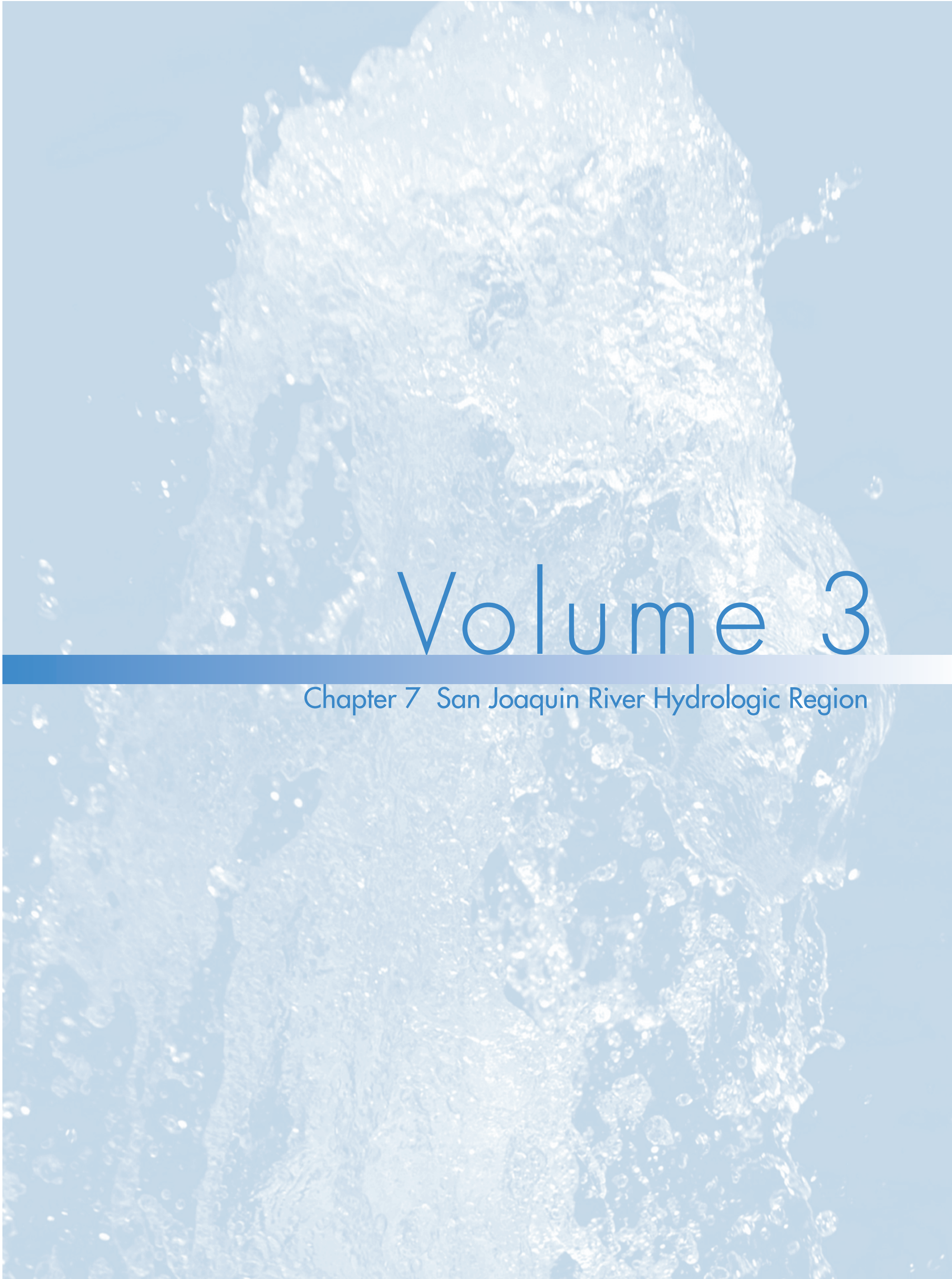

Volume 3

Chapter 7 San Joaquin River Hydrologic Region

Chapter 7 San Joaquin River Hydrologic Region

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Figure 7-1 San Joaquin River Hydrologic Region

Sacramento River Region
Delta Mendota Canal (CVP)
Folsom South Canal
California Aqueduct (SWP)

Flow in TAF

1998	2000	2001
5,119	6,174	4,572

Sacramento River Region
Sly Park

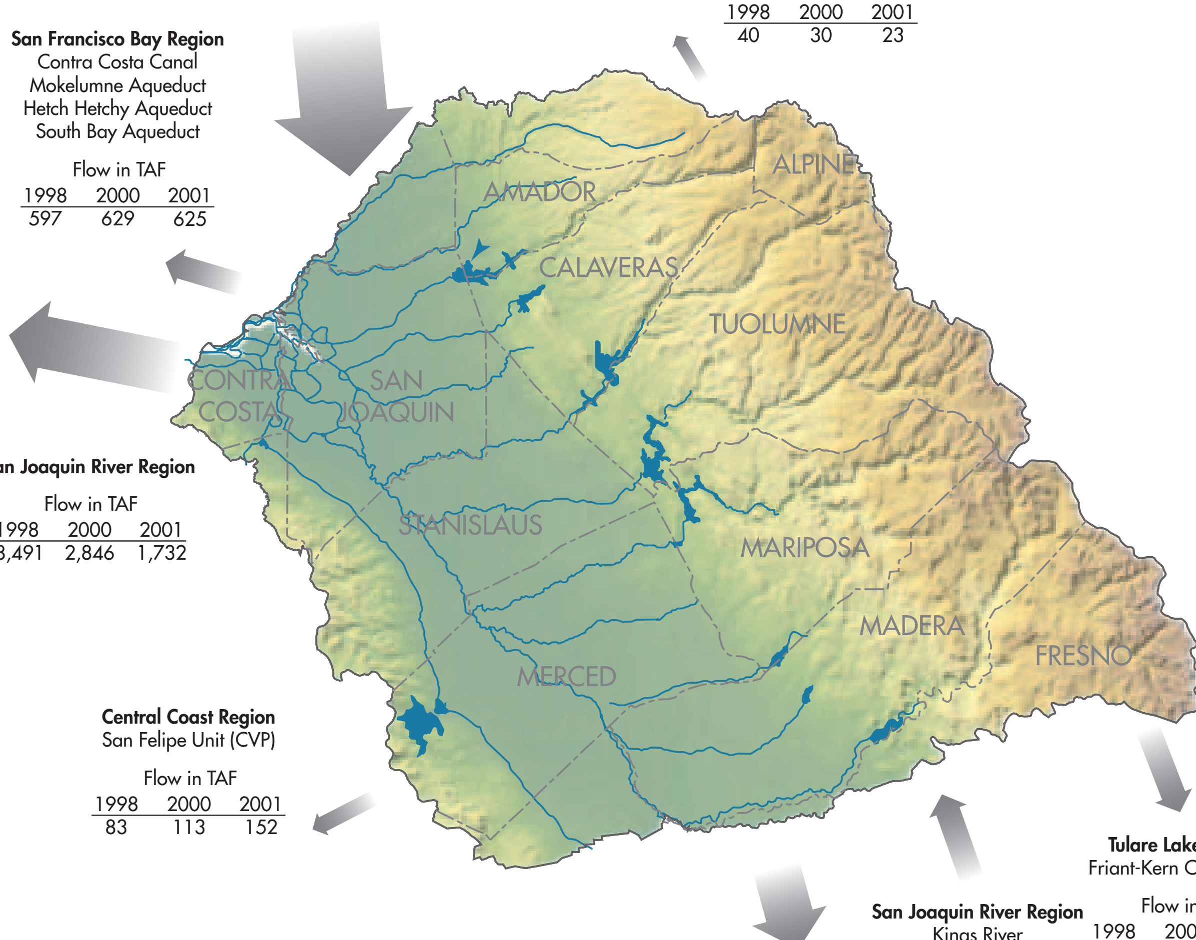
Flow in TAF

1998	2000	2001
40	30	23

San Francisco Bay Region
Contra Costa Canal
Mokelumne Aqueduct
Hetch Hetchy Aqueduct
South Bay Aqueduct

Flow in TAF

1998	2000	2001
597	629	625



San Joaquin River Region

Flow in TAF

1998	2000	2001
8,491	2,846	1,732

Central Coast Region
San Felipe Unit (CVP)

Flow in TAF

1998	2000	2001
83	113	152

Tulare Lake Region
Friant-Kern Canal (CVP)

Flow in TAF

1998	2000	2001
764	1,212	735

San Joaquin River Region
Kings River

Flow in TAF

1998	2000	2001
915	0	0

Tulare Lake Region
California Aqueduct (SWP)
San Luis Unit (CVP)
Delta-Mendota Pool

Flow in TAF

1998	2000	2001
2,952	4,414	2,961

Some Statistics

- Area -15,214 square miles (9.6% of State)
- Average annual precipitation - 26.3 inches
- Year 2000 population - 1,751,010
- 2030 population projection - 3,385,885
- Total reservoir storage capacity -11,477 TAF
- 2000 irrigated crop area - 2,050,400 acres

The San Joaquin River Hydrologic Region includes all of the San Joaquin River drainage area extending from Madera County in the south to the Delta in the north. Arrows indicate annual flows entering and leaving the region for water years 1998, 2000, and 2001.

