CHAPTER IV. ENVIRONMENTAL SETTING

Due to the significant interdependence of water supplies and uses in California, proposing standards for the Bay-Delta Estuary is relevant not only to the Estuary itself but also to a large portion of the State. Much has been already written on the environmental setting of the Estuary, the CVP and the SWP, and affected areas. Unless otherwise cited, the information presented in this chapter is extracted from two DWR sources (DWR 1990, 1993).

This chapter presents an overview of the principal features of the Central Valley (including the Sacramento River, San Joaquin River, and Tulare Lake basins), Sacramento-San Joaquin Delta, San Francisco Bay region, Suisun Marsh, Central Coast region and Southern California (SWP service areas). Because the facilities of the CVP and SWP are relevant to these areas, this chapter begins with a brief description of the two projects.

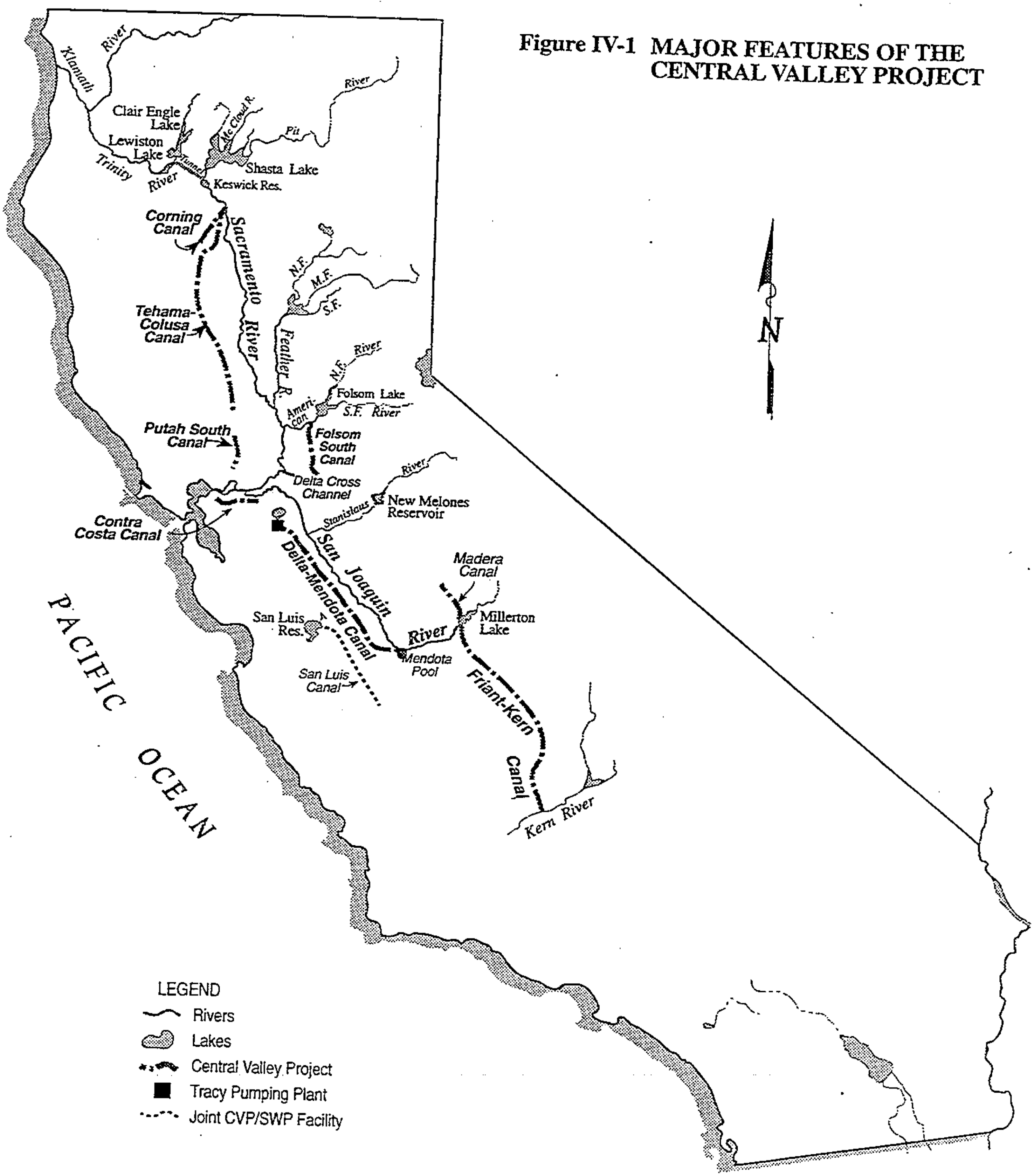
A. CENTRAL VALLEY PROJECT

The CVP, operated by the USBR, is a water storage and transport system designed to capture excess winter flows for flood control and power generation, and to deliver water for agricultural and municipal uses at various locations throughout the State. The CVP stores and controls waters of the Sacramento, Trinity, and American river basins in the northern part of the Central Valley basin for use in the Sacramento River basin and the water-deficient San Joaquin Valley. The CVP system consists of a series of facilities, including 20 reservoirs, eight hydroelectric power plants, two pumping-generating plants, and about 500 miles of major canals and aqueducts (USBR 1981, USBR and DWR 1986). The major features of the CVP are shown in Figure IV-1.

The CVP extends from the Cascade Range (at the northern end of the Central Valley) to the Kern River near Bakersfield (at the southern end of the Central Valley). The focal point of the CVP is Shasta Dam and Shasta Lake on the upper Sacramento River. This 4.5 MAF reservoir is fed by waters of the Sacramento, McCloud, and Pit rivers. Water released to the Sacramento River through Shasta Dam is augmented by water supplies from the Trinity River drainage to the west of the Central Valley. Water from the Trinity River basin, which is stored in Clair Engle and Lewiston lakes, is imported through a tunnel to the Sacramento River at Keswick Reservoir (north of Redding). At Sacramento, the Sacramento River is further augmented by water released from CVP reservoirs formed by Folsom and Nimbus dams on the American River.

A few miles downstream of the confluence with the American River, the Sacramento River enters the northern part of the Bay-Delta Estuary. About 30 miles south of Sacramento, the Delta Cross Channel regulates the passage of some Sacramento River water into interior Delta channels, with the remaining Sacramento River water flowing westward toward Suisun Bay. In the southern Delta, the CVP diverts water at Rock Slough and directly from Delta channels at the Tracy Pumping Plant. At Rock Slough, water is pumped into the Contra Costa Canal for municipal and industrial uses in Contra Costa County. At the Tracy

Figure IV-1 MAJOR FEATURES OF THE CENTRAL VALLEY PROJECT



Pumping Plant, water is lifted nearly 200 feet above sea level into the Delta-Mendota Canal and flows 117 miles southward to the Mendota Pool on the San Joaquin River.

