California **Water Plan**
Update 2009

# Tulare Lake

INTEGRATED WATER MANAGEMENT

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*Volume* 3
Regional Reports

# South Central Region Office

The Division of Integrated Regional Water Management assists public and private agencies and the general public with water issues throughout the state. Four regional offices are located throughout California to maintain close contact with local interests to facilitate communication and to work on water-related matters. The offices are:

- Northern Region in Red Bluff,
- North Central Region in West Sacramento,
- South Central Region in Fresno, and
- Southern Region in Glendale.

Each of the regional offices offers technical guidance and assistance in water resource engineering, project management, hydrology, groundwater, water quality, environmental analysis and restoration, surveying, mapping, water conservation, and other related areas within the boundaries of their offices. Because of the regional offices' close ties with local interests, DWR regional coordinators in each office facilitate overall communication between DWR divisions and local partners to ensure coordinated efforts throughout all DWR programs and projects.

**For more information on DWR and DWR projects, please contact the Regional Coordinators at:**
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***Cover Photos:***

*1. Tomato harvest*
*2. Carrizo Plain National Monument*
*3. Tree developing almond nuts*
*4. Region's dairy industry is the largest in the state*
*5. Drip irrigation in vineyard*
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# Tulare Lake Hydrologic Region

The Tulare Lake Hydrologic Region covers approximately 10.9 million acres (17,050 square miles) and includes all of Kings and Tulare counties and most of Fresno and Kern counties (Figure TL-1). The southern portion of the San Joaquin Valley is subdivided into two separate basins, the San Joaquin and the Tulare, by a rise in the valley floor resulting from an accumulation of alluvium between the San Joaquin River and the Kings River fan. The valley floor in this region had been a complex series of interconnecting natural sloughs, canals, and marshes.

The economic development of the region is closely linked to the surface water and groundwater resources of the Tulare Lake Hydrologic Region (Tulare Lake region). Major rivers draining into the Tulare Lake region include the Kings, Kaweah, Tule, and Kern rivers. The original ecological character of the area has been changed dramatically, largely from the taming of local rivers for farming. Significant geographic features include the Buena Vista/Kern Lake and Tulare Lake, comprising the southern half of the region; the Coast Range to the west; the Tehachapi Mountains to the south; and the southern Sierra Nevada to the east.

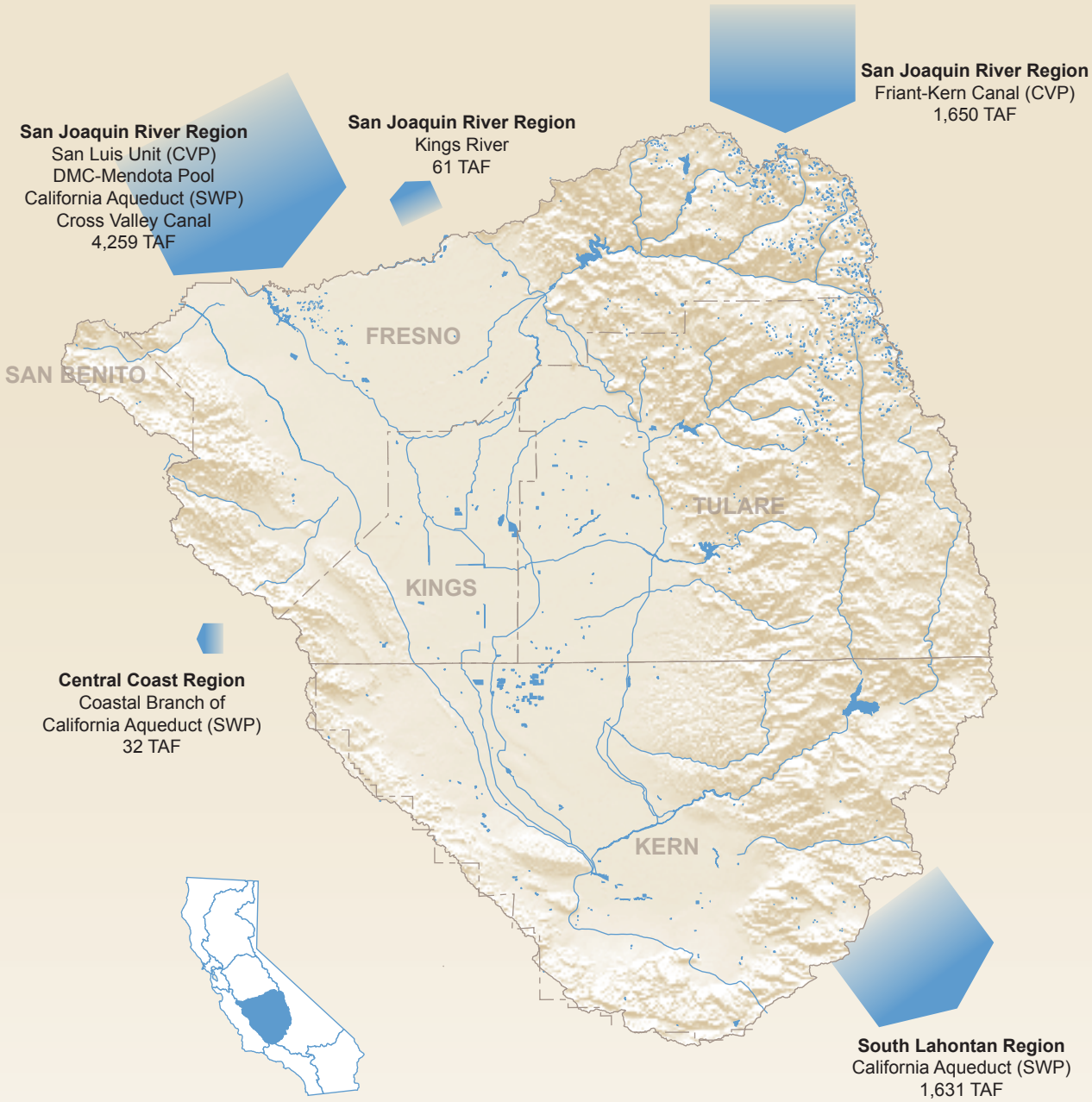
The Tulare Lake Hydrologic Region is one of the nation's leading agricultural production areas, growing a wide variety of crops on about 3 million irrigated acres. Agricultural production has been a mainstay of the region since the late 1800s. However, since the mid-1980s, other economic sectors, particularly the service sector, have been growing.

## Setting

The Tulare Lake region, the driest region of the Central Valley, once contained the largest single block of wetland habitat in California and provided more than 500,000 acres of permanent and seasonal wetlands. This provided habitat for millions of migrant waterfowl and shorebirds. Today, these areas are intensively farmed.

The California Aqueduct extends the entire length of the west side of the region, delivering water to State Water Project (SWP) and Central Valley Project (CVP) contractors and exporting water over the Tehachapi Mountains to Southern California. Along the eastern edge of the valley, the Friant-Kern Canal is used to divert San Joaquin River water from Millerton Lake for delivery to agencies extending into Kern County. All of the Tulare Lake region's streams are diverted for irrigation or other purposes, except in the wettest years. Historically, they drained into Tulare Lake, Kern Lake, or adjacent Buena Vista Lake. The latter ultimately drained to Tulare Lake, which is about 30 feet lower in elevation.

**Figure TL-1** Tulare Lake Hydrologic Region




**Some Statistics**

**Area:** 17,033 square miles (10.7% of state)

**Average annual precipitation:** 15.2 inches

**Year 2005 population:** 2,098,631

**2050 population projection:** 5,194,490

**Total reservoir storage capacity:** 2,046 TAF

**2005 irrigated agriculture:** 3,128,100 acres

**Box TL-1 Acronyms and Abbreviations Used in This Report**

| | |
|---|---|
| AHPS | Advanced Hydrologic Prediction Service |
| API | antecedent precipitation index |
| AWEP | Agricultural Water Enhancement Program |
| Cal EMA | California Emergency Management Agency |
| CDEC | California Data Exchange Center |
| CRS | Community Rating System |
| CVP | Central Valley Project (federal) |
| CVPIA | Central Valley Project Improvement Act |
| DWR | California Department of Water Resources |
| ESA | Endangered Species Act |
| FEMA | Federal Emergency Management Agency |
| FIRMs | Flood Insurance Rate Map(s) |
| HMP | hazard mitigation plan |
| ID | irrigation district |
| IRWM | integrated regional water management |
| NFIP | National Flood Insurance Program |
| NIMS | National Incident Management System |
| NRCS | Natural Resources Conservation Service |
| OCAP | Operating Criteria and Plan |
| RAP | regional acceptance process |
| Regional Water Board | Central Valley Regional Water Quality Control Board |
| SEMS | Standardized Emergency Management System |
| SWP | State Water Project (State) |
| TDS | total dissolved solids |
| USACE | US Army Corps of Engineers |
| USGS | US Geological Survey |
| WMI | Watershed Management Initiative |

Four main rivers emanate from the western flanks of the southern Sierra Nevada, and one substantial creek enters from the Coast Range. The largest river in terms of runoff is the Kings River, which originates high in Kings Canyon National Park and generally trends southwest into Pine Flat Lake. Downstream of Pine Flat Dam the river flows south and west toward Tulare Lake. During flood release events from Pine Flat Reservoir, the majority of the Kings River flow is diverted northwest into the Fresno Slough/James Bypass system (along the historically high-water outlet of Tulare Lake), emptying into the San Joaquin River. The Kaweah River begins in Sequoia National Park, flows west and southwest, and is impounded by Terminus Dam. It subsequently spreads into many distributaries around Visalia and Tulare trending toward Tulare Lake. The Tule River begins in Sequoia National Forest and flows southwest through Lake Success toward Tulare Lake.

The Kern River has the largest drainage basin area and produces the second highest runoff. It originates in Inyo and Sequoia national forests and Sequoia National Park, flowing southward into Lake Isabella. The river downstream of Isabella Dam flows southwest; and in high discharge years, water will spill into the ancient Buena Vista/Kern Lake bed. In very high discharge years, Buena Vista Lake historically spilled into Tulare Lake via sloughs and floodwater channels. In addition, some Kern River water may be allowed to flow into the SWP via the Kern River Intertie. Los Gatos Creek, arising in the Coast Range, flows southeast onto the valley floor north of Tulare Lake. In extreme floods it may join the Kings River, flowing south toward the lake. There are many smaller creeks that feed into the main rivers, which can present a localized flooding threat during specific storm conditions.

## Watersheds

The Tulare Lake region is divided into several main hydrologic subareas: the alluvial fans from the Sierra foothills and the basin subarea (in the vicinity of the Kings, Kaweah, and Tule rivers and their distributaries); the Tulare Lake bed; and the southwestern uplands. The alluvial fan/basin subarea is characterized by southwest to south flowing rivers, creeks, and irrigation canal systems that convey surface water originating from the Sierra Nevada. The dominant hydrologic features in the alluvial fan/basin subarea are the Kings, Kaweah, Tule, and Kern rivers and their major distributaries. The federal Forest Service, National Parks, Bureau of Land Management, and Fish and Wildlife Service are all actively involved in the management of the upper watersheds.

Critical concerns for watersheds in the region are varied depending upon the particular watershed in question. In the Sierra, some of the concerns include the following.

- Soil erosion
- Watershed/wetlands
- Agriculture/rangeland
- Vegetation management
- Wildlife habitat
- Environmental education
- Air quality
- Weed control – noxious weeds
- Sand and gravel mines within rivers and streams
- Water rights on rivers
- Funding for water conservation projects

In the valley portion of the region, the list of concerns follows.

- Salinity
- Water erosion
- Wind erosion
- Brackish agricultural drainage water
- Areas of toxic salt accumulation
- Excess use of groundwater and water penetration problems
- Extensive flooding of agricultural lands
- High water table/perched water conditions
- Water quality and quantity
- Erosion and sedimentation both in agricultural lands and subdivisions
- Irrigation water management problems
- Rangeland—fire and brush control
- Drainage problems both surface and subsurface
- Environmental education
- Alternate energy sources
- Groundwater depletion/recharge
- Groundwater/surface water quantity/quality
- Surface/irrigation water management/availability

**Table TL-1 Watershed characteristics of the Tulare Basin**

| Region | Seasonal patterns | Runoff characteristics | Precipitation |
|---|---|---|---|
| Sacramento, San Joaquin, and Tulare Lake (Region 5) | Valley: Hot, dry summers and cool, wet winters. Mountains: Mild summers with intermittent thundershowers, heavy winter snowfalls above 5,000 feet. | Prolonged spring runoff fed by Sierra Nevada snowpack; low sediment yields due to widespread vegetation and stable rock types/ soils; locally high sediment yields due to land uses (e.g., logging, grazing, and urbanization). | Valleys receive winter rainfall, and mountains receive moderate to heavy snowfall; total average annual precipitation ranges from 36 inches in the Sacramento River region to 13-14 inches for the San Joaquin and Tulare Lake regions. |

Source: Central Valley Regional Water Quality Control Board

The watersheds east of the valley floor range in elevation from 381 feet to 14,478 feet; the mean elevation is 4,080 feet. The Tulare Lake region's watershed is essentially a closed basin because surface water drains north into the San Joaquin River only in years of extreme rainfall. Its 10 subwatersheds are listed here.

- Kings River subwatershed
- Kaweah River subwatershed
- Kern River subwatershed
- South Valley Floor subwatershed
- Grapevine subwatershed
- Coast Range subwatershed
- Fellows subwatershed
- Temblor subwatershed
- Sunflower subwatershed
- Southern Sierra subwatershed

The State Water Resources Control Board and Regional Water Quality Control Boards are responding to watershed challenges through the Watershed Management Initiative (WMI). The WMI is designed to integrate various surface water and groundwater regulatory programs while promoting cooperative, collaborative efforts within a watershed (www.swrcb.ca.gov/centralvalley). See Table TL-1 Watershed characteristics of the Tulare Lake Basin.

The Information Center for the Environment follows water-related projects and conducts surveys of watershed groups regarding their projects, interests, and concerns. See its Web site at http://ice.ucdavis.edu/projects/water.

## Groundwater Basins and Recharge Areas

The Tulare Lake Hydrologic Region has 12 distinct groundwater basins and seven subbasins of the San Joaquin Valley Groundwater Basin, which crosses north into the San Joaquin River Hydrologic Region (Figure TL-2). These basins underlie approximately 5.33 million acres (8,330 square miles) or 49 percent of the entire hydrologic region. Groundwater has historically been important to both urban and agricultural uses, accounting for 41 percent of the region's total annual supply and

**Figure TL-2 Groundwater basins in the Tulare Lake Hydrologic Region**

35 percent of all groundwater use in the state. Groundwater use in the region represents about 10 percent of the state's overall water supply for agricultural and urban uses.

Water agencies in the Tulare Lake region have been practicing conjunctive use for many years to manage groundwater and assist dry year supplies. Groundwater recharge is primarily from rivers and natural streambeds, irrigation water percolating below the root zone of irrigated fields, direct recharge from developed ponding basins and water banks, and in-lieu recharge where surface water is made available in-lieu of groundwater pumping. Some water agencies accomplish recharge by directing available water into existing natural streambeds and sloughs, and others encourage application of water, when available, on farmed fields. The Deer Creek and Tule River Authority provides an example of how groundwater management activities can be coordinated with other resources. The authority, in conjunction with the US Bureau of Reclamation, has constructed more than 200 acres of recharge basins as part of its Deer Creek Recharge-Wildlife Enhancement Project. When available, the project takes surplus water during winter months and delivers it to the basins, which serve as winter habitat for migrating waterfowl, creating a significant environmental benefit. Most of the water also recharges into the underlying aquifer, thereby benefiting the local groundwater system (www.dpla2.water.ca.gov/publications/groundwater/bulletin118/Bulletin118-Chapter3.pdf).

Some of the developed groundwater recharge facilities in the Tulare Lake Basin are listed here.

- Kern Water Bank
- Arvin-Edison Water Storage District
- Rosedale-Rio Bravo Water Storage District
- Semitropic Water Storage District
- North Kern Water Storage District
- Tehachapi-Cummings County Water District
- Lower Tule Irrigation District
- City of Clovis
- City of Fresno
- Fresno Metropolitan Flood Control District
- Consolidated ID
- Fresno ID
- Apex Conjunctive Use Project (Kings County Water District, proposed)
- McMullin Recharge Group (Raisin City area, proposed)

## Ecosystems

The Tulare Lake region once supported vast tule marshes, riparian corridors, and other wetlands; however, development of the area largely for farming, and the taming of the region's major rivers, has dramatically changed the ecological character. The valley portion of the region once supported a diverse array of perennial bunchgrass ecosystems including prairies, oak-grass savannas, desert grasslands, as well as a mosaic of riparian woodlands, freshwater marshes, and vernal pools. In its original state, it comprised one of the most diverse, productive, and distinctive grasslands in temperate North America and more than 500,000 acres of permanent and seasonal wetlands (www.worldwildlife.org, California Central Valley grasslands [NA0801]).

Most basins in California have lost the majority of their wetlands habitat; but in the Tulare Lake region, changes have been especially detrimental for waterfowl. The region once contained a series of shallow lakebeds that provided 260,000 acres of seasonal wetlands and more than 250,000 acres of permanent and semi-permanent tule marshes.