Chapter 7 San Joaquin River Hydrologic Region

Setting

The San Joaquin River hydrologic region is in the heart of California and includes the northern portion of the San Joaquin Valley. It is bordered on the east by the Sierra Nevada and on the west by the coastal mountains of the Diablo Range. It extends from the southern boundaries of the Sacramento – San Joaquin Delta to include all of the San Joaquin River drainage area to the northern edge of the San Joaquin River in Madera. Roughly half of the Sacramento – San Joaquin Delta is within this hydrologic region, encompassing those portions of the Delta in Contra Costa, Alameda, and San Joaquin counties. The region extends south from just below the northeastern corner of Sacramento County and east to include the southern third of El Dorado County, almost all of Amador County, all of Calaveras, Mariposa, Madera, Merced, Stanislaus, and Tuolumne counties, and the western slope of Alpine County. The San Joaquin River Basin is hydrologically separated from the Tulare Lake Basin by a low, broad ridge that extends across the San Joaquin Valley between the San Joaquin and Kings rivers. A map and table of statistics describing the region are presented in Figure 7-1.

The San Joaquin River is roughly 300 miles long, which makes it one of the state's longest rivers. It has an average unimpaired runoff of about 1.8 million acre-feet per year, and its eight major tributaries drain about 32,000 square miles of watershed lands. The headwaters of the San Joaquin River begin near the 14,000 foot elevation of the crest of the Sierra Nevada. The river runs down the western slope of the Sierra, and then flows northwest to the Delta where it meets the Sacramento River. The two rivers converge in the 1,153-square-mile Sacramento-San Joaquin Delta—a maze of channels and islands—which also receives fresh-water inflow from the Cosumnes, Mokelumne and Calaveras rivers and other smaller streams. Historically, more than 40 percent of the state's annual run-off flowed to the Delta via the Sacramento, San Joaquin and Mokelumne rivers.

Climate

Because the San Joaquin Valley is isolated by mountains from the marine effects of coastal California, the maximum average daily temperature in the valley reaches a high of 101 degrees during late July. Daily temperatures during the warmest months usually range between 76 and 115 degrees. The northern part of this hydrologic region does benefit from Delta breezes during the hot summer periods, which are winds produced by the strong temperature difference between the hot valley regions and the cooler coastal climate of the San Francisco Bay area. Winter temperatures in the valley floor regions are usually mild, but during infrequent cold spells minimum readings occasionally drop below freezing. Heavy frost occurs in most fall and winter seasons, typically between the end of November and early March.

The San Joaquin River hydrologic region experiences a wide range of precipitation, which varies from low rainfall amounts on the valley floor to extensive amounts of snow in the higher elevations of the Sierra Nevada. The climate of much of the upland area on the west side of the valley floor resembles that of the Sierra Nevada foothills on the east side. The average annual precipitation of several Sierra Nevada stations is about 35 inches. Snowmelt runoff from the mountains is the major contributor to local water supplies for the eastern San Joaquin Valley. The climate of the valley is characterized by long, hot summers and mild winters. Average annual precipitation ranges from about 22 inches near the Stockton area in the north to about 11 inches in the southern portion of the region and further decreases to about 6.5 inches near the dry southwestern corner of the region.

Population

The population of the San Joaquin River region in year 2000 was about 1.7 million, which was about 5 percent of the state's total population. Although there are 15 counties partially or entirely in the San Joaquin River region, most of the popula-

The valley portion of the San Joaquin River region consists primarily of highly productive farmland and the rapidly growing urban areas of Stockton, Tracy, Modesto, Manteca, and Merced. The river runs down the western slope of the Sierra, and then flows northwest to the Delta. (DWR photo)

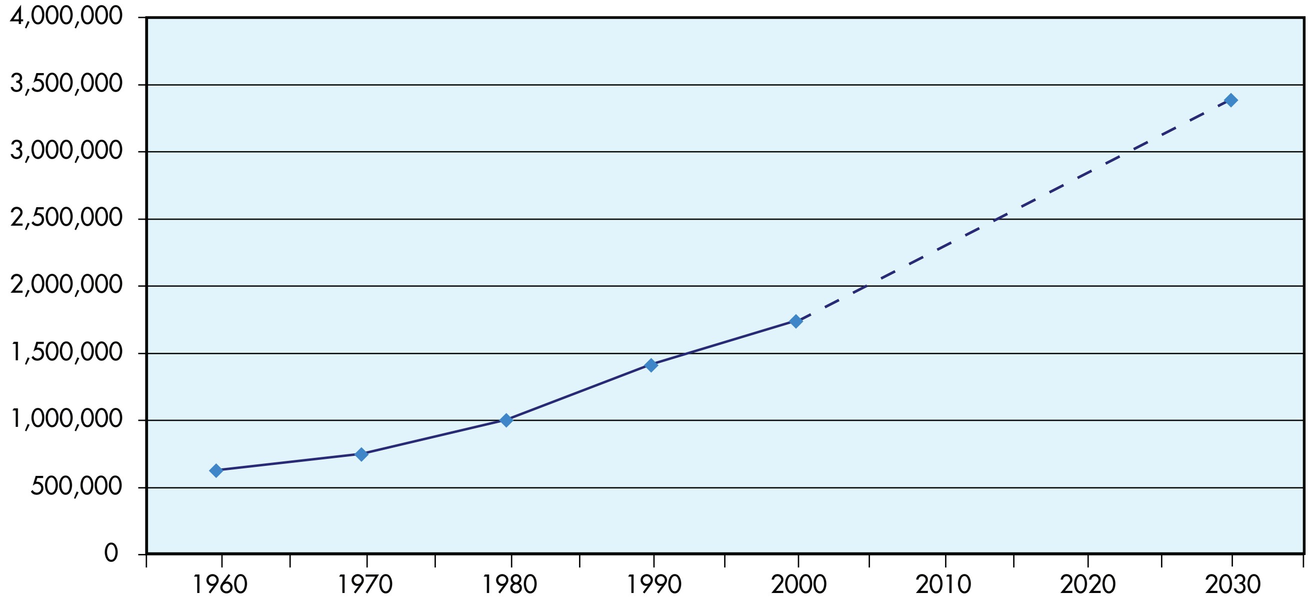
tion and agricultural land use occurs within five counties: San Joaquin, Stanislaus, Merced, Contra Costa, and Madera. Of these, the county with the largest year 2000 population was San Joaquin County with 567,600 people. Stockton, its largest city, had 243,771 people. Stanislaus County, population 567,600, was the second largest county in the region, and its largest city is Modesto with a population of 188,856. The county of Merced is the next largest with a population of 210,200; the city of Merced had a population of 63,800. For counties that are only partially within this hydrologic region, Contra Costa County had 145,775 residents, and Madera County had a year 2000 population of 127,400. Figure 7-2 provides a graphical depiction of the San Joaquin River region's total actual population from years 1960 through year 2000, with projections to year 2030.

California experienced a statewide population increase of almost 14 percent from 1990 to 2000, and the growth rates in San Joaquin valley cities and counties are projected to exceed that trend. According to California Department of Finance projections, growth rates for the above five counties will range between 18 and 32 percent over the next 10 years. The highest rate of urbanization will occur in the northern portion of the region. For San Joaquin County, the projected population will increase to 747,100 by 2010 and to 1,229,000 by 2030. Similarly, the projected population for Stanislaus County will increase to 559,100 by 2010, and to 744,600 by 2030. The rapid rates of growth and urbanization in these regions will generate significant land and water uses challenges for the entire San Joaquin Valley.