The Delta-Mendota Canal, which follows the Coast Range foothills on the west side of the San Joaquin River, conveys water to agricultural users in the San Joaquin Valley and to the CVP's San Luis Unit for municipal, industrial, and agricultural uses. The San Luis Unit consists of some joint federal-State facilities, including O'Neill Dam and Forebay, San Luis Dam and Reservoir, and San Luis Canal. Water from the reservoir is released into the San Luis Canal for irrigation in the southern San Joaquin Valley.

At the Mendota Pool (the terminus of the Delta-Mendota Canal), waters from the north replace the natural flows of the San Joaquin River which are stored in Millerton Lake and Friant Dam in the foothills above Fresno. Water released through Friant Dam is diverted north through the Madera Canal to serve areas in the central San Joaquin Valley, and south through the Friant-Kern Canal to serve areas in the southern reaches of the San Joaquin Valley.

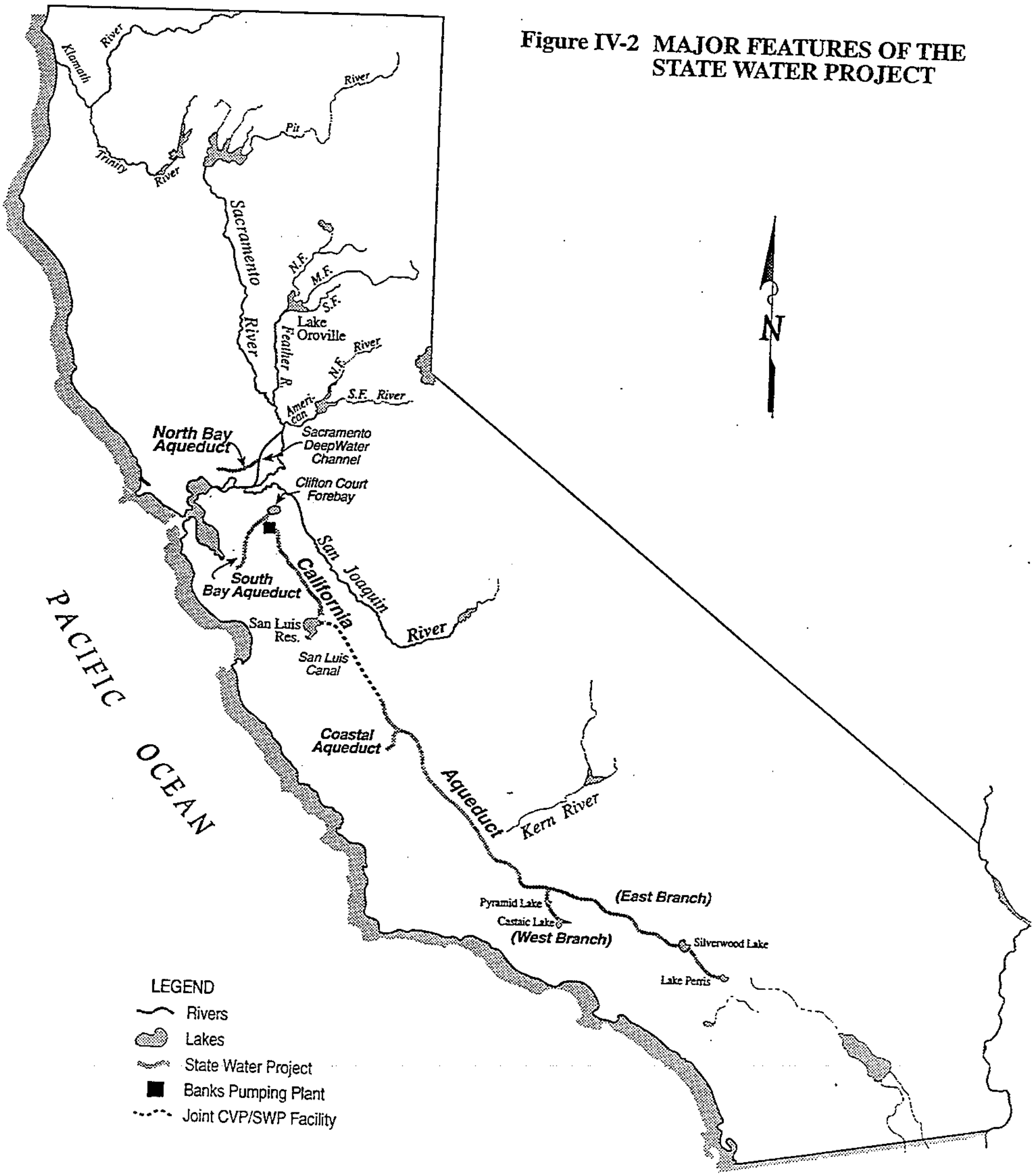
On the Stanislaus River, about 60 miles upstream from the confluence with the San Joaquin River, New Melones Dam forms New Melones Reservoir. Water from New Melones supplements existing supplies within the Stanislaus River basin and is used to maintain water quality in the San Joaquin River.

B. STATE WATER PROJECT

Like the CVP, the SWP stores runoff from the Sacramento Valley basin, releases stored water to the Sacramento River and the Delta, and pumps water out of the southern Delta for delivery to water users to the south and west. The SWP, operated by the DWR, includes 22 dams and reservoirs, 8 hydroelectric power plants, and 17 pumping plants. The major features of the SWP are shown in Figure IV-2.

The SWP's water storage facilities are on the Feather River, the chief component of which is Lake Oroville formed by Oroville Dam. Water from this 3.5 MAF capacity reservoir is released into the Feather River, where it flows into the Sacramento River 21 miles above Sacramento. This water, along with water managed by the CVP, flows in the Sacramento River to the Delta. In the northern Delta, water is diverted from Barker Slough, where it is pumped into the North Bay Aqueduct for use in Solano and Napa counties. In the southern Delta, water is diverted into Clifton Court Forebay, where the Harvey O. Banks Pumping Plant, near Byron, pumps it for diversion into the South Bay Aqueduct, which serves the southern San Francisco Bay area, and into the beginning of the California Aqueduct. The California Aqueduct is the main conveyance facility of the project and extends 444 miles from the Delta to Southern California. From the Delta, the California Aqueduct follows the west side of the San Joaquin Valley to the joint federal/State San Luis Reservoir and continues south to the Tulare Lake basin, where it serves most of the SWP agricultural users.

Figure IV-2 MAJOR FEATURES OF THE STATE WATER PROJECT



The California Aqueduct system was designed to have a capacity of not less than 10,000 cfs between the Banks Pumping Plant and San Luis Reservoir, and not less than 4,400 cfs at all points south of San Luis Reservoir where it leaves the Central Valley and is lifted nearly 2,000 feet into the Tehachapi Mountains by the A.D. Edmonston Pumping Plant. The water flows through a series of four tunnels until it splits into the West Branch, which transports water through Pyramid Lake to Castaic Lake in Los Angeles County, and the East Branch, which delivers water to the Antelope Valley and Silverwood Lake, and terminates at Lake Perris in Riverside County.

