</tr>
<tr>
<td>Kern Delta WD</td>
<td>12,742</td>
<td>25,495</td>
<td>38,237</td>
</tr>
<tr>
<td>Henry Miller WD</td>
<td>17,740</td>
<td>35,494</td>
<td>53,234</td>
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<tr>
<td>West Kern WD (M&amp;I)</td>
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<td>17,500</td>
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<tr>
<td>Wheeler Ridge-Maricopa WSD</td>
<td>126,389</td>
<td>252,880</td>
<td>379,269</td>
</tr>
<tr>
<td>Tehachapi Cummings CWD (Ag)</td>
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<td>4,299</td>
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<td>Tehachapi Cummings CWD (M&amp;I)</td>
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<td>10,500</td>
</tr>
<tr>
<td>Tejon-Castac WD (M&amp;I)</td>
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<td>1,400</td>
<td>1,400</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>516,900</td>
<td>1,117,520</td>
<td>1,634,420</td>
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</table>
### Table 2b
Kern County Water Agency
Member Unit Contract Entitlements
for 1990*-2035

<table>
<thead>
<tr>
<th>Member Unit</th>
<th>Firm</th>
<th>Surplus</th>
<th>Total</th>
<th>M&amp;I</th>
<th>Ag</th>
<th>Total</th>
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</thead>
<tbody>
<tr>
<td>Berrenda Mesa WD</td>
<td>155,100</td>
<td>8,100</td>
<td>163,200</td>
<td></td>
<td></td>
<td>163,200</td>
</tr>
<tr>
<td>Lost Hills WD</td>
<td>140,400</td>
<td>0</td>
<td>140,400</td>
<td></td>
<td></td>
<td>140,400</td>
</tr>
<tr>
<td>Belridge WSD</td>
<td>163,000</td>
<td>0</td>
<td>163,000</td>
<td>15,000 **</td>
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<td>163,000</td>
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<tr>
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<td>96,100</td>
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<td>96,100</td>
<td>96,100</td>
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<tr>
<td>Semitropic WSD</td>
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<td>8,900</td>
</tr>
<tr>
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<td>88,830</td>
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<td>Buena Vista WSD</td>
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<tr>
<td>Kern Delta WD</td>
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<tr>
<td>Henry Miller WD</td>
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<td>West Kern WD</td>
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<td>252,924</td>
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<td>Tehachapi-Cummings CWD</td>
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<td>2,000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1,153,400</strong></td>
<td><strong>100,000</strong></td>
<td><strong>1,253,400</strong></td>
<td><strong>134,000</strong></td>
<td><strong>1,119,400</strong></td>
<td><strong>1,253,400</strong></td>
</tr>
</tbody>
</table>

* Maximum annual entitlement is reached in 1990.

** Subject to agricultural water shortage provisions.
Table 3
SWP Water Deliveries to the
San Joaquin Valley Portion of Kern County
(in acre-feet)

<table>
<thead>
<tr>
<th>Year</th>
<th>Annual (1) Deliveries</th>
<th>Cumulative Deliveries</th>
<th>Intertie Deliveries</th>
<th>Deliveries (2) Outside SJV</th>
<th>Annual Importations</th>
<th>Cumulative Importations</th>
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</thead>
<tbody>
<tr>
<td>1968</td>
<td>127,384</td>
<td>127,384</td>
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<td>127,384</td>
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<tr>
<td>1969</td>
<td>141,265</td>
<td>268,649</td>
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<td>268,649</td>
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<tr>
<td>1970</td>
<td>204,634</td>
<td>473,283</td>
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<td>473,283</td>
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<td>1971</td>
<td>375,505</td>
<td>848,788</td>
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<td>848,788</td>
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<td></td>
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<tr>
<td>1972</td>
<td>535,573</td>
<td>1,384,361</td>
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<td>1,384,361</td>
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<td>515,546</td>
<td>1,899,907</td>
<td>25</td>
<td>1,899,907</td>
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<td>1974</td>
<td>656,773</td>
<td>2,556,680</td>
<td>4,992</td>
<td>2,551,663</td>
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<td>1975</td>
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<td>6,699</td>
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<td>888,112</td>
<td>4,273,229</td>
<td>4,755</td>
<td>4,256,758</td>
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<td>1977</td>
<td>432,837</td>
<td>4,706,066</td>
<td>3,424</td>
<td>4,686,171</td>
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<td>1978</td>
<td>678,400</td>
<td>5,384,466</td>
<td>64,100</td>
<td>5,297,645</td>
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<td>1979</td>
<td>1,295,388</td>
<td>6,679,854</td>
<td>2,826</td>
<td>6,589,403</td>
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<td>1980</td>
<td>968,092</td>
<td>7,647,946</td>
<td>3,630</td>
<td>7,489,662</td>
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<td>1981</td>
<td>1,386,641</td>
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<td>1,897</td>
<td>8,874,406</td>
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<td>1982</td>
<td>900,973</td>
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<td>601,183</td>
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<td>929,178</td>
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<td>13,107,810</td>
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<tr>
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<td>1,028,124</td>
<td>14,710,232</td>
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<tr>
<td>1988</td>
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<td>15,139,930</td>
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<td></td>
</tr>
<tr>
<td>1989</td>
<td>1,146,062</td>
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| Mean Deliveries | 729,444 AF |
| Median Deliveries | 828,437 AF |
| Mean Importations | 705,754 AF |
| Median Importations | 821,738 AF |

(1) Includes Pre-consolidation water deliveries.
(2) Includes Tehachapi-Cummings CWD and other deliveries outside the San Joaquin Valley portion of Kern County.
(3) From Table 4.
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This table shows contracted deliveries for calendar year 1991. For each district, deliveries may vary from amounts shown, due to: a) current year SWP/Kern river exchanges, b) payback of SWP water from prior year exchanges, c) conjunctive use agreements.

(1) Includes 318 AF of 1990 entitlement carryover and 400 AF of 1991 entitlement from Tejon-Castac WD transferred to a common landsaver in Wheeler Ridge-Maricopa WD.

(2) This water, which is normally delivered to Buena Vista WD via a long-term exchange with West Kern WD, was delivered to Belridge WD for M&I purposes.

(3) Includes 2,500 AF of ID4 exchange payback to Kern-Tulare WD/Lost Hills WD; includes 1,100 AF of Nickel water sold to Lost Hills WD (Ritchie & Westfarmers) and delivered via Nickel/ID4 exchange; includes 2 AF of a 100 AF ID4 sale to Marson (LHWD).

(4) Includes 300 AF of Hacienda water sold to Belridge WD (Starr) and delivered via the Hacienda/ID4 exchange; includes 100 AF of Nickel water sold to Belridge WD (Ritchie) and delivered via the Nickel/ID4 exchange.

(5) Cawelo WD's January SWP delivery prior to the 04 agricultural allocation. Accommodated through an exchange with ID4 for a like amount of Kern River water.

(6) Completion of 1990 ID4 exchange payback to Buena Vista WD.


(8) West Kern WD's 1991 entitlement delivered to Buena Vista WD via long-term exchange agreement.


(10) Imported supply of CVF water delivered to Lost Hills WD (Paramount) via Kern-Tulare WD/ID4 exchange date July 25, 1991 (Exhibit A to agreement between Lost Hills WD, Paramount and KCWA dated August 26, 1991).

(11) Includes 97,013 AF out of a 100,000 AF production target; remaining 2,987 AF delivered in 1992.

(12) Includes 2,333 AF of groundwater introduced into the Coastal Branch of the California Aqueduct, and 3,950 AF of groundwater from the Berrenda Mesa Spreading Grounds introduced into the California Aqueduct and/or exchanged in the Cross Valley Canal.

(13) Groundwater produced by West Kern WD and introduced into the California Aqueduct at Mile Post 240.20 and delivered to Belridge WD Turnout No. 5 at Mile Post 217.13 of the California Aqueduct per agreement dated July 12, 1991.

(14) Groundwater produced by ID4 and by private parties (Bartells and Castle & Cook) in excess of consumptive use limit; all for use by ID4.

(15) Kern River water and groundwater produced by Buena Vista WD and introduced into the California Aqueduct for delivery by district later in the year, as per draft agreement dated April 22, 1991.

(16) Groundwater produced by Henry Miller WD and introduced into the California Aqueduct for delivery by district later in the year, as per draft agreement dated April 22, 1991.

(17) Groundwater produced by Wheeler Ridge-Maricopa WD and introduced into the California Aqueduct for instantaneous delivery to various users with the district; as per agreement dated April 18, 1991.

(18) Groundwater account transferred from North Kern WD to the 2,800 Acre Spreading Facility for extraction and delivery to Paramount (LHWD); to be extracted by KCWA wells; pursuant to agreement dated September 19, 1991.

(19) Groundwater produced by private party (Bartell) and sold to Belridge WD (Starr) via agreement dated July 26, 1991.


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<th>Calendar Year</th>
<th>Annual Flows</th>
<th>Cumulative Unregulated Flows</th>
<th>Calendar Year</th>
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* Includes deliveries above First Point.
** Data incomplete. Flow extrapolated from available data.
*** Isabella Dam in operation. All subsequent flows are controlled releases.
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<td>1988</td>
<td>294,685</td>
<td>70,063,390</td>
<td>27,527,066</td>
<td></td>
</tr>
<tr>
<td>1989</td>
<td>397,038</td>
<td>70,460,428</td>
<td>27,924,104</td>
<td></td>
</tr>
<tr>
<td>1990</td>
<td>219,501</td>
<td>70,679,929</td>
<td>28,143,605</td>
<td></td>
</tr>
<tr>
<td>1991</td>
<td>335,913</td>
<td>71,015,842</td>
<td>28,479,518</td>
<td></td>
</tr>
</tbody>
</table>

*Table 5 (continued)*

*Historic Kern River Flows* *(in acre-feet)*
Figure 4 is a histogram of annual Kern River flows at First Point.

Entitlements to Kern River water are determined according to formulas 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 1991. Plate 10 at the end of this report 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 1991 were 204,396 acre-feet. Comparatively, 1990 deliveries of CVP water were 200,141 acre-feet. Supplies in 1991 were about 54 percent of the 1975-1991 average, and about 57 percent of the 1975-1991 median. For the fifth consecutive year no Class 2 entitlement was available. Since 1966, Class 2 entitlements have been unavailable in only seven years (1976-77 and 1987-91). Table 7 shows 1991 deliveries of CVP water by entity. As shown, 191,996 acre-feet of Class 1 entitlement and 12,400 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 histogram of CVP deliveries since 1950. At the end of 1991, over 11.7 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 stream watersheds. Streams which yield measurable runoff are grouped into four watershed groups; the Poso group (most significant of which is Poso Creek), the Caliente group (most significant of which are Caliente and Tehachapi Creeks), the El Paso group (most significant of which is El Paso Creek), and the San Emigdio group (most significant of which is San Emigdio Creek). Grouping of minor streams is based upon hydrologic similarity of watersheds, and representative gauging records. Total yields from minor streams can be substantial during above-average precipitation years, such as 1978, 1982 and 1983. Runoff for un-gaged streams is estimated by statistical methods based on historic relationships of area, precipitation and runoff for gaged streams. Gages on Poso and Tehachapi Creeks are still operating, and therefore actual measurements of runoff can be used for these watersheds. (An exception is Tehachapi Creek in very dry years, when the flow is too small for the gage to record, as occurred in 1990). Total minor stream volumes in 1991 were estimated to be about 34,600 acre-feet as follows:

<table>
<thead>
<tr>
<th>Group</th>
<th>Acre-Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poso</td>
<td>9,000</td>
</tr>
<tr>
<td>Caliente</td>
<td>7,700</td>
</tr>
<tr>
<td>El Paso</td>
<td>6,300</td>
</tr>
<tr>
<td>San Emigdio</td>
<td>11,600</td>
</tr>
</tbody>
</table>

| Total     | 34,600    |

During most years, some minor stream water is used for irrigation by farmers in the North Kern Water Storage District and Pond-Poso Improvement District. Much of the water percolates 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 32,900 acre-feet of the minor stream flows during 1991 contributed to groundwater 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, and can be seen graphically in Figure 6.

The Agency, in cooperation with local water districts, monitors stream flows on Poso and Tehachapi Creeks. Figures 7a and 7b are hydrographs for Poso Creek, showing runoff during 1991.

Effective Precipitation

Rainfall that occurs during the growing season of a crop, or is otherwise stored in the soil for later use,
Figure 4
Kern River Flows at First Point of Measurement

Acre-Feet
2,500,000
2,000,000
1,500,000
1,000,000
500,000
0


Projected
Regulated Mean Flow
<table>
<thead>
<tr>
<th>Area of Use</th>
<th>Deliveries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Above First Point</td>
<td></td>
</tr>
<tr>
<td>Olcese WD</td>
<td>1,465</td>
</tr>
<tr>
<td>Other Diversions</td>
<td>954</td>
</tr>
<tr>
<td>Sub-total</td>
<td>2,419</td>
</tr>
<tr>
<td>Below First Point</td>
<td></td>
</tr>
<tr>
<td>Buena Vista WSD</td>
<td>54,616</td>
</tr>
<tr>
<td>Cawelo WD</td>
<td>40,104</td>
</tr>
<tr>
<td>City of Bakersfield, Irrigation and Spreading (1)</td>
<td>23,499</td>
</tr>
<tr>
<td>Improvement District No. 4</td>
<td>25,728</td>
</tr>
<tr>
<td>Kern Delta WD</td>
<td>152,267</td>
</tr>
<tr>
<td>Kern-Tulare WD</td>
<td>192</td>
</tr>
<tr>
<td>North Kern WSD</td>
<td>27,984</td>
</tr>
<tr>
<td>Rag Gulch WD</td>
<td>28</td>
</tr>
<tr>
<td>Rosedale-Rio Bravo WSD</td>
<td>9,076</td>
</tr>
<tr>
<td>Sub-total</td>
<td>333,494</td>
</tr>
<tr>
<td>Grand Total</td>
<td>335,913</td>
</tr>
</tbody>
</table>

(1) Includes Carrier Canal loss and percolation, Kern River channel and percolation.
Table 7
1991 Central Valley Project
Deliveries by Entity
(in acre-feet)

<table>
<thead>
<tr>
<th>Entity</th>
<th>Cross Valley Canal (4)</th>
<th>Non-Project Water</th>
<th>Pumped into F.K. Canal</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arvin-Edison WSD (1)</td>
<td></td>
<td>32,815</td>
<td>200</td>
<td>33,015</td>
</tr>
<tr>
<td>Delano-Earlimart ID</td>
<td></td>
<td>14,993</td>
<td></td>
<td>14,993</td>
</tr>
<tr>
<td>Kern National Wildlife Refuge (2)</td>
<td></td>
<td>6,200</td>
<td></td>
<td>6,200</td>
</tr>
<tr>
<td>Kern-Tulare WD (3)</td>
<td></td>
<td>5,458</td>
<td>7,000</td>
<td>4,513</td>
</tr>
<tr>
<td>Rag Gulch WD (3)</td>
<td></td>
<td>5,081</td>
<td>0</td>
<td>5,081</td>
</tr>
<tr>
<td>Shafter-Wasco ID</td>
<td></td>
<td>44,116</td>
<td>500</td>
<td>44,616</td>
</tr>
<tr>
<td>So. San Joaquin MUD</td>
<td></td>
<td>83,333</td>
<td>187</td>
<td>83,520</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>191,996</strong></td>
<td><strong>7,000</strong></td>
<td><strong>204,396</strong></td>
</tr>
</tbody>
</table>

(1) Includes 15,020 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.