Land Use

The valley portion of the San Joaquin River region consists primarily of highly productive farmland and the rapidly growing urban areas of Stockton, Tracy, Modesto, Manteca, and Merced. Agriculture is the major economic and land use activity in the San Joaquin River region. The San Joaquin

Figure 7-2 San Joaquin River Hydrologic Region population



Data from California Department of Finance provide decadal population from 1960 to 2000 and population projection for 2030 for the San Joaquin River region.

Valley is recognized as one of the most important agricultural regions in California, with roughly 2 million acres of irrigated cropland and an annual agricultural output valued at more than $ 4.9 billion. The region has a high diversity of irrigated crops with about 34 percent as permanent orchard and vineyard crops and 29 percent as grains, hay, and pasture. Some of the other major crops include cotton, corn, tomatoes, and a variety of other field and truck crops. In addition to agriculture, other important industries in the region include food processing, chemical production, lumber and wood products, glass, textiles, paper, machinery, fabricated metal products, and various other commodities. About 1.95 million acres or 21 percent of the region's total land area were devoted to irrigated agriculture in year 2000.

While the valley floor areas of the San Joaquin River region are primarily privately owned agricultural land, much of the Sierra Nevada is national forest. The government-owned public lands include the El Dorado, Stanislaus, and Sierra national forests and Yosemite National Park. Public lands amount to about one-third of the San Joaquin River region's total land area. The national forest and park lands encompass more than 2.9 million acres; State parks and recreational areas and other State property account for about 80,000 acres; and U.S. Bureau of Land Management and military properties occupy over 200,000 and 5,100 acres, respectively. The valley portion of the region constitutes about 3.5 million acres, the eastern foothills and mountains total about 5.8 million acres, and the western coastal mountains comprise about 900,000 acres.

Restoration of Central Valley wetlands habitat is critical to the preservation of many species of fish and wildlife in the San Joaquin River ecosystem. Beginning in the 1990s, agencies began to make progress in efforts to set aside and restore acreage for wetland habitat. In 1990, the San Joaquin River Management Program was formed to restore the river system, which led to completion of the San Joaquin River Management Plan in 1995. This plan identified nearly 80 consensus-based actions intended to benefit the San Joaquin River system, which are organized into the categories of projects, feasibility studies, and riparian habitat acquisitions. Many federal and State agencies now have active roles in the funding and implementation of wetlands habitat restoration programs, including the U.S. Fish and Wild Service, the California Bay-Delta Authority and the California Department of Fish and Game. One of the larger projects along the San Joaquin River is the restoration of 775 acres of native riparian habitat on the

Table 7-1 San Joaquin River Hydrologic Region water balance summary - TAF

Water Entering the Region – Water Leaving the Region = Storage Changes in Region

	Water Year (Percent of Normal Precipitation)		
	1998 (174%)	2000 (113%)	2001 (79%)
Water Entering the Region			
Precipitation	35,535	23,209	16,120
Inflow from Oregon/Mexico	0	0	0
Inflow from Colorado River	0	0	0
Imports from Other Regions	6,034	6,174	4,572
Total	**41,569**	**29,383**	**20,692**
Water Leaving the Region			
Consumptive Use of Applied Water * (Ag, M&I, Wetlands)	3,705	4,762	4,983
Outflow to Oregon/Nevada/Mexico	0	0	0
Exports to Other Regions***	4,436	6,398	4,496
Statutory Required Outflow to Salt Sink	0	0	0
Additional Outflow to Salt Sink	176	196	218
Evaporation, Evapotranspiration of Native Vegetation, Groundwater Subsurface Outflows, Natural and Incidental Runoff, Ag Effective Precipitation & Other Outflows	31,448	18,055	13,690
Total	**39,765**	**29,412**	**23,387**
Storage Changes in the Region [+] Water added to storage [-] Water removed from storage			
Change in Surface Reservoir Storage	2,248	67	-1,435
Change in Groundwater Storage **	-444	-96	-1,260
Total	**1,804**	**-29**	**-2,695**
Applied Water * (compare with Consumptive Use)	6,035	7,584	7,817

***Footnote for applied water**

Consumptive use is the amount of applied water used and no longer available as a source of supply. Applied water is greater than consumptive use because it includes consumptive use, reuse, and outflows.

****Footnote for change in Groundwater Storage**

Change in Groundwater Storage is based upon best available information. Basins in the north part of the state (North Coast, San Francisco, Sacramento River and North Lahontan regions and parts of Central Coast and San Joaquin River regions) have been modeled – spring 1997 to spring 1998 for the 1998 water year and spring 1999 to spring 2000 for the 2000 water year. All other regions and year 2001 were calculated using the following equation:

GW change in storage =
intentional recharge + deep percolation of applied water + conveyance deep percolation - withdrawals

This equation does not include the unknown factors such as natural recharge and subsurface inflow and outflow.

West Unit of the San Joaquin River National Wildlife Refuge, west of Modesto. About 158,000 native trees, shrubs, and vines will be planted to accommodate the habitat needs of threatened and endangered species.

The San Joaquin Valley serves as a breeding and resting stop along the Pacific Flyway for many species of waterfowl. Public wildlife refuges in the San Joaquin River region include the San Luis National Wildlife Refuge, which encompasses 26,340 acres; the San Joaquin River National Wildlife Refuge with 2,875 acres; Merced National Wildlife Refuge with 8,280 acres; Los Banos Wildlife Area with 5,586 acres; Volta Wildlife Area with 2,891 acres; the North Grasslands Wildlife Area with 7,069 acres; the White Slough Wildlife Area with 969 acres; and the Isenberg Sandhill Crane Reserve at 361 acres. Toward the northern end of this region, the Cosumnes River Preserve is managed by the Nature Conservancy and has become the largest refuge area in the region at 36,300 acres. Additionally, there are many private duck clubs in the region that maintain wetland habitat.

Water Supply and Use

The primary sources of surface water in the San Joaquin River region are the rivers that drain the western slope of the Sierra Nevada. These include the San Joaquin River and its major tributaries, the Merced, Tuolumne, Stanislaus, Calaveras, Mokelumne, and Cosumnes rivers. Most of these rivers drain large areas of high-elevation watersheds that supply snowmelt runoff during the late spring and early summer. Other tributaries to the San Joaquin River include the Chowchilla and Fresno rivers, which originate in the Sierra Nevada foothills where most of the runoff results directly from rainfall.

The water balance table for the San Joaquin River hydrologic region (Table 7-1) summarizes all of the water supplies, uses, and outflows for years 1998, 2000, and 2001 and is supplemented by the detailed regional water accounting information in Table 7-2. As shown in Table 7-1, changes in groundwater storage are balanced with the available surface water each year to meet the regions needs. In wet years like 1998 excess surface water supply is added into groundwater storage, while in a drier year like 2001 the amount of groundwater pumped to meet water needs results in a net reduction of groundwater in storage. Table 7-3 (in large format at the end of this chapter) provides more specific information about the developed or dedicated component of water supplies for agricultural, urban and environmental purposes, as assembled from actual data for 1998, 2000 and 2001.