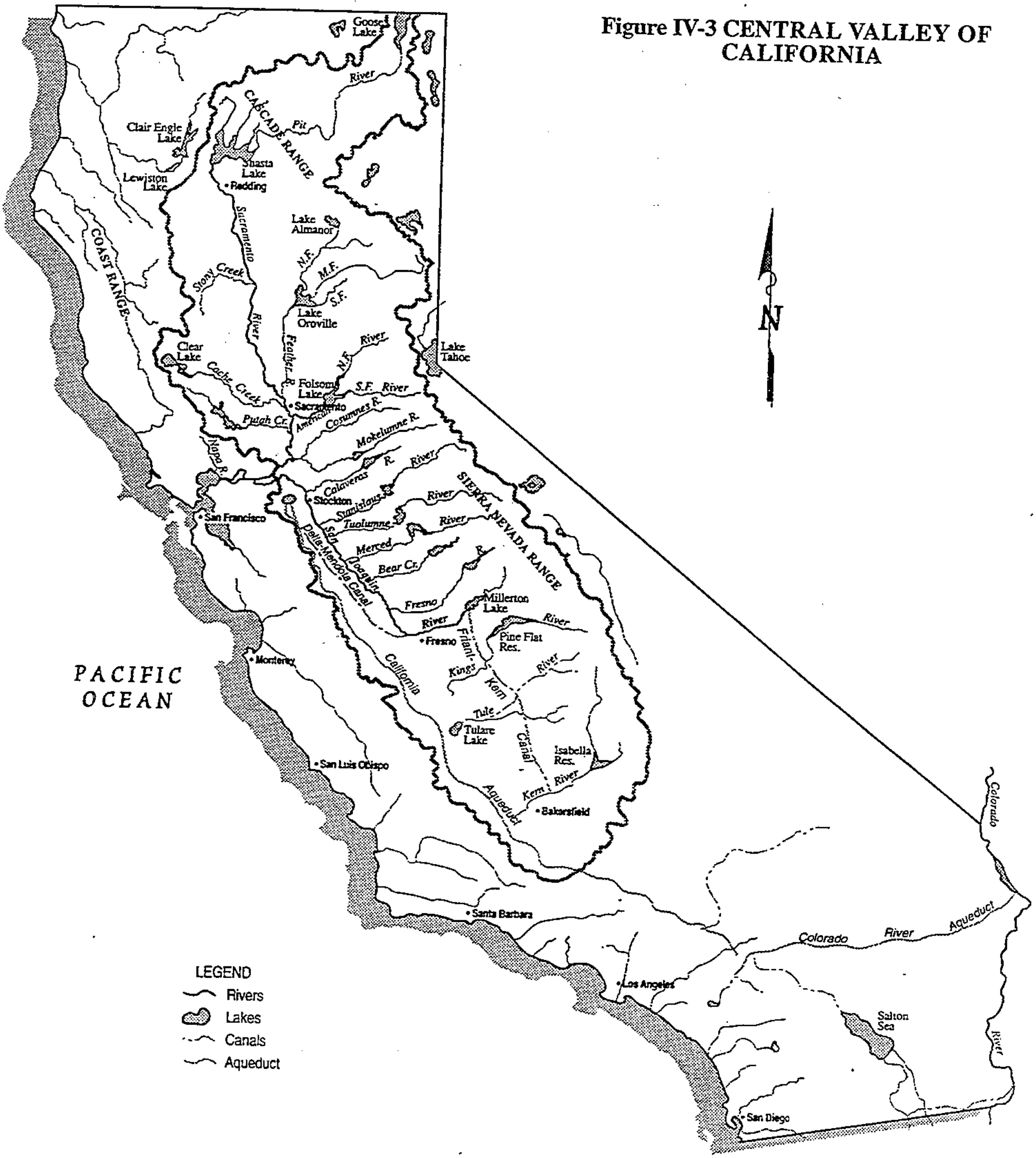
C. CENTRAL VALLEY BASIN

The Central Valley basin of California (Figure IV-3) is comprised of the 450-mile long Central Valley and the surrounding upland and mountain areas which drain into it. The basin, which encompasses about 60,000 square miles, makes up about 40 percent of California. The valley portion of the basin is an alluvial plain which is generally flat below an elevation of 400 feet and varies from 40 to 60 miles in width (USBR and DWR 1986), with an average width of about 45 miles. The valley floor occupies about one-third of the basin; the other two-thirds are mountainous. The basin is entirely surrounded by mountains except for a narrow gap on the western edge at the Carquinez Strait. The Cascade Range and Sierra Nevada on the north and east rise in elevation to about 14,000 feet. The Coast Range on the west generally rises to less than 4,000 feet, but rises to as high as 8,000 feet at the northern end.

Water supply for the Central Valley is chiefly derived from runoff from the mountains and foothills of the Sierra Nevada, with minor amounts from Coast Range streams entering the west side of the valley. Rainfall contributions on the floor of the basin add to the supply. About four-fifths of the annual precipitation, which varies widely, occurs during the winter between the last of October and the first of April, but snow storage in the high Sierra delays the runoff from that area until April, May, and June, in which months half the normal annual runoff occurs. Because a significant portion of precipitation in the basin occurs as winter snowfall in the mountains, runoff may lag precipitation, and the season of runoff often extends into late-spring and summer as the winter snows melt.

The primary use of water in the Central Valley basin is for the production of agricultural crops. However, water is also used by urban communities, industrial plants, and other uses. Surface water supplies have been developed by local irrigation districts, municipal utility districts, county agencies, private companies or corporations, and State and federal agencies. Flood control or water storage works exist on all major streams in the basin, which alters the natural flow patterns. These facilities store water for the dry season and protect against the winter floods that were common before water development. They also produce hydroelectric power, enhance recreation opportunities, and serve other purposes. A complex aquifer system underlies the Central Valley. Although ground water may occur near ground surface, the maximum depth to water is more than 900 feet. Usable storage capacity in a depth zone of 200 feet below ground surface has been estimated as between 80 to 93 MAF in the San

Figure IV-3 CENTRAL VALLEY OF CALIFORNIA



Joaquin River basin, and 22 to 33 MAF in the Sacramento River basin. Low yield in some areas is considered a limiting factor. The dissolved solids content of the ground water averages about 500 parts per million (ppm), but ranges from 64 to 10,700 ppm. The predominant water type varies with location in the aquifer, but calcium, magnesium, sodium, bicarbonates, sulfate, and chloride are all present in significant quantities.

The Central Valley basin is divided into the Sacramento Valley on the north and the San Joaquin Valley on the south. The Sacramento Valley encompasses the Sacramento River basin. The San Joaquin Valley has two sub-basins: the San Joaquin River basin and the Tulare Lake basin. The area in the center of the Central Valley where the Sacramento and San Joaquin valleys merge coincides with a break in the coastal mountains which border the basin on the west side. Here the Sacramento and San Joaquin rivers converge in the Bay-Delta Estuary, flow through Suisun Bay and Carquinez Strait into San Francisco Bay, and out the Golden Gate to the Pacific Ocean.