Note: No Class 2 allotments for 1991.
<table>
<thead>
<tr>
<th>Year</th>
<th>Annual Delivery</th>
<th>Cumulative Delivery</th>
<th>Year</th>
<th>Annual Delivery</th>
<th>Cumulative Delivery</th>
</tr>
</thead>
<tbody>
<tr>
<td>1950</td>
<td>762</td>
<td>762</td>
<td>1981</td>
<td>469,966</td>
<td>7,899,255</td>
</tr>
<tr>
<td>1951</td>
<td>27,005</td>
<td>27,767</td>
<td>1982</td>
<td>656,608</td>
<td>8,555,863</td>
</tr>
<tr>
<td>1952</td>
<td>49,500</td>
<td>77,267</td>
<td>1983</td>
<td>550,874</td>
<td>9,106,737</td>
</tr>
<tr>
<td>1953</td>
<td>83,558</td>
<td>160,825</td>
<td>1984</td>
<td>425,371</td>
<td>9,532,108</td>
</tr>
<tr>
<td>1954</td>
<td>112,093</td>
<td>272,918</td>
<td>1985</td>
<td>337,514</td>
<td>9,869,622</td>
</tr>
<tr>
<td>1955</td>
<td>126,238</td>
<td>399,156</td>
<td>1986</td>
<td>589,262</td>
<td>10,458,884</td>
</tr>
<tr>
<td>1956</td>
<td>279,134</td>
<td>678,290</td>
<td>1987</td>
<td>291,981</td>
<td>10,750,865</td>
</tr>
<tr>
<td>1957</td>
<td>141,684</td>
<td>819,974</td>
<td>1988</td>
<td>292,828</td>
<td>11,043,693</td>
</tr>
<tr>
<td>1958</td>
<td>223,830</td>
<td>1,043,804</td>
<td>1989</td>
<td>293,865</td>
<td>11,337,558</td>
</tr>
<tr>
<td>1959</td>
<td>166,099</td>
<td>1,209,903</td>
<td>1990</td>
<td>200,141</td>
<td>11,537,699</td>
</tr>
<tr>
<td>1960</td>
<td>156,978</td>
<td>1,366,881</td>
<td>1991</td>
<td>204,396</td>
<td>11,742,095</td>
</tr>
<tr>
<td>1961</td>
<td>126,412</td>
<td>1,493,293</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1962</td>
<td>231,045</td>
<td>1,724,338</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>1963</td>
<td>234,283</td>
<td>1,958,621</td>
<td>Mean Delivery</td>
<td>279,574 AF</td>
<td></td>
</tr>
<tr>
<td>1964</td>
<td>189,330</td>
<td>2,147,951</td>
<td>Median Delivery</td>
<td>245,482 AF</td>
<td></td>
</tr>
<tr>
<td>1965</td>
<td>245,482</td>
<td>2,393,433</td>
<td>Mean Delivery 1975-91</td>
<td>375,651 AF</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Median Delivery 1975-91</td>
<td>357,847 AF</td>
<td></td>
</tr>
<tr>
<td>1966</td>
<td>232,084</td>
<td>2,625,517</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1967</td>
<td>319,706</td>
<td>2,945,223</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1968</td>
<td>206,499</td>
<td>3,151,722</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1969</td>
<td>372,826</td>
<td>3,524,548</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1970</td>
<td>351,392</td>
<td>3,875,940</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1971</td>
<td>348,865</td>
<td>4,224,805</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1972</td>
<td>238,475</td>
<td>4,463,280</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1973</td>
<td>412,178</td>
<td>4,875,458</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1974</td>
<td>480,575</td>
<td>5,356,033</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1975</td>
<td>442,130</td>
<td>5,798,163</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1976</td>
<td>226,512</td>
<td>6,024,675</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1977</td>
<td>121,469</td>
<td>6,146,144</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1978</td>
<td>357,847</td>
<td>6,503,991</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1979</td>
<td>462,526</td>
<td>6,966,517</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1980</td>
<td>462,772</td>
<td>7,429,289</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 9
Annual and Cumulative
Minor Stream Flows in the
San Joaquin Valley Portion of Kern County
(in acre-feet)

<table>
<thead>
<tr>
<th>Year</th>
<th>Annual Stream Flows</th>
<th>Cumulative Stream Flows</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970</td>
<td>132,400</td>
<td>132,400</td>
</tr>
<tr>
<td>1971</td>
<td>63,200</td>
<td>195,600</td>
</tr>
<tr>
<td>1972</td>
<td>21,600</td>
<td>217,200</td>
</tr>
<tr>
<td>1973</td>
<td>22,900</td>
<td>240,100</td>
</tr>
<tr>
<td>1974</td>
<td>104,900</td>
<td>345,000</td>
</tr>
<tr>
<td>1975</td>
<td>39,400</td>
<td>384,400</td>
</tr>
<tr>
<td>1976</td>
<td>42,700</td>
<td>427,100</td>
</tr>
<tr>
<td>1977</td>
<td>32,900</td>
<td>460,000</td>
</tr>
<tr>
<td>1978</td>
<td>429,200</td>
<td>889,200</td>
</tr>
<tr>
<td>1979</td>
<td>96,700</td>
<td>985,900</td>
</tr>
<tr>
<td>1980</td>
<td>65,200</td>
<td>1,051,100</td>
</tr>
<tr>
<td>1981</td>
<td>63,600</td>
<td>1,114,700</td>
</tr>
<tr>
<td>1982</td>
<td>159,900</td>
<td>1,274,600</td>
</tr>
<tr>
<td>1983</td>
<td>327,700</td>
<td>1,602,300</td>
</tr>
<tr>
<td>1984</td>
<td>14,300</td>
<td>1,616,600</td>
</tr>
<tr>
<td>1985</td>
<td>20,200</td>
<td>1,636,800</td>
</tr>
<tr>
<td>1986</td>
<td>32,600</td>
<td>1,669,400</td>
</tr>
<tr>
<td>1987</td>
<td>28,600</td>
<td>1,698,000</td>
</tr>
<tr>
<td>1988</td>
<td>22,900</td>
<td>1,720,900</td>
</tr>
<tr>
<td>1989</td>
<td>26,300 *</td>
<td>1,747,200</td>
</tr>
<tr>
<td>1990</td>
<td>17,000 *</td>
<td>1,764,200</td>
</tr>
<tr>
<td>1991</td>
<td>34,600</td>
<td>1,798,800</td>
</tr>
</tbody>
</table>

Mean Flow 84,000 AF
Median Flow 37,000 AF

* Modified from previous Water Supply Reports
Figure 6
Minor Stream Flows in Kern County

Acre-Feet

450,000
400,000
350,000
300,000
250,000
200,000
150,000
100,000
50,000
0


Projected

Average Flow
Figure 7a
Poso Creek
Hydrograph, 1991

Mean Daily Flow (cfs)

Note:
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.

Figure 7b
Poso Creek
Cumulative Volumes, 1991

Cumulative Volumes (AF)

<table>
<thead>
<tr>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>3415</td>
<td>2918</td>
<td>873</td>
<td>12</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>3415</td>
<td>6333</td>
<td>7206</td>
<td>7218</td>
<td>7218</td>
<td>7218</td>
<td>7218</td>
<td>7218</td>
<td>7218</td>
<td>7218</td>
</tr>
</tbody>
</table>

7,218 AF
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 groundwater 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 groundwater, 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 50 acre-feet of rainfall was diverted into the Kern River system in 1991.

The Agency gathers monthly rainfall data for most of the measuring stations in the San Joaquin Valley portion of Kern County. Data for some mountain stations are also gathered. This rainfall data is subsequently used to compute effective precipitation, or in the case of mountain stations, minor stream runoff. Table 10 gives monthly rainfall for every measuring station gathered by KCWA. New to Table 10 is the addition of several mountain stations used to compute minor stream runoff. Except for March, very low rainfall in 1991 contributed 171,700 acre-feet of effective precipitation, with 157,700 acre-feet occurring over the useable groundwater basin. This includes the urban storm water diverted into the Kern River. Rainfall at Meadows Field, Bakersfield in 1991 was about 113 percent of normal, compared to 61 percent of normal during 1990. Following is a tabulation of 1990 and 1991 versus average monthly rainfall for Meadows Field near Bakersfield. The Agency estimates that rainfall provided about 2.45 inches of useable water for crops grown during 1991. Usually, rainfall provides about 2.5 inches of useable water for crops.

<table>
<thead>
<tr>
<th>Rainfall at Meadows Field, Bakersfield</th>
<th>1990</th>
<th>1991</th>
<th>Average</th>
<th>Percent of Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan</td>
<td>0.85</td>
<td>0.62</td>
<td>1.02</td>
<td>61</td>
</tr>
<tr>
<td>Feb</td>
<td>0.93</td>
<td>0.13</td>
<td>1.00</td>
<td>13</td>
</tr>
<tr>
<td>Mar</td>
<td>0.45</td>
<td>4.33</td>
<td>0.94</td>
<td>461</td>
</tr>
<tr>
<td>Apr</td>
<td>0.18</td>
<td>0.66</td>
<td>0.65</td>
<td>9</td>
</tr>
<tr>
<td>May</td>
<td>0.29</td>
<td>—</td>
<td>0.30</td>
<td>—</td>
</tr>
<tr>
<td>Jun</td>
<td>—</td>
<td>—</td>
<td>0.07</td>
<td>—</td>
</tr>
<tr>
<td>Jul</td>
<td>—</td>
<td>—</td>
<td>0.01</td>
<td>—</td>
</tr>
<tr>
<td>Aug</td>
<td>—</td>
<td>—</td>
<td>0.02</td>
<td>—</td>
</tr>
<tr>
<td>Sep</td>
<td>0.05</td>
<td>0.10</td>
<td>0.10</td>
<td>10</td>
</tr>
<tr>
<td>Oct</td>
<td>0.03</td>
<td>0.30</td>
<td>0.31</td>
<td>97</td>
</tr>
<tr>
<td>Nov</td>
<td>0.47</td>
<td>0.01</td>
<td>0.52</td>
<td>2</td>
</tr>
<tr>
<td>Dec</td>
<td>0.26</td>
<td>1.04</td>
<td>0.80</td>
<td>130</td>
</tr>
<tr>
<td>Total</td>
<td>3.51</td>
<td>6.50</td>
<td>5.74</td>
<td>113</td>
</tr>
</tbody>
</table>

A glaring anomaly in 1991 was March, with 461 percent of normal rainfall, followed by five straight months of practically no rain. This demonstrates the erratic nature of precipitation in the arid climate of the southern San Joaquin Valley. Most of the effective precipitation during 1991 occurred in March. The heavy March rains were roughly equivalent to an irrigation event for most crops. Thus, total yearly pre-irrigation and irrigation needs were reduced. (Pre-irrigation fills the soil profile with water prior to planting, so that the growing seedlings will have sufficient moisture. Many field crops and vegetables are planted in April-May after the spring rains). Likely, the March rains decreased the amount of water purchased from the State Bank. Figure 8 shows annual rainfall recorded at four 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 11 lists the annual amounts of effective precipitation, expressed as total acre-feet and inches per acre, along with cumulative amounts and descriptive statistics. Figure 9 is a graphic depiction of the same information.

**Waste Water Reuse**

The reuse of municipal and industrial waste water provides a minor source of water for Kern County agriculture. There are 13 active waste water sewage
Figure 8
Annual Precipitation at Three Stations
in the San Joaquin Valley of Kern County, California

Inches

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- Meadows Field
- Lost Hills NWS T26S/R21E-Sec
- Greenlee's Pasture T12N/R21W-Sec 36N
- Valley Average

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<td>0.45</td>
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<tr>
<td>So. Belridge (Shell Calif.)</td>
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<td><strong>0.03</strong></td>
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<td><strong>1.21</strong></td>
<td><strong>9.18</strong></td>
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* All stations with elevation of 700 feet above sea level or less.
Table 11
Annual and Cumulative Effective Precipitation
in the San Joaquin Valley Portion of Kern County
(in acre-feet)

<table>
<thead>
<tr>
<th>Year</th>
<th>Annual Effective Precipitation</th>
<th>Unit Rate (inches per acre)</th>
<th>Cumulative Effective Precipitation</th>
</tr>
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<tbody>
<tr>
<td>1970</td>
<td>380,200</td>
<td>5.72</td>
<td>380,200</td>
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<td>1971</td>
<td>148,300</td>
<td>2.13</td>
<td>528,500</td>
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<td>1972</td>
<td>264,900</td>
<td>3.78</td>
<td>793,400</td>
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<tr>
<td>1973</td>
<td>131,900</td>
<td>1.84</td>
<td>925,300</td>
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<td>1974</td>
<td>220,200</td>
<td>2.88</td>
<td>1,145,500</td>
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<td>240,500</td>
<td>3.17</td>
<td>1,386,000</td>
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<td>175,300</td>
<td>2.25</td>
<td>1,561,300</td>
</tr>
<tr>
<td>1977</td>
<td>198,400</td>
<td>2.74</td>
<td>1,759,700</td>
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<tr>
<td>1978</td>
<td>612,500</td>
<td>8.08</td>
<td>2,372,200</td>
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<tr>
<td>1979</td>
<td>152,600</td>
<td>1.97</td>
<td>2,524,800</td>
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<tr>
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<td>281,200</td>
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<td>2,806,000</td>
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<tr>
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<td>255,400</td>
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<td>3,061,400</td>
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<td>160,700</td>
<td>2.04</td>
<td>4,131,800</td>
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<td>1986</td>
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<td>4,294,400</td>
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<td>1987</td>
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<td>2.57</td>
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<td>90,500</td>
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<td>1991</td>
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<table>
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<th>Statistic</th>
<th>Value</th>
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<td>219,600 AF</td>
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<tr>
<td>Median EP (total)</td>
<td>171,700 AF</td>
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<tr>
<td>Mean EP (per acre)</td>
<td>2.99 Inches/Acre</td>
</tr>
<tr>
<td>Median EP (per acre)</td>
<td>2.45 Inches/Acre</td>
</tr>
</tbody>
</table>
Figure 9
Effective Precipitation in the San Joaquin Valley Portion of Kern County

Acre-Feet

700,000

600,000

500,000

400,000

300,000

200,000

100,000

0


Inches/Acre

9.00

8.00

7.00

6.00

5.00

4.00

3.00

2.00

1.00

0.00

Unit Rate

Projected

treatment plants in the valley portion of Kern County. Waste water 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 waste water 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 discharged to the groundwater basin. The remainder is evaporated. In 1991, about 45,200 acre-feet of waste water was treated (see Table 12).