More than 95 percent of historical wetlands and 98 percent of all riparian habitats have been destroyed or modified (Table TL-2). The remnant of intensively managed wetlands and associated agricultural habitats now support an average of 5.5 million waterfowl annually.

Environmental restoration and enhancement efforts are proving successful. The Central Valley Habitat Joint Venture has been a leader in conservation of wildlife resources such as wetlands and associated migratory bird habitats. A lack of reliable water is one of the largest obstacles for restoration efforts in the region. Interest in restoring historical wetland habitat conditions within the Tulare Lake region has greatly increased since the passage of the Central Valley Project Improvement Act (CVPIA). Private wetlands

**Table TL-2 Tulare Lake region current and historical acres of riparian habitat**

| Basin | Current acres | Historic acres | | | |
|---|---|---|---|---|---|
| Tulare | 7,195 | 272,158 | | | |
| Annual water requirements (af/acre) by habitat type and basin | | | | | |
| **Basin** | **Seasonal wetlands (af/acre)** | **Semi-permanent wetlands (af/acre)** | **Winter flooded agriculture (af/acre)** | | |
| Tulare | 5.25 | 8 | 0 | | |
| Total annual water needs for existing wetland habitats in Tulare Basin | | | | | |
| **Basin** | **Seasonal wetland (acres)** | **Seasonal wetland water needs (af)** | **Semi-permanent wetlands (acres)** | **Semi-permanent wetland water needs (af)** | **Total (af)** |
| Tulare | 20,212 | 106,113 | 2,245 | 17,960 | 124,073 |
| Total annual water needs for additional wetland habitats that must be restored to fully meet integrated bird habitat objectives | | | | | |
| Tulare | 21,263 | 111,631 | 5,935 | 47,480 | 159,111 |
| Total annual water needs for wetland and winter-flooded agricultural habitats in the Central Valley when integrated bird habitat objectives are met | | | | | |
| **Basin** | **Seasonal wetland (af)** | **Semi-permanent wetland water needs (af)** | **Agricultural winter flooding (af)** | **Total (af)** | |
| Tulare | 217,744 | 65,440 | 0 | 283,184 | |
| Note : acre-feet (af); acre feet per acre (af/acre) | | | | | |
| (Central Valley Joint Venture, 2006 Implementation Plan) | | | | | |
| (San Joaquin River National Wildlife Refuge, Comprehensive Conservation Plan, USFW 2006) | | | | | |

within this area did not directly benefit from provisions of the CVPIA, but the vast improvements in wetland basins that receive CVPIA water supplies has sparked renewed discussion at regional, State, and federal levels. Additional acreage has been purchased; easements obtained, mitigation banking strategies developed, and corridor and conservation plans developed; and studies have been conducted. Various groups, such as the Tulare Lake Wildlife Partners are collaborating with the California Department of Fish and Game, US Bureau of Reclamation, and the US Department of Agriculture Natural Resources Conservation Service (NRCS) to inform elected officials, landowners, and other interested parties about strategies for additional development. Recently completed was the Tulare Lake Basin Wetland Enhancement Project. Funded by the North American Wetlands Conservation Act, 25,398 acres of wetlands and wildlife habitat on public and private lands were conserved through a series of projects. Several projects were completed at the Kern National Wildlife Refuge, conserving 7,565 acres of habitat. Private lands benefiting from the work included the ECLA complex, Etchegary Farms, Gooselale Holding Co., Kahala Ranch, Robin's Roost, and Wheatville Ranch where more than 5,500 acres of wetlands and associated habitats were conserved (www.ducks.org/media/conservation/reports/california.pdf).

## Climate

The climate in combination with the fertile soil in the valley portion of the region is well suited for farming. Runoff from the adjacent Sierra Nevada provides good quality water for irrigation along with local groundwater. The San Joaquin Valley's long growing season (April through October), warm/hot summers, and a fall harvest period usually sparse in rain provides a near ideal environment for production of many crops. Winters are moist and often blanketed with tule fog. Nearly all of the year's precipitation falls in the six months from November to April. The valley floor is surrounded on three sides by mountain ranges, resulting in a comparative isolation of the valley from marine effects. Because of this and the comparatively cloudless summers, normal maximum temperature advances to a high of 101 degrees Fahrenheit during the latter part of July. Valley winter temperatures are usually mild, but during infrequent cold spells air temperature occasionally drops below freezing. Heavy frost occurs during the winter in most years, and the geographic orientation of the valley generates prevailing winds from the northwest.

The mean annual precipitation in the valley portion of the region ranges from about 6 to 11 inches, with 67 percent falling from December through March, and 95 percent falling from October through April. The region receives more than 70 percent of the possible amount of sunshine during all but four months, November through February. Tule fog, which can last up to two weeks, reduces sunshine to a minimum.

## Population

Tulare Lake Hydrologic Region had 2.1 million people in 2005. About 6 percent of the state's total population lives in this region, and 72 percent of the region's population lives in incorporated cities. Between 2000 and 2005, the region grew by 213,956 people, a growth of 11 percent over the 5-year period. For historical population data, 1960-2005, see Volume 5, Technical Guide.

In Water Plan Update 2009, we project population growth based on the assumptions of future scenarios. Discussion of the three scenarios used in this Water Plan and how the region's population may change through 2050 can be found later in this report under Looking to the Future.

Senate Bill 18 (Chapter 905, Statutes of 2004) requires cities and counties to consult with California Native American Tribes during the adoption or amendment of local general plans or specific plans. A contact list of appropriate Tribes and representatives within a region is maintained by the Native American Heritage Commission. A Tribal Consultation Guideline, prepared by the Governor's Office of Planning and Research, is available online at http://www.opr.ca.gov/programs/docs/09_14_05%20Updated%20Guidelines%20(922).pdf. (See Box TL-2 for information about regional Tribal concerns.)

**Box TL-2 California Native American Tribal Information, Tulare Lake Hydrologic Region**

**Demographics:**

- Tribes with historic or cultural ties to the Tulare Basin region are primarily the Chukchansi, Chumash, Mono and Western Mono, Tachi, Tehachapi (Kawaiisu), Tejon (Kawaiisu), Tubatulabals, and Yokuts.
- Currently, Tribal landholdings located in this region include: Bakersfield (Chumash Council), Clovis (Kings River Choinumni), Dunlap, Sanger (Choinumni), Tule River, Cold Springs, and Santa Rosa. Fifteen individual allotments also located within this region.

**Collaborative Efforts:**

- The use of fire management in a test restoration of Jackass Meadow, in the Sierra National Forest, is restoring sedge – an important basketry material. Volunteer crews from local schools and High Sierra Volunteer Trail assisted with trail maintenance and plantings.
- Restoration efforts at Bass Lake and Crane Valley were supported by funding from the State Water Boards' Adopt-A-Watershed Program and grants from the Sierra Nevada Conservancy. Working with the Forest Service and a Rural Action Committee, the area was restored and deer grass was revived.

**Concerns and Priorities:**

- Water quality threats from abandoned mines.
- The need to protect sacred sites during dam renovation or construction.
- Rural access to drinking water.

**Accomplishments:**

- Successful partnerships with US Bureau of Indian Affairs, US Indian Health Services and allotment owners to address water and housing needs and integrated resource management.
- Raising the issue of, and protecting, access to native plant resources in working with utilities, the Forest Service, and the Federal Energy Regulatory Committee.
- Increasing awareness of, and protecting, cultural resources in working with utilities, the Forest Service and FERC.

NOTE: Above information was gathered from Tribal input at the California Water Plan Update regional workshops and the Tribal water plenary sessions that are supporting the California Tribal Water Summit.

## Land Use Patterns

Based on data from Department of Water Resources (DWR) land use surveys, the amount of irrigated land cultivated in the region was 3 million acres in 2005. This compares to 3.2 million acres in 1990. The amount of land area identified as urbanized in 2005 was about 400,000 acres. State and federal land have remained relatively stable at 3.2 million acres, about 30 percent of the regions acreage. Most of the urban growth has occurred adjacent to the agricultural towns along Highway 99. Cities such as Fresno, Visalia, and Bakersfield have become major urban centers, between 100,000 and 500,000 residents. Metropolitan Fresno now approaches 1 million people.

A large portion of the land area in the Tulare Lake region consists of forest and similar land cover in the foothill and mountain areas of the region, with a large part of that consisting of federal or other public lands. This land includes about 1.7 million acres of national forest, 0.8 million acres of national parks and recreation areas, and 1 million acres of land managed by the US Bureau of Land Management. Privately owned land totals about 7.4 million acres. Most of the valley floor is under private ownership and intensively farmed. However, urbanization of the valley floor has grown significantly, especially in the last 25 years.

Between 1984 and 2006, the trend was a declining acreage of field crop and a rising acreage of deciduous crops, truck crops, and urban-related land use. See Table TL-3 for

crop acreage by county in thousands acres, comparing 2006 with 1984 based on DWR surveys. For acreage and percent changes for specific crops, comparing 1958 and 2005, see Table TL-4. Corn acreage has increased dramatically in response to the growth of the dairy industry and to a lesser degree, for ethanol production.

Tulare County is the largest dairy county in the state. Bulk milk production was 10.59 million pounds in 2007, nearly twice that produced in Stanislaus County, which is the second largest dairy county in California. The region also contains about 37 percent of the state's total dairies; however, these dairies account for more than 56 percent of the total number of cows. The average number of cows per dairy in the region is about 1,700, which is 76 percent higher than the state average.

Agriculture will continue to dominate land uses in the Tulare Lake region. It will also continue to be an important economic driver in the regional economy as well as a factor in the socioeconomic structure of the San Joaquin Valley and will likely continue to play a decisive role as it adapts to changing market, technological, and regulatory forces. Increased public concerns about clean water, pesticide use, groundwater contamination, air quality, food safety, and long-term impacts on ecosystems likely will increasingly shape the future role of agriculture in the Tulare Lake region and the entire Central Valley. Intensification of production in fruits and nuts and vegetables and movement away from field crop acreage is likely to continue in coming years.

### Tribal Lands

The area is home to many California Native American Tribes with historical and cultural ties to the region. There are three federally recognized Tribes in the Tulare Lake region, residing on the Santa Rosa, Tule River, and Cold Springs rancherias (Table TL-5). However, there are many more non-federally recognized Tribes and members not residing on rancherias, with some involved in efforts to become federally recognized. The Cold Spring Rancheria is near the San Joaquin River and Millerton Lake. The Santa Rosa Rancheria is south of the City of Lemoore and situated on the southern end of Mud Slough. The Tule River Rancheria is south of Porterville; this is the only Tribe in the region to date to have entered into water rights settlement negotiations.

## Regional Water Conditions

Tulare Lake region's groundwater use rises and falls contingent on the availability of both local and imported surface supplies. The management of water resources within this region is a complex activity and critical to the region's agricultural operations. Local annual surface supplies are determined by the amount of runoff from the Sierra Nevada watersheds, the flows captured in local reservoirs, and carryover storage over a series of years. Imported surface supply availability is contingent not only on runoff in any year or series of years but also by regulations determining the amount of water that can be pumped month to month from the Sacramento-San Joaquin River Delta due to fishery and other concerns. The recent San Joaquin River settlement will reduce the overall

**Table TL-3 Changes in crop acreage in thousand acres by county**

| County | Thousand acres | Thousand acres | |
|---|---|---|---|
| **Kern** | **1984** | **2006** | **Change** |
| Citrus | 37.10 | 62.40 | 25.30 |
| Deciduous | 120.80 | 261.30 | 140.50 |
| Field | 536.10 | 285.10 | -251.00 |
| Pasture | 114.50 | 98.50 | -16.00 |
| Truck | 83.40 | 66.20 | -17.20 |
| Urban | 63.00 | 179.40 | 116.40 |
| Vineyard | 104.40 | 103.30 | -1.10 |
| Total | 1,059.30 | 1,056.20 | -3.10 |
| **Kings** | **1981** | **2003** | **Change** |
| Citrus | 1.40 | 1.10 | -0.30 |
| Deciduous | 22.00 | 49.30 | 27.30 |
| Field | 514.00 | 299.60 | -214.40 |
| Pasture | 75.70 | 78.00 | 2.30 |
| Truck | 6.00 | 36.00 | 30.00 |
| Urban | 15.40 | 26.00 | 10.60 |
| Vineyard | 4.30 | 7.70 | 3.40 |
| Total | 638.80 | 497.70 | -141.10 |
| **Tulare** | **1985** | **1999** | **Change** |
| Citrus | 112.90 | 134.40 | 21.50 |
| Deciduous | 100.00 | 124.30 | 24.30 |
| Field | 311.20 | 253.40 | -57.80 |
| Pasture | 82.40 | 104.50 | 22.10 |
| Truck | 7.20 | 8.50 | 1.30 |
| Urban | 42.20 | 57.70 | 15.50 |
| Vineyard | 93.90 | 85.70 | -8.20 |
| Total | 749.80 | 768.50 | 18.70 |
| **Fresno** | **1986** | **2000** | **Change** |
| Citrus | 26.00 | 36.20 | 10.20 |
| Deciduous | 109.10 | 182.80 | 73.70 |
| Field | 574.60 | 445.20 | -129.40 |
| Pasture | 151.00 | 113.60 | -37.40 |
| Truck | 159.30 | 197.90 | 38.60 |
| Urban | 95.40 | 134.50 | 39.10 |
| Vineyard | 242.40 | 258.50 | 16.10 |
| Total | 1,357.80 | 1,368.70 | 10.90 |
| Estimated double crop acreage was 375,000. | | | |
| Source: DWR survey | | | |

**Table TL-4 Irrigated crop acreage, Tulare Lake Hydrologic Region, percent change 1958 to 2005**

| Irrigated crop | 1958 | 2005 | Difference | % Change |
|---|---|---|---|---|
| Grain | 688,193 | 181,700 | -506,493 | -74% |
| Rice | 31,480 | 0 | -31,480 | -100% |
| Cotton | 668,259 | 542,800 | -125,459 | -19% |
| Sugar Beets | 23,578 | 13,100 | -10,478 | -44% |
| Corn | 48,313 | 326,400 | 278,087 | 576% |
| Dry Beans | 10,272 | 13,700 | 3,428 | 33% |
| Safflower | 4,656 | 5,100 | 444 | 10% |
| Other Field Crops | 96,844 | 228,000 | 131,156 | 135% |
| Alfalfa | 460,731 | 353,900 | -106,831 | -23% |
| Pasture | 150,429 | 21,100 | -129,329 | -86% |
| Tomatoes | 3,007 | 129,400 | 126,393 | 4203% |
| Other Truck Crops | 109,904 | 219,800 | 109,896 | 100% |
| Almonds/Pistachio | 39 | 325,700 | 325,661 | 835,028% |
| Other Deciduous Trees | 109,089 | 210,500 | 101,411 | 93% |
| Subtropical | 64,645 | 219,300 | 154,655 | 239% |
| Vineyard | 289,729 | 339,600 | 49,871 | 17% |
| Total | 2,761,126 | 3,130,100 | 368,974 | 13% |

Source: DWR surveys

**Table TL-5 Granted Tribal lands with acreage, Tulare Lake Hydrologic Region**

| Rancheria/reservation | Acres | Tribal owner(s) |
|---|---|---|
| Cold Springs Reservation | 155 | Western Mono Indians |
| Santa Rosa Rancheria | 1,803 | Tache, Tachi, and Yokuts Indians |
| Tule River Reservation | 55,395 | Yokuts Indians |

Note Includes Tribal, Allotted and Public Domain Allotments; as per data taken from the San Diego State University's online library and information access (http://infodome.sdsu.edu/research/guides/calindians/calinddict.shtml#a)

See also: http://en.wikipedia.org/wiki/Cold_Springs_Rancheria_of_Mono_Indians_of_California

http://en.wikipedia.org/wiki/Santa_Rosa_Rancheria

http://en.wikipedia.org/wiki/Tule_River_Indian_Tribe_of_the_Tule_River_Reservation

volume of water available for diversion into the Friant-Kern Canal. The new biological opinion on the Operating Criteria and Plan (OCAP) for the SWP and CVP will impact surface water supplies to south-of-Delta water users.

Groundwater recharge is primarily from natural streams, other water added to streambeds, from deep percolation of applied irrigation water, and from impoundment of surface water in developed water bank/percolation ponds.

Reductions in imported supplies interfere with the carefully planned long-term water management strategies of many areas in the Tulare Lake region and result in more reliance on stressed groundwater supplies.