1. Sacramento Valley

The Sacramento Valley encompasses the drainage areas of California's largest river, the Sacramento. The valley lands comprise the western drainage of the Sierra Nevada and the Cascade Range, the eastern drainage of the Coast Range, and the valley floor (which makes up 34 percent of the basin). The Sacramento River basin (Figure IV-4) includes the McCloud and Pit river basins, the Goose Lake basin, the Feather, Yuba, Bear, and American river basins (which flow from the Sierra Nevada), and the basins of Cottonwood, Stony, Cache, and Putah creeks (which drain the Coast Range).

The climate of the valley floor areas of the Sacramento River basin is characterized by hot, dry summers and mild winters with relatively light precipitation. Warm, dry summers and cold winters with heavy rain and snow prevail in the mountainous areas where elevations exceed 5,000 feet. The average annual precipitation varies with elevation and ranges from less than 10 inches in the valley to over 95 inches in the Sierra Nevada and Cascade ranges.

Surface Water Hydrology. The Sacramento River basin has about two-thirds of the surface water supply of the Central Valley. Average runoff from the basin is estimated at 22.4 MAF per year (DWR 1994a). Water resources in the basin have been extensively developed for a wide range of purposes. The area has a total of about 16.0 MAF of surface storage capacity, with over 10.5 MAF in four major reservoirs: Lake Shasta on the Sacramento River (4.6 MAF), Oroville Reservoir on the Feather River (3.5 MAF), Folsom Lake on the American River (1.0 MAF), and Lake Berryessa on Putah Creek (1.6 MAF). A list of the major reservoirs in the Sacramento River basin is presented in Table IV-1. Substantial amounts of water are imported into the valley from the Trinity River Division of the CVP. Much smaller quantities of water are also imported into the region from the Cosumnes River (Sly Park), the Truckee River (Little Truckee Ditch), and the Echo Lake Conduit.