Another source of waste water 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. 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). 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. From a basin-balance standpoint, these two water reuse activities are internal and do not add to the hydrologic system.

Oilfield Waste Water

Another source of waste water is a by-product of oilfield production. Unlike treated municipal effluent or tail water, oilfield waste water is a true addition to the hydrologic system, 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 2,100 acre-feet of production water from the Kern Front oilfield was reused in 1991. This was about 3,200 acre-feet less than was produced during 1990. Likely, this is an indicator of the severity of the continued oilfield slowdown which has accompanied lower prices for crude oil.

In other areas, some oil companies discharge their waste waters into lined and unlined sumps, some of which 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.

Total waste water reuse was estimated to be about 47,300 acre-feet in 1991, excluding any tailwater reuse, which were not estimated. Table 13 gives a historical summary of waste water reuse in the San Joaquin Valley portion of Kern County since 1970. Figure 10 charts the same information as a hydrograph. Note that waste water production stays fairly constant.

Groundwater Extractions

Most of the groundwater extractions in Kern County are not recorded. In the past, agricultural power records from the utility companies were matched with calculated numbers for groundwater production. However, the accuracy of such power record calculations were unsatisfactory. Thus, in this report groundwater extractions are estimated by backfilling, or solving for the missing number in the groundwater change-in-storage equation (see Figure 14).

Total groundwater extractions in 1991 were calculated to be about 2,002,400 acre-feet. This is about 203,500 acre-feet more than was extracted in 1990. The obvious reason for this increase was the reduction in surface water supplies due to the lingering drought. Groundwater is pumped for a variety of uses in the valley. Agriculture, the largest user of groundwater, used about 1,889,400 acre-feet in 1991. Municipal and industrial uses of groundwater were about 113,000 acre-feet. Since the present drought began in 1987, about 8,134,400 acre-feet of groundwater have been pumped, with resultant water level declines of 40-80 feet.

Since 1977 it has become apparent that groundwater 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 in lieu of
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<th>Volume</th>
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<td>#2</td>
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<td>Evaporation</td>
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For influent source:
- Dom - domestic
- Ind - industrial
- Agr - agricultural

* Million gallons, based on daily average flow.
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<th>Treated Wastewater Annual Flows</th>
<th>Treated Wastewater Cumulative Flows</th>
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<th>Oilfield Wastewater Cumulative Flows</th>
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</tbody>
</table>

|                      | Mean Waste Water Flows 33,700 AF | Median Waste Water Flows 32,800 AF | Mean Oilfield Flows 8,300 AF | Median Oilfield Flows 8,500 AF |
Figure 10
Wastewater Reuse in Kern County

Acre-Feet
50,000
45,000
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
Projected

Treated Wastewater
Oilfield Wastewater
pumping groundwater. However, when surface water supplies are low, the opposite is true and farmers are forced to rely more heavily on their groundwater 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 greatly benefit Kern County's groundwater basin.

Timing is another factor affecting groundwater 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 14 gives historic groundwater pumping in the San Joaquin Valley portion of Kern County since 1970. Both annual and cumulative amounts are tabulated, along with descriptive statistics. Figure 11 provides a histogram of groundwater pumping, graphically displaying the relative variations.
### Table 14

**Historic Ground Water Pumping**

(in acre-feet)

<table>
<thead>
<tr>
<th>Year</th>
<th>Annual Ground Water Pumped</th>
<th>Cumulative Ground Water Pumped</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970</td>
<td>1,422,000</td>
<td>1,422,000</td>
</tr>
<tr>
<td>1971</td>
<td>1,700,000</td>
<td>3,122,000</td>
</tr>
<tr>
<td>1972</td>
<td>1,857,000</td>
<td>4,979,000</td>
</tr>
<tr>
<td>1973</td>
<td>1,662,000</td>
<td>6,641,000</td>
</tr>
<tr>
<td>1974</td>
<td>1,333,000</td>
<td>7,974,000</td>
</tr>
<tr>
<td>1975</td>
<td>1,587,000</td>
<td>9,561,000</td>
</tr>
<tr>
<td>1976</td>
<td>1,738,000</td>
<td>11,299,000</td>
</tr>
<tr>
<td>1977</td>
<td>1,703,000</td>
<td>13,002,000</td>
</tr>
<tr>
<td>1978</td>
<td>825,000</td>
<td>13,827,000</td>
</tr>
<tr>
<td>1979</td>
<td>1,260,000</td>
<td>15,087,000</td>
</tr>
<tr>
<td>1980</td>
<td>977,000</td>
<td>16,064,000</td>
</tr>
<tr>
<td>1981</td>
<td>1,161,000</td>
<td>17,225,000</td>
</tr>
<tr>
<td>1982</td>
<td>802,200</td>
<td>18,027,200</td>
</tr>
<tr>
<td>1983</td>
<td>762,700</td>
<td>18,789,900</td>
</tr>
<tr>
<td>1984</td>
<td>1,252,200</td>
<td>20,042,100</td>
</tr>
<tr>
<td>1985</td>
<td>1,293,800</td>
<td>21,335,900</td>
</tr>
<tr>
<td>1986</td>
<td>947,600</td>
<td>22,283,500</td>
</tr>
<tr>
<td>1987</td>
<td>1,208,700</td>
<td>23,492,200</td>
</tr>
<tr>
<td>1988</td>
<td>1,540,200</td>
<td>25,032,400</td>
</tr>
<tr>
<td>1989</td>
<td>1,588,500</td>
<td>26,620,900</td>
</tr>
<tr>
<td>1990</td>
<td>1,796,500</td>
<td>28,417,400</td>
</tr>
<tr>
<td>1991</td>
<td>2,002,400</td>
<td>30,419,800</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mean Ground Water Pumping</th>
<th>1,387,600 AF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median Ground Water Pumping</td>
<td>1,422,000 AF</td>
</tr>
<tr>
<td>Minimum Pumping in 1983</td>
<td>762,700 AF</td>
</tr>
<tr>
<td>Maximum Pumping in 1991</td>
<td>2,002,400 AF</td>
</tr>
</tbody>
</table>
Figure 11
Groundwater Pumping
in the San Joaquin Valley Portion of Kern County

Acre-Feet


Projected
Water Requirements

Agricultural

Gross irrigated acreage in the San Joaquin Valley portion of Kern County was about 767,600 acres in 1991. Since about 27,700 acres were double-cropped, total gross cropped acreage in 1991 was about 739,900 acres. About 701,400 acres (including double-cropping) were irrigated over the useable groundwater basin, and about 66,300 acres were irrigated on lands outside the useable groundwater basin. Some of the acreage outside the useable groundwater basin received only partial irrigation during the early part of the year, then was abandoned when the water supply situation became clear. Cotton acreage decreased about 50,000 acres from 1990, likely reflecting the continuing drought conditions. Vegetables showed a 15,000 acre increase over 1990, perhaps due to the favorable prices received for fresh-market produce. Particularly, carrots increased by about 18,000 over 1990. Potatoes decreased about 9,000 acres from 1990. Potatoes are a fairly cyclical crop, with acreage changes following product prices. Small grains showed a decrease of about 16,000 acres from 1990. Grains are typically a rotation crop with cotton. Thus, the decrease is likely due to the large drop in cotton acreage. A total of about 101,700 acres were idled during 1991, an obvious victim of the lingering drought. Much of this reduction came from the west side areas, which are entirely dependent upon surface water for irrigation. A historical summary of irrigated acreage is provided on Table 15, along with descriptive statistics. Figure 12 shows historic irrigated acreage plotted as a bar graph.

Per unit crop water demands in 1991 were quite normal. Evaporation, which corresponds to crop water use, was only slightly higher than normal. Table 16 is a summary of monthly evaporation as measured at three climatic stations in the County, The Bakersfield 12S and Lamont 2NW stations (operated by the State Department of Water Resources) are representative of evaporation on the valley floor. Figure 13 displays monthly evaporation for these stations as a percent of normal. Overall, 1991 was a good growing season, marked by a long, warm summer and dry harvest season. The moderate growing season benefited the cotton crop, which yielded an average 1,256 pounds of lint per acre (2.5 bales per acre), about the same as in 1990. The moderate growing season benefitted some vegetable crops, which showed increased yields over 1990. In particular, potatoes enjoyed a 20 percent yield increase, fresh garlic enjoyed a 30 percent increase in yields over 1990. While production levels for these crops were bright spots, overall field and vegetable crop yields in 1991 were slightly lower than in 1990. Permanent crops also saw a general decline in yields from 1990, part of which may be related to water stress as a result of the reduction in water availability and subsequent higher water costs. Hardest hit were oranges (which yielded only about 50 percent of 1990 per unit production), and olives (which went from a banner year in 1990 to a dismal year in 1991). Olive yields were reduced by 97 percent from 1990 production.

The Kern County Agricultural Commissioners annual crop report shows that, in 1991, the agricultural products of Kern County had a market value of $1,512,542,000, down 17 percent from 1990’s value of $1,837,516,000. The reduction can be attributed to the impacts of the December, 1990 freeze which decimated local citrus groves, and the sixth consecutive year of drought when over 101,000 acres of agricultural land were idled. Citrus in particular was hard hit, showing a loss in value of 56 percent due to the December, 1990 freeze. Only 28 percent of the citrus crop for 1991 was harvested, clearly demonstrating the devastation reaped upon local citrus groves. Overall, the trend during 1991 was for unit values and gross crop values to be reduced from 1990 levels. Comparisons of 1991 to 1990 gross crop values shows:

<table>
<thead>
<tr>
<th></th>
<th>1991</th>
<th>1990</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field crops</td>
<td>$348,446,000</td>
<td>$515,764,000</td>
<td>-$167,318,000</td>
</tr>
<tr>
<td>Fruits and nuts</td>
<td>614,306,000</td>
<td>736,408,000</td>
<td>-$122,102,000</td>
</tr>
<tr>
<td>Vegetables</td>
<td>385,278,000</td>
<td>390,576,000</td>
<td>-$5,298,000</td>
</tr>
<tr>
<td>Nursery</td>
<td>62,128,000</td>
<td>57,197,000</td>
<td>+$4,931,000</td>
</tr>
<tr>
<td>Other</td>
<td>111,384,000</td>
<td>137,471,000</td>
<td>-$26,087,000</td>
</tr>
<tr>
<td>Total</td>
<td>$1,521,542,000</td>
<td>$1,837,516,000</td>
<td>-$315,874,000</td>
</tr>
</tbody>
</table>

Note that fruits and nuts account for about 40 percent of Kern County’s gross agricultural value, reflecting the importance these crops hold in the local economy. While cotton is usually the number one crop in Kern County in terms of production value, the reduced acreage resulting from the drought was enough to
Table 15
Historic Irrigated Acreage *
in the San Joaquin Valley Portion
of Kern County
(in Acres)

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Irrigated Acreage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970</td>
<td>797,300</td>
</tr>
<tr>
<td>1971</td>
<td>834,800</td>
</tr>
<tr>
<td>1972</td>
<td>841,000</td>
</tr>
<tr>
<td>1973</td>
<td>858,700</td>
</tr>
<tr>
<td>1974</td>
<td>919,000</td>
</tr>
<tr>
<td>1975</td>
<td>909,600</td>
</tr>
<tr>
<td>1976</td>
<td>934,800</td>
</tr>
<tr>
<td>1977</td>
<td>868,100</td>
</tr>
<tr>
<td>1978</td>
<td>909,400</td>
</tr>
<tr>
<td>1979</td>
<td>928,700</td>
</tr>
<tr>
<td>1980</td>
<td>943,500</td>
</tr>
<tr>
<td>1981</td>
<td>955,400</td>
</tr>
<tr>
<td>1982</td>
<td>954,100</td>
</tr>
<tr>
<td>1983</td>
<td>854,200</td>
</tr>
<tr>
<td>1984</td>
<td>972,800</td>
</tr>
<tr>
<td>1985</td>
<td>945,100</td>
</tr>
<tr>
<td>1986</td>
<td>819,500</td>
</tr>
<tr>
<td>1987</td>
<td>786,800</td>
</tr>
<tr>
<td>1988</td>
<td>831,100</td>
</tr>
<tr>
<td>1989</td>
<td>856,100</td>
</tr>
<tr>
<td>1990</td>
<td>842,400</td>
</tr>
<tr>
<td>1991</td>
<td>729,400</td>
</tr>
</tbody>
</table>

* Mean Irrigated Acreage 876,900
* Maximum Irrigated Acreage in 1984 972,800
* Minimum Irrigated Acreage in 1991 729,400

* 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.
Figure 12
Irrigated Acreage in the San Joaquin Valley Portion of Kern County

[Bar chart showing irrigated acreage from 1970 to 1991 with projected data for 1992]
Table 16
1991 Monthly Evaporation for
Four San Joaquin Valley Climatic Stations
(in inches)