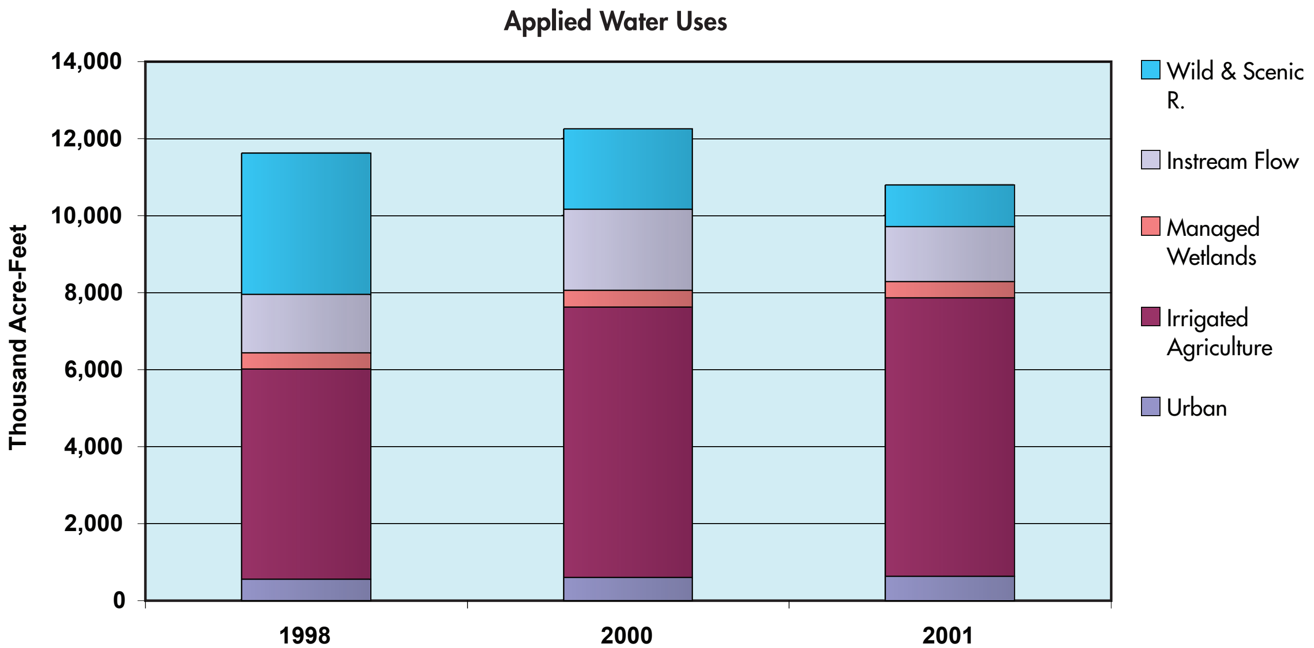
In 2000, an average water year, about 44 percent of the San Joaquin River region's developed water supply came from local surface sources, 23 percent was from imported surface supplies, and groundwater provided about 33 percent of the water supply. About 26 percent of the developed supply, excluding surface water and groundwater reuse, was used for dedicated natural flows to meet instream flow requirements. Figure 7-3 and Table 7-2 summarize all of the developed urban, agricultural and dedicated environmental water uses in this region for years 1998, 2000 and 2001.

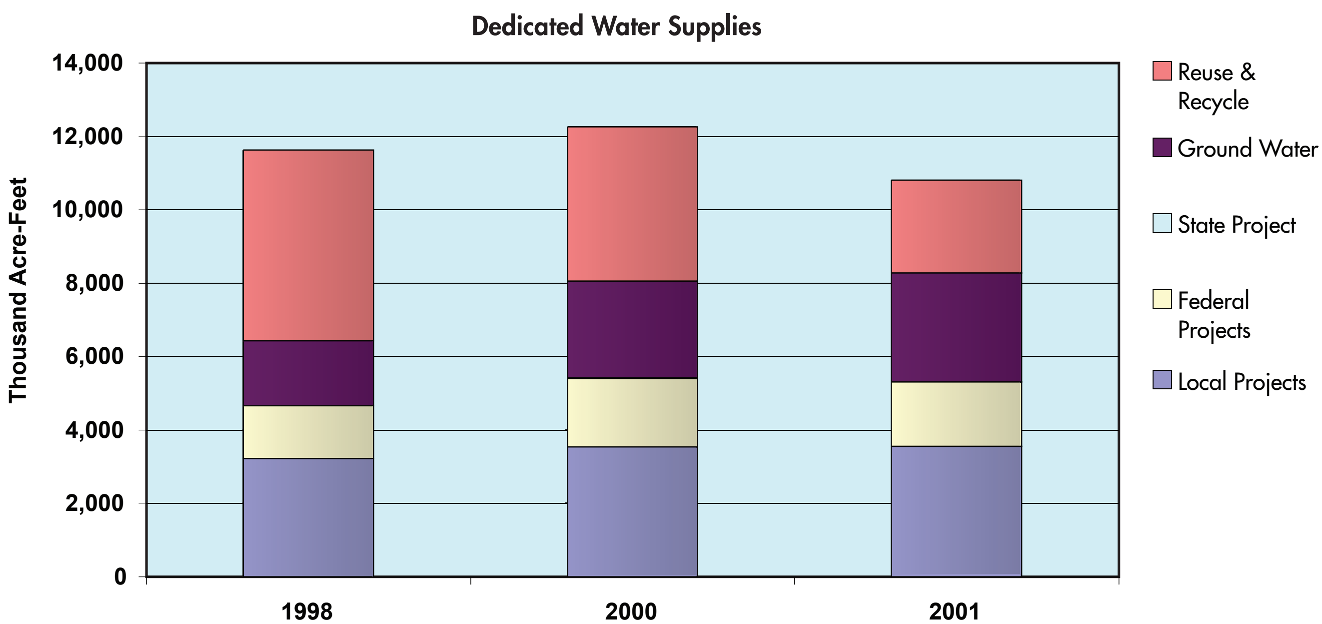
Many surface water supply systems in the Sierra Nevada streams and rivers follow a similar pattern of use. Often a series of small reservoirs in the mountain valleys will gathers and store snowmelt runoff. This water is used to generate electricity as it is released downstream. Some diversions occur for consumptive use in local communities, but most flows are recaptured in larger reservoirs in the foothills and along the eastern edge of the valley. Most of these larger reservoirs were built primarily for flood control. However, many of them also store water for urban and agricultural purposes, and make downstream releases for fish and environmental needs. Irrigation canals and municipal pipelines divert much of the water from these reservoirs. Many of the small communities in the Sierra Nevada foothills receive most of their water from local surface supplies. The extensive network of canals and ditches constructed in the 1850s for hydraulic mining forms the basis of many of the conveyance systems. In addition to surface water, many of these foothill and mountain communities pump groundwater from hard rock wells and old mines to augment their supplies, especially during droughts. Groundwater supplies in the foothills are limited, but this is the primary source of water for individual residents who are not connected to municipal water systems.

On the valley floor, many agricultural and municipal users receive their water supply from large irrigation districts, such as the Modesto, Merced, Oakdale, South San Joaquin and Turlock Irrigation Districts. Most of this region's imported surface water supplies are delivered by the federal Central Valley Project, which average about 1.9 million acre-feet per year. In addition, Oak Flat Water District receives about 4,500 acre-feet per year from the State Water Project.

Most of the surface water in the upper San Joaquin River is stored and diverted at Friant Dam, and is then conveyed north through the Madera Canal and south through the Friant-Kern Canal. Average annual diversions from the San Joaquin River through the Friant-Kern and Madera Canals total about 1.5 million acre-feet per year. Releases from Friant Dam to the San Joaquin River are generally limited to those required to satisfy

Figure 7-3 San Joaquin River region water balance for water years 1998, 2000, 2001





Three years show a marked change in the amount and relative proportions of water delivered to San Joaquin River region's urban and agricultural sectors and water dedicated to the environment (applied water, top chart), where the water came from, and how much water was reused among sectors (dedicated water supplies, bottom chart).

Table 7-2 San Joaquin River Hydrologic Region water use and distribution of dedicated supplies (TAF)