**Table TL-6 Dedicated natural flows (taf) for Kings and Kern rivers scenic regions, 1998-2005**

| | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|---|---|---|
| Kings River | 1,788.7 | 745.1 | 900.3 | 601.0 | 680.5 | 847.2 | 695.2 | 1,210.6 |
| Kern River – No. Fork | 1,136.3 | 363.5 | 396.1 | 317.1 | 314.4 | 467.9 | 370.0 | 871.4 |
| Kern River – So. Fork | 280.0 | 41.9 | 34.7 | 46.0 | 24.4 | 71.5 | 32.8 | 202.7 |
| Kings River from segment of main stem from Tulare-Kern Co. line to its headwaters in Sequoia National Park. | | | | | | | | |
| North Fork Kern River from headwaters in Inyo National Forest to southern boundary of the Domelands Wilderness in Sequoia National Forest. | | | | | | | | |
| South Fork Kern River designation includes Middle Fork from headwaters at Lake Helen to main. South Fork from its headwaters at Lake 11599 to main. Main stem from confluence of middle and south forks to the point at elevation 1,595 feet mean sea level. | | | | | | | | |

**Table TL-7 Surface water deliveries to Kern National Wildlife Refuge (acre-feet)**

| Source | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|---|---|---|
| CVPIA | 12,223 | 14,859 | 7,544 | 18,784 | 19,315 | 21,060 | 23,421 | 19,900 |

## Environmental Water

The natural communities in the Tulare Lake region include the mountain and foothill, valley, the riverine (intermittent and continuous), lacustrine, and estuarine (wetland) communities. Efforts continue to secure water for riverine and wetland environments. In addition, efforts have increased the past several years to protect areas containing remaining natural vernal pools (valley and terrace). Some recent efforts to restore and enhance environmental water needs have been addressed through the CVPIA.

All of the major rivers in the Tulare Lake region are regulated. The Wild and Scenic water dedications in the Tulare Lake region are for the designated stretches along the Kings and Kern Rivers and are based on unimpaired runoff or natural flows. Table TL-6 presents flows for the years 1998-2005.

The portion of the Kaweah River that passes through the proposed Mineral King Wilderness has been determined eligible for Wild and Scenic status by the US Bureau of Land Management.

The Omnibus Public Land Management Act provided settlement of the San Joaquin River Restoration effort and designates wilderness areas in the Sierra watershed for the Tulare Lake region.

Surface water is delivered to the Kern National Wildlife Refuge. The surface water received by the refuge is a direct result of the CVPIA. Reported deliveries for 1998 through 2005 are in Table TL-7.

At Pine Flat Dam on the Kings River, the Kings River Fisheries Management Program was established in 1999. The program is a cooperative effort between the Kings River Conservation District, the Kings River Water Association, and the California Department of Fish and Game. The program endeavors to enhance the fishery and wildlife resources below the dam and protect the water rights held by Kings River water users.

## Water Supplies

The Tulare Lake region has experienced water-short conditions for more than 100 years, which has resulted in a water industry that has consciously developed—through careful planning, management and facility design—the possibility of a shortage occurring in any year. Water demand is more or less controlled by available, reliable long-term water supplies. Over the years, agricultural acreage has risen and dropped largely based on water supplies. The region initially developed with surface water supplies; but local water users learned these supplies could widely vary in volume from year to year and drought conditions could quickly develop. The introduction of deep well turbines resulted in a dramatic rise in groundwater use in the early 1900s, subsequently resulting in dropping groundwater levels and land subsidence. Surface water storage and conveyance systems built to alleviate the overuse of groundwater provided an impounded supply of water that could be used during years with deficient surface water. This resulted in a regional reliance on conjunctive water use in the development of the local water economy. Efforts to address Delta environmental issues and the subsequent loss of surface water to the region is increasing groundwater use and creating concern that additional pumping will increase subsidence.

Runoff from local streams, most of which is from the Kings, Kern, Kaweah, and Tule rivers, is stored in reservoirs (Table TL-8). Most of this water is conveyed via gravity through natural stream channels (St. Johns River, Deer Creek, James By-Pass, etc.) and constructed canals and ditches. In general, surface water does not leave the region in average and drier years. However, surface water stored in and pumped from the Kern Water Bank and surface water in the Cross Valley Canal may be mixed and pumped occasionally into the California Aqueduct in drier years.

Most of the agricultural water districts below the western slopes of the Sierra Nevada capture and use runoff from major and minor streams and rely on groundwater supplies. Multiple purpose reservoirs have been constructed on all major streams for flood control and storage. These reservoirs provide flood control and conservation storage for fish and wildlife protection, recreation, irrigation, and municipal and industrial water supplies, and hydroelectric power generation. Long-held water rights determine the amount of water that can be delivered to any particular user in any particular year based on projected volume of runoff. Water districts in the western area of the valley floor depend heavily on contracts for imported water from the CVP and SWP. These two projects follow a coordinated operation agreement for water shortages, water quality, and environmental requirements. In the western valley area, groundwater quality is often poor, and availability is highly variable. In addition, drainage problem areas have developed with high water tables with high total dissolved solids (TDS).

**Table TL-8 Reservoir statistics, Tulare Lake Hydrologic Region**

| | Year completed | Capacity (acre-feet) | Operator |
|---|---|---|---|
| **Kings River** | | | |
| Pine Flat Dam | 1952 | 1,000,000 | USACE |
| Courtwright Reservoir | 1958 | 123,300 | PG&E |
| Wishon Reservoir | 1957 | 128,600 | PG&E |
| **Kaweah River** | | | |
| Terminus Dam | 1951 | 143,000 | USACE |
| Spillway raise | 2004 | 185,630 | |
| **Tule River** | | | |
| Success Dam | 1961 | 82,300 | USACE |
| **Kern River** | | | |
| Isabella Dam | 1953 | 568,000 | USACE |
| USACE = US Army Corps of Engineer | | | |
| PG&E = Pacific Gas and Electric utility company | | | |

Water management is a high priority in the region. Projects and programs to augment water supplies through infrastructure improvements and management have resulted in the extension of available supplies. Improvements in conjunctive use, on-farm water management and irrigation systems, water exchange agreements, water optimization studies and projects, water transfers and the utilization of water banking facilities all emphasize long-term water management objectives. Several water banking efforts include agencies from other regions whose water is banked during sufficient water supply years. In years when surface water supply is deficient, the imported surface supply of local districts is sometimes conveyed out of region while the Tulare Lake region becomes more reliant on local groundwater.

Increased reliance on groundwater due to reduced surface water supplies is resulting in water extraction exceeding recharge to some of the region's groundwater aquifers. This increases pumping costs and energy usage; and some areas are experiencing groundwater-related land subsidence. Historically, the Arvin-Maricopa and Tulare-Wasco areas have experienced subsidence. Land subsidence may damage wells and water conveyance facilities such as canals and flood channels. Recently, the US Geological Survey (USGS) announced it is starting a new round of studies on the San Joaquin Valley's west side. New satellite tracking data will help scientists gain a better understanding of how land subsidence is affecting the California Aqueduct.

The uplands areas rely heavily on fractured rock groundwater wells. Available water from fractured rock wells fluctuates and is vulnerable to even short periods of low precipitation. Population growth in the upland areas has increased the number of wells with dropping water levels and declining yields.

The development of CALFED was the result of an effort to forestall what many believed was an impending significant reduction in water supplies due to possible non-compliance of the CVP and the parallel SWP with Clean Water Act and Endangered Species Act (ESA) requirements. Implementation of these laws combined with the CVPIA in 1992 have resulted in reduced water deliveries to agricultural contractors in some cases and remains an ongoing tension for water management and water supply reliability in the Tulare Lake region. More recently, the 2009 OCAP biological opinion is expected to further reduce water supplies in the region.

## Water Uses

Agricultural water use is the region's largest user of water, followed by environmental and urban. Irrigation using both groundwater and surface water dominates water use volume, but municipal water use has grown along with the rising population. Communities and rural homes in the valley floor historically have used groundwater directly, but rising concern of certain constituents in the water and declining groundwater levels underlying some of the larger metropolitan areas is resulting in more use of treated surface water for municipal supplies. Recently the cities of Fresno and Clovis constructed water treatment facilities for their Kings and San Joaquin river supplies, and Bakersfield added a second facility for its Kern River supply. Bakersfield's initial treatment facility treated imported SWP water. Management of the major streams benefits environmental instream uses, primarily fisheries.

In the higher elevations of the Sierra Nevada, water is directed into reservoirs and pipelines where it is used to produce electricity as the water moves to lower elevations. The water eventually reaches the large reservoirs in the foothills where it is managed for flood control, to produce power, to provide irrigation water, and for recreational opportunities.

On average, agriculture applied water use is 82 percent; environmental, 13 percent; urban water use, 5 percent. The percentage of urban applied water use has been increasing over the years, climbing from 3.4 percent in 1980 to 5.4 percent in 2005. The volume of agricultural applied water use has slightly declined since 1980 along with total irrigated land.

Normally, all native surface water supplies, imported water supplies, and direct precipitation percolate into valley groundwater if they are not lost through consumptive use, evapotranspiration, or evaporation. Because of its closed nature, Tulare Lake Hydrologic Region has little subsurface outflow. Thus, salts accumulate within the basin due to importation and evaporation of the water.

## Water Balance Summary

Figure TL-3 summarizes the total developed water supplies and distribution of the dedicated water uses within this hydrologic region for the eight years from 1998

through 2005. As indicated by the variation in the horizontal bars for wet (1998) and dry (2002) years, the distribution of the dedicated supply to various uses can change significantly based on the wetness or dryness of the water year. The more detailed numerical information about the developed water supplies and uses is presented in the Update 2009 Volume 5 Technical Guide, which provides a breakdown of the components of developed supplies used for agricultural, urban, and environmental purposes and Water Portfolio data.

For the Tulare Lake region, agricultural water uses are the largest component of the developed water use, while urban water use is a very small portion of the total. Dedicated water required for instream flows are also a significant component of water use in this region. The water supply portion of Figure TL-3 also indicates that groundwater and surface water are equally significant components of the water supply to this region. A large amount of the surface water supply is delivered from federal and State water project systems. Water reuse from agricultural runoff is also a component of the supply to downstream water users within the region.

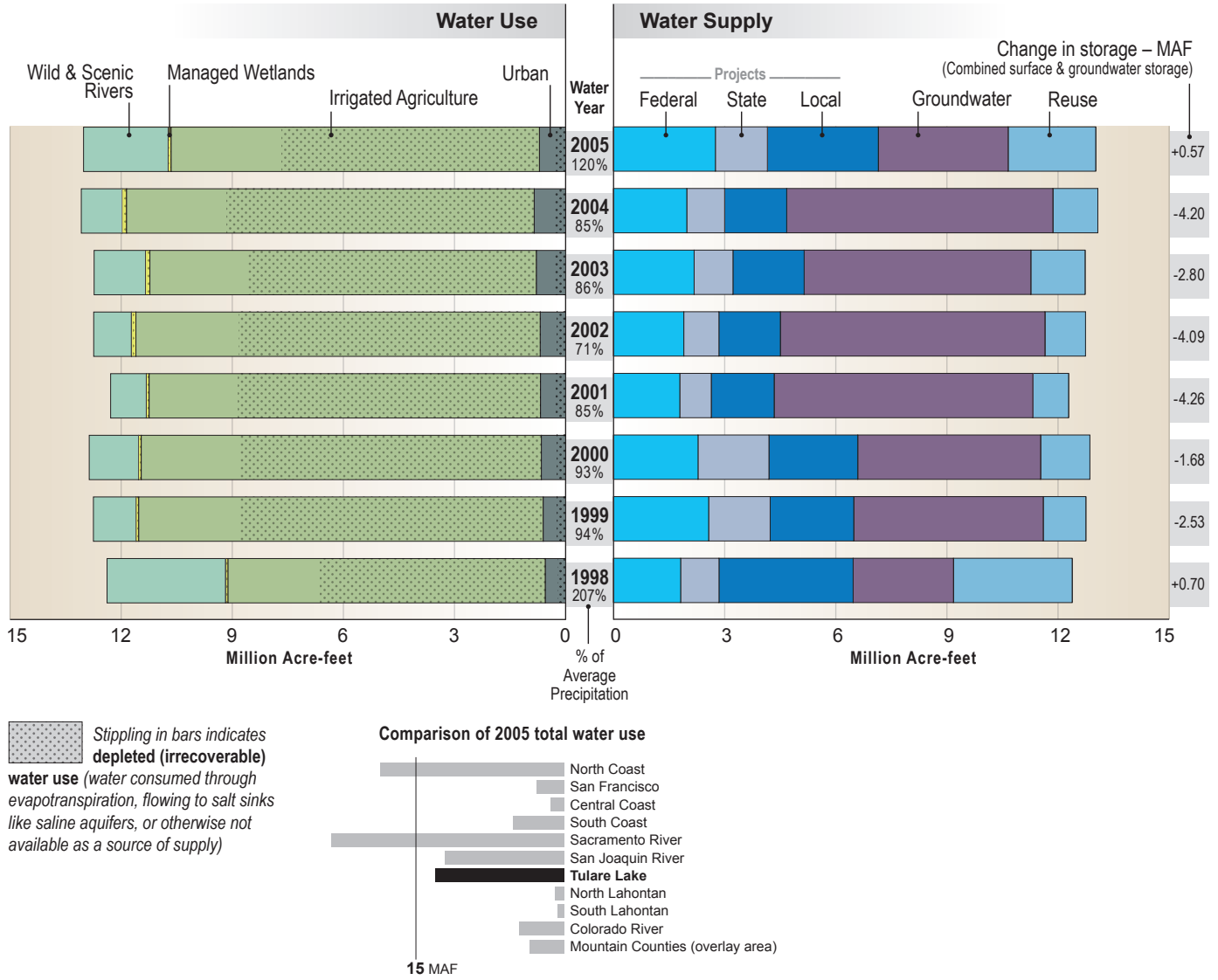
Table TL-9 presents information about the total water supply available to this region for the eight years from 1998 through 2005, and the estimated distribution of these water supplies to all uses. The annual change in the region's surface and groundwater storage is also estimated, as part of the balance between supplies and uses. In wetter water years, water will usually be added to storage, while during drier water years storage volumes may be reduced. Of the total water supply to the region, more than half is either used by native vegetation; evaporates to the atmosphere; provides some of the water for agricultural crops and managed wetlands (effective precipitation); or flows to the Pacific Ocean in years of high precipitation, and salt sinks like saline groundwater aquifers. The remaining portion, identified as consumptive use of applied water, is distributed among urban and agricultural uses and for diversions to managed wetlands. For some of the data values presented in Table TL-9, the numerical values were developed by estimation techniques, because actual measured data are not available for all categories of water supply and use.

## Water Quality

The Tulare Lake Hydrologic Region corresponds to approximately the southern one-third of Central Valley Regional Water Quality Control Board (Regional Water Board) Region 5. Water quality issues relate to the relative impacts to the beneficial uses of water, including its drinking quality, use in irrigated agriculture, etc. Below are key water quality issues in this region. For further discussion, see Appendix B Water Quality.

**Salinity.** Salinity is the primary contaminant affecting water quality and habitat in the Tulare Lake region. Because the groundwater basin in the San Joaquin Valley portion of the region is an internally drained and closed basin, salts, much of which are introduced into the basin with imported water supplies, build up in the soil and groundwater.

**Figure TL-3** **Tulare Lake region water balance for water years 1998-2005**




Salt contained in the imported water supply is the primary source of salt circulating in the Tulare Lake region. The California Aqueduct, Friant-Kern Canal, and to a less extent Delta Mendota Canal supply most of the higher quality surface irrigation water in the Tulare Lake region. The quality of this supply may be impaired by the recirculation of salts from the San Joaquin River to the Delta Mendota Canal intake pump, leading to a greater net accumulation of salts in the basin. Delivery data from the two major water projects in California indicate there is a substantial amount of salt being transported from the Delta to other basins throughout the state. Annual import of salt into the Tulare Lake region is estimated to be 1,206 thousand tons of salt. In situ dissolution of salts and pumping from the underlying confined aquifer are important secondary sources.

## Table TL-9 Tulare Lake Hydrologic Region water balance for 1998-2005 (thousand acre-feet)

| Tulare Lake Region | Water Year (Percent of Normal Precipitation) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1998 (207%) | 1999 (94%) | 2000 (93%) | 2001 (85%) | 2002 (71%) | 2003 (86%) | 2004 (85%) | 2005 (120%) |
| **Water Entering the Region** | | | | | | | | |
| Precipitation* | 27,306 | 13,298 | 12,693 | 11,564 | 10,021 | 12,137 | 11,964 | 16,939 |
| Inflow from Oregon/Mexico | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Inflow from Colorado River | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Imports from Other Regions | 3,716 | 4,817 | 5,627 | 3,696 | 4,239 | 5,174 | 4,816 | 5,909 |
| **Total** | **31,022** | **18,115** | **18,320** | **15,260** | **14,260** | **17,311** | **16,780** | **22,848** |
| **Water Leaving the Region** | | | | | | | | |
| Consumptive Use of Applied Water ** (Ag, M&I, Wetlands) | 5,401 | 7,486 | 7,427 | 7,591 | 7,938 | 7,430 | 8,031 | 6,655 |
| Outflow to Oregon/Nevada/Mexico | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Exports to Other Regions | 1,857 | 821 | 1,540 | 1,093 | 1,643 | 1,898 | 1,961 | 1,724 |
| Statutory Required Outflow to Salt Sink | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Additional Outflow to Salt Sink | 457 | 456 | 457 | 458 | 305 | 458 | 457 | 300 |
| Evaporation, Evapotranspiration of Native Vegetation, Groundwater Subsurface Outflows, Natural and Incidental Runoff, Ag Effective Precipitation & Other Outflows | 22,606 | 11,885 | 10,578 | 10,374 | 8,462 | 10,327 | 10,532 | 13,596 |
| **Total** | **30,321** | **20,648** | **20,002** | **19,516** | **18,348** | **20,113** | **20,981** | **22,274** |
| **Storage Changes in the Region** [+] Water added to storage [-] Water removed from storage | | | | | | | | |
| Change in Surface Reservoir Storage | 438 | -595 | -57 | -141 | -161 | 173 | -199 | 680 |
| Change in Groundwater Storage *** | 263 | -1,938 | -1,625 | -4,115 | -3,927 | -2,975 | -4,002 | -106 |
| **Total** | **701** | **-2,533** | **-1,682** | **-4,256** | **-4,088** | **-2,802** | **-4,201** | **574** |
| **Applied Water ** (compare with Consumptive Use)** | 8,429 | 10,803 | 10,717 | 10,717 | 11,318 | 10,858 | 11,603 | 10,082 |

* The percent precipitation is based upon a running 30-year average of precipitation for the region; discrepancies can occur between information calculated for Update 2009 and earlier published data.