<table>
<thead>
<tr>
<th></th>
<th>Bakersfield 12S</th>
<th>Lamont 2NW</th>
<th>USDA Cotton Station</th>
<th>Greenlee's Pasture</th>
<th>All Stations</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>1.45</td>
<td>1.4</td>
<td>1.67</td>
<td>1.81</td>
<td>1.58</td>
</tr>
<tr>
<td>February</td>
<td>2.44</td>
<td>2.49</td>
<td>2.95</td>
<td>2.91</td>
<td>2.70</td>
</tr>
<tr>
<td>March</td>
<td>4.01</td>
<td>3.64</td>
<td>4.05</td>
<td>3.06</td>
<td>3.69</td>
</tr>
<tr>
<td>April</td>
<td>6.06</td>
<td>5.75</td>
<td>7.30</td>
<td>6.59</td>
<td>6.43</td>
</tr>
<tr>
<td>May</td>
<td>8.16</td>
<td>8.21</td>
<td>9.96</td>
<td>8.56</td>
<td>8.72</td>
</tr>
<tr>
<td>June</td>
<td>8.73</td>
<td>9.69</td>
<td>11.13</td>
<td>9.99</td>
<td>9.89</td>
</tr>
<tr>
<td>July</td>
<td>9.65</td>
<td>10.44</td>
<td>10.87</td>
<td>10.15</td>
<td>10.28</td>
</tr>
<tr>
<td>August</td>
<td>7.96</td>
<td>8.75</td>
<td>9.12</td>
<td>7.41</td>
<td>8.31</td>
</tr>
<tr>
<td>September</td>
<td>6.64</td>
<td>7.9</td>
<td>8.88</td>
<td>7.61</td>
<td>7.76</td>
</tr>
<tr>
<td>October</td>
<td>4.39</td>
<td>5.82</td>
<td>6.09</td>
<td>4.63</td>
<td>5.23</td>
</tr>
<tr>
<td>November</td>
<td>2.17</td>
<td>2.55</td>
<td>2.82</td>
<td>1.85</td>
<td>2.35</td>
</tr>
<tr>
<td>December</td>
<td>1.66</td>
<td>1.39</td>
<td>1.98</td>
<td>1.81</td>
<td>1.71</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>63.32</strong></td>
<td><strong>68.03</strong></td>
<td><strong>76.82</strong></td>
<td><strong>66.38</strong></td>
<td><strong>68.64</strong></td>
</tr>
<tr>
<td><strong>Percent of Normal</strong></td>
<td>100</td>
<td>108</td>
<td>102</td>
<td>106</td>
<td>104</td>
</tr>
</tbody>
</table>

**Station Locations**

- **Bakersfield 12S**: NW1/4, NW1/4, Section 36, T31S, R27E, MDB&M. Equipment: USWB Class "A" evaporation pan in an irrigated pasture environment.
- **Lamont 2NW**: NW1/4, SW1/4, Section 25, T30S, R28E, 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 13
1991 Percent of Normal Evaporation

Percent of Normal, Total:
- Bakersfield 12S: 99.7
- Lamont 2NW: 107.1
- Greenlee's Pasture: 105.9

**Bakersfield 12S**
1991 observed monthly EP, Bakersfield 12S (irrigated pasture) compared to long-term average for pasture pans in the San Joaquin Valley. This station is indicative of EP on the valley floor.

**Lamont 2NW**
1991 observed monthly EP, Lamont 2NW (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**
1991 observed monthly EP, Greenlee's Pasture (irrigated pasture - Wheeler Ridge area) compared to long-term average for pasture pans in the San Joaquin Valley. This station is indicative of EP in the foothill regions of the valley.
move it into the second position, allowing grapes to capture the number one position.

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 1991, is summarized on Table 17, 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 consumersively 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. Generally, how well-managed an irrigation system is determines how efficient it will be.

Gross agricultural applied water requirements in 1991 were estimated to be about 2,502,900 acre-feet with 2,341,100 acre-feet occurring over the useable groundwater basin. This was about 409,000 acre-feet less than was applied in 1990. Likely, this decrease reflects the reduction in irrigated acreage during 1991, combined with the water-consciousness of the continuing drought. Net agricultural requirements in 1991 were about 2,093,500 acre-feet with about 1,934,800 acre-feet occurring over the groundwater basin. This was about 130,700 acre-feet less than was consumptively used in 1990, reflecting the decrease in irrigated acreage, along with lower per-unit applied water rates. The difference between gross and net water requirements over the basin (adjusted for effective precipitation) is an estimate of agricultural return flows to groundwater. Not all return flows return to useable groundwater. Some is lost to saline sinks (such as perched water areas). Over moisture-deficient soils, return flows are absorbed by the soils and are irrecoverable. About 112,800 acre-feet of water was lost to saline sinks during 1991, and about 7,100 acre-feet was lost to moisture-deficient soils. About 368,100 acre-feet of agricultural applied water in 1991 returned to useable groundwater storage.

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 18 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 1991 were estimated to be about 134,800 acre-feet, with about 120,000 acre-feet required over the useable groundwater basin. Of the total amount used over the useable basin, 19,800 acre-feet was supplied by the Agency's water treatment plant. The Olcese Water District, which serves the Rio Bravo area, used about 600 acre-feet of Kern River water. The East Niles Community Services District received an additional 1,400 acre-feet of surface water from Arvin-Edison Water Storage District. The remainder, about 98,200 acre-feet, was likely drawn from groundwater. Table 19 gives a breakdown of urban water deliveries by water purveyor service area. The total production of these purveyors, as listed on Table 19, 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.
<table>
<thead>
<tr>
<th>Crop</th>
<th>Acres</th>
<th>Percent of Total</th>
<th>Consumptive Water Use (AF/Acre)</th>
<th>Crop</th>
<th>Acres</th>
<th>Percent of Total</th>
<th>Consumptive Water Use (AF/Acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa (including seed)</td>
<td>90,823</td>
<td>11.8</td>
<td>3.72</td>
<td>Misc. Truck Crop</td>
<td>4,182</td>
<td>0.5</td>
<td>0.38</td>
</tr>
<tr>
<td>Almonds</td>
<td>71,601</td>
<td>9.3</td>
<td>3.54</td>
<td>Nursery</td>
<td>3,052</td>
<td>0.4</td>
<td>2.42</td>
</tr>
<tr>
<td>Apples</td>
<td>4,955</td>
<td>0.6</td>
<td>3.36</td>
<td>Oats</td>
<td>1,493</td>
<td>0.2</td>
<td>1.62</td>
</tr>
<tr>
<td>Apricots</td>
<td>907</td>
<td>0.1</td>
<td>3.36</td>
<td>Olives</td>
<td>8,044</td>
<td>1.0</td>
<td>3.47</td>
</tr>
<tr>
<td>Asparagus</td>
<td>704</td>
<td>--</td>
<td>3.01</td>
<td>Onions, Garlic</td>
<td>11,709</td>
<td>1.5</td>
<td>3.32</td>
</tr>
<tr>
<td>Avocado</td>
<td>6</td>
<td>--</td>
<td>3.74</td>
<td>Pasture, Turf</td>
<td>4,677</td>
<td>0.6</td>
<td>4.79</td>
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<tr>
<td>Barley</td>
<td>9,235</td>
<td>1.2</td>
<td>1.68</td>
<td>Peaches, Nectarines</td>
<td>4,198</td>
<td>0.5</td>
<td>3.33</td>
</tr>
<tr>
<td>Beans</td>
<td>8,010</td>
<td>1.0</td>
<td>1.90</td>
<td>Pears</td>
<td>75</td>
<td>--</td>
<td>3.54</td>
</tr>
<tr>
<td>Broccoli</td>
<td>10</td>
<td>--</td>
<td>0.00</td>
<td>Peas</td>
<td>2</td>
<td>--</td>
<td>1.56</td>
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<tr>
<td>Carrots</td>
<td>36,847</td>
<td>4.8</td>
<td>0.56</td>
<td>Peppers</td>
<td>1,589</td>
<td>0.2</td>
<td>2.05</td>
</tr>
<tr>
<td>Citrus</td>
<td>40,033</td>
<td>5.2</td>
<td>3.30</td>
<td>Pistachios</td>
<td>24,189</td>
<td>3.2</td>
<td>3.36</td>
</tr>
<tr>
<td>Corn, Field</td>
<td>5,647</td>
<td>0.7</td>
<td>2.76</td>
<td>Plums, Prunes</td>
<td>3,202</td>
<td>0.4</td>
<td>3.39</td>
</tr>
<tr>
<td>Cotton</td>
<td>240,480</td>
<td>31.3</td>
<td>2.88</td>
<td>Potatoes</td>
<td>18,159</td>
<td>2.4</td>
<td>1.98</td>
</tr>
<tr>
<td>Figs</td>
<td>12,379</td>
<td>1.6</td>
<td>2.81</td>
<td>Rice</td>
<td>710</td>
<td>--</td>
<td>0.00</td>
</tr>
<tr>
<td>Grapes</td>
<td>75,257</td>
<td>9.8</td>
<td>2.54</td>
<td>Safflower</td>
<td>4,570</td>
<td>0.6</td>
<td>2.56</td>
</tr>
<tr>
<td>Guayule and Jojoba</td>
<td>502</td>
<td>--</td>
<td>1.00</td>
<td>Sorghum/Milo</td>
<td>9,759</td>
<td>1.3</td>
<td>2.24</td>
</tr>
<tr>
<td>Kiwi</td>
<td>507</td>
<td>--</td>
<td>2.57</td>
<td>Sudan Grass</td>
<td>2,011</td>
<td>0.3</td>
<td>2.37</td>
</tr>
<tr>
<td>Lettuce</td>
<td>6,173</td>
<td>0.8</td>
<td>0.24</td>
<td>Sugar Beets</td>
<td>7,907</td>
<td>1.0</td>
<td>3.44</td>
</tr>
<tr>
<td>Melons, Squash, Cucumbers</td>
<td>8,272</td>
<td>1.1</td>
<td>1.79</td>
<td>Tomatoes</td>
<td>4,441</td>
<td>0.6</td>
<td>2.48</td>
</tr>
<tr>
<td>Misc. Deciduous Trees</td>
<td>6,440</td>
<td>0.8</td>
<td>2.96</td>
<td>Turnips</td>
<td>436</td>
<td>--</td>
<td>0.70</td>
</tr>
<tr>
<td>Misc. Field Crop</td>
<td>2,680</td>
<td>0.3</td>
<td>1.82</td>
<td>Walnuts</td>
<td>1,730</td>
<td>0.2</td>
<td>2.84</td>
</tr>
<tr>
<td>Misc. Hay/Grain</td>
<td>1,924</td>
<td>0.3</td>
<td>2.00</td>
<td>Wheat</td>
<td>15,446</td>
<td>2.0</td>
<td>2.29</td>
</tr>
<tr>
<td>Misc. Subtropical Trees</td>
<td>12,659</td>
<td>1.6</td>
<td>3.24</td>
<td>Total</td>
<td>767,632</td>
<td>100.0</td>
<td>2.77*</td>
</tr>
</tbody>
</table>

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

* Weighted average consumptive use of all crops.
Table 18
Average Applied Water Requirements for Various Crops
in Kern County
(in acre-feet per acre)

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

(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 19

**1991 Urban Water Use, San Joaquin Valley Portion of Kern County**

<table>
<thead>
<tr>
<th>Water Purveyor Service area</th>
<th>Metered Connections</th>
<th>Non-metered Connections</th>
<th>Million Gals</th>
<th>Acre Feet</th>
<th>Permanent Population</th>
<th>GPCD (1)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Arvin</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arvin CSD</td>
<td>1,780</td>
<td>584</td>
<td>1,792</td>
<td>10,000</td>
<td>160</td>
<td></td>
</tr>
<tr>
<td><strong>Bakersfield Metro Area</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Airport Mutual WC</td>
<td>--</td>
<td>--</td>
<td>10</td>
<td>32</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>California Water Service</td>
<td>13,415</td>
<td>39,426</td>
<td>19,250</td>
<td>59,071</td>
<td>210,600</td>
<td>250</td>
</tr>
<tr>
<td>Casa Loma WC</td>
<td>--</td>
<td>212</td>
<td>122</td>
<td>375</td>
<td>3,000</td>
<td>112</td>
</tr>
<tr>
<td>City of Bakersfield</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ashe Water Division</td>
<td>15,913</td>
<td>5,710</td>
<td>17,522</td>
<td>62,060</td>
<td>252</td>
<td></td>
</tr>
<tr>
<td>East Niles CSD</td>
<td>6,035</td>
<td>2,085</td>
<td>6,398</td>
<td>21,122</td>
<td>270</td>
<td></td>
</tr>
<tr>
<td>Fairfax WC</td>
<td>--</td>
<td>--</td>
<td>2</td>
<td>5</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Greenfield CWD</td>
<td>617</td>
<td>358</td>
<td>309</td>
<td>948</td>
<td>5,384</td>
<td>157</td>
</tr>
<tr>
<td>North of the River MWD</td>
<td>326</td>
<td>1,469</td>
<td>677</td>
<td>2,077</td>
<td>7,000</td>
<td>265</td>
</tr>
<tr>
<td>Oldale MWC</td>
<td>379</td>
<td>6,011</td>
<td>1,839</td>
<td>5,643</td>
<td>24,000</td>
<td>210</td>
</tr>
<tr>
<td>Rancho Verdugo WC</td>
<td>--</td>
<td>289</td>
<td>132</td>
<td>404</td>
<td>1,002</td>
<td>360</td>
</tr>
<tr>
<td>Stockdale MWC</td>
<td>--</td>
<td>--</td>
<td>47</td>
<td>143</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Stockdale Annex MWC</td>
<td>--</td>
<td>--</td>
<td>38</td>
<td>116</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Vaughn WC</td>
<td>1,796</td>
<td>1,028</td>
<td>1,557</td>
<td>4,778</td>
<td>12,665</td>
<td>337</td>
</tr>
<tr>
<td>Victory MWC</td>
<td>--</td>
<td>--</td>
<td>44</td>
<td>136</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td><strong>Metro Area Subtotal</strong></td>
<td>38,481</td>
<td>48,793</td>
<td>31,821</td>
<td>97,649</td>
<td>356,833</td>
<td>248</td>
</tr>
<tr>
<td><strong>Buttonwillow</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Buttonwillow CWD</td>
<td>--</td>
<td>406</td>
<td>47</td>
<td>146</td>
<td>1,250</td>
<td>104</td>
</tr>
<tr>
<td><strong>Delano</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>City of Delano</td>
<td>1,468</td>
<td>4,074</td>
<td>1,916</td>
<td>5,880</td>
<td>23,334</td>
<td>225</td>
</tr>
<tr>
<td><strong>Lamont</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lamont PUD and ID#1</td>
<td>250</td>
<td>2,952</td>
<td>not avail.</td>
<td>not avail.</td>
<td>12,600</td>
<td>--</td>
</tr>
<tr>
<td><strong>Lost Hills</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lost Hills Utility District</td>
<td>173</td>
<td>--</td>
<td>106</td>
<td>324</td>
<td>700</td>
<td>413 (2)</td>
</tr>
<tr>
<td><strong>McFarland</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>McFarland MWC</td>
<td>1,587</td>
<td>6</td>
<td>396</td>
<td>1,215</td>
<td>7,000</td>
<td>155</td>
</tr>
<tr>
<td><strong>Rio Bravo</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Olesse WD</td>
<td>271</td>
<td>--</td>
<td>188</td>
<td>577</td>
<td>640</td>
<td>804 (3)</td>
</tr>
<tr>
<td><strong>Shafter</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>City of Shafter</td>
<td>19</td>
<td>3,032</td>
<td>821</td>
<td>2,519</td>
<td>10,133</td>
<td>222</td>
</tr>
<tr>
<td><strong>Taft-Maricopa-McKittrick</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>West Kern WD</td>
<td>6,887</td>
<td>--</td>
<td>4,695</td>
<td>14,407</td>
<td>25,000</td>
<td>515 (2)</td>
</tr>
<tr>
<td><strong>Wasco</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>City of Wasco</td>
<td>87</td>
<td>2,901</td>
<td>987</td>
<td>3,029</td>
<td>12,897</td>
<td>210</td>
</tr>
<tr>
<td>Wasco State Prison</td>
<td>--</td>
<td>--</td>
<td>57</td>
<td>175</td>
<td>2,450</td>
<td>64</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>89,484</td>
<td>110,957</td>
<td>73,439</td>
<td>225,361</td>
<td>452,837</td>
<td>240 (4)</td>
</tr>
</tbody>
</table>

* 1991 data unavailable, data shown is for 1990.