Figure IV-4 SACRAMENTO RIVER BASIN

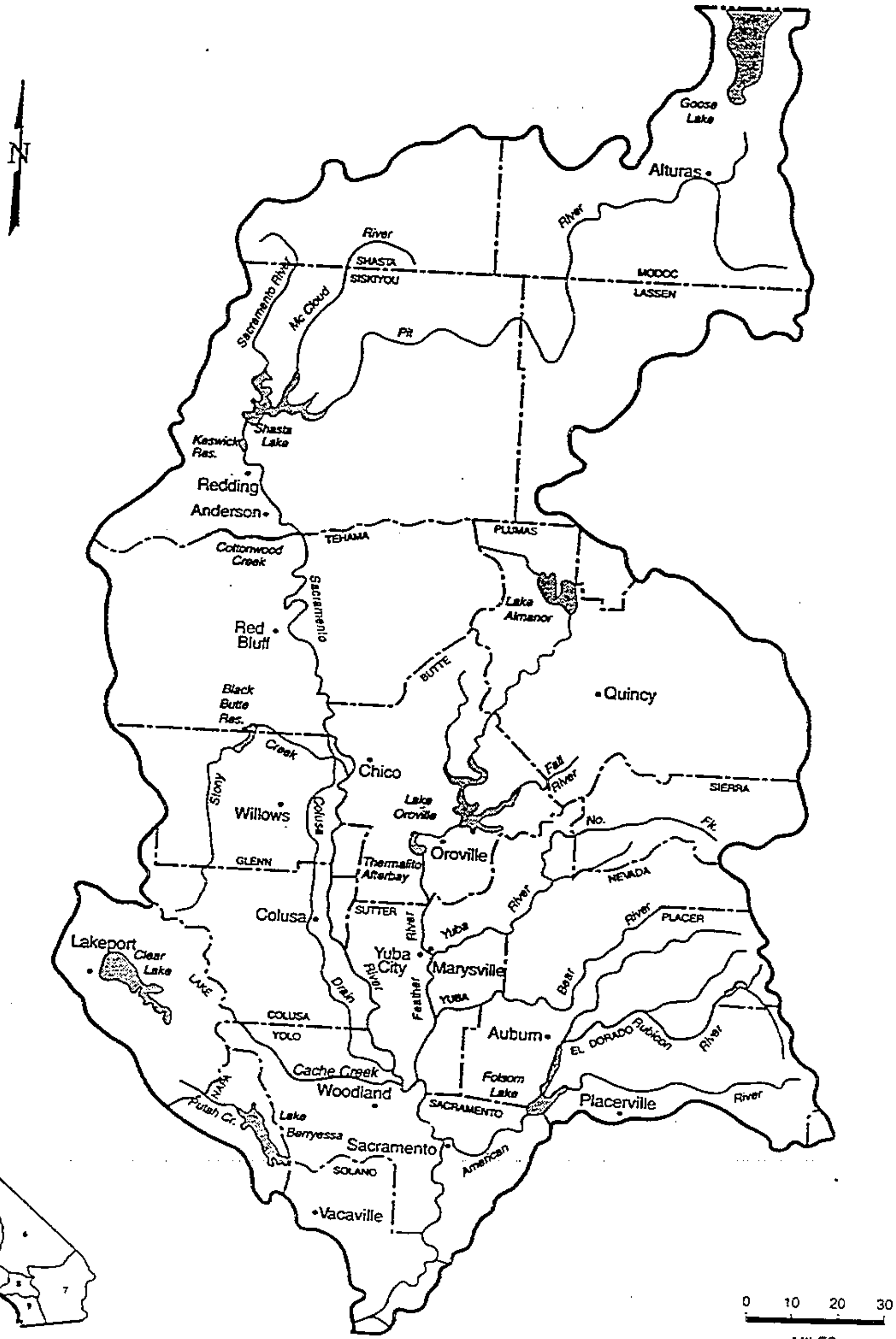


Table IV-1. Major Reservoirs in the Sacramento River Basin

Reservoir Name	Stream	Capacity (TAF)	Owner
McCloud	McCloud River	35.2	PG&E
Iron Canyon	Pit River	24.2	PG&E
Lake Britton	Pit River	40.6	PG&E
Pit No. 6	Pit River	15.9	PG&E
Pit No. 7	Pit River	34.6	PG&E
Shasta	Sacramento River	4,552.0	USBR
Keswick	Sacramento River	23.8	USBR
Whiskeytown	Clear Creek	241.1	USBR
Lake Almanor	Feather River	1,143.8	PG&E
Mountain Meadows	Feather River	23.9	PG&E
Butt Valley	Butt Creek	49.9	PG&E
Bucks Lake	Bucks Creek	105.6	PG&E
Antelope	Indian Creek	22.6	DWR
Frenchman	Little Last Chance Creek	55.5	DWR
Lake Davis	Big Grizzly Creek	84.4	DWR
Little Grass Valley	Feather River	94.7	Oroville Wyandotte ID
Sly Creek	Lost Creek	65.7	Oroville Wyandotte ID
Thermalito	Feather River	81.3	DWR
Oroville	Feather River	3,537.6	DWR
New Bullards Bar	Yuba River	966.1	Yuba County WA
Jackson Meadows	Yuba River	69.2	Nevada ID
Bowman Lake	Canyon Creek	68.5	Nevada ID
French Lake	Canyon Creek	13.8	Nevada ID
Spaulding	Yuba River	74.8	PG&E
Englebright	Yuba River	70.0	USCOE
Scotts Flat	Deer Creek	48.5	Nevada ID
Rollins	Bear River	66.0	Nevada ID
Camp Far West	Bear River	104.0	So. Sutter WD
French Meadows	American River	136.4	Placer Co. WA
Hell Hole	Rubicon River	207.6	Placer Co. WA
Loon Lake	Gerle River	76.5	SMUD
Slab Creek	American River	16.6	PG&E
Caples Lake	Caples Creek	26.6	PG&E
Union Valley	Silver Creek	277.3	SMUD
Ice House	Silver Creek	46.0	SMUD
Folsom Lake	American River	976.9	USBR
Lake Natoma	American River	9.0	USBR
East Park	Stony Creek	50.9	USBR
Stony Gorge	Stony Creek	50.4	USBR
Black Butte	Stony Creek	143.7	USCOE
Clear Lake	Cache Creek	313.0	Yolo Co. FCWCD
Indian Valley	Cache Creek	300.0	Yolo Co. FCWCD
Lake Berryessa	Putah Creek	1,600.0	USBR

Source: DWR 1994a

In addition to the major reservoirs built for flood control, there are other flood control measures consisting of more than 2.2 MAF of potential flood control storage. These are a highly developed system of flood control basins, levees, channels, and bypasses. Sacramento Valley levees and bypasses extend over 150 miles, from Red Bluff on the north to Suisun Bay on the south, and include the Butte, Colusa, Sutter, American, and Yolo basins. The basins are composed of a series of natural and man-made bypass overflow areas that act as auxiliary channels to the Sacramento River during floodwater times. The bypass areas are used for agriculture during the summer and fall months, and are valuable wetlands during the flood season.

Runoff from the upper Sacramento River watershed (the southern Cascade mountains, the Warner mountains, and the Trinity mountains) is stored in Shasta Reservoir near Redding. Major tributaries above Shasta Dam are the Pit, McCloud, and Sacramento rivers. The Pit River, which is the most extensive tributary to Shasta Reservoir contributes about 59.5 percent of the average annual surface inflow to the reservoir. The McCloud River, which originates in southeastern Siskiyou County at an elevation of about 4,900 feet, represents about 9.3 percent of the average annual surface inflow to Shasta Lake since the completion of McCloud Dam 16.5 miles upstream from Shasta Lake in 1965. Water from Lake McCloud, which has a storage capacity of 35.2 TAF, is diverted to Iron Canyon Reservoir in the Pit River drainage for power production. The Sacramento River, which originates as the north, middle, and south forks on the east slopes of the Trinity Divide in Siskiyou County, contributes about 13.9 percent of the total average annual surface inflow to Shasta Lake. Minor tributaries to the lake provide the remaining inflow.

About 8 miles downstream from Shasta Dam, Keswick Dam impounds Keswick Reservoir, with a storage capacity of 23.8 TAF, which regulates releases from Shasta and Spring Creek powerplants. To control sediment and debris above Spring Creek Powerplant and to regulate acid mine drainage from Iron Mountain Mine, the Spring Creek Debris Dam, located on Spring Creek, was constructed above the tailrace of the Spring Creek Powerplant. Releases from the 5.9 TAF reservoir are made into Keswick Reservoir.

Whiskeytown Reservoir regulates diversions from Lewiston Lake on the Trinity River. Diverted water is released into the Clear Creek Tunnel to the Judge Francis Carr Powerhouse, which discharges to Whiskeytown Reservoir. Water from Whiskeytown Lake, a 241 TAF reservoir on Clear Creek, is released through a 3-mile long tunnel to the Spring Creek Powerplant and discharged to Keswick Reservoir. Clear Creek, the second largest tributary on the west side of the basin, is tributary to the Sacramento River, below Keswick Dam between Redding and Anderson.

The 56-mile stretch of the Sacramento River from Keswick Dam to Red Bluff is largely contained by steep hills and bluffs. River flows in the upper part of this reach are highly controlled by releases from Shasta Reservoir, but become more influenced by tributary inflow downstream. Major tributaries to the Sacramento River between Keswick Dam and Red Bluff include Cow, Stillwater, Bear, Battle, Paynes, Cottonwood, and Clear creeks.

The 98 miles of Sacramento River between Red Bluff and Colusa is a meandering stream, migrating through alluvial deposits between widely spaced levees. From about Colusa to the Delta, the Sacramento River is regulated by the Sacramento River Flood Control Project system of levees, weirs, and bypasses which divert floodwater in the Sacramento River into the Sutter Bypass. Sutter Bypass, running roughly parallel and between the Sacramento and Feather Rivers, receives additional flow from the Feather River, and the combined flow enters the Yolo Bypass at Fremont Weir near Verona. American River flood flows enter the Yolo Bypass through the Sacramento Weir. The Yolo Bypass returns the entire excess flood flow to the Sacramento River, about 10 miles above Collinsville. The system provides flood protection to about 800,000 acres of agricultural lands and many communities, including the cities of Sacramento, Yuba City, and Marysville.

Stream flow in this stretch of the Sacramento River is modified well upstream by Shasta Dam and several diversion structures, especially the Sacramento River Flood Control Project. Major streams entering the Sacramento River include Thomes, Elder, Stony, and Putah creeks from the west, and Antelope, Mill, Deer, and Big Chico creeks and the Feather and American rivers from the east. Numerous small tributaries drain the low foothills on either side of the valley.

Over 200,000 acres in the Sacramento Valley in Tehama, Glenn, Colusa, and Yolo counties are served by the Sacramento Canals Unit of the CVP, which consists of the Red Bluff Diversion Dam, Corning Pumping Plant, and several canals (USBR 1975). The Red Bluff Diversion Dam, which creates a 3,900 acre-foot lake on the Sacramento River, diverts water from the river at Red Bluff to the Tehama-Colusa Canal service areas. The Corning Pumping Plant, in the canal about half a mile downstream from the Diversion Dam, lifts water 56 feet from the Tehama-Colusa Canal into the 21 mile long Corning Canal. The capacity of the Corning Canal varies from 500 cfs at the Pumping Plant to 88 cfs at the terminus, 4 miles southwest of Corning. The 122 mile long Tehama-Colusa Canal, which terminates in the northern part of Yolo County, has an initial diversion capacity of 2,300 cfs.