** 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.

*** 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) were 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 years were calculated using the following equation:

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

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

**Sedimentation and Erosion.** In the Central Valley, erosion is occurring from the headwaters down to the valley floor. Although naturally occurring, erosion can be accelerated by timber harvest activities, land use conversion, rural development, and grazing. Excessive soil erosion and sediment delivery can impact the beneficial uses of water by (1) silting over fish spawning habitats; (2) clogging drinking water intakes; (3) filling in pools creating shallower, wider, and warmer streams and increasing downstream flooding; (4) creating unstable stream channels; and (5) losing riparian habitat. Timber harvesting in the riparian zone can adversely affect stream temperatures by removing stream shading, a concern for spawning and rearing habitat for salmonids. Thousands of miles of streams are potentially impacted, and the lack of resources has prevented a systematic evaluation of these impacts.

During the past five years in the Tulare Lake region, timberland owners have submitted 18 timber harvest plans that allow harvesting on almost 10,000 acres.

Another major source of erosion is construction activities that expose or loosen soils. In the past five years, the Regional Water Board has documented 15 incidents that could result in water quality impacts if not corrected.

**Nitrates and Groundwater Contaminates.** Groundwater is a primary water supply, but in many places it is impaired or threatened because of elevated levels of nitrates and salts that are derived principally from irrigated agriculture, dairies, discharges of wastewater to land, and from disposal of sewage from both community wastewater systems and septic tanks. As population has grown, many cities have struggled to fund improvements in wastewater systems. Recently, some federal stimulus funds have been distributed to the towns of Cutler ($1.7 million) and Caruthers ($2.5 million) to renovate their systems. The areas of high TDS content are primarily along the west side of the San Joaquin Valley and in the trough of the valley. High TDS content of west-side water is due to recharge of streamflow originating from marine sediments in the Coast Range.

Naturally occurring arsenic and human-made organic chemicals—pesticides and industrial chemicals—in some instances have contaminated groundwater that is used as domestic water supplies in this region. In some cases, nitrates are from natural sources.

Agricultural pesticides and herbicides have been detected throughout the valley, but primarily along the east side where soil permeability is higher and depth to groundwater is shallower. The most notable agricultural contaminant is DBCP, a now-banned soil fumigant and known carcinogen once used extensively on grapes.

**Legacy Mine Impacts.** San Carlos, Silver, and Panoche creeks in the northwest part of the region are impacted by discharges from legacy mercury mining activities. Asbestos is also a concern in the western part of this hydrologic region where two asbestos mines in the Los Gatos Creek watershed are part of US Environmental Protection Agency Superfund remediation efforts.

**Dairies, Stockyards, and Poultry Ranches.** Concern has increased in the region regarding dairy, stockyard, and poultry ranch loadings of pathogens, nutrients, salts, and potential contaminants (such as antibiotics) to water bodies. Some dairies and other agricultural operations are already subject to regulatory review. Recently, $1.2 million of funding from the Cooperative Conservation Partnership Initiative, a program established in the 2008 Farm Bill, became available to be distributed to California counties with significant dairy operations to protect water quality by helping dairy operator improve manure utilization systems.

## Water Project Operations

The two largest water projects in the region are the CVP (Friant and San Luis units) delivering water along the eastern areas and western areas of the San Joaquin Valley and the SWP (California Aqueduct) delivering most water along the western San Joaquin Valley from Kings County south. The majority of local surface water originates from the reservoir projects on the Kings, Kern, Kaweah, and Tule rivers delivering water to numerous eastside water agencies and Kern County water agencies. The Flood Management/Structural Approaches section has a more detailed discussion of local reservoir flood control efforts.

## Water Governance

Today's water governance in the Tulare Lake region is strongly tied to the period following the Gold Rush, reclamation law, the passage of the Wright Act in the 1860s, the Municipal Utility District Act of 1921, and various related historical legislation. Most of the large irrigation districts can trace their origins to private investor's efforts to build water distribution systems to divert local rivers and streams to outlying land and expansion of farmland, land reclamation, and levee maintenance.

The region's water management, planning, and flood control activities are generally governed by counties, cities, private companies, and special districts created to perform specific functions. Table TL-10 lists various types of special districts for selected agencies in the region. In addition, some federal entities involved in the Tulare Lake region include the Department of the Navy, US Forest Service, National Park Service, and the US Bureau of Land Management.

The interregional water conveyance systems of the CVP and SWP are operated by the federal and State governments, respectively. Local developed surface water systems include the diversion points and canals along the Kings River for the Fresno Irrigation District, Alta ID, Consolidated ID; along the Tule River for Porterville ID and Lower Tule River ID; and along the Kern River for Kern Delta ID and North Kern Water Storage District to name a few.

Many organizations are involved in the sale, delivery, management, maintenance, planning, reuse, and flood control aspects of water in the Tulare Lake region. Table TL-11 lists a selection of organizations involved in water governance in the

**Table TL-10 Partial list of agencies and roles in relation to DWR water management strategies in the Tulare Lake Hydrologic Region**

| Organization | Roles related to DWR water management strategies | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Agricultural lands stewardship | Agricultural water use efficiency | Conveyance (canals) | Drinking water treatment & distr. | Economic incentives | Ecosystem restoration | Floodplain management | Groundwater storage/conj use | Groundwater/aquifer remediation | Matching water quality to use | Pollution prevention | Precipitation enhancement | Recharge areas protection | Recycled municipal water | Surface storage-regional/local | System re-operation | Urban land use management | Urban runoff management | Urban water use efficiency | Water-dependent recreation | Watershed management | Water transfers | Wastewater treatment | Permit requirements |
| **Local** | | | | | | | | | | | | | | | | | | | | | | | | |
| Special Districts | | | | | | | | | | | | | | | | | | | | | | | | |
| Alta Irrigation District | | ● | ● | | ● | ● | | ● | | ● | | | | | ● | ● | | ● | | | | ● | | |
| Consolidated Irrigation District | | ● | ● | | ● | ● | | ● | | ● | | | | | ● | ● | | ● | | | | ● | | |
| Fresno Irrigation District | | ● | ● | | ● | ● | ● | ● | | ● | | | | ● | ● | ● | | ● | | | | ● | | |
| King River Conservation District | | ● | | | ● | ● | ● | ● | | ● | ● | ● | ● | | ● | ● | | | | | ● | ● | | |
| Fresno Metropolitan Flood Control District | | | ● | | ● | ● | ● | ● | | | | | ● | | ● | | ● | ● | | | ● | | | |
| **Water Associations** | | | | | | | | | | | | | | | | | | | | | | | | |
| Kings River Water Association | | | | | | | | | | | | | | | ● | ● | | | | | | ● | | |
| Friant Water Users | | ● | ● | | | ● | ● | ● | | | | | | | ● | ● | | | | | | ● | | |
| Community Services Districts | | | | ● | | | | | | | | | | ● | | | ● | ● | ● | | | | ● | |
| Counties (Fresno, Kings, Tulare) | | | | | | | | | | | | | | | | | | | | | | | | |
| Public Works | | | ● | ● | ● | | ● | ● | | | | | | ● | | | | ● | ● | | | | ● | |
| Planning | ● | | | | ● | ● | ● | | | | | | | | | | ● | | | | | | | ● |
| Health/Environmental Health | | | | ● | ● | | | | ● | | ● | | | ● | | | | | | | | | ● | |
| Cooperative Extension | ● | ● | | | | | | | | | | | | | | | | | | | | | | |
| Agricultural Commissioner | | | | | | | | | | | ● | | | | | | | | | | | | | |
| **Cities** | | | | | | | | | | | | | | | | | | | | | | | | |
| Clovis | | | | ● | ● | | | ● | | | ● | | ● | ● | ● | | ● | ● | ● | | | | ● | ● |
| Fresno | | | | ● | ● | | | ● | | | ● | | ● | ● | ● | | ● | ● | ● | | | | ● | ● |
| Fowler | | | | ● | ● | | | | | | ● | | | | | | ● | ● | ● | | | | | ● |
| Kerman | | | | ● | ● | | | | | | ● | | | | | | ● | ● | ● | | | | ● | ● |
| Kingsburg | | | | ● | ● | | | | | | ● | | | | | | ● | ● | ● | | | | | ● |
| Parlier | | | | ● | ● | | | | | | ● | | | | | | ● | ● | ● | | | | ● | ● |
| Reedley | | | | ● | ● | | | | | | ● | | | | | | ● | ● | ● | | | | ● | ● |
| Sanger | | | | ● | ● | | | | | | ● | | | | | | ● | ● | ● | | | | ● | ● |
| Selma | | | | ● | ● | | | | | | ● | | | | | | ● | ● | ● | | | | | ● |
| Diruba | | | | ● | ● | ● | | | | | ● | | | ● | | | ● | ● | ● | | | | ● | ● |

**Table TL-11 Selection of organizations in Tulare Lake region involved in water governance**

| Entity | Task |
|---|---|
| **Federal** | |
| Friant-Kern Canal (CVP) | Interregional water supply |
| US Bureau of Reclamation | operation of Friant Dam |
| US Corps of Engineers | operation of Pine Flat, Isabella, Kaweah dams |
| **State** | |
| Kern County Water Agency | Water supply and flood control |
| State Water Project | Interregional water supply |
| **Local** | |
| Alpaugh Joint Powers Authority | Alpaugh ID and Tulare Co. Water Works District |
| Bear Valley Springs Community Services District | Water, police, roads, wastewater, solid waste |
| City of Fresno, Water Division | Water |
| Deer Creek and Tule River Authority | Water conservation, groundwater management |
| Dudley Ridge Water District | SWP contractor |
| Fresno Metro Flood Control District | Local flood control |
| Friant Water Authority | Friant-Kern Canal maintenance |
| Henry Miller Recreation District 2131 | Evacuate runoff and maintain internal drainage |
| Kaweah Delta Water Cons District | Management of Kaweah River water |
| Kings River Conservation District | Flood protection, water supply, power |
| Kings River Water Association | Kings River entitlements, deliveries, water quality environment |
| Panoche Drainage District | Maintain internal drainage |
| Pinedale County Water District | Water, wastewater, solid waste |
| So. San Joaquin Municipal Utility District | Agricultural water from CVP, WAPA Power |
| Tulare Lake Basin Water Storage District | Delivery, storage of SWP water |
| Tulare Lake Drainage District | Drainage Management |

region. More complete information on water governance will be developed for California Water Plan Update 2013. This will include identification of local, State, Tribal, and federal government agencies and institutions that are responsible for managing the region's water resources, flood protection, and wastewater. A list of regional flood management participants is included in Appendix A Flood Management, and Integrated Regional Water Management (IRWM) Plans provide information about water planning organizations in this region.

## Flood Management

### Flood Hazards

Flood events in the Tulare Lake region are caused by rainfall, snowmelt, and the resultant rising of normally dry lakes. Although significant progress has been made to

contain floodwaters in the region, improvements to the flood control system are still needed to lessen the flood risk to life and property. Flood hazards in the region include the following representative situations (for specific instances, see Challenges):

- Protection from flooding is not provided for a flood equal to the event with 1 percent probability (1 percent event) for some residences and commercial facilities.
- Some existing culverts and channels do not have sufficient capacity to carry flow resulting from the 1 percent event.
- For some levees, maintenance has not kept pace with deterioration.
- Some existing levees are not able to retain the 1 percent event.
- Some existing urban levees are not able to retain the 0.5 percent event.
- Unmanaged vegetation has reduced floodflow capacity at some locations.
- Clogged conveyance structures exacerbate flood risk.
- Some dams do not meet current State seismic, spillway or other structural requirements.
- Uncontrolled runoff from minor watersheds and other areas often causes significant damage.

## Historic Floods

Recent notable flood events have been

- the rainfall and snowmelt floods of December 1955, February 1969, January 1997, and winter 1998;
- the region-wide rainfall floods in winter 1966-67 and March of the 1995 El Niño year; and
- the Tulare Lake floods of February 1969 and January 1997.

For more information on these floods see Appendix A, Flood Management. Flood records for selected flood-producing streams are listed in Appendix A in Table TLA-1, Record floods for selected streams.

## Flood Governance

Flood management is a cooperative effort in which federal, tribal, State, and local governments play significant parts. The principal participants are listed in Box TL-3, Flood Management Agencies. For more information on the agencies' roles, see Table TLA-2, Flood management participants, in Appendix A.

## Flood Risk Management

Flood risk management includes a wide variety of projects and programs, which may be grouped as Structural Approaches (constructed facilities, coordination and reservoir operations, maintenance), Land Use Management (floodplain restoration, regulation, flood insurance), and Disaster Preparedness, Response, and Recovery (information and education, event management).

**Box TL-3 Flood Management Agencies**

**Federal**

- Federal Emergency Management Agency
- National Weather Service
- Natural Resources Conservation Service
- US Geological Survey
- US Army Corps of Engineers

**Tribal**

- Tribal governments of the region

**State**

- California Conservation Corps
- California Emergency Management Agency
- Central Valley Flood Protection Board
- Department of Corrections
- Department of Forestry and Fire Protection
- Department of Water Resources

**Local**

- City of Bakersfield
- Levee Districts 1 and 2 of Tulare County
- Ten reclamation districts Kings River Conservation District
- County and city emergency services units
- County and city planning departments
- County and city building departments
- Local flood maintenance organizations
- Local conservation corps
- Local emergency response agencies
- Local initial responders to emergencies

## Structural Approaches

**Constructed Facilities.** The Tulare Lake Hydrologic Region has four multipurpose reservoirs with flood control reservations, 10 single-purpose flood control reservoirs, leveed streams, and a connection to the California Aqueduct for floodwaters. Two additional reservoirs provide incidental flood storage.

All multipurpose reservoirs are part of US Army Corps of Engineers projects, and all were constructed by USACE. They are Pine Flat Lake on the Kings River, protecting southern Fresno county and Kings County areas; Lake Kaweah on the Kaweah River above Visalia; Lake Success above Porterville; and Lake Isabella above Bakersfield. Single-purpose reservoirs are related to flood protection from streams above Fresno and Clovis, known as the Fresno County Streams Group, and from two streams in the vicinity of Tehachapi. Those also part of the Redbank-Fancher Creeks Flood Control Project include the USACE-constructed Big Dry Creek Reservoir, Redbank Creek Reservoir, Redbank Creek Detention Basin, Fancher Creek Reservoir, Alluvial Drain Detention Basin, and Pup Creek Detention Basin and the Big Dry Creek Detention Basin, constructed by the Fresno Metropolitan Flood Control District. Not a part of Redbank-Fancher Creeks Flood Control Project is Fancher Creek Detention Basin, also constructed by the Fresno district. Tehachapi Creek Reservoir and Mendiburu Creek Reservoir provide flood protection on adjacent streams in the southern Sierra.

The Kings River Flood Control Project controls local flooding in the vicinity of Laton and directs floodwaters either to Tulare Lake or into the San Joaquin River under the USACE flood operation plan. It consists of levees on four divisions of the Kings River and four other streams, channel clearing, and improvements to a preexisting weir.

USACE constructed the project in conjunction with Pine Flat Dam to complement the reservoir operations.

The Kern River Intertie was constructed by USACE to convey floodwaters of the Kern River into the California Aqueduct on a controlled basis for beneficial use in Southern California. Fresno Metropolitan Flood Control District constructed the Holland Creek Rediversion Channel to return diverted floodwaters to the Kings River near Sanger. NRCS funded construction of projects including flood control reservoirs on Tehachapi and Mendiburu creeks at Tehachapi, owned by Tehachapi-Cummings County Water District; channel improvements on Cottonwood Creek tributaries east of Seville, owned by Stone Corral Irrigation District; and channel improvements on Antelope Creek near Woodlake, owned by Tulare County Flood Control and Water Conservation District. There are also levees that have been constructed and are maintained by local government or individuals. Notable among these are levees for confinement of flood waters at Tulare Lake.

Local sponsors and descriptions for reservoirs and non-storage flood control facilities in the region are listed in Appendix A in Table TLA-3, Flood control facilities. Also in Appendix A, Figure TLA-1 is a schematic of the Kings River Flood Control project.