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

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

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

The average municipal and industrial water use over the groundwater basin in 1991 was estimated to be about 250 gallons per capita per day (gpcd), about the same as 1990. Long-term, average M&I water use is about 250 gpcd. Residential water use is about 200 gpcd. Industrial, commercial and public authority water use accounts for the difference. It should be noted that domestic water use by the west side towns (Taft, Maricopa, Lost Hills) is quite low when compared to the average domestic water use over the groundwater basin. The average domestic water use during 1991 was about 136 gallons per capita per day for the west side towns.

Net M&I consumptive use in 1991 was about 45,400 acre-feet over the groundwater basin. Gross return flows from M&I uses over the groundwater basin were about 74,600 acre-feet. About 45,200 acre-feet of M&I return flows were treated in sewage treatment facilities and evaporated, percolated or reused for agriculture. The remaining 29,400 acre-feet returned to groundwater supplies. Since virtually all of the M&I water used outside the groundwater 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

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 1991.

Water Surface Evaporation

Water surface evaporation normally accounts for a small amount of water lost from the valley portion of Kern County. In 1991, about 38,800 acre-feet of evaporation losses occurred, with about 38,300 acre-feet occurring over the groundwater basin. This was slightly less than was lost in 1990, due to a smaller water surface area. Any water lost in this manner is lost from this regional hydrologic system.
Change in Groundwater Storage

Water supplies and demands for the San Joaquin Valley portion of Kern County, as shown by Figure 14, show a total gross water demand of about 2,817,000 acre-feet in 1991. About 2,636,800 acre-feet occurred over the groundwater basin, including 150,900 acre-feet of water used for direct recharge or delivery system losses. Total net water losses were about 2,311,500 acre-feet, with about 2,131,300 acre-feet over the groundwater basin. Gross available surface water supplies were about 829,000 acre-feet. Hence, there was a net withdrawal from groundwater storage of about 1,482,500 acre-feet. This was consistent with the fact that 1991 was the fifth dry year in a row. The 1987-91 drought period has proven to be more severe than the 1976-77 drought, in terms of water lost from groundwater storage. During the 1976-77 period, 1,858,000 acre-feet of water was lost from underground storage. The 1987-91 period has seen 4,227,000 acre-feet of water lost from storage.

Figure 15 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 groundwater 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 surface water was available because of the drought. During 1970 to 1991, when about 10,870,000 acre-feet of water was withdrawn from groundwater storage, the balance of additions over extractions has replenished about 4,614,000 acre-feet. Figure 16 shows the cumulative groundwater balance since 1970 when SWP water was first introduced over the Kern County groundwater basin. In volume of groundwater storage, the basin now stands well below 1977 levels, erasing the improvements achieved during the 1978-86 wet period.

It has become apparent that Kern County's groundwater management plans depend upon the sustained delivery of surface water from all three major sources: Kern River, State Water Project and Central Valley Project. A reduction in one supply, unless accompanied by an increase in another, can have a serious impact upon the groundwater basin. Table 20, 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, groundwater comprised only 25 percent of the total water supply. But in 1987 the reverse was true, and groundwater pumping increased to make up for the dry-year conditions. Conditions during the ongoing drought have certainly demonstrated this dependence; as surface water sources were reduced, groundwater pumping increased to make up the shortfall.
Figure 14
1991 Hydrologic Balance
San Joaquin Valley Portion of Kern County
(in acre-feet)

Surface Water Supplies to Kern County
- SWP: 80,300
- CVP: 204,400
- Kern River: 335,900
- Minor Streams: 34,600
- Effective Precip.: 171,700
- Oilfield Wastewater: 2,100
- Groundwater: 2,002,400
Total: 2,831,400

Uses Not Overlying Groundwater Basin
- Irrigation: 161,800
- M & I: 14,800
- Water Surface Evap.: 500
- Subsurface Losses: 4,000
Total: 181,100

Uses Overlying Groundwater Basin
- Irrigation: 2,341,100
- M & I: 120,000
- Water Surface Evap.: 38,300
- Direct Recharge/Delivery System Losses: 150,900
Total: 2,650,300

Total Water Lost from Kern County
- Crop ET: 2,093,500
- M & I Consumptive Use: 60,200
- Water Surface Evap.: 38,800
- Subsurface Losses: 119,900
Total: 2,312,400

Groundwater Basin Storage
- Direct Recharge/Losses: 150,900
- Return Flows: 368,100
- Groundwater Pumping: 2,002,400
Total: -1,483,400

829,000 (Surface Supplies) minus 2,312,400 (Consumptive Use) equals -1,483,400 (Change in Storage)

Notes:
1. Includes 3,100 AF return flows, 4,000 AF delivery losses lost to moisture deficient soils.
2. Of this, 45,200 AF was treated in wastewater facilities and reused.
3. (gw) Groundwater
4. (sw) Surface Water
Figure 15
Gross Water Supplies and Net Water Requirements
San Joaquin Valley, Kern County, California

Acre-Feet

Projected

Additions to Groundwater Storage
Withdrawals from Groundwater Storage

SWP
CVP
Local
Demand (Net Water Requirements)
## Table 20

**Historic Surface* and Groundwater Usage or Availability in the San Joaquin Valley Portion of Kern County**

*(in acre-feet)*

<table>
<thead>
<tr>
<th>Kern River Available</th>
<th>% of Total</th>
<th>Other Local Water Available</th>
<th>% of Total</th>
<th>Central Valley Project Usage</th>
<th>% of Total</th>
<th>State Water Project Usage</th>
<th>% of Total</th>
<th>Groundwater Usage</th>
<th>% of Total</th>
<th>Total Supplies</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970 589,500</td>
<td>19.1</td>
<td>517,900</td>
<td>16.8</td>
<td>351,400</td>
<td>11.4</td>
<td>204,600</td>
<td>6.6</td>
<td>1,422,000</td>
<td>46.1</td>
<td>3,085,400</td>
</tr>
<tr>
<td>1971 427,500</td>
<td>13.9</td>
<td>217,100</td>
<td>7.1</td>
<td>348,900</td>
<td>11.4</td>
<td>375,500</td>
<td>12.2</td>
<td>1,700,000</td>
<td>55.4</td>
<td>3,069,000</td>
</tr>
<tr>
<td>1972 268,400</td>
<td>8.4</td>
<td>292,600</td>
<td>9.2</td>
<td>238,300</td>
<td>7.5</td>
<td>535,600</td>
<td>16.8</td>
<td>1,857,000</td>
<td>58.2</td>
<td>3,192,100</td>
</tr>
<tr>
<td>1973 979,700</td>
<td>26.3</td>
<td>161,200</td>
<td>4.3</td>
<td>412,200</td>
<td>11.0</td>
<td>515,500</td>
<td>13.8</td>
<td>1,662,000</td>
<td>44.6</td>
<td>3,730,600</td>
</tr>
<tr>
<td>1974 818,600</td>
<td>22.6</td>
<td>332,000</td>
<td>9.2</td>
<td>480,600</td>
<td>13.3</td>
<td>651,800</td>
<td>18.0</td>
<td>1,333,000</td>
<td>36.9</td>
<td>3,616,000</td>
</tr>
<tr>
<td>1975 564,600</td>
<td>15.2</td>
<td>287,300</td>
<td>7.8</td>
<td>442,100</td>
<td>11.9</td>
<td>821,700</td>
<td>22.2</td>
<td>1,587,000</td>
<td>42.9</td>
<td>3,702,700</td>
</tr>
<tr>
<td>1976 249,500</td>
<td>7.5</td>
<td>225,700</td>
<td>6.8</td>
<td>226,500</td>
<td>6.8</td>
<td>883,400</td>
<td>26.6</td>
<td>1,738,000</td>
<td>52.3</td>
<td>3,323,100</td>
</tr>
<tr>
<td>1977 197,000</td>
<td>7.3</td>
<td>239,400</td>
<td>8.9</td>
<td>121,500</td>
<td>4.5</td>
<td>429,400</td>
<td>16.0</td>
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<td>23.3</td>
<td>357,800</td>
<td>8.0</td>
<td>611,500</td>
<td>13.6</td>
<td>825,000</td>
<td>18.3</td>
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<td>258,700</td>
<td>6.6</td>
<td>462,500</td>
<td>11.7</td>
<td>1,291,800</td>
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<td>22.3</td>
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<td>5.7</td>
<td>292,500</td>
<td>9.4</td>
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<td>33.0</td>
<td>1,208,700</td>
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<td>5.4</td>
<td>292,800</td>
<td>8.8</td>
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<td>1989 397,000</td>
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<td>4.0</td>
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<td>8.3</td>
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<td>1990 219,500</td>
<td>6.9</td>
<td>112,800</td>
<td>3.5</td>
<td>200,100</td>
<td>6.3</td>
<td>857,300</td>
<td>26.9</td>
<td>1,796,500</td>
<td>56.4</td>
<td>3,186,200</td>
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<tr>
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<td>11.9</td>
<td>208,400</td>
<td>7.4</td>
<td>204,400</td>
<td>7.2</td>
<td>80,300</td>
<td>2.8</td>
<td>2,002,400</td>
<td>70.7</td>
<td>2,831,400</td>
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<td>Avg. 765,100</td>
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<td>230,000</td>
<td>7.0</td>
<td>373,500</td>
<td>11.4</td>
<td>768,600</td>
<td>23.4</td>
<td>1,382,700</td>
<td>42.0</td>
<td>3,289,900</td>
</tr>
</tbody>
</table>

*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 its ET requirements percolates past the root zone and usually returns to groundwater supplies, where it is available for reuse. Most of this deep percolation returns to groundwater within two years. Sometimes the deep percolation is intercepted by shallow clay lenses in the soil. (This condition is referred to as perched water or shallow groundwater). In some areas the deep percolation may return to unusable saline groundwater. 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 the 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. Geohydrologists estimate it would take over 3 million acre-feet of water to satisfy the holding capacity of these moisture-deficient soils.

Over the entire San Joaquin Valley portion of Kern County, gross water demands were about 2,831,400 acre-feet during 1991 (2,502,900 for agriculture, 134,800 for M&I, 38,800 of evaporation losses, 150,900 acre-feet for groundwater recharge, and 7,100 of unrecoverable delivery system losses). The total consumption of water was about 2,192,500 acre-feet (2,093,500 by agriculture, 60,200 by M&I, 38,800 of evaporation losses). Effective precipitation was about 171,700 acre-feet. The agricultural irrigation efficiency, therefore, was about 77 percent. A total of 45,200 acre-feet of M&I water was treated and reused, mostly by agriculture. The difference between gross and net requirements (adjusted for waste water reuse) is an estimate of groundwater returns, which amounted to 638,900 acre-feet. However, about 112,800 acre-feet of deep percolation was intercepted by perched water and about 7,100 acre-feet was absorbed by moisture-deficient soils. Therefore, net groundwater returns were 368,100 acre-feet in 1991. Expressed another way, of the 2,831,400 acre-feet of gross water demand during 1991, 2,711,500 acre-feet was beneficially used or available for reuse (via net deep percolation). As a percent, 96 percent of the total applied water during 1991 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 is a structure connecting the Kern River to the California Aqueduct near Tupman. Built by the Army Corps of Engineers in 1977, its basic purpose is to dispose of floodwater, thereby preventing damages on the Kern River floodplain downstream. 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. Water from the Kern River channel first passes through a sedimentation basin to remove sand and silt. Water then passes through trash racks to remove floating debris before it enters the aqueduct. The structure has a capacity of 3,500 cfs. However, downstream aqueduct demands can become the limiting factor in wet years when demands are low.

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

The Intertie has not operated since 1986. Through the end of 1986, 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. Table 21 is a historical summary of Intertie activity to date, showing the inflow by source, as well as amounts exported and retained in the County.
Table 21
Summary of Kern River-California Aqueduct Intertie Activity
(in acre-feet)

<table>
<thead>
<tr>
<th></th>
<th>Intertie Inflow</th>
<th></th>
<th>Amount Exported</th>
<th></th>
<th>Retained in County</th>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Kern River</td>
<td>Friant-Kern Total</td>
<td>Kern River</td>
<td>Friant-Kern Total</td>
<td>Kern River</td>
<td>Friant-Kern Total</td>
</tr>
<tr>
<td>1978</td>
<td>168,818</td>
<td>9,113</td>
<td>177,931</td>
<td>n/a*</td>
<td>113,831</td>
<td>n/a*</td>
</tr>
<tr>
<td>1980</td>
<td>138,816</td>
<td>0</td>
<td>138,816</td>
<td>74,024</td>
<td>0</td>
<td>74,024</td>
</tr>
<tr>
<td>1982</td>
<td>10,339</td>
<td>11,968</td>
<td>22,307</td>
<td>5,928</td>
<td>2,700</td>
<td>8,628</td>
</tr>
<tr>
<td>1983</td>
<td>662,856</td>
<td>96,200</td>
<td>759,056</td>
<td>n/a*</td>
<td>n/a*</td>
<td>393,551</td>
</tr>
<tr>
<td>1984</td>
<td>27,524</td>
<td>0</td>
<td>27,524</td>
<td>13,885</td>
<td>0</td>
<td>13,885</td>
</tr>
<tr>
<td>1986</td>
<td>1,867</td>
<td>15,580</td>
<td>17,447</td>
<td>0</td>
<td>4,746</td>
<td>4,746</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1,010,220</strong></td>
<td><strong>132,861</strong></td>
<td><strong>1,143,081</strong></td>
<td></td>
<td><strong>608,665</strong></td>
<td></td>
</tr>
</tbody>
</table>

*A breakdown between sources was not available.