The Glenn Colusa Irrigation District supplies water from the Sacramento River near Hamilton City to about 175,000 acres of land, including 25,000 acres within three federal wildlife refuges. Numerous small diversions along the Sacramento River provide irrigation to riparian lands. The Colusa Basin drainage area, which consists of 1,619 square miles of watershed, is located west of the Sacramento River, extending from Orland to Knights Landing. The basin contains some 350,000 acres of rolling foothills, intersected by several stream channels located along the eastern slopes of the Coast Range, and about 650,000 acres lying in the flat agricultural lands of the Sacramento Valley. The Colusa Basin Drain, a multi-purpose drain that is used both as an irrigation supply canal and as an agricultural return flow facility, flows southerly along the eastern boundary of the basin. The drain eventually discharges into the Sacramento River through the regulated outfall gates at Knights Landing or, during flood events, into the Yolo Bypass through the Knights Landing Ridge Cut.

The Yolo Bypass, a low lying area of about 40,000 acres bordered by flood control levees, is part of the Sacramento River Flood Control Project. The flood control project consists of about 1,000 miles of levees plus overflow weirs, pumping plants, and bypass channels that provide flood protection to urban areas, communities, and agricultural lands in the Sacramento Valley and Sacramento-San Joaquin Delta. A deep channel, the Toe Drain, borders the east levee. Water enters the Yolo Bypass from the Sacramento River flood flows, local and regional stormwater runoff, tidal action, wastewater discharge, and direct diversion for agriculture. Water is present in the Bypass throughout the year, with peak flows occurring during the winter in response to storm events. During high flows, water is diverted into the Yolo Bypass from the Sacramento River via the Fremont and Sacramento weirs, near Knights Landing and West Sacramento, respectively. When the Yolo Bypass floods, large areas of seasonal wetlands, seasonal mud flats, and deep, open water cover types are created. Several private duck clubs with wetlands are located in the Yolo Bypass. In the summer, agricultural return flows enter the area primarily along the west side bypass levee.

On the Feather River, Oroville Reservoir controls potential floodwater, conserves water for release downstream, stores water for power generation, and provides recreational opportunities. The reservoir has a capacity of over 3.5 MAF. Electrical power is generated in the Hyatt-Thermalito complex at the base of the dam. The intake structure to the powerplant is designed so water can be drawn from various depths in the reservoir pool, thus allowing adjustments in the temperature of released water. Water released through the powerplant enters the Thermalito Diversion Pool created by the Thermalito Diversion Dam, about 4,000 feet downstream from Oroville Dam.

A portion of the fish maintenance flow is released directly to the Feather River from the Diversion Pool, but greater volumes of water are diverted to two irrigation canals, the Feather River Fish Hatchery, and the Thermalito Powerplant. Four canals divert from the Afterbay of the Thermalito Powerplant. Return flows from the fish hatchery and Thermalito Afterbay releases for fish and the Delta make up river flow below the Afterbay outlet. The Feather River then flows south for 65 miles before emptying into the Sacramento River near Verona, about 21 river miles above Sacramento.

Above Oroville Dam, the Feather River drains 3,634 square miles of watershed with an average annual runoff of 4.2 MAF. Three small reservoirs (Davis, Frenchman, and Antelope) on separate forks of the Feather River have a combined storage capacity of 162.4 TAF and provide local irrigation, recreation, and incidental flood control. All three reservoirs are stocked with trout, and water releases are regulated to improve downstream fish habitat. Below Oroville Dam, an additional 2,297 square miles of watershed contribute 1.5 MAF annually, principally from two large tributaries, the Yuba River and the Bear River.

The Yuba River, on the western slope of the Sierra Nevada mountains, has a watershed of about 1,300 square miles. Flows in the North Yuba River are impounded in the Yuba

County Water Agency's New Bullards Bar Reservoir about 29 miles northeast of Marysville. The reservoir has a storage capacity of 966 TAF, with a usable capacity of 727.38 TAF. Releases from New Bullards Bar Reservoir join the Middle Yuba River and flow into Englebright Reservoir, which stores 70 TAF. The South Yuba River also flows into Englebright Reservoir. Releases from Englebright Dam flow westerly 12.7 miles to Daguerra Point Dam and then 11.4 miles to join the Feather River at Marysville. Daguerra Point Dam serves both as a barrier to impair downstream movement of mining debris and as the point of diversion for the major water irrigation districts utilizing Yuba River flows. Operation of the facilities for power production, fisheries maintenance, water supply, recreation, and flood control are presently beneficial uses.

The American River drains a 1,921 square mile area in the north-central portion of the Sierra Nevada, with mean annual unimpaired runoff estimated at 2.6 MAF (at Fair Oaks). CVP facilities on the American River include Folsom Dam and Reservoir, with 1.01 MAF of storage capacity, and Nimbus Dam which impounds Lake Natomas as an afterbay for Folsom Dam. These facilities regulate river flow for irrigation, power, flood control, municipal and industrial use, and other purposes. The project provides about 500 TAF annually for irrigation and municipal water supplies. The American River joins the Sacramento River about 25 miles downstream from Nimbus Dam.

Surface Water Quality. Water quality problems in the Sacramento River basin associated with irrigated agriculture and municipal and industrial discharges are relatively minor compared with other parts of the Central Valley. This has resulted in part from the use of the Sacramento River to convey increasing quantities of water developed within the Sacramento River basin or imported from the North Coastal basin.

Water quality in Shasta Lake reflects the high quality of the tributary streams. Mineral and nutrient quality is excellent. However, mine and mine tailing contaminated runoff from Squaw and Backbone creeks causes localized copper pollution and fish kills.

Shasta Lake thermally stratifies, producing significant differences between surface and bottom water temperatures. Surface water temperatures have ranged to a maximum of 88°F, during the summer of 1976, with bottom temperatures of 47.5°F for the same period. Typically, however, surface water temperatures during the summer range from 70 to 75°F, with bottom temperatures ranging from 40 to 45°F. During summer thermal stratification, minimum dissolved oxygen levels have been found near the thermocline as low as 3 to 6 parts per million (ppm).

Surface waters in the Sacramento River area between Keswick Dam and Red Bluff are an excellent mineral quality suitable for most beneficial uses. Waste discharges originating from industrial and municipal developments enter the Sacramento River along the entire length from Keswick to Red Bluff. Lumber by-product industries, cities and towns, light industries, food product plants, and a considerable volume of irrigation return flow all contribute a significant waste load to the Sacramento River. Conversion to regional sewer plants rather than individual septic systems, while alleviating much of the concern for ground water contamination, has resulted in effluent with concentrated nutrient loads. This concentrated effluent is discharged to the Sacramento River by the cities of Redding south of Clear Creek, Red Bluff upstream from the diversion dam, and Chico. Sewer treatment plant failure has occurred at the Red Bluff facility, resulting in the discharge to the Sacramento River of untreated domestic and municipal effluent.