**Coordination and Reservoir Operations.** The USACE prescribes formal emergency operating rules for Big Dry Creek Reservoir, Redbank Creek Reservoir, Redbank Creek Detention Basin, Fancher Creek Reservoir, Alluvial Drain Detention Basin, and Pup Creek Detention Basin, which are operated by other agencies (see Appendix A, Table TLA-3). There are no forecast-based operations agreements for operation of flood protection facilities in the region. During high water periods, USACE participates in daily operations conferences at the State-Federal Flood Operations Center in Sacramento. These conferences often lead to voluntary modifications of individual schedules to improve overall system operation. In flood events, the Kings River flows are diverted into the San Joaquin River via Fresno Slough and James Bypass. Coordination of reservoir releases to both rivers is paramount to minimizing flooding risks in the San Joaquin and Tulare Lake hydrologic regions. Therefore, Kings River Water Association and the USACE cooperate closely on reservoir operations during high water periods. Additionally, cooperation between Pacific Gas and Electric Company and USACE in the Kings River Basin has resulted in more effective reservoir flood control operations.

The space reserved for flood in multipurpose reservoirs is most often defined by a trapezoidal diagram of volume required versus date, modified by conditions in the latter part of flood season. Generally, the diagrams require a flood space reservation increasing from zero from the beginning of the flood season, invariant with date during mid-season, and decreasing to zero again at season's end. Superimposed on these diagrams are modifications based on either an antecedent precipitation index (API) or a runoff forecast. The API-controlled diagrams are usually decreased from the trapezoid and shortened in time during drier years, beginning in mid-season. The runoff-controlled

diagrams increase the trapezoid and extend it in time for the greater runoff forecasts. Conditional reservation space in Wishon and Courtright reservoirs can be credited to Pine Flat Lake if the upstream lakes together contain more than 20,000 acre-feet of space. Single-purpose flood control reservoirs are kept as low as possible. For any reservoir, there are usually downstream controls of various kinds on evacuation rates.

For more information on flood control reservoirs, see Table TLA-3, Flood control facilities, in Appendix A.

**Maintenance.** Maintenance of flood control works is a critical activity which preserves the integrity of the facilities, ensuring continued protection for the public. This effort is made more difficult by two factors: (1) Lack of adequate financing for many installations is the result of tax-management efforts of the late twentieth century which have placed controls on former sources of revenue, and (2) heightened public awareness of the environment has resulted in new regulations making the permitting process lengthy and expensive. Compounding the problem, deferred maintenance can cause establishment of new habitat which then must be protected.

Maintenance of flood control facilities is usually the responsibility of the local maintaining agency, which is usually the local sponsor, or if there is none, the constructing agency. Most USACE projects are maintained by the sponsoring local maintaining agency, but reservoirs in particular may be exceptions. In this region, Pine Flat Lake, Lake Kaweah, Lake Success, Lake Isabella, and the Kern River intertie are maintained directly by the USACE. NRCS projects follow a pattern of close cooperation with a local sponsor, with NRCS providing maintenance standards and the local sponsor performing the maintenance. The local constructing agency maintains non-federal projects in this region.

### Land Use Management

**Floodplain Restoration.** Much former floodplain area in the Tulare Lake region consists of the beds of Tulare Lake and Buena Vista/Kern lakes, which have been converted to agricultural operations for many years and are not amenable to restoration to floodplain status. Agricultural strategy in the area includes much effort devoted to containing floodwaters in as small an area as possible, leaving the remainder for use in the long growing season.

The purpose of the Kern River Restoration Project (completed 1991) was to enhance the Kern River channel and provide for the safe carriage of floodflows through the urbanized Bakersfield area. This project implemented a program of planting low-maintenance native trees and riparian vegetation along the river frontage areas. Approximately 4,200 trees were planted along four miles of streambank in several phases from 1988 to 1991, with around 320,000 feet of irrigation line installed. The project was implemented in conjunction with the Kern River Parkway Plan and Channel Maintenance Program adopted by the Bakersfield City Council in 1986 to protect existing levees and riverfront

riparian areas, while providing open space recreation for the Bakersfield community along the Kern River corridor.

**Regulation.** Counties and the Central Valley Flood Protection Board are the main agencies responsible for designating and regulating floodways. Fresno, Kings, Tulare, and Kern counties regulate floodplain development and restrict floodway encroachment with their zoning ordinances. General plans for the four counties discuss flood hazards and control measures in the context of projected population growth, and provide guidelines for future flood control strategies. All local land use jurisdictions must adopt a floodplain management ordinance identifying 1 percent floodplains and floodways in order to qualify for Federal Emergency Management Agency (FEMA) flood insurance.

Adopting designated floodways facilitates enforcement of floodplain building ordinances. The Central Valley Flood Protection Board has designated the following streams as floodways: Kings, Kaweah, Tule, and Kern rivers and Porter Slough.

**Flood Insurance.** The National Flood Insurance Program is administered by FEMA. NFIP enables property owners in participating communities to purchase insurance as protection against flood losses in exchange for State and community floodplain management regulations that reduce future flood damages. About 97 percent of California communities participate in NFIP. Of those, approximately 12 percent participate in the Community Rating System (CRS) Program, which encourages communities to go beyond minimum NFIP requirements in return for reduced insurance rates. Quality mapping is critical to administering an effective flood insurance program, developing hydrologic and hydraulic information for determining floodplain boundaries and allocating flood protection project funds.

FEMA has provided Flood Insurance Rate Maps (FIRMs) for all areas within the region. As of June 2009, maps in all of the region's six counties are new since 2008. CRS rates communities from 1 to 10 on the effectiveness of flood protection activities. The lower ratings bring larger discounts on flood insurance. Of the six counties and 35 cities in the hydrologic region, two counties and one city participate in CRS. As of May 2009, Fresno County, Kern County, and Fresno are all in CRS Class 8. See http://www.fema.gov/business/nfip/crs.shtm for more information on the CRS system.

## Disaster Preparedness, Response, and Recovery

**Information and Education.** The California Data Exchange Center (CDEC) provides real-time and historical hydrometeorological data for hundreds of stations statewide, as well as real-time data on releases, spill rates, and elevations of many reservoirs. For this region, CDEC provides gage data from DWR (32 gages), Kern County (27), PG&E (28), USACE (29), and several other federal, State, and local agencies, a total of 193 gages; and real-time flow and stage data for the Kings, Tule, Kern, and White rivers, Los Gatos, and Cantua creeks, and Arroyo Pasajero. For access to CDEC data, see http://cdec.water.ca.gov.

The USGS maintains and publishes statistics for stream gages nationwide. USGS gages are the source of data for the eight stations listed in Appendix A, Table TLA-1, Record floods for selected streams. For access to USGS gage data, see http://waterdata.usgs.gov/nwis.

DWR's Awareness Floodplain Mapping program provides an easy-to-use computer interface for viewing areas vulnerable to flooding by the flood event having a 1 percent probability of occurrence. The program applies to areas not already covered by FEMA FIRMs. For this region, maps have been drawn for all counties, but coverage of some areas may have been deferred. By 2015, all areas expected to develop over the next 25 years will have mapped floodplains. All of Fresno and Tulare counties have been mapped as part of the project. By 2012, all areas expected to develop over the next 25 years will have mapped floodplains.

Accurate hydrologic and hydraulic models inform the design of effective flood control structures and emergency actions before, during, and after floods. The National Weather Service's Advanced Hydrologic Prediction Service (AHPS) uses historical hydrologic data, current river and watershed conditions, and near-term meteorological outlooks to forecast river flows. The service is publicly available for certain streams of the Tulare Lake region. Locations are given in Appendix A, Table TLA-5, AHPS stream forecast points

A number of other models describing the hydrology of the region's rivers provide data relevant to flooding issues. The Kings River Water Association has an operational streamflow-prediction model that is used to estimate the amount of water available for beneficial uses. The Kings River Conservation District and Upper Kings Basin Water Forum have developed a regional model which simulates the groundwater and surface water systems of the Kings Groundwater Basin. The Berkeley National Laboratory has modeled Kings River flows based on two climate change scenarios (one dry and cool, the other wet and warm). For the Tule River, the University of California, Davis created a conjunctive use model. Lyle Engineering modeled the river's hydraulics near East Porterville for a bridge replacement project. The Central Valley Ground-Surface Water model calculates a water budget for all four of the region's major rivers.

Event Management. Under the Standardized Emergency Management System (SEMS) and the National Incident Management System (NIMS), initial flood emergency response is made by the responsible party at the site. When its resources are exhausted, the county emergency management organization (operational area) provides support. If necessary, additional support is coordinated by a region of the California Emergency Management Agency (Cal EMA). Through the Cal EMA region and Cal EMA headquarters help can be obtained from any State agency. Cal EMA coordinates with federal agencies and private organizations as well. The State-Federal Flood Operations Center (a joint facility of DWR and the Sacramento Weather Office and California-Nevada River Forecast Center, both units of the National Weather Service, is normally called early in the event to provide weather and river forecasts, facilitate information

flow, provide field situation analysis, and give flood fight expertise. Severe situations that require Cal EMA involvement may also require emergency response by USACE, which is obtained by request of DWR. Table TLA-4, Flood emergency response organizations, in Appendix A, is a listing of specific response organizations.

Recovery after a flood event may involve the funding and construction services of USACE if the facilities are parts of federal projects. Availability of resources to repair local and private facilities; remove floodwater; and restore housing, businesses, and infrastructure often depends on the severity of the event and the allocation of event-specific federal or State funds.

Flood preparedness and mitigation efforts are promoted and funded by many organizations, including city and county governments, Cal EMA, DWR, National Weather Service, and USACE.

## Relationship with Other Regions

The Tulare Lake region receives CVP water from the San Joaquin River region via the Friant-Kern Canal and imported water from the Sacramento-San Joaquin Delta via the SWP California Aqueduct and the CVP San Luis and Delta-Mendota canals. The regional map (see Figure TL-1) identifies the amounts of water imports and exports for recent years. The economic health of the region heavily depends on the availability of imported surface water to meet current and future needs. Several water districts within the Tulare Lake region have developed groundwater storage and recovery programs that benefit water districts outside of the region. Groundwater overdraft has created sufficient dewatered storage space to store water for local uses and for extraction and exchange or delivery to other agencies. Revenues generated by these storage and recovery programs have helped finance additional conveyance infrastructure to move surface water to areas that were previously served with groundwater. This type of conjunctive use activity ultimately helps relieve overdraft, while providing additional water supplies to agencies outside of the region.

In 1988, Natural Resource Defense Council and a broad coalition of anglers and conservation groups brought suit in US district court in an effort to bring the San Joaquin River and its native fisheries back to life. In August 2004, the court ruled that the operation of Friant Dam violates one of California's most important fishery protection statutes. The San Joaquin River Settlement Act (HR 24 and S. 27: January 2007) aims to restore continuous flows downstream of Friant Dam and revive the river's salmon runs. The settlement also mitigates water supply impacts and provides certainty to Friant water users, most of which are in the Tulare Lake region. It is expected to have far-reaching benefits for all of California, including improved water quality, enhanced flood protection, healthier wildlife habitat, economic development, and recreational opportunities.

### Flood Diversions

Kings River outflow normally flows toward Tulare Lake and is usually intercepted for irrigation use or stored in Pine Flat Lake. In flood events, the Kings is diverted northward into the San Joaquin River Hydrologic Region, generally along the path of historical distributaries. Although this flow may correspond to a natural occurrence, northward disposal of excess flows is encouraged by river operators to protect agricultural interests in Tulare Lake. Disposal of floodwaters into the region is limited by flood conditions on the San Joaquin River itself and the area's susceptibility to flood damage. Also, the South Wilbur and Hacienda flood areas can store floodwater on nearly 20,000 acres during wet years. During dry years, the floodwater basins are colonized by native alkali scrub and grassland, along with their associated sensitive species.

Similarly, high flows in the Kern River can damage agricultural lands in the Buena Vista Lake basin and, theoretically, can overflow into Tulare Lake. Some excess floodwater can be routed into the California Aqueduct through the Kern River Intertie. This water is transported to the South Coast Hydrologic Region. Quantities are limited by the flow capability of the aqueduct and by available space in the SWP reservoirs in Southern California.

## Regional Water and Flood Planning and Management

### Integrated Regional Water Management (IRWM)

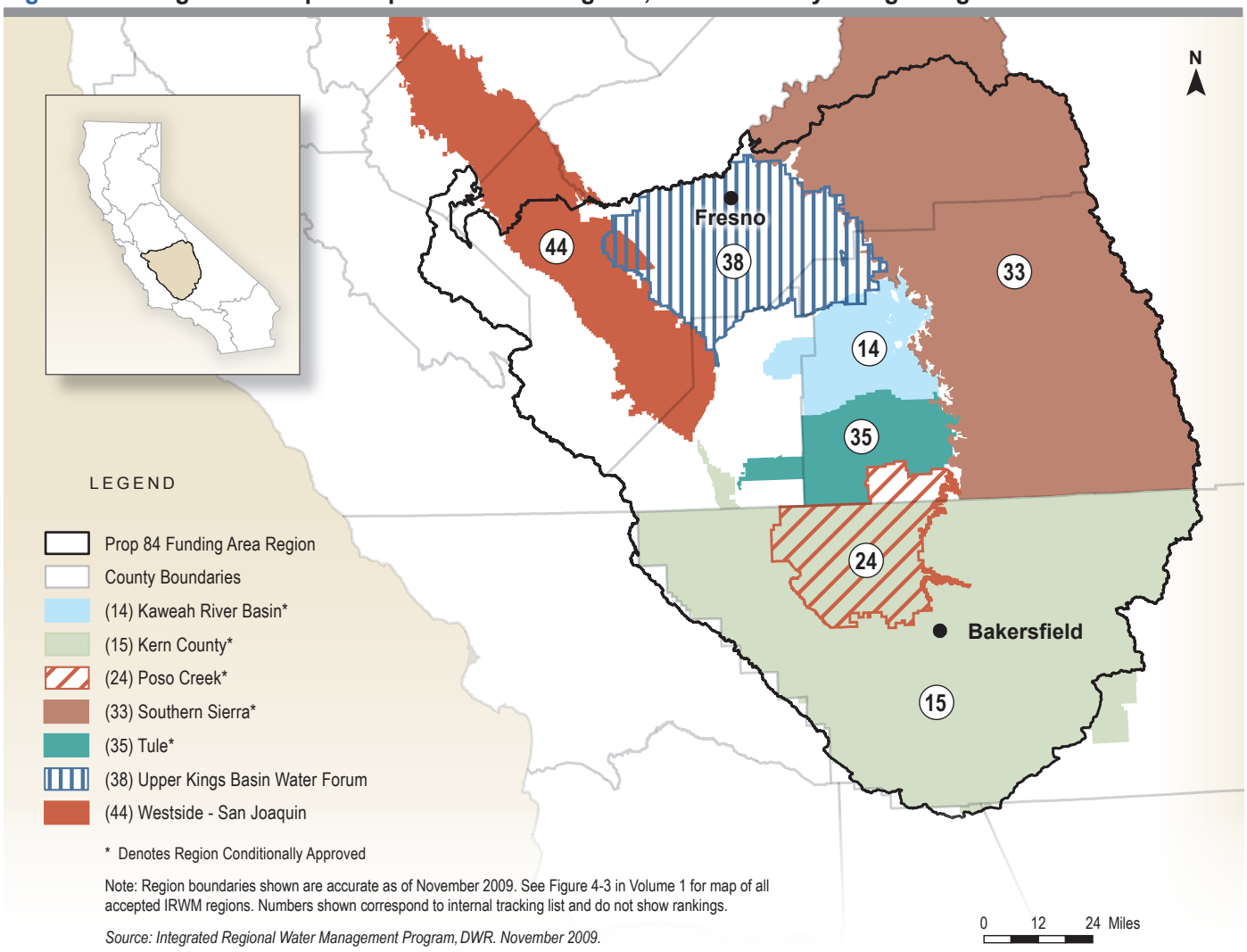
The IRWM Planning Act, signed by the Governor as part of SB 1 in 2008 (CWC Sec 10530 et seq), provides a general definition of an IRWM plan as well as guidance to DWR as to what IRWM program guidelines must contain. The Act states that the guidelines shall include standards for identifying a region for the purposes of developing or modifying an IRWM plan. The first regional acceptance process (RAP) spanned 2008-2009. Final decisions were released in fall 2009. The RAP is used to evaluate and accept an IRWM region into the IRWM grant program. Many IRWM regions have many proposed, some approved, and some conditionally approved. Figure TL-4 shows RAP regions in this hydrologic region. Table TL-12 lists strategies from earlier IRWM efforts.

Some examples of water-related regional strategies are[1]:

- **Southern Sierra IRWM effort.** Some of the projects that are being considered include fuel breaks and treatments to reduce the risk of catastrophic fire; riparian restoration for water quality improvements; fencing strategic locations to protect water quality in riparian areas; implementing best management practices regarding grazing and roads on federal and private lands; and restoring mountain meadows to improve water quality and supply.
- **Alta Irrigation District Harder Pond.** The Harder Pond is a recharge and banking project that is included in the Upper Kings IRWM Plan. The facility uses flows

1 Information about these projects came to the Water Plan by the Roundtable of Regions, which provides links to and works with IRWM planning groups.

**Figure TL-4 Regional acceptance process IRWM regions, Tulare Lake Hydrologic Region**




that Alta has not been able to put to beneficial use to help recharge the aquifer that diminishes in dry years on the east side of the valley.