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

Groundwater Recharge

Several entities in Kern County are actively engaged in groundwater replenishment operations. Kern River water is recharged to groundwater 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, in order to maximize seepage, and 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 groundwater 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 groundwater recharge in Kern County is accomplished as part of these programs. Table 22 outlines major conjunctive use and banking programs since 1971, listing the amounts of water by source. About 150,900 acre-feet of water was spread in 1991, both deliberately and incidentally. The approximate breakdown between sources was:

<table>
<thead>
<tr>
<th>Source</th>
<th>Amount (acre-feet)</th>
</tr>
</thead>
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<tr>
<td>Kern River</td>
<td>106,000</td>
</tr>
<tr>
<td>SWP</td>
<td>8,500</td>
</tr>
<tr>
<td>CVP</td>
<td>200</td>
</tr>
<tr>
<td>Waste water</td>
<td>3,300</td>
</tr>
<tr>
<td>Minor Streams</td>
<td>32,900</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>150,900</strong></td>
</tr>
</tbody>
</table>

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 22 is more than the amount of recharge listed here. This is because Table 22 includes in-lieu recharge, but excludes incidental recharge and minor stream flows that have naturally recharged the groundwater basin.

Such recharge efforts, from whatever source, show the importance attached to reducing groundwater over-draft in Kern County, as well as saving water by conservation. Since the 1976-77 drought, a total of about 7,773,100 acre-feet of water has been recharged (both deliberately and incidentally) to replenish groundwater supplies. The effectiveness of such recharge activities are apparent in Figure 16. The Agency estimates that the 7,773,100 acre-feet of recharged water results in a gross basin-wide groundwater pumping lift difference of about 77 feet, or about one foot for every 100,000 acre-feet.

Groundwater Banking

Groundwater 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 groundwater storage is now more environmentally acceptable and financially feasible, DWR is expanding its below-ground storage planning and operations. The intent of banking programs is to store surface water in the underground when it is available and extract it during times of need. Hence, available surface water supplies are used conjunctively with groundwater. This mode of operation is known as conjunctive use. While conjunctive use has been practiced since the turn of the century by local water managers, it is a new approach for the SWP.

The Kern Water Bank is a planned banking/extraction program which will ultimately provide as much as 100,000 acre-feet of annual dry-year 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, where KCWA and others have deposited water. Tables 23a, 23b, 23c,
## Table 22
Summary of Groundwater Recharge Activities *
(in acre-feet)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
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<th></th>
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<td><strong>BANKING</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>City of Bakersfield **</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
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<td>0</td>
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<td>Berrenda Mesa Spreading Area Combined</td>
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<td>0</td>
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<td>0</td>
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<td>2,800 Acre Spreading Area SWP</td>
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<td>0</td>
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<td>0</td>
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<td><strong>Total Banking</strong></td>
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<td>0</td>
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<td>6,800</td>
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<td>60,751</td>
<td>34,870</td>
<td>697</td>
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<td>986 (1)</td>
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<td>18,200</td>
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<td>14,040</td>
<td>3,116</td>
<td>6,279</td>
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<td>14,000</td>
<td>5,210</td>
<td>6,990</td>
<td>10,713</td>
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<td>4,038</td>
<td>0</td>
<td>1,385,214</td>
</tr>
<tr>
<td>In-Lieu Rechg.</td>
<td>421,700</td>
<td>15,950</td>
<td>15,135</td>
<td>6,762</td>
<td>0</td>
<td>1,326</td>
<td>0</td>
<td>460,831</td>
</tr>
<tr>
<td>Rosedale-Rio Bravo WSD</td>
<td>489,404</td>
<td>6,000</td>
<td>6,000</td>
<td>7,500</td>
<td>0</td>
<td>9,076</td>
<td>0</td>
<td>517,980</td>
</tr>
<tr>
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<td>21,888</td>
<td>23,600</td>
<td>32,700</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>514,643</td>
</tr>
<tr>
<td>F-K</td>
<td>161,807</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>62</td>
<td>0</td>
<td>161,869</td>
</tr>
<tr>
<td>Combined</td>
<td>279,800 (1)</td>
<td>0</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>279,800</td>
</tr>
<tr>
<td>Wheeler Ridge-Maricopa WSD</td>
<td>SWP</td>
<td>86,186</td>
<td>377</td>
<td>0</td>
<td>0</td>
<td>9,000</td>
<td>0</td>
<td>95,563</td>
</tr>
<tr>
<td>In-Lieu Recharge</td>
<td>SWP</td>
<td>86,186</td>
<td>377</td>
<td>0</td>
<td>0</td>
<td>9,000</td>
<td>0</td>
<td>95,563</td>
</tr>
<tr>
<td><strong>Total Conjunctive Use</strong></td>
<td>5,358,949</td>
<td>299,737</td>
<td>197,025</td>
<td>216,602</td>
<td>74,099</td>
<td>30,099</td>
<td>0</td>
<td>6,086,511</td>
</tr>
<tr>
<td><strong>OVERDRAFT CORRECTION</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Groundwater Replenishment Program (GRP) In-Lieu Rechg. SWP</td>
<td>96,871</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>96,871</td>
</tr>
<tr>
<td>Direct Rechg.</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>257,920</td>
</tr>
<tr>
<td>Kern</td>
<td>57,230</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>57,230</td>
</tr>
<tr>
<td>F-K</td>
<td>7,723</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>7,723</td>
</tr>
<tr>
<td>Idle Lands Spreading</td>
<td>Kern</td>
<td>130,935</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>130,935</td>
</tr>
<tr>
<td><strong>Total Overdraft Correction</strong></td>
<td>550,699</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>550,699</td>
</tr>
<tr>
<td><strong>GRAND TOTALS</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SWP</td>
<td>1,718,873</td>
<td>95,268</td>
<td>82,256</td>
<td>119,904</td>
<td>211,483</td>
<td>9,148</td>
<td>2,236,932</td>
<td></td>
</tr>
<tr>
<td>F-K</td>
<td>1,000,794</td>
<td>6,921</td>
<td>3,334</td>
<td>0</td>
<td>232</td>
<td>0</td>
<td>1,011,281</td>
<td></td>
</tr>
<tr>
<td>Combine</td>
<td>320,063 (1)</td>
<td>986 (1)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>321,049</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>6,691,067</td>
<td>217,116</td>
<td>197,025</td>
<td>216,602</td>
<td>214,599</td>
<td>30,099</td>
<td>7,566,508</td>
<td></td>
</tr>
</tbody>
</table>

---

* Includes direct and in-lieu recharge.

** Includes banking by Olkoose WD, Hacienda WD, Buena Vista WSD, City of Bakersfield; for breakdown between districts see Table 23.

*** Includes 1990 Kern Water Bank Demonstration Program deliveries.

(1) Breakdown between sources not available.

Note: For a breakdown of 1971 to 1986, see prior Water Supply Reports.

Table 23a
Kern County Water Agency
Groundwater Banking Summaries
Recharge/Purchase or Recovery/Sale by Year and Contracting Entity
City of Bakersfield 2,800 Acre Recharge Facility
(in acre-feet)

<table>
<thead>
<tr>
<th>Calendar Year</th>
<th>KCWA General Account</th>
<th>Wheeler Ridge-Maricopa WSD</th>
<th>Berrenda Mesa WD</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Recharge/Purchase</td>
<td>Recovery/Sale</td>
<td>Recoverable Balance</td>
</tr>
<tr>
<td>1981</td>
<td>29,812</td>
<td>0</td>
<td>29,812</td>
</tr>
<tr>
<td>1982</td>
<td>0</td>
<td>0</td>
<td>29,812</td>
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<tr>
<td>1983</td>
<td>0</td>
<td>0</td>
<td>29,812</td>
</tr>
<tr>
<td>1984</td>
<td>0</td>
<td>0</td>
<td>29,812</td>
</tr>
<tr>
<td>1985</td>
<td>15,055</td>
<td>0</td>
<td>44,867</td>
</tr>
<tr>
<td>1986</td>
<td>10,000</td>
<td>0</td>
<td>54,867</td>
</tr>
<tr>
<td>1987</td>
<td>0</td>
<td>0</td>
<td>54,867</td>
</tr>
<tr>
<td>1988</td>
<td>0</td>
<td>0</td>
<td>54,867</td>
</tr>
<tr>
<td>1989</td>
<td>16,105</td>
<td>(1)</td>
<td>38,762</td>
</tr>
<tr>
<td>1990</td>
<td>0</td>
<td>0</td>
<td>38,762</td>
</tr>
<tr>
<td>1991</td>
<td>44,131</td>
<td></td>
<td>49,577</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Calendar Year</th>
<th>Improvement District No. 4</th>
<th>State of California</th>
<th>Total of All Accounts</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Recharge/Purchase</td>
<td>Recovery/Sale</td>
<td>Recoverable Balance</td>
</tr>
<tr>
<td>1981</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1982</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1983</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1984</td>
<td>0</td>
<td>0</td>
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</tr>
<tr>
<td>1985</td>
<td>0</td>
<td>0</td>
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</tr>
<tr>
<td>1986</td>
<td>12,766</td>
<td>0</td>
<td>12,766</td>
</tr>
<tr>
<td>1987</td>
<td>0</td>
<td>0</td>
<td>12,766</td>
</tr>
<tr>
<td>1988</td>
<td>0</td>
<td>0</td>
<td>12,766</td>
</tr>
<tr>
<td>1989</td>
<td>3,500</td>
<td>(2)</td>
<td>16,266</td>
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<tr>
<td>1990</td>
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<td>0</td>
<td>16,266</td>
</tr>
<tr>
<td>1991</td>
<td>0</td>
<td>0</td>
<td>16,266</td>
</tr>
</tbody>
</table>

(1) Total of 1,086 AF owed by ID#4 to KCWA General and delivered in 1991; 15,019 AF transferred to Wheeler Ridge-Maricopa WSD's acc
(2) Assignment of 3,500 AF from City of Bakersfield groundwater storage to ID#4 on behalf of Kern-Tulare WD (2,800 AF) and Rag Gulch ¹
(3) Transferred to DWR as part of 1990 Demonstration Program.

Note: Purchases and sales are shown as italicized and larger.
### Table 23b
Kern County Water Agency
Groundwater Banking Summaries
Recharge and Recovery Accounting
Berrenda Mesa Spreading Grounds
(in acre-feet)

<table>
<thead>
<tr>
<th>Calendar Year</th>
<th>SWP</th>
<th>Imported Floodwater</th>
<th>Total</th>
<th>SWP</th>
<th>Imported Floodwater</th>
<th>Total</th>
<th>SWP</th>
<th>Imported Floodwater</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1981</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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</tr>
<tr>
<td>1982</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1983</td>
<td>0</td>
<td>14,155</td>
<td>14,155</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>14,155</td>
<td>14,155</td>
</tr>
<tr>
<td>1984</td>
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<td>416</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>14,571</td>
<td>14,571</td>
</tr>
<tr>
<td>1985</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>14,571</td>
<td>14,571</td>
</tr>
<tr>
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<td>3,093</td>
<td>16,296</td>
<td>19,389</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>3,093</td>
<td>30,867</td>
</tr>
<tr>
<td>1987</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3,093</td>
<td>30,867</td>
</tr>
<tr>
<td>1988</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3,093</td>
<td>30,867</td>
</tr>
<tr>
<td>1989</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3,093</td>
<td>30,867</td>
</tr>
<tr>
<td>1990</td>
<td>0</td>
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<td>0</td>
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<td>0</td>
<td>3,093</td>
<td>30,867</td>
</tr>
<tr>
<td>1991</td>
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<td>0</td>
<td>0</td>
<td>15,298</td>
<td>15,298</td>
<td>0</td>
<td>15,298</td>
<td>15,298</td>
<td>3,093</td>
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Table 23c
Kern County Water Agency
Groundwater Banking Summaries
Recharge and Recovery Accounting
Kern River Channel Within Improvement District No. 4
(in acre-feet)

<table>
<thead>
<tr>
<th>Calendar Year</th>
<th>RECHARGE</th>
<th></th>
<th>RECOVERY</th>
<th></th>
<th>RECOVERABLE BALANCE</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SWP</td>
<td>Imported Floodwater</td>
<td>Total</td>
<td>SWP</td>
<td>Imported Floodwater</td>
<td>Total</td>
</tr>
<tr>
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<td>0</td>
<td>33,552</td>
<td>0</td>
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<td>0</td>
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<td>0</td>
<td>0</td>
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</tr>
<tr>
<td>1987</td>
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<td>0</td>
<td>0</td>
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<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1988</td>
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<td>0</td>
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<td>0</td>
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<td>0</td>
<td>0</td>
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</tr>
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<td>1990</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1991</td>
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<td>18,161</td>
</tr>
<tr>
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<td>33,552</td>
<td>18,161</td>
<td>0</td>
<td>18,161</td>
</tr>
</tbody>
</table>
### Table 23d
Groundwater Banking Summaries
Recharge/Purchase and Recovery/Sale
Department of Water Resources, Kern Water Bank
(in acre-feet)

<table>
<thead>
<tr>
<th>Contracting Entity or Location</th>
<th>Buena Vista WSD</th>
<th>City of Bakersfield 2,800 Acres</th>
<th>KCWA ID#4</th>
<th>Kern Delta WD</th>
<th>Kern Fan Element</th>
<th>La Hacienda WD</th>
<th>North Kern WSD</th>
<th>Rosedale-Rio Bravo WSD</th>
<th>Semitropic WSD</th>
<th>West Kern WSD</th>
<th>Total</th>
</tr>
</thead>
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<tr>
<td>1987</td>
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<td>7,379</td>
<td>0</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>7,379</td>
</tr>
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<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1989</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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</tr>
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<td>20,000</td>
<td>9,500 (1)</td>
<td>0</td>
<td>7,500</td>
<td>0</td>
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<td>7,500</td>
<td>105,500</td>
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<td>0</td>
<td>0</td>
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<td>0</td>
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<td>0</td>
</tr>
</tbody>
</table>

20,000 16,879 7,500 98,005 7,500 105,500 0 255,385

(1) Transfer of storage account from Berrenda Mesa WD to DWR as a result of 1990 Demonstration Program.