Drainage from abandoned mines and tailings has upon occasion caused severe local losses of fish in the upper watershed. A few miles northwest of Redding lies the Iron Mountain region containing metallic ore deposits, some of which are presently being mined. Water draining from this area, especially via Spring Creek, is frequently acidic and has undesirable concentrations of copper, zinc, iron, aluminum, and other toxic salts which are leached from tailings of both operating and abandoned mines. Water from this area is at times lethal to fish, and adversely affects animal and plant organisms on which fish feed. To alleviate this problem, USBR constructed the Spring Creek debris dam near the mouth of Spring Creek, which drains to Keswick Reservoir. Because high flows cause frequent uncontrolled releases of toxic laden water to Keswick Reservoir, USEPA has declared the Iron Mountain complex a Superfund site and has initiated actions to reduce the output of toxic materials.

Dioxins, which are closely related group of highly toxic compounds produced as by-products of various industrial processes, were discovered as a by-product of the pulp bleaching process of paper mills in 1987. High levels of dioxins are discharged with mill waste into the Sacramento River near Anderson. The Department of Health Services has issued an advisory not to eat resident fish from the Sacramento River between Keswick and Red Bluff. The Central Valley RWQCB has ordered the paper company to reduce dioxins concentrations in the discharge.

The Sacramento River downstream from Keswick Dam has been designated as spawning waters for anadromous fish, with a minimum allowable dissolved oxygen level of 7 mg/l. Dissolved oxygen concentrations have ranged from slightly below 10 mg/l to over 12 mg/l. Overall, the river remains well oxygenated throughout the reach from Keswick Dam to the Red Bluff Diversion Dam.

Warm water temperatures in the Sacramento River downstream from Shasta Dam have affected upstream salmon migration and caused egg mortalities. Temperatures are generally too warm for optimum spawning and rearing in the late-summer and fall, and too cold for optimum juvenile growth in the spring. The problem is most severe in the early-fall during dry years when low flows of relatively warm water are further influenced by high ambient air temperatures. Although high water temperatures occur naturally in the river, operation of Shasta Dam has aggravated the problem. Fall release temperatures from Shasta Dam are too warm for salmon spawning during dry years. Temperatures are partially controlled by modifying operations and importing colder water from Clair Engle Lake. Operational modifications include release of colder water through lower dam outlets, which result in loss of power generation through hydroelectric facilities at the dam. Construction of a temperature curtain in Shasta Reservoir to allow the control of temperature of water releases and the maintenance of hydroelectric power generation, although not yet started, was planned for the fall of 1994.

The Central Valley RWQCB has established a temperature objective of 56°F to be attained to the extent controllable throughout the spawning area between Keswick Dam and Hamilton City. The current interim bypass operation required under the USBR's water rights at Shasta Dam is to meet the 56°F temperature objective, most of the time, immediately between Keswick Dam and Red Bluff, except during the months of August, September, and October, when temperatures may exceed this level on occasion. Temperatures remain below 62°F at Red Bluff in 75 percent of the years during September.

Effects of Shasta Dam releases on upper Sacramento River water temperatures decrease with downstream distance. River temperatures are greatly affected by ambient air temperature between the point of release and the Red Bluff Diversion Dam, particularly during the summer months. Ambient air temperature and tributary accretions combine to produce high summer river temperatures detrimental to some fishery resources in the river between Keswick Dam and the Red Bluff Diversion Dam. Elevated temperatures in the upper river during late-summer and early-fall is a primary factor limiting winter-run chinook salmon survival, which has been listed as an endangered species by the State and federal governments.

The Sacramento River between Red Bluff and the Delta is generally of good quality. Although the river appears suitable for beneficial uses, periodic degradation occurs from the discharge of toxins, untreated sewage, and other non-point source contaminants. In the lower Sacramento River, water quality is affected by intrusion of saline sea water, which is of increasing concern as consumptive uses of freshwater continue to increase statewide.

The upper reaches of major tributaries, including the Feather, Yuba, and American rivers, all have excellent water quality characteristics. Downstream from storage reservoirs, however, some degradation occur due to various discharges. Downstream water temperature is a concern on the Yuba and American rivers.

Agricultural drainage is the major source of waste water, and contributes to lower water quality during low flow periods in the Sacramento River and lower reaches of the major tributaries. In the past, rice field herbicides caused the most significant degradation, but recent efforts by the State Department of Food and Agriculture (DFA) and the Central Valley RWQCB have largely controlled this problem.

Water quality concerns in tributaries include: low dissolved oxygen levels in Butte Slough, Sutter Bypass, and Colusa Basin Drain; high water temperatures below diversion structures on Butte Creek; concentrations of minor elements (chromium, copper, iron, lead, manganese, selenium, and zinc) that exceed beneficial use criteria in the Sutter Bypass; and pesticide residues in the Sutter and Yolo bypasses and Colusa Basin Drain. Additional concern exists for effects of tributary discharges to the Sacramento River, including elevated temperature, dissolved solids, minor elements, pesticides, and turbidity, especially from the Sutter and Yolo bypasses and Colusa Basin Drain.

Ground Water Hydrology. Ground water in the Sacramento Valley is pumped from over 20 principal basins, most of which underlie the valley floor. Total storage capacity of the 22 ground water basins in the Sacramento River basin has been estimated as 139 MAF. Of these basins, only 8 have sufficient data available to estimate usable ground water storage. The total usable storage for these basins is 22.1 MAF with 22 MAF in the Sacramento Valley. The safe ground water yield is about 1.6 MAF per year, and the annual overdraft is about 140 TAF.

Ground water in the basin between Keswick Dam and Red Bluff may be either abundant or sparse. The lack of water has precluded major development in the upper areas. The Redding Ground Water Basin contains most of the usable ground water in this portion of the Sacramento River drainage.

The Sacramento Valley ground water basin encompasses about 5,000 square miles, extending from Red Bluff to the Sacramento-San Joaquin Delta. The basin includes all of Sutter County and portions of Yuba, Tehama, Glenn, Butte, Colusa, Yolo, Solano, Placer, and Sacramento counties. Large quantities of water are stored in thick sedimentary deposits in this area. The total ground water in storage to a depth of 600 feet is estimated to be 113.6 MAF.

Ground water is used intensively in some areas and only slightly in others where surface water supplies are abundant. However, overall consumption has been increasing steadily since the early-1900's. In 1990, ground water accounted for about 29 percent of all agricultural water in the valley. The total amount of Sacramento Valley ground water pumped represents about 12 percent of the 15 MAF pumped annually from all basins in the State.

Ground water levels fluctuate according to supply and demand on daily, seasonal, annual, and even longer bases. Short-term and long-term water level changes have been recorded for wells since the first documented measurements in 1929. In the north valley, there are no consistent downward trends, but the southern representative wells show long-term declines in nearly all counties since early measurements were made.

Ground water replenishment occurs through deep percolation of stream flow, precipitation, and applied irrigation water. Stream percolation and deep percolation of rainfall combine to provide a greater amount of recharge than does applied irrigation water. Recharge by subsurface inflow is considered negligible compared to other sources. Approximately two-thirds of the basin's total recharge under natural conditions occurs north of the Sutter Buttes, with the remainder in the southern valley.