## Recent Accomplishments

The region has always strived to ensure adequate, reliable supply of water to supplement local surface water and groundwater and incorporation of water management strategies and infrastructure that improve water use efficiency at all levels. Many projects and programs have minimized flooding, saving lives and millions of dollars over the years. The following is a list of some accomplishments and ongoing endeavors within the

**Table TL-12 Strategies of Integrated Regional Water Management efforts in Tulare Lake Hydrologic Region**

| Strategy | Poso Creek IRWMP | Upper Kings IRWMP | Westside Integrated Water Resources Plan[1] | Kaweah Delta Regional Water Management Implementation Program[2] |
|---|---|---|---|---|
| | July 2007 | Jul 2007 | May 2007 revised | Nov 2006 |
| Adopt water dispute resolution procedure | | | | ✓ |
| Conjunctive water management | ✓ | ✓ | | ✓ |
| Desalination (R/O) | | ✓ | | |
| Ecosystem restoration | | ✓ | ✓ | |
| Environmental and habitat protection and improvement | ✓ | ✓ | ✓ | |
| Flood management | | ✓ | ✓ | |
| Get stakeholders involved | | ✓ | | ✓ |
| Groundwater management | ✓ | ✓ | ✓ | ✓ |
| Implement third-party banking programs | ✓ | | | |
| Imported water | | ✓ | | |
| Increase operational flexibility | ✓ | | | |
| Land acquisition | | ✓ | | |
| Land use planning | | ✓ | | ✓ |
| Monitoring inelastic land subsidence due to water pumping | | ✓ | | ✓ |
| Nonpoint source pollution control | | ✓ | | |
| Participate in regional groundwater committee | ✓ | ✓ | | |
| Prevent saline water intrusion | | | | ✓ |
| Recreation | | ✓ | ✓ | |
| Secure grant funding to offset capital cost | ✓ | ✓ | | |
| Storm water capture and management | | ✓ | ✓ | |
| Strengthen relationship and cooperation with other agencies | | ✓ | | ✓ |
| Support District's water supply pricing policy | ✓ | | | |
| Surface storage | | ✓ | | |
| Water and wastewater treatment | | ✓ | | |
| Water conservation | | ✓ | ✓ | |
| Water quality protection and improvement | ✓ | ✓ | ✓ | |
| Water recycling | | ✓ | ✓ | |
| Water supply reliability | ✓ | ✓ | ✓ | |
| Water transfers | ✓ | ✓ | | ✓ |
| Watershed planning | | ✓ | | |
| Wetlands enhancement and creation | | ✓ | ✓ | |

Note: The summary information contained in these tables was obtained from various IRWM plans. For additional details or information related to a specific plan, please consult the current version of the plan or its authors.

[1] The Westside Integrated Water Resources Plan regional boundaries overlap hydrologic regions. This plan can also be found in the Volume 3 San Joaquin River report.

[2] The Kaweah Delta Regional Water Management Implementation Program consists of a groundwater management plan, water management agreement, and supporting elements. It was considered here as a functionally equivalent IRWM plan.

**Box TL-4 California Partnership for the San Joaquin Valley, Strategic Plan**

"The California Partnership for the San Joaquin Valley has developed a strategic plan to address water planning and is currently working to develop a Regional Water Plan. Several other local groups are in the process of developing IRWM plans. In addition, the Council of Governments within the Tulare Basin are actively involved in a Blueprint Planning process in an attempt to reconcile "pro-growth" and "anti-growth" forces and attitudes, such as concerns about the need for housing production and regional economic development, on the one hand, and resistance to community change and environmental disruption, on the other. Blueprint planning seeks mainly to coordinate long-range regional and local plans for transportation investment, air quality, and housing, although in some cases such policy areas as energy and habitat planning are also incorporated. An exception is the California Environmental Quality Act (CEQA) – California's version of NEPA."

region since Water Plan Update 2005. (See also Box TL-4 on California Partnership for the San Joaquin Valley)

- Agricultural Water Management Planning and adoption of efficient water management practices: 27 of the 79 signatories are in the Tulare Lake region accounting for 43 percent of the irrigated acreage
- Kern County, California Multi-Hazard Mitigation Plan, adopted in 2005
- Terminus Dam Enlargement, 2005
- Fancher Creek Detention Basin, 2007
- Conservation efforts of the Tulare Basin Wildlife Partners
- Water districts working with individual growers to improve on-farm irrigation water management systems and efficiency through loans, irrigation services, delivery scheduling changes/modification, water transfers, and other resources
- Growers with irrigation system changes/upgrades, especially in permanent crops allowing more efficient application of irrigation water
- Reconciling inconsistent year-to-year contract deliveries from the CVP and SWP through local optimization studies, shared infrastructure, and cooperation
- Increasing number of urban areas preparing Urban Water Management Plans and becoming members of the California Urban Water Conservation Council and memorandum of understanding cities with approved plans
- Increasing number of areas with prepared Groundwater Management Plans
- Improving water quality through diversification of urban water sources, additional surface water treatment plants, and new sewage treatment systems for water released into the environment, into recharge basins, and for irrigation
- Increasing number of cooperative conjunctive use projects, irrigation system distribution system interconnections, management strategies, water banks, etc.
- US Department of Agriculture and NRCS agricultural and environmental enhancement programs
- The Lake Kaweah Enlargement Project
- Coordinated Resource Management and Planning groups in the region, including the Panoche/Silver Creek, the Stewards of the Arroyo Pasajero Watershed, and the Cantua/Salt Creek watersheds
- Kern County Water Agency's Kern River Restoration and Water Supply Improvement Program

In California, 107 groundwater management plans have been adopted, 25 of the areas lie within the Tulare Lake Hydrologic Region. More than 60 agencies in the region have adopted plans. Many of these agencies are covered by coordinated groundwater management plans.

Surface water availability can vary widely year to year in the Tulare Lake region. Consequently, local conjunctive use water management and groundwater banking projects are continually being expanded and updated. Recently, the Upper Kings Basin Water Forum received a $6 million grant to fund two projects in Kings and Tulare counties. Both projects will result in increased groundwater recharge capabilities. Nearly $3.6 million of the grant will go to a local groundwater recharge and banking project in northern Kings County. The grant money is part of the DWR's $3.4 billion program enabled by Proposition 50 (passed by California voters in 2002). An IRWM plan for the upper Kings River region covers portions of Fresno, Tulare, and Kings counties.

## Challenges

The San Joaquin Valley's most notable issues surround water supply and quality, air quality, and population growth and urban sprawl. Although significant progress has been achieved in addressing some of these issues, the San Joaquin Valley continues to face major environmental issues that are closely related to existing economic sectors and can affect economic development planning for the future. This includes prosperous growing urban economies and maintaining prosperous agricultural, dairy, and processing industries economies, to name a few.

- Growing urbanization and population increases have resulted in new demand for water for municipal and industrial purposes.
- Local environmental enhancement efforts have increased the need for water beginning with the CVPIA in 1992.
- Sacramento-San Joaquin River Delta water quality needs and environmental needs are reducing the export volume of water pumped and available in the Tulare Lake region—the new biological opinion for endangered species in December 2008 reduced export pumping 20-30 percent.
- Changes to the OCAP could worsen water delivery reliability issues of imported water from the CVP and SWP and along with the growing acreage of permanent crops.
- The San Joaquin River Settlement will impact water diverted into the Friant-Kern Canal, possibly as much as 15 percent of supply as interim flows begin in fall 2009.
- Water costs influence the crop types that can be grown profitably.
- Water delivery contractual obligations and priority of water use brings many questions.

In some instances, water systems operating in disadvantaged communities have little or no resources for necessary upgrades and maintenance. In these rural, often smaller communities, efforts will continue to maintain/obtain adequate quantity and quality potable water and sufficient wastewater treatment capabilities through assistance, grants and loans which can fund feasibility plans to determine the best way to provide safe and

affordable drinking water. As such, the goal is to address water system infrastructure that is in critical need of repair and redesign to assure clean drinking water remains available to all residents.

Also, the number of invasive species spreading throughout California has increased, raising costs for local communities. The quagga and zebra mussels are a threat to local lakes and other water bodies; regular inspections are needed to prevent their introduction to the area. *Arundo* is an invasive plant species adding control costs to local communities as well.

Some of the challenges ahead relate to flood protection.

- Taking measures to reduce flood impacts for the hazards
- Developing and gaining USACE acceptance for higher standards for design for flood facilities in urban and urbanizing areas.
- Taking steps to ameliorate the effects of unprecedented urbanization of agricultural lands, which include increased runoff peaks and totals and degraded water quality.
- Assisting the public in making choices whether to live in floodplains and how to prepare for and insure against flooding, by linking land use decisions to flood risk and flood protection costs.
- Mapping the floodplain around Exeter as quickly as possible in order to provide sound guidelines for flood control projects and flood insurance rates.
- Expediting flood map updates for Visalia, Porterville, Bakersfield, and surrounding areas to reflect recent changes in flood control infrastructure, particularly structural and operational changes to dams.
- Formalizing coordination of high water flows on the San Joaquin and Kings rivers using coordination agreements.

The limitations and reliability issues of surface water deliveries to the region will continue to exacerbate groundwater overdraft in the Tulare Lake Hydrologic Region where groundwater often is used to replace surface water shortfalls.

For many years, portions of the Tulare Lake region have experienced significant drainage problems.

## Drought and Flood Planning

During drought periods, those who most feel the effects of water shortages are small water systems and others who rely on marginal wells, springs, and small creeks, sources especially sensitive to annual rainfall totals. Following a recommendation made by the Governor's Advisory Drought Planning Panel, California Rural Water Association will bring small water systems a myriad of resources to aid in dealing with water shortages.

**Hazard Mitigation Plans.** The Disaster Mitigation Act (Congress 2000) makes mitigation funds available for states and local entities that have hazard mitigation plans. Kern County has adopted a HMP that identifies flood-prone areas and presents measures for lessening the impacts of floods.

**Regional Flood Management Plans.** FloodSAFE is a strategic initiative of DWR that is guiding development of regional flood management plans, which encourage regional cooperation in identifying and addressing flood hazards and will include flood-hazard identification, risk analyses, existing measures, and potential projects, and funding strategies. The plans will emphasize multiple objectives, system resiliency, and compatibility with State goals and IRWM plans.

**Governor's Plan for California's water future.** The Governor's plan proposes to invest $4.5 billion to develop additional surface and groundwater storage to capture more water from storms and prepare California for the impacts of global warming, invest $1 billion to protect the Delta following the recommendation of the Delta Vision Blue Ribbon Commission Task Force, and provide $450 million for restoration and conservation projects throughout the state.

Some grants under the NRCS's Agricultural Water Enhancement Program (AWEP) and some stimulus funds were awarded in response to the recent drought. AWEP five-year contracts for cost share assistance were awarded to Westlands Water district, $10 million; Tulare Irrigation District, $4 million; and Kings River Conservation District, $14 million.

## Looking to the Future

In the Tulare Lake Hydrologic Region, the efficiency of water diversions from local rivers and streams is continually being optimized to meet agricultural and urban purposes. In addition, water agencies have worked with the CVP and SWP to find ways to improve delivery capabilities. The predominantly agricultural economy is now adapting to share water resources with the rapidly growing urban economy. New projects have been identified as necessary to better manage the local water supplies, as well as to adhere to more stringent water quality standards and environmental regulations. IRWM will be an important part of the region's future water management and projects. Supply augmentation, water use efficiency, demand reduction, flood control improvement, and salt management will all be part of the effort of meeting this challenge. Regional efforts by various water agencies and the public will continue to adjust to changes and/or push for changes in the regulations that have resulted in reduced Delta water exports.

CVP Friant-Kern Canal water users will be facing about a 15 percent reduction in deliveries when the San Joaquin River Restoration effort begins in fall 2009, which marks the beginning of interim flows and be challenged with water management strategies to cope with this loss of this surface water. However, new facilities and operations could recover at least a portion of the water used for restoration.

## Climate Change

In general, climate change models are predicting annual average statewide temperature rises of up to 4 degrees Celsius and up to 5 degrees Celsius for individual months. These changes will vary by location with the smallest increases forecast for the Tulare Lake Hydrologic Region. The months of February, March, and May are shown to have the largest temperature response. The net result is milder winter temperatures, an earlier arrival of spring, and increased summer temperatures. Under this model, snow accumulation is significantly decreased in all months, with snow accumulation still beginning in November but with lower monthly accumulations and ending about a month earlier (large decreases in April 1 snowpack.) The impact would be much less in the higher elevation of southern Sierra. For example, in the San Joaquin River and Tulare Lake hydrologic regions, about 70 percent of the snow zone would remain. It is anticipated that the overall evapotranspiration will increase while soil moisture will generally decline except in areas where precipitation will significantly increase. The higher water consumption with warmer temperatures will likely only be partially offset by the carbon dioxide-based reductions. Thus, the net result could be slightly higher agricultural water requirements. Warmer winter temperatures between storms would be expected to increase evapotranspiration, thereby drying out the soil between storms. Changes in recharge will result from changes in effective rainfall as well as a change in the timing of the recharge season (Paper No. 02153 of the Journal of the American Water Resources Association).

The warmer temperatures impact valley permanent crop production as well. A recent study at UC Davis found that the number of winter chilling hours has declined as much as 30 percent since 1950 in large swaths of the Central Valley, where most of the tree crops are grown. The report indicates that by the end of the century, "areas where safe winter chill exists for growing walnuts, pistachios, peaches, apricots, plums and cherries are likely to almost completely disappear."

## Future Scenarios

For Update 2009, we evaluated different ways of managing water in California depending on alternative future conditions and different regions of the state. The ultimate goal is to evaluate how different regional response packages, or combinations of resource management strategies from Volume 2 perform under alternative possible future conditions. The alternative future conditions are described as future scenarios. Together the response packages and future scenarios show what management options could provide for sustainability of resources and ways to manage uncertainty and risk at a regional level. See Box TL-5 for scenario descriptions.

### Total Demand Change

The change in total water demand in the Tulare Lake region for the three scenarios—Current Trends, Slow & Strategic Growth, and Expansive Growth—is shown in

### Box TL-5 Scenario Descriptions

Update 2009 uses three baseline scenarios to better understand the implications of future conditions on water management decisions. The scenarios are referred to as baseline because they represent changes that are plausible and could occur without additional management intervention beyond those currently planned. Each scenario affects water demands and supplies differently.

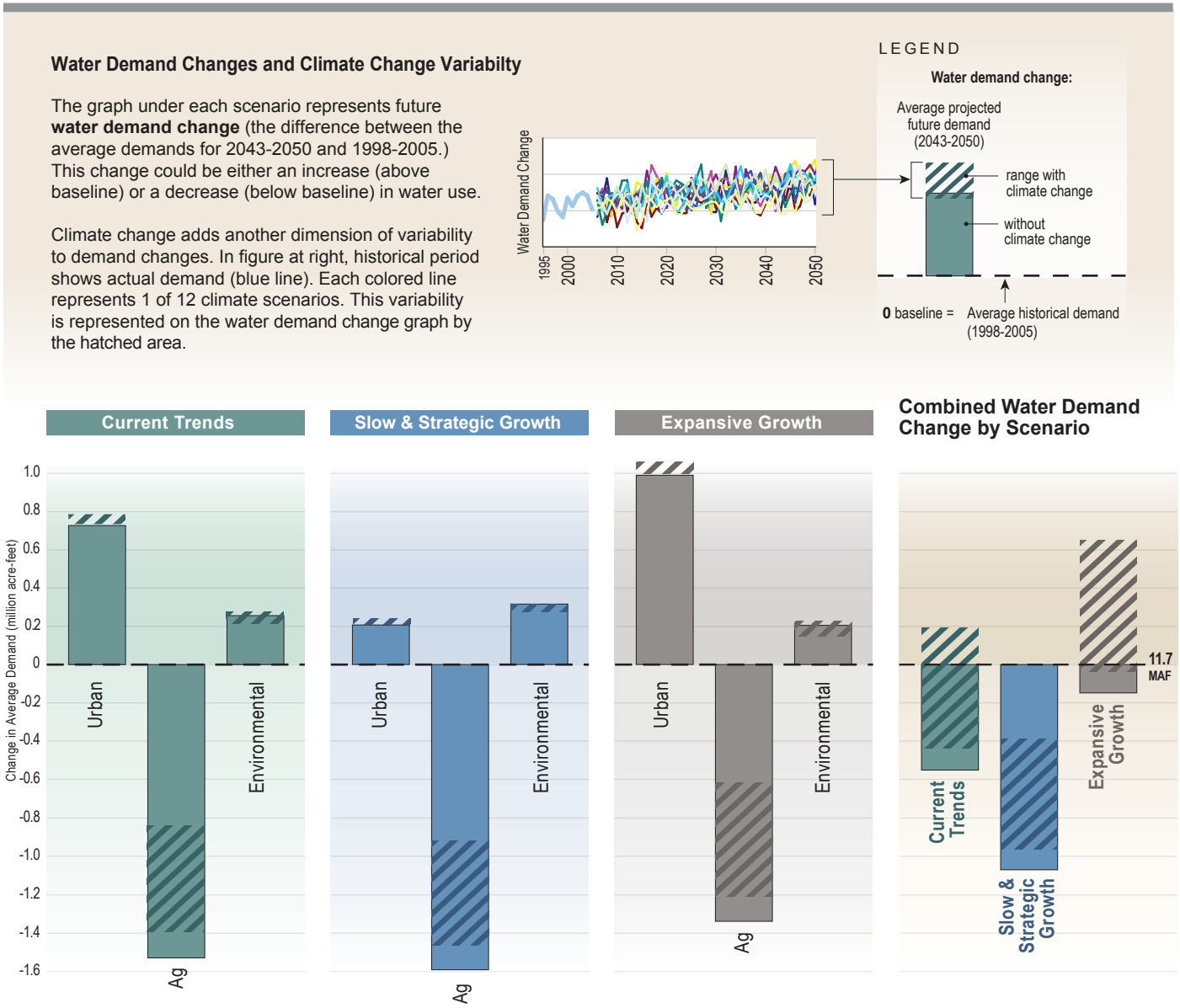
- **Scenario 1 – Current Trends.** For this scenario, recent trends are assumed to continue into the future. In 2050, nearly 60 million people live in California. Affordable housing has drawn families to the interior valleys. Commuters take longer trips in distance and time. In some areas where urban development and natural resources restoration has increased, irrigated crop land has decreased. The state continues to face lawsuits: from flood damages to water quality and endangered species protections. Regulations are not comprehensive or coordinated, creating uncertainty for local planners and water managers.
- **Scenario 2 – Slow & Strategic Growth.** Private, public, and governmental institutions form alliances to provide for more efficient planning and development that is less resources intensive than current conditions. Population growth is slower than currently projected—about 45 million people live here. Compact urban development has eased commuter travel. Californians embrace water and energy conservation. Conversion of agricultural land to urban development has slowed and occurs mostly for environmental restoration and flood protection. State government implements comprehensive and coordinated regulatory programs to improve water quality, protect fish and wildlife, and protect communities from flooding.
- **Scenario 3 – Expansive Growth.** Future conditions are more resource intensive than existing conditions. Population growth is faster than currently projected with 70 million people living in California in 2050. Families prefer low-density housing, and many seek rural residential properties, expanding urban areas. Some water and energy conservation programs are offered but at a slower rate than trends in the early century. Irrigated crop land has decreased significantly where urban development and natural restoration have increased. Protection of water quality and endangered species is driven mostly by lawsuits, creating uncertainty.