	1998			2000			2001		
	Applied Water Use	Net Water Use	Depletion	Applied Water Use	Net Water Use	Depletion	Applied Water Use	Net Water Use	Depletion
WATER USE									
Urban									
Large Landscape	30.2			32.9			35.5		
Commercial	34.5			37.6			39.6		
Industrial	86.3			89.4			90.1		
Energy Production	0.0			0.0			0.0		
Residential - Interior	176.2			191.5			199.7		
Residential - Exterior	214.0			231.3			243.7		
Evapotranspiration of Applied Water		191.0	191.0		206.6	206.6		218.4	218.4
E&ET and Deep Perc to Salt Sink		0.0	0.0		0.0	0.0		0.0	0.0
Outflow		142.3	142.3		150.0	150.0		160.8	160.8
Conveyance Applied Water	19.2			17.5			20.5		
Conveyance Evaporation & ETAW		12.6	12.6		12.0	12.0		13.6	13.6
Conveyance Deep Perc to Salt Sink		0.0	0.0		0.0	0.0		0.0	0.0
Conveyance Outflow		6.6	6.6		5.5	5.5		6.9	6.9
GW Recharge Applied Water	0.0			0.0			0.0		
GW Recharge Evap + Evapotranspiration		0.0	0.0		0.0	0.0		0.0	0.0
Total Urban Use	**560.4**	**352.5**	**352.5**	**600.2**	**374.1**	**374.1**	**629.1**	**399.7**	**399.7**
Agriculture									
On-Farm Applied Water	4,823.5			6,215.8			6,533.0		
Evapotranspiration of Applied Water		3,408.1	3,408.1		4,406.0	4,406.0		4,627.8	4,627.8
E&ET and Deep Perc to Salt Sink		74.4	74.4		11.6	11.6		14.3	14.3
Outflow		1,183.4	4.0		954.1	5.0		980.8	12.4
Conveyance Applied Water	379.0			461.5			449.1		
Conveyance Evaporation & ETAW		207.7	207.7		248.8	248.8		245.3	245.3
Conveyance Deep Perc to Salt Sink		0.0	0.0		0.0	0.0		0.0	0.0
Conveyance Outflow		22.9	22.9		35.4	35.4		37.9	37.9
GW Recharge Applied Water	255.5			340.5			260.9		
GW Recharge Evap + Evapotranspiration		0.0	0.0		0.0	0.0		0.0	0.0
Total Agricultural Use	**5,458.0**	**4,896.5**	**3,717.1**	**7,017.8**	**5,655.9**	**4,706.8**	**7,243.0**	**5,906.1**	**4,937.7**
Environmental									
Instream									
Applied Water	1,528.9			2,098.5			1,424.4		
Outflow		0.0	0.0		0.0	0.0		0.0	0.0
Wild & Scenic									
Applied Water	3,661.1			2,093.8			1,091.0		
Outflow		0.0	0.0		0.0	0.0		0.0	0.0
Required Delta Outflow									
Applied Water	0.0			0.0			0.0		
Outflow		0.0	0.0		0.0	0.0		0.0	0.0
Managed Wetlands									
Habitat Applied Water	414.5			444.8			414.7		
Evapotranspiration of Applied Water		105.9	105.9		149.7	149.7		136.6	136.6
E&ET and Deep Perc to Salt Sink		0.0	0.0		0.0	0.0		0.0	0.0
Outflow		134.2	1.6		128.3	1.6		135.7	1.5
Conveyance Applied Water	0.0			0.0			0.0		
Conveyance Evaporation & ETAW		0.0	0.0		0.0	0.0		0.0	0.0
Conveyance Deep Perc to Salt Sink		0.0	0.0		0.0	0.0		0.0	0.0
Conveyance Outflow		0.0	0.0		0.0	0.0		0.0	0.0
Total Managed Wetlands Use	414.5	240.1	107.5	444.8	278.0	151.3	414.7	272.3	138.1
Total Environmental Use	**5,604.5**	**240.1**	**107.5**	**4,637.1**	**278.0**	**151.3**	**2,930.1**	**272.3**	**138.1**
TOTAL USE AND OUTFLOW	**11,622.9**	**5,489.1**	**4,177.1**	**12,255.1**	**6,308.0**	**5,232.2**	**10,802.2**	**6,578.1**	**5,475.5**
DEDICATED WATER SUPPLIES									
Surface Water									
Local Deliveries	3,229.8	3,229.8	2,321.5	3,540.7	3,540.7	2,837.2	3,548.5	3,548.5	2,812.5
Local Imported Deliveries	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Colorado River Deliveries	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CVP Base and Project Deliveries	1,367.0	1,367.0	982.6	1,803.5	1,803.5	1,445.2	1,666.5	1,666.5	1,320.9
Other Federal Deliveries	64.3	64.3	46.2	65.8	65.8	52.7	97.6	97.6	77.4
SWP Deliveries	4.3	4.3	3.1	4.6	4.6	3.7	3.5	3.5	2.8
Required Environmental Instream Flow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Groundwater									
Net Withdrawal	821.8	821.8	821.8	891.5	891.5	891.5	1,260.1	1,260.1	1,260.1
Deep Percolation of Surface and GW	943.8			1,754.8			1,708.5		
Reuse/Recycle									
Reuse Surface Water	5,190.0			4,192.3			2,515.6		
Recycled Water	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9
TOTAL SUPPLIES	**11,622.9**	**5,489.1**	**4,177.1**	**12,255.1**	**6,308.0**	**5,232.2**	**10,802.2**	**6,578.1**	**5,475.5**
Balance = Use - Supplies	***0.0***	***0.0***	***0.0***	***0.0***	***0.0***	***0.0***	***0.0***	***0.0***	***0.0***

downstream water rights, above Gravelly Ford, and for flood control. In the vicinity of Gravelly Ford, a high amount of subsurface percolation into the groundwater basin occurs because the river bed is primarily sand and gravel. As a result of the operation of Friant Dam, there are seldom any surface flows in the middle reaches of the San Joaquin River until it is joined by the Merced River and other major downstream tributaries Agricultural and municipal return flows into the river also contribute to the surface flow of the lower San Joaquin River.

The tributaries of the San Joaquin River provide the region with high-quality water that constitutes most of the surface water supplies for local uses. Much of this water is regulated by reservoirs and used on the east side of the San Joaquin Valley. Significant amounts of water are also diverted west across the valley to the San Francisco Bay Area via the Mokelumne Aqueduct, which supplies some for the urban water demands of East Bay Municipal Utility District, and the Hetch Hetchy Aqueduct, which supplies urban water to San Francisco and several other Bay Area cities. The average annual water diversions from the Mokelumne and Tuolumne rivers for export from the basin include 245,000 acre-feet through the Mokelumne Aqueduct and 267,000 acre-feet through the Hetch-Hetchy Aqueduct. Major dams on the tributary streams include Pardee and Camanche dams on the Mokelumne River, New Melones, Donnells, and Beardsley dams on the Stanislaus River, O'Shaunessy and New Don Pedro dams on the Tuolumne River, and Exchequer Dam on the Merced River.

In 2000, an average water year, agriculture accounted for about 57 percent of the San Joaquin River region's total developed water use, while urban water use was about 5 percent and environmental water use for dedicated purposes was 38 percent. Regional average urban per capita water use was about 304 gpcd. Imported water supplies to this region from the Central Valley Project, the State Water Project, and other federal deliveries, amounted to 1,874,000 acre feet. Environmental demands, including for refuges, instream requirements, and wild and scenic flows, totaled 4,637,100 acre feet (see Figure 7-3 and Table 7-2)

State of the Region

Challenges

Historically, the surface water originating from Sierra Nevada rivers has proven to be a dependable supply of high quality water, but it meets only half of the region's total water requirements. Imported surface water and groundwater-pumping make up the difference. Because the region relies on imported surface water from other regions, there is growing concern over the long-term availability of external supplies. Additionally, proposals to restore fisheries on the San Joaquin River through larger releases of water from Friant Dam have resulted in growing concerns over the long-term stability of the existing surface water supplies.

One of the major challenges facing the San Joaquin River hydrologic region is restoring the ecosystem along the San Joaquin River below Friant Dam while maintaining water supply reliability for other purposes. The river's historic salmon populations upstream of the Merced River were eradicated after the river water was diverted with the construction of Friant Dam in the 1940s. In August 2004, a federal judge ruled that the U.S. Bureau of Reclamation violated California State Fish and Game Code 5937 by not providing enough water downstream to sustain fish populations. Efforts to restore some surface flows to the San Joaquin River would help restore the ecosystem and improve the reliability and quality of water available to downstream farmers in the Delta. The litigation of these issues is not resolved, and the development of acceptable solutions will be challenging because of the potential to adversely impact water supplies to the Friant Water Users Authority.

Another major challenge is maintaining the integrity of the Sacramento – San Joaquin Delta levee system. More than 1,000 miles of levees protect Delta islands, and these lands are commonly 10 to 15 feet below sea level. The potential failure of a levee could occur as the result of major earthquakes or floods, or because of gradual deterioration and inadequate maintenance. Composed largely of peat soils, many islands are vulnerable to seepage and subsidence, which contributes to settlement and the risk of levee failure. Protection and restoration of the Delta levees is one of the key objectives of the CALFED Bay-Delta program as discussed in Chapter 12 of this volume.