Source: KCWA records.
Table 23e

Groundwater Banking Summaries
Recharge/Purchase and Extraction/Sale
Contracting Entities Other Than KCWA or DWR
City of Bakersfield 2,800 Acre Recharge Facility*
(in acre-feet)

<table>
<thead>
<tr>
<th>Calendar Year</th>
<th>City of Bakersfield Recharge</th>
<th>Ocense/Hacienda WD Recharge</th>
<th>Buena Vista WSD Recharge</th>
<th>Total Banking Recharge</th>
<th>Storage Balance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1978</td>
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<td>6,056</td>
<td>134,971</td>
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<td>9,913</td>
<td>14,418</td>
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<tr>
<td>1980</td>
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<td>(13,772)</td>
<td>52,604</td>
<td>121,408</td>
<td>(13,772)</td>
</tr>
<tr>
<td>1981</td>
<td>2,603</td>
<td>(100,837)</td>
<td>4,465</td>
<td>7,068</td>
<td>(100,837)</td>
</tr>
<tr>
<td>1982</td>
<td>37,913</td>
<td>14,266</td>
<td>24,465</td>
<td>76,644</td>
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</tr>
<tr>
<td>1983</td>
<td>113,380</td>
<td></td>
<td></td>
<td>113,380</td>
<td>0</td>
</tr>
<tr>
<td>1984</td>
<td>16,058</td>
<td>(472)</td>
<td></td>
<td>16,058</td>
<td>(472)</td>
</tr>
<tr>
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<td></td>
<td>402</td>
<td>(1,615)</td>
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<td>10,000</td>
<td>130,365</td>
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</tr>
<tr>
<td>1987</td>
<td>109</td>
<td>5,344</td>
<td>(6,000)</td>
<td>5,453</td>
<td>(6,656)</td>
</tr>
<tr>
<td>1988</td>
<td>(5,432)</td>
<td>3,214</td>
<td>(3,138)</td>
<td>3,214</td>
<td>(10,432)</td>
</tr>
<tr>
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<td>(873)</td>
<td>(3,138)</td>
<td>0</td>
<td>(6,870)</td>
</tr>
<tr>
<td>1990</td>
<td>(23,318)</td>
<td>(99,405)</td>
<td>(2,242)</td>
<td>0</td>
<td>(124,965)</td>
</tr>
<tr>
<td>1991</td>
<td>(37,159)</td>
<td>22,096</td>
<td>(23,496)</td>
<td>(4,410)</td>
<td>22,096</td>
</tr>
</tbody>
</table>

Total: 412,529 (206,120) 182,514 (123,774) 50,434 (20,790) 645,477 (350,684) 294,793

* A more detailed breakdown is provided in the City of Bakersfield 2,800 Acre Recharge Facility Report.
Source: City of Bakersfield 2,800 Acre Recharge Facility 1991 Report.
Table 23f
Private Land Owner Transfers of Groundwater in 1991

<table>
<thead>
<tr>
<th>CASTLE &amp; COOK</th>
<th>STRAND RANCH</th>
<th>BARTELL</th>
<th>West Kern WD</th>
<th>ID#4</th>
</tr>
</thead>
<tbody>
<tr>
<td>ID#4 to WRMWSD</td>
<td>ID#4 to WRMWSD</td>
<td>Non-district to WRMWSD</td>
<td>ID#4 to</td>
<td>ID#4 to</td>
</tr>
<tr>
<td>Pumped (AF)</td>
<td>3,631</td>
<td>318</td>
<td>1,891</td>
<td>448</td>
</tr>
<tr>
<td>Acres Idled</td>
<td>1,007</td>
<td>N/A</td>
<td>600</td>
<td>176</td>
</tr>
</tbody>
</table>

* 176 acres is the total acres idled for the Bartel transfers.
23d, 23e and 23f outline the banking account balances for those entities who are involved in various banking programs. These tables are an in-depth breakdown of the banking portion of Table 22, and includes recharge, extractions and transfers-sales of bank accounts.

In January, 1991 the Agency began developing the 1991 Emergency Groundwater Recovery Program that would recover about 100,000 acre-feet of previously banked water and deliver it via local canals to the California Aqueduct. Agreements with DWR provided for re-regulation of the local groundwater by using SWP storage reservoirs. Essentially, DWR delivered about 100,000 acre-feet of water from reservoir storage on an agricultural demand schedule (with the bulk of the deliveries made during the summer months). In return, local groundwater was pumped into the California Aqueduct at a fairly constant rate until the entire amount was repaid. Groundwater production began in January, 1991 and continued until mid-1992. Through the end of December, 1991 approximately 63,000 acre-feet of groundwater had been pumped into the Aqueduct, as shown on Tables 23a, b, and c.

In addition to KCWA’s banking program, Table 23f shows the result of local, water district-sponsored programs. A total of 13,000 acre-feet of groundwater was pumped and delivered to west side lands under these district programs. Generally, these programs involved farmers overlying the groundwater basin idling their lands and allowing their wells to be used to pump groundwater for the west side areas. The water was needed to keep perennial crops alive, since no alternative supplies are available on the west side. West Kern WD pumped 4,425 acre-feet from its bank account with Buena Vista WSD. Also, KCWA’s Improvement District No. 4 drilled two new wells and pumped 1,646 acre-feet for use in their Henry C. Garnett Water Treatment Plant. This water was needed to make up a shortfall in surface water for the urban purveyors who normally receive water from the treatment plant.

Perched Groundwater

When the downward movement of water is intercepted by shallow clay beds, perched water accumulations result. These accumulations generally are undesirable in farming operations if the water accumulates enough to reach the crop root zone. 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.

Not enough is known about the perched water phenomenon to allow for definite conclusions as to its causes. 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 nearly six 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. Recent studies by the United States Geological Survey (USGS) suggest that such EC layering may indicate the relative age of the water deposits. Much more study is needed before perched water relationships can be well understood.

Generally, the areas suffering from perched water in Kern County follow the historic lower-elevation trace of the Kern River channel, including the old Kern Lake and Buena Vista Lake beds (where Kern River flows ponded). Increases in perched water area appear after a year of high Kern River runoff. Likewise, contractions seem to occur during years when runoff is low. In this sense, perched water appears to be largely a natural phenomenon. Table 24 lists historic areas with perched water problems, categorized into five foot 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. Likely, this increase is perceived rather than real. KCWA and cooperating water districts have been expanding the monitoring grid, therefore this large increase was more likely the result of better monitoring as the grid was expanded. Table 24 clearly show the continuing expansion of the monitoring grid. Expanding the grid has now allowed the eastern and western boundaries of the perched water areas to be fairly well defined. Monitoring wells located in these areas are consistently reading dry.

Depth to perched water, as measured in shallow monitoring wells, is contoured on Plate 1. Water within five feet of the ground surface occurred under
Table 24
Areal Extent of Shallow Groundwater
(in acres)

<table>
<thead>
<tr>
<th>Year</th>
<th>Summer Measurements</th>
<th>Winter Measurements</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0-5 ft.</td>
<td>5-10 ft.</td>
</tr>
<tr>
<td>1976</td>
<td>27,940</td>
<td>64,700</td>
</tr>
<tr>
<td>1977</td>
<td>19,320</td>
<td>68,980</td>
</tr>
<tr>
<td>1978</td>
<td>27,680</td>
<td>65,760</td>
</tr>
<tr>
<td>1979</td>
<td>30,270</td>
<td>67,310</td>
</tr>
<tr>
<td>1980</td>
<td>74,357</td>
<td>82,787</td>
</tr>
<tr>
<td>1981</td>
<td>62,002</td>
<td>85,556</td>
</tr>
<tr>
<td>1982</td>
<td>78,725</td>
<td>95,615</td>
</tr>
<tr>
<td>1983</td>
<td>109,915</td>
<td>90,090</td>
</tr>
<tr>
<td>1984</td>
<td>110,500</td>
<td>57,650</td>
</tr>
<tr>
<td>1985</td>
<td>49,396</td>
<td>120,396</td>
</tr>
<tr>
<td>1986</td>
<td>84,160</td>
<td>79,774</td>
</tr>
<tr>
<td>1987</td>
<td>57,600</td>
<td>84,864</td>
</tr>
<tr>
<td>1988</td>
<td>82,700</td>
<td>86,500</td>
</tr>
<tr>
<td>1989</td>
<td>65,536</td>
<td>95,949</td>
</tr>
<tr>
<td>1990</td>
<td>67,561</td>
<td>91,257</td>
</tr>
<tr>
<td>1991</td>
<td>40,363</td>
<td>101,888</td>
</tr>
</tbody>
</table>

(1) 10-20 ft. measurement.
(2) Data insufficient to establish a 20 foot contour. Total is area within 15 feet.
(3) No 15 foot contour established. Total is within 20 feet.
-- Data not available.

Note: Annual changes in 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.
an area of about 40,400 acres in the summer of 1991. This was a 40 percent decrease from the summer of 1990 area. The area of shallow groundwater between 5-10 feet of the ground surface increased from 91,300 acres to 101,900 acres in the same period. This 12 percent increase is due mainly to the migration of water that was formerly in the 0-5 foot area to a greater depth. Water in the 10-15 feet of the ground surface decreased from 82,800 acres in the summer of 1990 to 45,100 acres in the summer of 1991. This amounted to a 45 percent decrease. Total acreage between ground surface and a depth of 15 feet decreased from 241,600 acres to 187,400 acres, or a 22 percent decrease.

For the summer of 1990, the area with shallow groundwater from 15-20 feet was not computed, due to shallow groundwater levels dropping below the 20 foot deep monitoring wells situated along the boundaries of the affected area. This situation had continued into the summer of 1991, with many wells that had previously shown shallow groundwater at 15 feet or less being dry. Large portions of the 15 foot contour are now dashed to show its predicted location due to the lack of adequate data. It appears that the boundary areas and also the area outlined by the five foot contour are experiencing the greatest effect from the drought. The decrease in area affected by the shallow groundwater problem may be the result of a combination of factors. Imported surface water to this area has been severely restricted during the protracted drought conditions. As a result, groundwater use in the vicinity increased, with the possible effect of lowering perched groundwater levels. This would suggest that more of a hydraulic connection between perched groundwater and the unconfined aquifer may exist than previously interpreted. Additionally, large portions of farmland throughout this area have been taken out of production due to the cutbacks in surface water. Again, the resulting decrease in irrigation could result in a decrease in the conditions which lead to perched water accumulations.

**Groundwater Quality**

The groundwater 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 groundwater 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 groundwater basin in 1991 (some 855,700 acre-feet) carried about 198,800 tons of new salts into the groundwater basin. This volume of salt was about 140,700 tons less than was introduced in 1990, reflecting the reduced surface water availability from the worsening drought. 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 for 1991:

<table>
<thead>
<tr>
<th>Source</th>
<th>Volume (AF)</th>
<th>Avg. TDS (ppm)</th>
<th>Salt Load (Tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SWP Over</td>
<td>80,300</td>
<td>350</td>
<td>36,100</td>
</tr>
<tr>
<td>G.W. Basin</td>
<td>335,900</td>
<td>112</td>
<td>31,100</td>
</tr>
<tr>
<td>Kern River</td>
<td>34,600</td>
<td>575</td>
<td>27,000</td>
</tr>
<tr>
<td>Minor Streams</td>
<td>202,300</td>
<td>150</td>
<td>41,300</td>
</tr>
<tr>
<td>Other Local Supplies</td>
<td>202,600</td>
<td>150</td>
<td>41,300</td>
</tr>
<tr>
<td>Total</td>
<td>855,700</td>
<td></td>
<td>198,800</td>
</tr>
</tbody>
</table>

Groundwater pumped and used for irrigation will become degraded as salts are leached from the crop root zones. A portion (averaging about 25 percent in this basin) of applied water percolates through the soil profile to the groundwater. 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 areas dependent upon supplemental water supplies, sustained large-scale importation of water and large-scale agriculture will eventually result in the degradation of groundwater supplies, and ultimate loss of irrigable land. This phenomena is likely occurring in the unconfined groundwater 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. One of the greatest challenges of water leaders is to relieve the destruction of our precious groundwater 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 groundwater 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 groundwater
wells producing from the confined or lower aquifer
system. This lower system is partially protected from
surface contaminants by the Corcoran Clay. 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 Super-
visors 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 groundwater by setting
standards for construction and abandonment of wells
to prevent poor quality groundwater from moving into
fairly high quality groundwater. The ordinance re-
quires close monitoring of new well construction and
abandonment of old wells in order to ensure that
degradation of groundwater quality is avoided.

Following adoption of the ordinance in 1981, prob-
lems 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. Incon-
sistencies between the municipal and agricultural
well ordinances brought about a re-thinking of the
ordinances. 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 respec-
tive duties of KCWA and County Department of
Environmental Health, as well as appeal procedures,
much more clearly than before. To better address the
revised ordinance, KCWA funded a study that fo-
cused upon the regional geologic structure of the
shallow sediments of the San Joaquin Valley portion
of Kern County. This study mapped the structure and
areal extent of the regional confining clay layer north
of the Kern River. South of the river, the study focused
upon the structure of the shallow sediments, but could
not directly address the existence of a southern corre-
lation to the regional confining clay. The inability to
correlate this clay to the south is due to the broad
northeast-to-southwest trending basement high known
as the Bakersfield arch, which lies beneath the present
Kern River channel. The confining clay to the north
terminates on the northern flank of this broad struc-
ture. The results of this study have many immediate
applications, which include correlation of strata(s) for
implementation of the well ordinance, implementa-
tion of the well head protection program, design of
industrial waste injection wells, groundwater modell-
ing, and increased efficiency of conjunctive use
programs. The study was subjected to a peer review
by numerous groundwater geologists working in the
public and private sectors. The direction of future
hydrogeologic studies will remain unclear until a
comprehensive groundwater management plan for
the basin is defined. This plan is presently being
formulated by the KCWA. A common technical data
base as well as a common methodology for problem
solving are requisite for a groundwater management
plan to be effective. The development and implementa-
tion of this plan will require resolution of differ-
ces in institutional perspective of the various local
and state governmental entities.