Figure TL-5. Change in water demand is based on the difference between the historical average (1998-2005) and future average (2043-2050) water demands. Future water demand is shown with and without climate change. The change in water demand without climate change is shown with solid bars and change with climate change is shown with hatched bars. As shown in the figure, future water demand relative to historical period without climate change (solid bar) shows a reduction of about 550 thousand acre-feet under Current Trends scenario. The reduction was even more significant under Slow & Strategic Growth (1,075 thousand acre-feet). Expansive Growth scenario shows a decrease in water demand (about 150 thousand acre-feet). Considering the 12 climate change sequences (hatched bar), the Current Trends scenario shows a lower reduction in water demand of 435 thousand acre-feet to an increase of 195 thousand acre-feet. The Slow & Strategic Growth scenario also shows a lower future water demand than historical demands across the 12 climate alternatives. Under the Expansive Growth scenario, the range of possible future water demand varies across the 12 climate sequences, from a decrease of 35 thousand acre-feet to an increase of 650 thousand acre-feet.

## Urban Demand Change

Figure TL-5 shows urban water demand change in the Tulare Lake region with and without climate change under the Current Trends, Slow & Strategic Growth and

**Figure TL-5 2050 Water demand changes, Tulare Lake Hydrologic Region**




Expansive Growth scenarios. Without climate change (solid bar), all three scenarios show an increase in urban water demand relative to historical water use. The Current Trends scenario shows about a 725 thousand acre-feet increase in future demand, while the Slow & Strategic Growth scenario shows a smaller increase in demand (about 205 thousand acre-feet). The Expansive Growth scenario shows an increase of about 990 thousand acre-feet. When climate change is factored in, all three scenarios show relatively moderate increases in urban demand.

### Agricultural Demand Change

Change in agricultural water demand in Tulare Lake region is shown in Figure TL-5. Agricultural water demand is generally lower under future conditions due to reduction in irrigated acreage and increases in background water conservation. Without climate change (solid bar), Slow & Strategic Growth had slightly larger reduction (1,600 thousand acre-feet), followed by Current Trends scenario (1,535 thousand acre-feet). Expansive Growth scenario shows slightly less reduction (about 1,345 thousand acre-feet). When climate change is considered (hatched bar), there is a smaller reduction in future water demand under all three scenarios.

### Environmental Demand Change

Figure TL-5 shows environmental water demand change in the Tulare Lake region. Future environmental water demand is based on historical unmet demand and indexed to climate. Without climate change, Slow & Strategic Growth shows the most increase in future environmental demand (320 thousand acre-feet) and Expansive Growth shows a smaller increase (200 thousand acre-feet). This is due to assumption that more additional water will be provided under the Slow & Strategic Growth scenario than the other two scenarios. Future increases in environmental water demand under the Current Trends scenario is somewhere in between (250 thousand acre-feet). When climate change is factored in, all three scenarios show a variation around the "without climate" condition across the 12 climate change sequences. Current Trends shows a minimum and maximum range of change in water demand between 210 thousand acre-feet and 270 thousand acre-feet, respectively. The Slow & Strategic Growth scenario shows a narrower range between 270 thousand acre-feet and 320 thousand acre-feet. Expansive Growth, however, shows a slightly larger range of between 150 thousand acre-feet and 230 thousand acre-feet.

# Appendix A. Flood Management

## Historic Floods

### Flood Parameters

Table TLA-1, Record floods for selected streams, is based on US Geological Survey records. The stations were selected from all USGS gaging stations in the hydrologic region, according to the criteria in Box TLA-1.

**Box TLA-1 Selection Criteria**

- The watercourse must be a natural stream with a watershed of at least 100 square miles.
- The station must have a reasonably continuous record of discharge from 1996 to the present.
- The station must be far enough from other stations on the same river to reasonably represent a separate condition.
- Stations in well defined watercourse locations such as deep canyons are omitted, unless particularly important to the overall flood situation.

### Flood Descriptions

**December 1955.** A family of cyclones from the mid-Pacific Ocean poured rain and snowmelt on low elevations of the Tulare Lake Hydrologic Region in December 1955, inundating 183,000 acres of agricultural land and the towns of Visalia, Three Rivers, and Exeter.

**1966-1967.** Flooding during the winter of 1966-1967 took three lives and drowned 142,000 acres of agricultural land.

**January-February 1969.** Heavy precipitation plus a prodigious snowpack in January and February 1969 caused flooding throughout the region and re-inundated 89,000 acres of the Tulare Lake bed.

**Table TLA-1 Record floods for selected streams, Tulare Lake Hydrologic Region**

| Stream | Location | Mean annual runoff (taf) | Peak stage of record (ft) | Peak discharge of record (cfs) |
|---|---|---|---|---|
| Kern River | near Democrat Springs | 480[2] | 18.6 | 10,100 |
| South Fork Kern River | near Onyx | 90 | 18.9 | 28,700 |
| Kern River | near Kernville | 344[2] | 24.4[1] | 60,000 |
| South Fork Tule River | near Reservation Boundary | 23 | 13.0 | 5,060 |
| Middle Fork Kaweah River | near Potwisha Camp[3] | 105[2] | 29.0 | 46,800 |
| Los Gatos Creek | above Nuñez Canyon, near Coalinga | 4 | 14.0[1] | 5,700 |
| North Fork Kings River | below Dinkey Creek, near Balch Camp | 248 | 19.2 | 27,400 |
| North Fork Kings River | near Cliff Camp | 33[2] | 12.0 | 5,110 |

taf = thousand acre-feet; ft = feet; cfs = cubic feet per second

1 Different date than peak discharge.

2 Most recent but less than period of record.

3 Low flow gage only, beginning 2004.

**Table TLA-2 Flood management participants, Tulare Lake Hydrologic Region**

| | Structural approaches | | | | | | Land use management | | | | | | | | Preparedness, response and recovery | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Flood projects | | | | | | Floodplains | | | Flood insurance | | | Regulation | | Data management | | | Flood education | Event management | | | | | | |
| | Financing | Development | Construction | Operation | Encroachment control | Maintenance | Conservation | Restoration | Delineation | Administration | Participation | FIRM mapping | Building permits | Designated floodways | Data collection | Hydrologic analysis | Data station maintenance | | Preparedness | Response management | Response personnel | System administration | Recovery funding | Recovery operations | Mitigation |
| **Federal agencies** | | | | | | | | | | | | | | | | | | | | | | | | | |
| Federal Emergency Management Agency | | | | | | | | | | ● | | ● | | | | | | | | | | | ● | | ● |
| National Weather Service | | | | | | | | | | | | | | | ● | ● | ● | ● | ● | ● | ● | | | | |
| Natural Resources Conservation Service | ● | ● | ● | | | | | | | | | | | | | | | ● | | | | | | | |
| US Geological Survey | | | | | | | | | | | | | | | ● | ● | ● | | | | | | | | |
| US Army Corps of Engineers | ● | ● | ● | ● | ● | ● | | | | | | | | | ● | ● | ● | ● | ● | ● | ● | | ● | ● | ● |
| **State agencies** | | | | | | | | | | | | | | | | | | | | | | | | | |
| California Conservation Corps | | | | | | | | | | | | | | | | | | | | ● | ● | | | | |
| Central Valley Flood Protection Board | | | | | ● | ● | | | | | | | | ● | | | | | | | | | | | |
| Department of Corrections | | | | | | | | | | | | | | | | | | | | | ● | | | | |
| Department of Forestry and Fire Protection | | | | | | | | | | | | | | | | | | | | ● | | | | | |
| Department of Water Resources | ● | ● | ● | ● | ● | ● | | | ● | ● | | ● | | | ● | ● | ● | ● | ● | ● | ● | | ● | ● | |
| Emergency Management Agency | | | | | | | | | | | | | | | | | | | ● | ● | ● | ● | ● | | ● |
| **Local agencies** | | | | | | | | | | | | | | | | | | | | | | | | | |
| County emergency services units | | | | | | | | | | | | | | | | | | | ● | ● | ● | | | | |
| County planning departments | | | | | | | | | | | | | | ● | | | | | | | | | | | |
| County building departments | | | | | | | | | | | | | ● | | | | | | | | | | | | |
| Local flood maintenance organizations | | | | ● | ● | ● | | | | | | | | | | | | | | | | | | | |
| Local conservation corps | | | | | | | | | | | | | | | | | | | | ● | ● | | | | |
| Local initial responders to emergencies | | | | | | | | | | | | | | | | | | | ● | ● | ● | | | | |
| City of Bakersfield | | | | ● | ● | ● | | | | | | | | | | | | | | | | | | | |
| Levee Districts 1 and 2 of Tulare County | | | | ● | ● | ● | | | | | | | | | | | | | | | | | | | |
| Ten reclamation districts | | | | ● | ● | ● | | | | | | | | | | | | | | | | | | | |
| Kings River Conservation District | | | | ● | ● | ● | | | | | | | | | | | | | | | | | | | |

**March 1995.** An El Niño year contributed a string of subtropical storms that walloped the region in March 1995, which resulted in severe flooding and destroyed an Interstate 5 bridge near Coalinga.

**January 1997.** Heavy precipitation in January 1997 flooded the region, causing a levee break on the Tule River and submerging 50,000 acres of agricultural lands in the Tulare Lake bed.

**1998.** In 1998 a heavy snowpack and warm rains produced flooding in the White River that flooded the City of Earlimart and closed US 99 for a week.

## Flood Governance

Many federal, State, and local agencies have responsibilities in the overall effort to manage floods. The principal participants in the Tulare Lake Hydrologic Region and their activities are listed in Table TLA-2. Most listed activities are self-explanatory. Descriptions of some follow.

- **Flood project development.** Performing feasibility studies, planning, and design of constructed facilities.
- **Encroachment control.** Establishing, financing and operating a system of permitting and enforcing permits to encroach on constructed facilities.
- **Floodplain conservation or restoration.** Any overt activity causing part of a floodplain to remain in effect or to be reinstated as a watercourse overflow area.
- **Flood insurance administration or participation.** Contribution to the management of or acting as a sponsor and cooperator in the National Flood Insurance Program including the Community Rating System.
- **Hydrologic analysis.** Hydrologic or statistical analysis of collected hydrometeorological data.
- **Flood education.** Informing the general public about any aspect of flood management; publishing or broadcasting collected hydrometeorological data or other flood-related material.
- **Recovery operations.** Financing or performing any activity intended to return flood-impacted facilities or persons to normal status.
- **Event management system administration.** Oversight of the National Incident Management System/Standardized Emergency Management System (NIMS/SEMS) as applied to California.

## Flood Risk Management

### Structural Approaches

The Kings River Flood Control Project is a large project including 14 weirs and many miles of levees to provide flood protection to agricultural lands near Hanford and to manage division of floodflows between Tulare Lake and the San Joaquin River.

The principal reservoirs and non-storage facilities contributing to flood control are listed below in Table TLA-3, Flood control facilities.

### Disaster Preparation, Response, and Recovery

Management of flood emergencies is the responsibility of many organizations and individuals. Response is required by law to conform to the SEMS, under which action is taken by levels of organization. It is begun by the person or organization on the site. That entity resists personal injury and property damage to the best of its ability, only calling on the next level when its resources become insufficient, and succeeding levels follow the same procedure. Table TLA-4 indicates the responsible entities at successive levels of response.

Accurate hydrologic and hydraulic models inform the design of effective flood control structures and emergency actions before, during, and after floods. The National Weather Service's Advanced Hydrologic Prediction Service uses historical hydrologic data, current river and watershed conditions, and near-term meteorological outlooks to forecast river flows. The service is publicly available for certain streams of the Tulare Lake region. AHPS stream forecast points are given in Table TLA-5.

## Regional Water and Flood Planning and Management

### Integrated Regional Water Management

Two of the four regional water management plans in this region address flood control. The Westside Regional Drainage Plan proposes constructing a flood detention reservoir on Arroyo Pasajero within retired farm lands. The Upper Kings Basin Water Forum addresses the importance of curtailing flood damages through structural works, floodplain management, and conjunctive uses; it has two projects directed toward enhanced flood control and a number of conjunctive use projects that have ancillary flood reduction benefits.

**Table TLA-3 Flood control facilities, Tulare Lake Hydrologic Region**

| Facility | Stream | Owner (sponsor) | Description | Protects |
|---|---|---|---|---|
| **Reservoirs and lakes** | | | | |
| Pine Flat L. | Kings R. | USACE | Rain 260 taf flood control. Snow 1,000 taf flood control | Areas downstream on the Kings River, Tulare Lake Basin, and areas downstream on the San Joaquin River |
| L. Kaweah | Kaweah R. | USACE | 185 taf flood control | Visalia and vicinity and Tulare Lake Basin |
| L. Success | Tule R. | USACE | 82 taf flood control | Porterville and vicinity and Tulare Lake basin |
| L. Isabella | Kern R. | USACE | Rain 325 taf flood control. Snow 568 taf flood control | Bakersfield and vicinity and Tulare Lake Basin |
| Big Dry Creek Reservoir (RFCFCP) | Big Dry Cr., Dog Cr. | USACE (FMFCD) | 30 taf flood control, diversion channels | Fresno, Clovis, and vicinity |
| Big Dry Creek Detention Basin (RFCFCP) | Big Dry Cr. | FMFCD | 260 af flood control | Fresno and Clovis |
| Redbank Creek Reservoir (RFCFCP) | Redbank Cr. | USACE (FMFCD) | 1,030 af flood control | Fresno and Clovis |
| Redbank Creek Detention Basin (RFCFCP) | Redbank Cr., Mill Ditch | USACE (FMFCD) | 940 af flood control | Fresno and Clovis |
| Fancher Creek Reservoir (RFCFCP) | Fancher Cr., Hog Cr. | USACE (FMFCD) | 9,908 af flood control | Fresno and Clovis |
| Alluvial Drain Detention Basin (RFCFCP) | Alluvial Drain | USACE (FMFCD) | 385 af flood control | Fresno and Clovis |
| Pup Creek Detention Basin (RFCFCP) | Pup Cr. | USACE (FMFCD) | 630 af flood control | Fresno and Clovis |
| Fancher Creek Detention Basin | Fancher Cr., Mud Cr. | FMFCD | 1,891af flood control | Fresno and Clovis |
| Tehachapi | Tehachapi Cr., Mendiburu Cr. | NRCS | 764 af and 625 af flood control, channels | Tehachapi and vicinity |
| **Non-storage flood control facilities** | | | | |
| Kings River Flood Control Project | Kings R., North Fork Kings R., South Fork Kings R., Clark Fork Kings R., Dutch John Cut, Cole Slough, Fresno Slough, Crescent Bypass | USACE (KRCD) | Levees, improved channels, weir modification | Laton and vicinity |
| Redbank-Fancher Creeks Flood Control Project (RFCFCP) | Big Dry Cr., Redbank Cr., Fancher Cr., Dog Cr., Hog Cr., Mud Cr., Pup Cr., Mill Ditch, Alluvial Drain | USACE, FMFCD (FMFCD) | Seven flood control dams (See above under "Reservoirs and Lakes"), diversion channels | Fresno, Clovis and vicinity |
| Kern River Intertie | Kern R., California Aqueduct | USACE | Sedimentation basin and inlet gate | Buena Vista Lake Basin |
| Holland Creek Rediversion Channel | Holland Cr. | FMFCD | Diversion channel | Fresno and Clovis |
| Stone Corral | Unnamed tributaries to Cottonwood Cr. | NRCS | Channels | East of Seville |
| Woodlake-Antelope Valley | Antelope Cr. | NRCS | Channels | Woodlake and vicinity |