Groundwater pumping is a major source of water supply for the San Joaquin River region, and it continues to increase in response to the growing urban and agricultural demands. Over the long-term, groundwater extraction cannot continue to meet all of the current and projected water demands without causing negative impacts on the groundwater basins. The primary impact is groundwater overdraft, a condition where the average long-term amount of water pumped out of the basin exceeds the amount of water recharged or naturally replenished into the groundwater basin. A serious consequence of long-term groundwater overdraft is land subsidence and compaction of the aquifer, with a resulting drop in the natural land surface. Land subsidence results in a reduction of aquifer storage space and may damage public facilities such as canals, utilities, pipelines, and roads. Pumping depressions from wells have caused poor quality water from the Delta to migrate underground toward eastern San Joaquin County. Several municipal wells in western Stockton have been abandoned because of the resulting decline in groundwater quality. Several existing and proposed measures can help counteract potentially serious overdraft conditions in some areas of the region, such as groundwater spreading basins and recharge programs. In some situations, the over-irrigation of crops with extra surface water in wet years and seepage from unlined canal systems can aid in groundwater recharge.

The major water quality problems of the San Joaquin River region are a result of many factors, including depleted freshwater flows, municipal and industrial wastewater discharges, salt loads from agricultural drainage and runoff, and other pollutants associated with long-term agricultural irrigation and production, including nutrients, selenium, boron, and organophosphate pesticides. The entire Central Valley, which includes the San Joaquin River, as well as the Sacramento River and Tulare Lake basins, has 40 water bodies that are impaired due to agriculture, including 800 miles of waterways, and 40,000 acres in the Delta. In its most recent triennial review of its basin plan, the Central Valley Regional Water Quality Control Board identified high priority problems as salinity and boron discharges to the San Joaquin River, low dissolved oxygen problems in the lower San Joaquin River, control of organophosphorous pesticides, and the need for stronger policies to protect Delta drinking water quality.

High salinity is a problem in the San Joaquin River basin because of the greatly altered flows of the river, most of which is diverted from its natural course at Friant Dam. In addition, imported irrigation water from State and federal projects annually transport more than a half million tons of salts into the west side of the San Joaquin River region. Water released from New Melones Reservoir on the Stanislaus River is used to help meet the salinity and dissolved oxygen requirements at Vernalis on the lower San Joaquin River. Agricultural drainage and discharges from managed wetlands are already regulated in the 370,000 acre Grasslands watershed, which contributes high levels of salts, selenium, boron, and nutrients to Mud and Salt Sloughs. These sloughs are some of the primary contributors of selenium to the San Joaquin River. Dairies, stockyards, and poultry ranches are also a concern in the region because they generate waste products including pathogens, nutrients, salts, and emerging contaminants that enter the waterways. Some dairies and other agricultural operations are already subject to regulatory review. Water releases from managed wetlands, part of State and federal wildlife refuge system, also can discharge salts and nutrients. The erosion of westside streams is the primary source of organochlorine pesticides in the San Joaquin River.

Migrating and spawning salmonids face high temperatures in the Stanislaus, Tuolumne, and Merced rivers downstream from dams during certain times of the year, depending on hydrologic and water supply conditions. Contamination of fish is also a concern in these three rivers as well as the main stem of the San Joaquin River. For example, the Central Valley Regional Water Quality Control Board cites one study of a 43-mile reach of the San Joaquin River (between the confluences with the Merced and the Stanislaus rivers) to be toxic to fish about half the time. In the lower San Joaquin River, low dissolved oxygen levels in the Stockton Deepwater Ship Channel are attributable to warm temperatures, low flows, nutrients, and channel configuration. This portion of the river with low dissolved oxygen is potentially a barrier to fall-run Chinook salmon migrating upstream to the Merced, Tuolumne, and Stanislaus rivers to spawn.

Groundwater quality throughout the region is generally adequate for most urban and agricultural uses. However there are roughly 1,000 square miles overlying groundwater along the western edge of the valley floor that is contaminated with high salinity from naturally occurring marine sediments of the Coast Range. The salinity of groundwater in the region can increase as a result of agricultural practices in which the evapotranspiration of crops and wetlands leaves behind the majority of salts contained in the imported water. In addition, high water-table conditions underlying marginal lands along the west side of the San Joaquin River region contribute to subsurface drainage problems. In order to maintain a salt balance in the root zone, much of this salt is leached into the groundwater. For aesthetic purposes, such as taste, Department of Health Services regulations recommend that drinking water contain less than 500 mg/L of salinity as measured by total dissolved solids. For agricultural uses, water with a salinity of less than 450 mg/L total dissolved solids is generally considered acceptable. While the above Department of Health Services recommendation is adopted by reference into the Regional Water Quality Control Board's basin plan to protect domestic use of groundwater, the basin plan contains no numerical salinity objectives for protection of agricultural beneficial uses.

Nitrates that are generated from the disposal of human and animal waste products or from the inefficient application of fertilizer and irrigation water have contaminated 200 square miles of groundwater in the region and do threaten some domestic water supplies. Pesticides have contaminated 500 square miles of groundwater basins, primarily in agricultural areas on the east side of the San Joaquin Valley, where soil permeability is higher and the depth to groundwater is more shallow. The entire Central Valley is home to about 500,000 single-family residential septic systems, each with leach fields that discharge to the groundwater. The most notable agricultural contaminant detected in groundwater samples from this region is dibromochloropropane, DBCP, which is a banned nematocide that has been found mostly along the State Route 99 highway corridor. There are also roughly 200 square miles of groundwater basins that are contaminated by naturally occurring selenium.

As of January 1, 2003, the passage of Senate Bill 390 ended the previously used conditional waivers for waste discharge requirements for 23 types of waste discharges, including irrigated agriculture and logging. A previously submitted petition from three environmental groups had requested that these waivers be rescinded because of concerns about pesticides in discharges. Unlike the federal Clean Water Act, which specifically exempts agricultural discharges from regulation, California's Porter-Cologne Water Quality Control Act allows a waiver from regulation only if it does not conflict with the public interest. The Central Valley Regional Water Quality Control Board granted such a waiver to irrigated lands in 1982, exempting the agricultural discharges using the waste discharge requirements process. That waiver did have conditions imposed, but because of a lack of staff resources, the regional board did not monitor or review compliance. Senate Bill 390 still allows the continuation of waivers, but only when specifically renewed by the regional board and when subject to a five-year review.

In relation to other regions of the State, water discharges from irrigated lands have their greatest impact to water quality in the Central Valley, which covers 40 percent of California's land area and contains 7-million irrigated acres and more than 25,000 individual agricultural dischargers. As an interim measure in July 2003, the Central Valley regional board adopted two types of conditional waivers for such discharges into surface water, one for "coalition groups" and the other for individuals. These waivers applied to surface runoff or tailwater, excess water diverted but not used, subsurface drainage to lower the water table for growing, and storm water runoff. Additional commodity-specific and low-threat waivers are also under consideration. The requirements contained in these new waivers include water quality monitoring and implementation of best management practices or management measures to control pollution. This new waiver program, which focuses on data collection, monitoring for toxicity, and drinking water constituents will expire on December 31, 2005. Subsequently, a 10-year implementation program is envisioned that would fully protect the state's waters from quality problems associated with discharges from irrigated lands in order to meet water quality objectives.

Although existing agricultural land use practices affect water quality now, the expanding urbanization of Central Valley cities will generate new and different water quality problems in the future. In anticipation of these problems, the Central Valley regional board has recently started requiring many municipal wastewater discharge systems to construct and operate more costly tertiary wastewater treatment facilities.

Accomplishments

The Reclamation Board of California and the U.S. Army Corps of Engineers in coordination with a broad array of stakeholders, have recently developed a new Comprehensive Plan for the flood management system of the Sacramento and San Joaquin River regions. Rather than a physical plan for flood facilities and systems, this Comprehensive Plan recommends an approach to design and implement projects in the future in ways that would reduce damage from flooding and restore the ecosystem.

The Millerton Area Watershed Coalition is conducting a comprehensive assessment of the San Joaquin River watershed and will evaluate activities that need to be changed to better protect and care for the watershed. The information and recommendations from this study will be developed into an outreach program to promote the protection and enhancement of the watershed, including the economic and environmental well-being of the communities within it. This comprehensive assessment is sponsored by the CALFED Watershed Program and coordinated through the U.S. Bureau of Reclamation.