The persistent drought resulted in a continuation of
increased water well activity during 1991. A total of
152 well permits were issued by the Kern County
Environmental Health Services Department in 1991.
Of these permits, 142 were for the construction of
agricultural wells. Annular seals were required in 69
of the new wells to prevent degradation of lower
groundwater zones. Annular seals are plugs of cement
between the well casing and the drilled hole adjacent
to a regional stratum of low permeability. Water
quality is also a concern during the destruction of
existing wells. The permitted destruction of 10 wells
required the casing to be parted and a cement seal set
at depth to prevent downward migration of groundwa-
ter from above. From the time of implementation of
the Kern County Water Well Ordinance in 1981 to the
end of 1991, a total of 530 agricultural wells have been
constructed, 181 of which required annular seals.

Groundwater Levels

Plate 4, Depth to Groundwater, Winter 1992 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
groundwater 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 surface elevations, being on
foothill regions of the valley.

Areas of lesser pumping lifts appear in the west cen-
tral 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 shal-
low lifts, less than 50 feet, are probably linked to the
shallow perched water problem. However, the shal-
low 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 managed
recharge efforts in the Kern River channel.

A Groundwater Surface Elevation map (Plate 5) was
prepared, based on the same measured wells as the
Depth to Groundwater map. This map exhibits move-
ment of groundwater from higher to lower elevations.
For simplicity, the directions of flow are assumed to
be perpendicular to the contour lines. The contours
emphasize the relative highs and lows of groundwater
elevation.

The major direction of groundwater movement is
away from the sources of recharge. Historically, the
Kern River has been the major groundwater recharge
source. Mounding of water occurs longitudinally
along the Kern River channel, and groundwater 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.

Groundwater lows are often areas of higher ground-
water pumping. The largest of these 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 groundwater level changes from the
differences were plotted and contoured to show areas
of relative improvement or decline. Color has been
added to this map to emphasize significant changes.
In an unexpected departure from the previous ground-
water level change map representing the drought
years, this year's map shows areas in which groundwa-
ter levels appear to have risen by as much as 20 feet.
One explanation for this occurrence may be that in
1991 many agricultural wells were being used at the
time of monitoring (January-February) for pre-irriga-
tion, because of extremely low rainfall and anticipated
cuts in surface water supplies. These events may have
produced significant lowering of the water table much
carlier than normal. However, significant rainfall
occurred during the time of the winter monitoring in
1992, which may have indicated a greater supply of
imported water. Thus, much less demand may have
been placed on the unconfined aquifer at that time. As
a result, some areas would have shown higher ground-
water levels even with the continuing drought. It
should be noted that, unless the annual change for a
given unconfined well exceeds 10 feet, little impact
(either losses or gains) to storage can be deduced. This
is due to the degree of error associated with surface
elevation and pumping influence.

Plate 7 depicts groundwater level changes from the
winter of 1985 to the winter of 1992. This map shows
the impact of six years of drought conditions on the
groundwater basin. In some areas water levels have
dropped 80 to 100 feet. Average water level drop for
the basin is probably in the range of 40 to 60 feet.
As in the one-year change map (Plate 6), there are some
anomalous areas showing rises in groundwater levels.
Possible explanations may include agricultural acre-
age being taken out of production, sampling error, and
sporadic groundwater recharge.

Water level changes in six key water wells are dis-
played on hydrographs as Figures 17a, 17b and 17c.
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 or semi-
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, result-
ing from surface water deliveries to the area. The
continuing drought is taking its toll, however. Water
Figure 17a
Water Well Hydrograph
Wildlife Refuge Area

Depth in Feet

Unconfined Well
25S/22E-32R1

Confined Well
25S/22E-28P1

Year

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
Figure 17b
Water Well Hydrograph
Wasco Area

Depth in Feet

Unconfined Well
26S/23E-10E1

Confined Well
27/23-16N1

Year

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

Figure 17c
Water Well Hydrograph
Southwest Bakersfield

Depth in Feet

Confined Well
30S/26E-22P3

Unconfined Well
30S/26E-22P1

Year

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

levels are showing a downward trend in both the unconfined and confined wells in response to increased pumping since 1987. The Wasco area hydrographs show the unconfined well dropping in early years, but coming up in the early 1980s. Now it appears to be falling off somewhat. While the unconfined well seems to be fairly stable, the confined well is showing a pronounced downward trend. Most of the groundwater pumping in the Wasco area is from the confined aquifer, due to its better quality and transmissivity. The southwest Bakersfield graphs show the continual decline in water levels until 1978. From 1978 to 1986, the wet period is reflected by a rise, and now the persistent drought (and its associated increase in groundwater pumping) has caused a consistent decline in water levels in both the unconfined and semi-confined aquifers.

Economists studying the impacts of the current drought have estimated that the decline in groundwater levels (ranging from 40-60 feet throughout the valley portion of Kern County for 1987-1991) has resulted in increased energy costs of $9.30 per irrigated acre.

Partial records of well drilling activity show 266 new farm wells have been drilled due to the drought since 1990 (87 were permitted by the Kern County Health Department during 1990, 152 during 1991 and 27 were permitted by the end of June, 1992), at a cost of about $32 million. It is clear that the increased costs associated with the continuing drought are extremely large.

Indian Wells Valley

Indian Wells Valley is located in the northeast corner of Kern 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 3-4 inches per year. Little rainfall reaches the groundwater table; it is rapidly evaporated by the high winds or transpired by desert plants. Presently, the only source of water is groundwater.

In October, 1987 a group of concerned citizens founded the Indian Wells Valley Water Coordinating Committee to address the groundwater 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 groundwater 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 California Department of Water Resources, Indian Wells Valley Water District, East Kern Resource Conservation District and KCWA resulted in a report entitled 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 the US Navy, KCWA and local entities.

Recently, KCWA began a groundwater monitoring program in the valley. Measurements from 72 wells were the basis for Plate 8, Depth to Groundwater, Indian Wells Valley and Plate 9, Groundwater Surface Elevations, Indian Wells Valley. Plate 9 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.

In 1990, the U.S. Bureau of Reclamation initiated the Indian Wells Valley Groundwater Project. This project is a cost-sharing program with local entities within Indian Wells Valley. The objective is to better define the groundwater resources in the area. Additionally, the goal is the development of a tool to predict aquifer response to various future pumping scenarios. The ultimate result will be a plan for the long-term optimal utilization of the areas groundwater resources. To date, eight multi-completion monitoring wells have been drilled under the project. The Indian Wells Valley Water District has concurrently drilled three.

similar multi-completion monitoring wells that complement the Bureaus wells. The Geothermal Division of the US Naval Weapons Center has made available the 7,200 foot geothermal test well drilled in 1991. Portions of the upper 2,000 feet will be perforated, allowing a clustered piezometer at this site. This well will reasonably replace two Bureau wells previously scheduled to be drilled in this area. Completion of the entire Bureau project is scheduled for late 1992. The monitoring wells are expected to improve the base of information with respect to areal and vertical variations in groundwater chemistry, aquifer characteristics, long-term groundwater recharge and local/regional groundwater flows.

In 1991, KCWA began a weather monitoring program for the Indian Wells Valley. The primary purpose is to collect precipitation and temperature data in the Scodie Mountain watersheds tributary to the Indian Wells Valley to determine if climatic conditions would justify a precipitation enhancement program, similar to the program that the Department of Water Resources presently operates in the Feather River watershed in northern California. Even a modest increase in rainfall and runoff in this arid region could have a significant impact on the water supply for the population. In April, 1991 the Agency installed monitoring equipment at Horse Peak to determine icing conditions. A precipitation gage was installed in Indian Wells Canyon to collect rainfall data. This monitoring program is expected to continue through 1996.
Focus: Delano-Earlimart Irrigation District

The Delano-earlimart Irrigation District (district) was formed in 1938, and signed its original water service contract with the U.S. Bureau of Reclamation (Bureau) in 1951. The contract calls for water service from the Friant Unit of the Central Valley Project. Mr. H. K. Nelson, who was instrumental in bringing the Friant Division of the CVP to fruition, and signed the districts contract with the Bureau, just retired from the Board of Directors in December, 1989 at the age of 92.

The district includes a total of 56,500 acres situated in southern Tulare County and northern Kern County, along the east side of the San Joaquin Valley. The district serves about 400 landowners with an average farm size of 147 acres. More than one-third of the landowners own less than 40 acres. Virtually all of the land in the district has been developed. About 75 percent is planted in permanent crops, grapes being the most prevalent. Other perennial crops include pistachios, almonds, and a variety of tree fruits. Over 30 different crops are grown in the district.

The irrigation water distribution system is completely piped, with all customer deliveries having water meters. This system allows the district to make water deliveries with virtually no system losses, thus creating an extremely efficient project that is the foundation for the districts overall water conservation and management program. The high operating efficiency has extended to the growers by the introduction of drip irrigation and mister technology. Today, much of the district's acreage utilizes these advanced water application techniques. Table 25 shows irrigated acreage in the Kern County portion of DEID during 1991.

The total gross value of crops grown in the district exceeds $159 million annually, which, by the most conservative estimates, translates into nearly one half billion dollars for the regional economy. The vast majority of this crop value, about $122 million, is produced by the permanent crops, most notably table and wine grapes. Less than five percent of the total crop value comes from crops that are part of any USDA subsidy program.

The district has limited groundwater available, thus growers do not have a reliable alternative water supply other than the districts water service contract. DEID holds the largest Class 1 contract in the Friant Division, totaling 108,800 acre-feet, nearly 14 percent of the total firm yield of the Friant Unit. The district also contracts for 74,500 acre-feet of Class 2 water. In an average water year, DEID would receive about 150,000 acre-feet, which allows an allocation of just under three acre-feet per acre to eligible lands.

In the late 1800s, development of the Delano-earlimart area began with a water supply originating from numerous artesian wells. However, by the 1930s, groundwater supplies were rapidly diminishing to levels that threatened the area's continued economic viability. By 1947, the mean depth to groundwater was 209 feet. With the introduction of a surface water supply in 1951, groundwater conditions have improved dramatically. Considering that this area once had the largest groundwater overdraft in the San Joaquin Valley, it is quite an accomplishment that by the end of 1986 the average depth to groundwater had risen by 93 feet. However, the past six years of drought have taken their toll, forcing district growers to turn from surface supplies to groundwater. This has resulted in a drop of groundwater levels of 31 feet. Put another way, it took 35 years to raise the level by 93 feet, but only six years of drought to erase a third of the gain. Clearly, the groundwater is a fragile resource.

Table 25
1991 Irrigated Acreage in the Kern County Portion of Delano-earlimart Irrigation District

<table>
<thead>
<tr>
<th>Crop</th>
<th>Acres</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Annual Crops</strong></td>
<td></td>
</tr>
<tr>
<td>Alfalfa</td>
<td>626</td>
</tr>
<tr>
<td>Cotton</td>
<td>25</td>
</tr>
<tr>
<td>Dry Beans</td>
<td>15</td>
</tr>
<tr>
<td>Milo</td>
<td>8</td>
</tr>
<tr>
<td>Wheat</td>
<td>17</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td>691</td>
</tr>
<tr>
<td><strong>Permanent Crops</strong></td>
<td></td>
</tr>
<tr>
<td>Almonds</td>
<td>306</td>
</tr>
<tr>
<td>Apples</td>
<td>110</td>
</tr>
<tr>
<td>Citrus</td>
<td>745</td>
</tr>
<tr>
<td>Grapes</td>
<td>4,94</td>
</tr>
<tr>
<td>Olives</td>
<td>8</td>
</tr>
<tr>
<td>Persimmons</td>
<td>12</td>
</tr>
<tr>
<td>Plums</td>
<td>20</td>
</tr>
<tr>
<td>Quince</td>
<td>6</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td>6,151</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>6,842</td>
</tr>
</tbody>
</table>

Outlook: 1992

The good news is that the 1991-92 precipitation season was the best since 1986. El Niño, a condition of elevated sea surface temperatures, was in effect. This produced much higher than normal rainfall in the southern half of the state. Although the large storage reservoirs are in northern California, the higher rainfall in the south (primarily the Los Angeles basin) satisfied some of their demand for water. In fact, serious flooding occurred in February, 1992 with property damage and loss of life. Unfortunately, most of the floodwater (about 14,000 acre-feet) flowed out to sea instead of being stored for use. Another factor that is good news for Kern County agriculture is that it now shares allocated SWP water equally with other uses. According to the Agency’s master contract with the state Department of Water Resources, if cuts in requested entitlement must be made, agriculture must first be cut up to 50 percent in any given year or 100 percent in any seven year period, before sharing available water equally with other uses. At the end of 1991, agriculture had already accumulated its 100 percent share during the past drought years.

The bad news is that the northern half of the state did not fare so well with precipitation, including the Kern River watershed. Sacramento River tributaries were about 69 percent of normal, and Central Sierra watersheds were about 86 percent of normal. Statewide precipitation averaged 90 percent of normal. Other factors further reduced the effectiveness of the precipitation. In April, export pumping at the Sacramento Delta for storage in San Luis Reservoir was reduced for the protection of Winter-Run Salmon, which have been declared a threatened species. Unofficial estimates of the loss of storage to the water projects as a result of this declaration were about 250,000 acre-feet. Also, the cumulative effect of six years of drought has created a hydrologic deficit in the watersheds. The water which is held in the interstitial spaces in the rocks and alluvium has already drained into the streams over this time. These voids must first be refilled before normal runoff can resume. The result is that, even if precipitation were normal, runoff would be below normal. This is seen by a comparison of the 1992 Sacramento River watersheds rainfall of 69 percent of normal, with a projected runoff of only 49 percent of normal.

At this writing, the allocation to State Water Contra-
KERN COUNTY WATER AGENCY

WATER DISTRICT MAP
SHOWING

MAJOR SURFACE WATER SUPPLIES AND INTERMEDIATE TRANSMISSION FACILITIES

LEGEND

KCWA MEMBER UNIT BOUNDARIES
NON-MEMBER UNIT BOUNDARIES
CENTRAL VALLEY PROJECT – FRIANT KERN CANAL
KERN RIVER
STATE WATER PROJECT
ESTABLISHED GROUNDWATER REPLENISHMENT SITES

SCALE

MAP PREPARED BY KERN COUNTY WATER AGENCY JULY 1977
Revised October 1991