Note: af = acre-feet; taf = thousand acre-feet

**Table TLA-4 Flood emergency responders, Tulare Lake Hydrologic Region**

| Responder | Level | Comment |
|---|---|---|
| Person(s) or organization(s) on the site | 0 | Any emergency |
| Emergency services units of the 35 cities in the region | 1 | Any emergency |
| Emergency services units of the six counties in the region | 1 or 2 | Any emergency, and by request from Level 1 responders |
| Department of Water Resources | 2 | Flood Operations Center, flood fight and Corps liaison |
| California Emergency Management Agency, Coastal Region | 3 | Any emergency, San Benito County, by request of county (operational area) |
| California Emergency Management Agency, Inland Region | 3 | Any emergency, Fresno, Kern, Kings and Tulare Counties, by request of county (operational area) |
| California Emergency Management Agency, Southern Region | 3 | Any emergency, San Luis Obispo County, by request of county (operational area) |
| US Army Corps of Engineers | 3 | Specified water-related emergencies, by request of DWR |
| California Conservation Corps | 3 | Personnel and equipment for flood fight |
| Department of Forestry and Fire Protection | 3 | Personnel and equipment for flood fight |
| Office of Emergency Services Headquarters | 4 | All emergencies, entire hydrologic region, by request of Cal EMA region |

**Table TLA-5 Advanced Hydrologic Prediction Service stream forecast points, Tulare Lake Hydrologic Region**

| River Basin | Stream | Location |
|---|---|---|
| Tulare Lake | Kaweah River | Lake Kaweah |
| Buena Vista Lake | Kern River | Lake Isabella |
| Tulare Lake | Kings River | Pine Flat Reservoir |
| Tulare Lake | Tule River | Lake Success |

# Appendix B. Water Quality

## Salinity

When water is used, salts are left behind. Sometimes this salt is intentionally added (e.g., home water softeners, plant fertilizers), but even when no salts are added to the system, evaporation and consumptive use act to concentrate unused salts. Additionally, salts move with water so salts originating in one basin will turn up in another. This is a significant problem when the receiving basin has no reliable way of disposing the salt, as is the case in the Tulare Lake Hydrologic Region. Salinity increases can affect municipal, agricultural, and industrial beneficial uses of water and the ability to recycle and reuse municipal wastewater.

Irrigated agriculture accounts for most of the developed water use in the Tulare Lake region. The crucial problem in the region is the salts brought in with irrigation water and leached out of soils. Evaporation and crop transpiration remove water from soils, which can result in an accumulation of salts in the root zone of the soils at levels that retard or inhibit plant growth. Additional amounts of water often are applied to leach the salts below the root zone. The leached salts eventually enter groundwater or surface water.

The groundwater basin in the San Joaquin Valley portion of the Tulare Lake Hydrologic Region is an internally drained and closed basin. It has no appreciable surface or subsurface outflow, except in extremely wet years. Salts (generally measured as total dissolved solids [TDS]) are introduced into the basin with imported water supplies. In addition, many of the naturally occurring geologic deposits along the western portion of the region are of marine origin and, therefore, have high salt content. A number of regulated point sources discharge treated wastewater into the region's surface waters, including municipal sewage treatment plants and food processing, manufacturing, and oil and gas facilities.

Over the years, the Central Valley Regional Water Quality Control Board (Regional Water Board) has been aware of the growing problem of increasing salinity in the Central Valley. The salinity impairment of surface water and groundwater in the Central Valley is a subset of a more far-reaching problem shared by most of California, other arid western states, and much of the developed world.

The movement of the salts to surface waters can occur as shallow subsurface groundwater flows, or it can result from the surface water discharge of agricultural subsurface collection systems (or tile drains), which are employed in areas where farm lands have naturally poor drainage. Tile drains consist of pipe systems below the root zone of crops that drain water from the soil profile that would otherwise stay saturated. Salinity of tile drainage can range from 1,000 milligrams per liter TDS to more than 30,000 mg/L TDS. Tile drain water can also contain trace elements and nutrients.

Subsurface drainage will be a constant threat to surface water and usable groundwater quality unless the disposal method is adequate. Disposal must be in a manner that isolates the salts in the drainage from the usable groundwater body. In some areas of the region, evaporation ponds or basins are used to concentrate drainage water and contain salts. Concentrations of salt within evaporation basins can range from 2,000 mg/L to more than 200,000 mg/L TDS.

Evaporation ponds constitute attractive oases for many species of wildlife. Aquatic migratory birds of the Pacific Flyway are drawn to the ponds, in part because almost all of the native aquatic and wetland habitats in the San Joaquin Valley (especially in the Tulare Lake region) have been lost and because the ponds hold surface water in a vast, agricultural landscape with few water bodies. The ponds also produce abundant aquatic invertebrates that feed large numbers of waterbirds. Evaporation basins have varying potentials to impact wildlife, specifically shorebirds. Selenium is the predominate constituent linked to wildlife impacts.

The Water Quality Control Plan for the Tulare Lake Basin (Basin Plan) recognizes that the degradation of groundwater in the Tulare Lake Basin by salts is unavoidable without a plan for removing salts from the basin so the Basin Plan provides for controlled degradation to protect the water as long as possible. Recommended strategies include application or disposal of consolidated treated effluents to the west toward the drainage trough of the valley and reuse of salts, such as nitrates, in waste streams to reduce the need to import salts. In 2002, the US Bureau of Reclamation released the San Luis report, which declared that an “in-valley” solution to the drainage problem on the valley’s west side should be implemented. The proposed alternative includes the following features: a drainwater collection system, regional drainwater reuse facilities, selenium treatment, reverse osmosis treatment for the northerly area, and evaporation ponds for salts disposal.

Considerable increase in groundwater TDS and nitrate occurs in the San Joaquin Valley as result of surface disposal of municipal wastewater and agricultural operations resulting in the deep percolation of fertilizer and natural minerals. Contributions to TDS occurs from agricultural water users, concentrated animal feeding operations (CAFOs), urban water users, rural water users, environmental water uses, industrial users, water providers, petroleum production among others.

Consumptive use of water increases salinity and surface disposal of water results in deep drainage which eventually reaches the water table. All of these activities contribute to salinity impairments in surface water and groundwater, essentially identifying most of society a contributor to the problem. It is essential that locals are part of the solution through development and implementation of a salinity management plan. Because these salinity concentrations typically occur very slowly, surface water and groundwater impairments can be difficult to measure and quantify.

According to a Regional Water Board program statement, "The Central Valley Regional Water Quality Control Board and State Water Resources Control Board have initiated a comprehensive effort to address salinity problems in California's Central Valley and adopt long-term solutions that will lead to enhanced water quality and economic sustainability. Central Valley Salinity Alternatives for Long-Term Sustainability (CV-SALTS) is an effort to develop and implement a comprehensive salinity management program. The goal of CV-SALTS is to maintain a healthy environment and a good quality of life for all Californians by protecting our most essential and vulnerable resource: WATER." (http://www.swrcb.ca.gov/rwqcb5/water_issues/salinity/)

CV-SALTS has three goals: (1) engage all water users to actively participate, (2) all users contributing or impacted by salts contribute financially to planning and control efforts, and (3) develop and implement a regional Salinity Management Plan.

Protecting high quality source waters should be part of the solution. These solutions go beyond the board's jurisdiction and require cooperation by a number of local, State, and federal agencies. Solutions within the board's jurisdiction need to be incorporated into the board's basin plans. Basin plan amendments that the board could consider may result in more restrictive discharge limits, requirements to conduct costly studies, implementation of treatment measures or projects to manage salt, and potentially prohibition of certain discharges. Design, construction, and operation of infrastructure necessary to control salinity also will be expensive. Failure to control salinity, however, will result in continued decline of San Joaquin Valley water quality at an enormous cost to all water users, eventually creating even greater hardship for the environment, agriculture, industry, municipal utilities, and the entire economy of the valley and the state.

The Department of Water Resources and other groups are working to explore ways to reduce the volume of drainage effluent through various means such as integrated on-farm drainage management, drainage treatment (by reverse osmosis, reducing and removing selenium through biological processes, and managing salt by using solar salt-gradient ponds and agro forestry), and drainage monitoring.

The issue and impacts of salinity are lasting and far reaching. In the very long-term, the solution must entail effective source control measures and a permanent and sustainable removal of salts from the valley.

## Pesticides

The 2003 update of California' Groundwater (DWR Bulletin 118) includes a summary of water quality from public supply water wells sampled from 1994 to 2000. From 1994 through 2000, 1,476 public supply water wells were sampled in 14 of the 19 groundwater basins and subbasins in the Tulare Lake Basin. In general, groundwater quality throughout the region is suitable for most urban and agricultural uses with only local impairments.

## Nitrates and Other Groundwater Contaminants

Tulare County has been addressing nitrates in groundwater for years. County officials estimate that at least 20 percent of the nearly 400 small, public drinking water supply systems in the county are polluted, with nitrate levels exceeding the federal limit of 45 parts per billion.

From 1994 through 2000, 1,476 public supply water wells were sampled in 14 of the 19 groundwater basins and subbasins in the Tulare Lake Basin. Evaluation of analyzed samples shows that 1,049 of the wells, or 71 percent, met the state primary maximum contaminant levels for drinking water; 427 or 27 percent, exceeded one or more MCLs.

High TDS content in the trough of the valley is the result of concentration of salts because of evaporation and poor drainage. In the central and west-side portions of the valley, where the Corcoran Clay confining layer exists, water quality is generally better beneath the clay than above it. Nitrates may occur naturally or as a result of disposal of human and animal waste products and fertilizer. Areas of high nitrate concentrations are known to exist near the town of Shafter and other isolated areas in the San Joaquin Valley. High levels of arsenic occur locally and appear to be associated with lakebed areas. Elevated arsenic levels have been reported in the Tulare Lake, Kern Lake, and Buena Vista Lake bed areas.

Organic contaminants can be broken into two categories, agricultural and industrial. Agricultural pesticides and herbicides have been detected throughout the valley, but primarily along the east side where soil permeability is higher and depth to groundwater is shallower. The most notable agricultural contaminant is DBCP, a now-banned soil fumigant and known carcinogen once used extensively on grapes. Industrial organic contaminants include TCE, DCE, and other solvents. They are found in groundwater near airports, industrial areas, and landfills (DWR Bulletin 118).

During May through June 2006, the State Water Board's Domestic Well Project sampled private domestic supply wells in Tulare County. Among the 181 wells tested in Tulare County (most are to the east of Highway 99), 33 percent (60 of 181) tested positive for total coliform bacteria, and 41 percent (75 of 181) had nitrate levels at or above the drinking water standard (23 were in both categories) (SWRCB 2007).

A 1988 State Water Board report to the State Legislature on Nitrate in Drinking Water (1988) reported that 10 percent of the samples in STORET (the US Environmental Protection Agency database) were above primary maximum contaminant levels (10 mg/L nitrate as nitrogen). A geographical depiction of wells with levels of nitrate above background (greater than 4.5 mg/L nitrate as nitrogen) showed the highest densities in the Central Valley are close to the Highway 99 corridor and primarily around population centers (e.g., Modesto, Yuba City, Fresno, and Bakersfield) and concentrated animal confinement areas (e.g., feedlots and dairies). In California, nitrate is one of the most frequently exceeded constituents in public supply wells.

The primary health concern with the consumption of water with elevated nitrate is the condition known as methemoglobinemia. Methemoglobinemia, more commonly known as the "blue baby syndrome," is the interference by nitrate byproducts in the absorption of oxygen by hemoglobin in the blood. The nitrogen byproduct combines with hemoglobin to form methemoglobin, which is much less efficient in transporting oxygen. Infants younger than a year old are most susceptible; the oxygen deficit in the blood stream produces blue coloration of the lips and skins hence the term "blue baby." More severe cases result in death.

The primary sources of nitrate in groundwater are application of nitrogen fertilizers, disposal or reuse of animal waste at confined animal production facilities, and disposal of human sewage either in community sewer systems or individual sewer systems (septic systems).

Areas of intensive crop production in highly permeable soils, especially of crops with a high nitrogen demand (e.g., vegetables, citrus, and silage corn), are known or suspected of causing elevated nitrate levels in the groundwater (e.g., Salinas Valley, the Chico non-urban area, and Hilmar area of Merced County). Groundwater in crop production areas can become contaminated with nitrate when nitrogen fertilizers are applied at rates in excess of crop utilization and inefficient irrigation or high rainfall leach the nitrate to groundwater. Other factors that put groundwater at risk are a shallow aquifer, the absence of a restricting layer to vertical migration of nitrate, permeable soils and poor well construction. The Regional Water Board adopted general waste discharge requirements in May 2007 to control the discharges from the 1,550 milk cow dairies in the Central Valley. The board found that many dairies in the region have impacted groundwater quality with salt and nitrates. The general waste discharge requirements provide for a phased approach with several milestones that culminate in five years with Discharger certifications of facility retrofit and implementation of the Nutrient Management Plan with the goal of reducing salt and nitrate contamination. This program is implemented with the cooperation of the industry.

## Land Disposal

The Central Valley has approximately 600,000 individual onsite systems within its boundaries (equivalent dwelling units), of which the Tulare Lake region comprises of a significant portion. Collectively, these systems discharge approximately 120 million gallons per day to the subsurface. Pollutants of concern in these discharges consist primarily of nutrients and pathogens, but metals, salts, and personal care products (e.g., pharmaceuticals) are also a concern.

The Regional Water Board developed "Guidelines for Waste Disposal from Land Developments" (1976) to protect drinking water beneficial uses and human health concerns from contact. Since then, regulatory agencies have not had adequate

opportunity to evaluate the many developments in the onsite disposal industry, especially in foothill areas that have shallow soil cover and sloping surfaces.

In 2000, the legislature passed Assembly Bill 885, which required the State Water Board to develop regulations for onsite wastewater systems that ought to include criteria to evaluate new engineered onsite disposal systems. However, these regulations have not yet been adopted.

In the past, the Regional Water Board has prohibited discharge in problematic service areas. In the Tulare Lake Hydrologic Region, the board has adopted four prohibitions of discharge from individual sewage disposal systems. Currently, all of these areas are served by community sewage systems.

Water quality impacts can occur if septic tanks are not properly sited. There are likely other areas in the region that have groundwater contamination problems due to onsite wastewater treatment systems, but this potential problem has not been investigated.

## Legacy Mine Impacts

In the Tulare Lake Hydrologic Region, San Carlos, Silver, and Panoche creeks in the northwest part of the region are impacted by discharges from legacy mercury mining activities. Asbestos is also a concern in the western part of this hydrologic region where there are two asbestos mines in the Los Gatos Creek watershed that are part of US Environmental Protection Agency Superfund remediation efforts. These mines are also within the Clear Creek Management Area, which are public lands administered by the US Bureau of Land Management. The Clear Creek Management Area has naturally high levels of asbestos, which has resulted in the US Bureau of Land Management closing a portion of the Clear Creek Management

Historical mercury mining on the Coast Range side of the Central Valley and use of the mercury to amalgamate gold on the Sierra side has resulted in substantial mercury loads discharged to the Central Valley waterways. Methylmercury is the most toxic form of mercury and accumulates in successive levels of the food chain. It is a neurotoxicant that adversely affects reproductive and immune systems in humans and wildlife that consume contaminated fish and shellfish.

## Delta Drinking Water Policy

Establishing a policy for protecting Delta drinking water quality was seen as a priority by the Regional Water Board.

## Dairies, Stockyards, and Poultry Ranches

As of July 2008, there were 620 dairies with more than 1.013 million cows in the Tulare Lake Hydrologic Region. Half of the dairies (and more than one-half the cows)

are in Tulare County. Of these, approximately 575 are of sufficient size to meet the federal definition of a large CAFO, based on a threshold of 700 mature dairy cows. Concern in the region for their loadings of pathogens, nutrients, salts, and emerging contaminants (such as antibiotics) to water bodies has increased. Some dairies and other agricultural operations are already subject to regulatory review. Historically, most dairies in the region operated under a waiver of waste discharge requirements; this waiver expired in January 2003 (California's San Joaquin Valley: A Region in Transition, December 12, 2005).

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**The California Water Plan** provides a framework for resource managers, legislators, Tribes, other decision-makers, and the public to consider options and make decisions regarding California's water future. Our goal is that this document meet Water Code requirements, receive broad support among those participating in California's water planning, and be a useful document. With its partners, DWR completed the final Update 2009 volumes and Highlights in December 2009.

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