The San Joaquin River Group Authority was formed in the 1990s in response to the development of the Sacramento – San Joaquin Bay Delta Water Quality Control Plan by the State Water Resources Control Board. The water quality control plan was adopted in 1995 and included significant water quality and flow standards for the lower San Joaquin River. The goals of the authority are to investigate fishery and water quality issues on the San Joaquin River and develop solutions that will protect the salmon fishery and improve water quality. To respond to water quality issues, the regional board is studying agricultural discharge quality controls, and may consider the use of agriculture waivers at a watershed level. Additional water quality monitoring will be necessary to address the various water quality problems on the Lower San Joaquin River. Landowners will have the choice of participating in water quality monitoring and improvement programs on a watershed level or on an individual basis. The watershed approach can be used to identify and address "hot spots" by working directly with individual landowners or encouraging individuals to work together to find solutions.

The San Joaquin River Group Authority also led the development of the Vernalis Adaptive Management Plan as a 10-year test program designed to study methods to improve salmon smolt survival in the lower San Joaquin River. Starting in the year 2000, the Vernalis plan has coordinated the release of water from upstream reservoirs each spring to generate a calculated pulse flow down the lower river to help salmon smolts migrate to San Francisco Bay and the ocean. The timing and duration of this pulse flow is coordinated with reduced State Water Project and Central Valley Project Delta export pumping in order to improve Delta flow patterns to guide the salmon smolts to the ocean. The plan's technical group coordinates extensively with several local and government agencies to oversee the successful test flow each year, which include real-time facility operations and monitoring, tracking of water flows and fish migration, and outreach and education. It is still too early in the 10-year test to determine how successful this program will be.

The Upper San Joaquin River Basin Storage Investigation evolved out of the CALFED Record of Decision of 2000. That decision states, "250 to 700 [thousand acre-feet] of additional storage in the upper San Joaquin watershed … would be designed to contribute to restoration of and improve water quality for the San Joaquin River, and facilitate conjunctive water management and water exchanges that improve the quality of water deliveries to urban communities. Additional storage could come from enlargement of Millerton Lake at Friant Dam or a functionally equivalent storage program in the region." Surface storage options in the San Joaquin River region that may be considered as part of the CALFED program include of the investigation of (1) raising Friant Dam, (2) Fine Gold Creek Dam, and (3) Temperance Flat Dam, which includes three alternative sites. Additionally, Yokohl Valley Reservoir near Visalia in the Tulare Lake region could also be considered as part of these planning studies.

The Farmington Groundwater Recharge and Seasonal Habitat Program is a regional effort to recharge the underground aquifer in the Eastern San Joaquin County Basin. The basin aquifer is threatened by the eastward movement of saltwater from the Delta, which could eventually contaminate municipal wells in Stockton and limit the ability of farmers to grow crops, except for some salt-tolerant, low-value varieties. By periodically spreading an average of 35,000 acre feet of surplus water per year using the flooded-field method, the program is intended to reduce groundwater overdraft and establish a barrier to prevent saline water intrusion. The $33.5 million program is a partnership between Stockton East Water District and the U.S. Army Corps of Engineers. The program will initially seek to secure flooding rights on about 25 agricultural parcels totaling 1,200 acres. The initial 35,000 acre-foot per year objective was based on the Farming Groundwater Recharge and Seasonal Habitat Study, which was completed in 2001. Stockton East Water District was the lead local sponsor of the feasibility study with the U.S. Army Corps of Engineers. Other study participants included Central San Joaquin Water Conservation District, North San Joaquin Water Conservation District, City of Stockton, San Joaquin County, and California Water Service Company.

Through the South San Joaquin County Surface Water Supply Project, the cities of Tracy, Manteca, Lathrop, and Escalon have joined with the South San Joaquin Irrigation District to plan for a water treatment plant on the Stanislaus River. The project will use water that the irrigation district has conserved from improvements in irrigation practices and water efficiencies. Water will be taken from Woodward Reservoir, treated to drinking standards, and conveyed to the cities. A 40-mile long transmission pipeline would also be built from the treatment plant to deliver water to each of the participant cities. The $150 million project is expected to begin deliveries around May 2005. The project is scheduled to deliver 30,000 acre feet per year to the cities through 2010 and up to 44,000 acre-feet per year thereafter. The intent of the project is to reduce the reliance on groundwater and to satisfy future urban demand increases.

Relationship with Other Regions

The San Joaquin River region is dependent on receiving surface water from other regions of the State to meet a portion of its developed agricultural and urban water uses. For many years, the region has received imported Central Valley Project water from the Sacramento-San Joaquin Delta via the Delta Mendota Canal and from the project's Friant Dam on the upper San Joaquin River. This region also receives some State Water Project water from the California Aqueduct. The regional map in Figure 7-1 includes arrows that summarize these regional imports and exports for the years 1998, 2000, and 2001.

Some surface water supplies that originate in the San Joaquin region are also diverted across the valley to the San Francisco Bay region via the Mokelumne Aqueduct by the East Bay Municipal Utility District and through the Hetch Hetchy Aqueduct by the City of San Francisco. The average annual diversions by these two projects from the Mokelumne and Tuolumne rivers are about 245,000 acre-feet per year through the Mokelumne Aqueduct and 267,000 acre-feet per year through the Hetch-Hetchy Aqueduct.

In 1998, Contra Costa Water District completed Los Vaqueros Reservoir, which can hold 100,000 acre-feet in storage. This is an offstream reservoir in the northwest corner of the San Joaquin hydrologic region. The reservoir stores Contra Costa Water District water that has been diverted from the Delta in the late winter and spring when water quality is good. Water is typically withdrawn from Los Vaqueros Reservoir in the summer and fall to meet demands and improve the quality of water delivered to the water district's service areas. However, because a portion of the service area is in the San Francisco Bay Hydrologic Region, this water is considered to be an export from the San Joaquin region. Los Vaqueros Reservoir has only been operated for a few years, such that normal patterns of diversion and water use have not yet been established.

Looking to the Future

The water agencies within this region have many projects and programs planned to address water supply problems. These include studies to evaluate new local surface storage projects and investigations for water storage development in conjunction with the CALFED program. Local agencies are further implementing groundwater conjunctive use projects and increasing their efforts on water use efficiency and water recycling programs. As the urban areas in the valley continue to grow and expand, the current trend of agricultural land conversion to subdivisions is likely to continue. As an outcome of urban expansion, urban water usage is expected to increase in the future, while agricultural water use is projected to decline slightly. The effectiveness of urban and agricultural water conservation and water use efficiency measures will influence these water use trends.

Regional Planning

The San Joaquin Valley Water Coalition is a forum where water entities and interest groups can come together to discuss common issues related to water supply, quality, and distribution. The objective of this group is to ensure a water supply for the valley that is sustainable and capable of meeting the needs and concerns of all water users. The Westside Integrated Water Resources Plan was initiated in 2000 and is evaluating alternatives to increase water supplies and reduce demands in order to address current water supply deficits. The West Stanislaus Hydrologic Unit Area Project is a program sponsored by the U.S. Department of Agriculture and local growers to enhance water quality by reducing soil erosion into the San Joaquin River.

There are several other programs that are focusing on ecosystem restoration for the Merced, Stanislaus, Tuolumne, and San Joaquin rivers. The Grassland Bypass Project on the west side of the valley will consolidate the conveyance of subsurface drain flows on a regional basis. A portion of the federal San Luis Drain will be used to convey drainage flows around the Grassland habitat areas into Mud Slough before being discharged into the San Joaquin River above its confluence with the Merced River. The San Joaquin River Parkway and Conservation Trust has goals to preserve and restore San Joaquin River lands that have ecological, scenic, or historic significance. This group also works to educate the public on the need for river stewardship, research issues affecting the river, and promote educational, recreational and agricultural uses consistent with the protection of the river's resources.

Work is continuing on several programs at the watershed level in the region. For example, the San Joaquin River Management Program is seeking solutions to the common problems facing the region that affect the environment, water quality, agriculture, and flood control in the San Joaquin River watershed, without the limitations imposed by political boundaries. Also, several public and private partnerships on the east side of the valley are attempting to develop a Comprehensive Plan for the management, protection and restoration of the watersheds of the San Joaquin, Merced, Chowchilla, and Fresno rivers. The goal of this plan is to attain designations as Resource Conservation and Development Areas, so that watershed projects can be coordinated in Mariposa County and eastern Madera County.

Water Portfolios for Water Years 1998, 2000, and 2001

Water Year 1998

California experienced the affects of El Nino weather patterns from July 1997 to June 1998. The wet winter set new records for precipitation at many locations throughout the state. Annual precipitation for Fresno exceeded 180 percent of average; Stockton had almost 200 percent of average; and Los Banos recorded 248 percent of average rainfall. Watershed runoff was well above average as streamflow in the San Joaquin, Merced, Stanislaus and Tuolumne rivers reached about 165 percent of average. More detailed information about how these water supplies were stored and used on a region-wide basis is presented in water portfolio Table 7-3, and the companion Water Portfolio flow diagram Figures 7-4 and 7-5 (large-format graphics placed at the end of this chapter).

Total irrigated acreage in the San Joaquin River region was about 2,053,700 acres in 1998. Alfalfa acreage accounted for 11.5 percent of all irrigated crops in the region; almond and pistachio acreage accounted for 13.8 percent; and vineyard acreage was 10.9 percent of the total. Compared to year 1995, irrigated pasture acreage declined by about 15,400 acres. However, the acreage of corn rose by 36,800 acres, almonds and pistachios increased 8,600 acres, and vineyards increased by 29,600 acres compared to 1995 levels. These crop shifts indicate that growers are continuing the trend of converting field crops to almond and pistachio orchards and vineyards, in an effort to find commodities that generate better long-term profits.

The effects of the wet El Nino phenomenon on the San Joaquin River region were extensive, such that growers had little need to irrigate during the first four to five months of 1998. As shown in Table 7-3, the total 1998 agricultural on-farm applied water use was 4.8 million acre feet, and total agricultural water use was 5.5 million acre feet or 47 percent of all uses. These water use volumes are significantly lower than what is usually required in a normal year such as 2000. The regional average for agricultural on-farm applied water was 2.4 acre feet per acre. The total agricultural evapotranspiration of applied water, or ETAW, in 1998 amounted to 3.4 million acre feet.

Total urban applied water use, including residential, commercial, industrial, and landscape, in the region totaled 560,400 acre feet. The average per capita water use was about 301 gallons per day, and the urban ETAW was 191,000 acre feet. Urban water use accounted for only about 5 percent of the total water use in the region, and the population for the region was 1,669,890, or 4.9 percent more than 1995.

Total environmental water use for instream flows, wild and scenic rivers, and refuges was about 5.6 million acre-feet. This accounted for 48 percent of total uses. Environmental water includes water that is reserved for instream and wild and scenic river flow but can be used later as a supply by downstream users. Most of these requirements are for locations on the major rivers that drain from the Sierra Nevada to the valley floor. Refuge water supplies, which are diverted and applied directly onto wildlife refuges, totaled 414,500 acre feet, or 7 percent of total environmental uses.

Total water supplies needed to meet all of the above demands were 11.6 million acre feet, including local and imported Central Valley Project and State Water Project surface water, groundwater, and water reuse.

Water Year 2000

The weather for the 1999-2000 water year in the San Joaquin River region produced normal precipitation and streamflow. Rainfall amounts were slightly above average for most of the measuring stations in the region. Annual precipitation in both Madera and Modesto was 120 percent of average; Stockton rainfall was 99 percent of average; and Los Banos had 88 percent of normal precipitation. Ample moisture was received in the local watersheds, and runoff resulted in good surface water supplies. Watershed runoff was about average, with unimpaired runoff from the Tuolumne, Merced and San Joaquin rivers at about 103 percent of average. The unimpaired runoff from the Stanislaus, Mokelumne, and Cosumnes rivers was 99, 89, and 70 percent, respectively, indicating the regional variability of surface flows from one watershed to the next. Heavy rainfall occurred in January and February, delaying many agricultural activities such as pruning, planting, spraying, and field preparation.

Total irrigated acreage decreased only slightly from 1998, and was 2,050,400 acres for year 2000. Almond and pistachio acreage in 2000 was 292,500 acres, which was 9,300 acres higher than in 1998. The acreage of sugar beets dropped 26 percent to 18,500 acres, while the acreages of most other crops in the region remained about the same as in 1998.

In general, 2000 weather, water supplies, and evaporative demand were close to average in the San Joaquin River region. The total agricultural on-farm applied water was 6.2 million acre feet, and total agricultural water use was 7 million acre-feet or 57 percent of all uses, about 29 percent more than 1998. The regional average on-farm unit applied water use was 3 acre-feet per acre. The total agricultural ETAW was about 4.4 million acre feet, 29 percent higher than 1998. Since both 1998 and 2000 had similar total crop acreage, the significant increase in total agricultural applied water (29 percent higher) confirms that wet weather patterns result in significantly reductions in agricultural water needs.

Total urban water use for the region was 600,200 acre feet, which was about 7 percent higher than the total urban water use for 1998. Average per capita water use was around 304 gallons per day, and total urban ETAW for the year was about 206,600 acre-feet, 8 percent higher than 1998. Urban applied water accounted for about 5 percent of the total water use in the region.

Total environmental water use for instream flows, wild and scenic rivers, and refuges was about 4.6 million acre feet, 17 percent less than in 1998. Although water for required instream flows was higher than in 1998, the amount of water dedicated to wild and scenic rivers was much lower than those of 1998. In 2000, total environmental water use accounted for 38 percent of all developed water uses. Refuge supplies accounted for 444,800 acre feet or 10 percent of total environmental uses.

As shown in Table 7-2, total water supplies, including local and imported Central Valley Project and State Water Project surface water, groundwater, and reuse, amounted to 12.3 million acre-feet in year 2000, which was a 5 percent increase from 1998.

Water Year 2001

The 2000-2001 water year started out cooler than normal with cumulative rainfall below average through most of January. Rainfall amounts were slightly less than average for the water year, and annual totals were 88 and 83 percent of average for Madera and Stockton, respectively. As the accumulated precipitation lagged in January, large-scale weather patterns changed significantly as February approached and a series of Pacific storms moved into the state, helping to bring precipitation totals closer to average. This cool, wet period delayed many agricultural activities such as pruning, planting, spraying, and ground preparation. The weather became warmer by late April and the balance of the growing season offered good growing conditions.

Irrigated crop acreage totaled 2,042,700 acres in 2001, representing a 7,700 acre decline from water year 1998. Irrigated pasture acreage decreased to 158,800 acres, a 28,900 acres decrease or 15.4 percent decline from 1998; sugar beet acreage decreased to 7,600 acres, a 70 percent decline from 1998. However, miscellaneous truck crop acreage increased 10,800 acres or 16.7 percent higher than 1998, and vineyard acreage increased 18,800 acres or 8.4 percent. The acreage of almond and pistachio orchards increased by 13,000 acres compared to 1998 levels.

The total agricultural on-farm applied water in 2001 was 6.5 million acre feet, and total agricultural water use was 7.2 million acre feet or 67 percent of all water uses, 33 percent more than 1998 and 3 percent more than 2000. The regional average on-farm unit applied water was 3.2 acre feet per acre. Total agricultural ETAW was estimated at 4.6 million acre feet. This was about 36 percent higher than 1998 and 5 percent higher than 2000.

Total urban applied water use in this region was 629,100 acre feet, which was 12 percent higher than 1998 and 5 percent more than in year 2000. Average per capita water use was about 307 gallons per day, and total urban ETAW was about 218,400 acre feet, a 14 percent increase from 1998 and 6 percent increase from 2000. Total urban applied water use accounted for about 6 percent of the total water use in the region. Population for the region was 1,812,710, which is an 8.6 percent increase from 1998 levels.

Total environmental water use for instream flows, wild and scenic rivers, and refuges was about 2.9 million acre feet, 48 percent less than in 1998 and 37 percent less than in 2000. This decline in environmental water use occurs because instream flow requirements and wild and scenic river flows do change in response to the wetness or dryness of water year conditions. Total environmental water use was 27 percent of all uses in 2001, which is much less than the 48 percent share from year 1998. Refuge water supplies accounted for 414,700 acre feet or 14 percent of total environmental uses.

Total water supplies needed to meet the 2001 water uses, including local and imported from Central Valley Project and State Water Project surface water, groundwater, and reuse, amounted to 10.8 million acre feet, which was 7 percent less than 1998 and 12 percent less than 2000.

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