Ground Water Quality. Between Red Bluff and the Delta, ground water is generally of excellent mineral quality and is considered class 1 for irrigation purposes. This water is generally suitable for domestic and industrial uses. Poor quality water, however, does exist in the basin fringe area near the base of the foothills, where the salt water bearing Chico formation rises near the surface.

The quality of ground water is generally excellent throughout the Sacramento Valley and is suitable for most uses. Concentration of TDS is normally less than 300 mg/l, although water in some areas may contain solids to 500 mg/l. Ground water beneath the eastern basin is commonly a magnesium-calcium or calcium-magnesium bicarbonate water. High concentrations of sodium chloride waters are found at Robbins, Clarksburg, and several areas near the edge of the basin where Cretaceous-age rocks are nearby. There are also some areas where iron, manganese, and boron are present in undesirable amounts, but the water generally remains suitable for most purposes.

In terms of mineral content, ground water in the west half of the valley is significantly poorer than that in the east half. This is a reflection of the rock types in the Coast Range, which contain more soluble minerals and saline connate waters than do the igneous and metamorphic rocks in the Cascade Range and Sierra Nevada. Calcium-magnesium and magnesium-calcium bicarbonate types are common here as well, but there are areas near Maxwell, Williams, and Arbuckle where high concentrations of sodium, chloride, and sulfate water occur with TDS concentrations of 500 mg/l or more. Some of these waters are unsuitable for irrigation and drinking.

At a considerable depth beneath the valley, nearly all ground water contains sodium chloride. Depth to the base of fresh water is about 1,100 feet beneath most of the northern valley and commonly over 1,500 feet in the southern valley. Two exceptions, where saline water occurs at shallow depths, are in the Robbins area, south of Sutter Buttes, and the Colusa area. Depth of saline water may be similarly shallow at the valley margins on both sides.

Vegetation. The Sacramento River between Red Bluff and Colusa contains most of the river's remaining natural riparian vegetation, with only a small fraction of the original acreage of woody riparian vegetation still intact and relatively undisturbed in the reach of the Sacramento River between Colusa and the Delta. Riparian trees and shrubs occur along the Sacramento River in widths ranging from a few yards where the levee is the riverbank, to a flood plain riparian forest several hundred yards wide.

The primary wetland types along the Sacramento River between Red Bluff and the Delta are defined in USFWS's National Wetlands Inventory as: (1) palustrine forested, scrub-shrub, or emergent wetlands, which are freshwater wetlands dominate by trees, shrubs and emergent vegetation; and (2) riverine wetlands, which are freshwater wetlands contained within a channel. These wetlands types are in decline according to USFWS.

Four special status plant species that may occur within habitats along this portion of the Sacramento River include: Suisun Marsh aster, California hibiscus, Mason's lilaeopsis, and Delta tule pea.

__Wildlife and Fish__. The Sacramento River basin supports a large variety of game and non-game species, including millions of wintering waterfowl. The wildlife resources between Keswick Dam and Red Bluff are associated with riparian, oak woodland, marsh, and grassland habitat, in addition to agricultural lands. The riparian corridor along the river below Keswick Dam is inhabited by passerine birds, waterfowl, shore and wading birds, upland game birds, and raptors. Riparian areas are also valuable habitats for numerous species of mammals, including furbearers.

Between Red Bluff and the Delta, populations of most species that are dependent on riparian, oak woodland, marsh and grassland habitats have declined with the conversion of these habitats to agriculture and urban areas. Populations of some Sacramento Valley species have declined so greatly that they have been listed as threatened or endangered, or are under study for future listing. In many cases, most of the remaining habitat for these species in the Sacramento Valley occurs along the Sacramento River.

DFG's Wildlife Habitat Relationship Program identifies a total of 249 species of wildlife using the valley foothill/riparian habitat of the Sacramento Valley. Included in this total are 151 species of birds, 65 species of mammals, and 33 reptile and amphibian species. Riparian zones also provide food and cover to other wildlife species more typical of adjacent upland areas and provide migratory corridors for many others.

Many birds species are common year-round or seasonal residents of the Sacramento Valley, while others are migrants or only occasional visitors. Wetland areas of the basin are important as prime waterfowl wintering areas in the Pacific Flyway, where wintering waterfowl population often exceeds three million birds. Passerine birds are found in great numbers in the riparian vegetative cover along the Sacramento River and tributaries because of the excellent food and habitat value. Raptor species such as hawks and owls nest within the larger trees of the riparian and grassland habitat and feed on small animals that also inhabit the area.

The Sacramento River and tributaries between Keswick Dam and the Delta provide important habitats for a diverse assemblage of fish, both anadromous and resident species. Anadromous fish include chinook salmon (four races), steelhead trout, striped bass, American shad, green and white sturgeon, and Pacific lamprey. Resident fish can be separated into warmwater game fish (such as largemouth bass, white crappie, black crappie, channel catfish, white catfish, brown bullhead, yellow bullhead, bluegill, and green sunfish), coldwater game fish (such as rainbow and brown trout), and non-game fish (such as Sacramento squawfish, Sacramento sucker, and golden shiner). Native non-game fish such as the Sacramento perch (California's only native sunfish) and the viviparous tule perch still persist in the Sacramento River. Although the Sacramento perch is thought to be threatened with extinction in the Sacramento River, it is presently listed as status undetermined pending collection of additional information. Baseline resource information on this species is lacking.

Keswick Dam forms a complete barrier to upstream migration of fish, primarily chinook salmon and steelhead. Migratory fish trapping facilities at the dam are operated in conjunction with the Coleman National Fish Hatchery on Battle Creek, 25 miles downstream. The Sacramento River upstream from Colusa produces about half of the Central Valley chinook salmon population. About one third of the river's naturally spawning salmon (mainly the fall run) spawn directly in the reach from Colusa to Red Bluff (mainly above Chico Landing), and all salmon use the river for rearing and migration.

Approximately two-thirds of the striped bass population in the State spawn in the Sacramento River system, while the remainder spawn in the lower San Joaquin River.

Construction of Oroville Dam on the Feather River eliminated spawning areas for salmon and steelhead upstream of the dam. To compensate for this loss, the DWR built the Feather River Fish Hatchery downstream from Oroville Dam, on the northern bank of the Feather River. The Feather River Fish Barrier Dam, about a half mile downstream from Thermalito Diversion Dam, diverts migrating salmon and steelhead into the Feather River Fish Hatchery for artificial spawning.

Surveys conducted in 1976 identified 28 species of resident and anadromous fish in the Yuba River system. Anadromous fish of special concern include chinook salmon, steelhead trout, and American shad. New Bullards Bar Reservoir supports both warmwater and coldwater fisheries. Common and abundant coldwater species include rainbow and brown trout, while warmwater species include smallmouth and largemouth bass, crappie, bluegill, catfish, carp, Sacramento squawfish, Sacramento sucker, and threadfin shad. No rare or endangered species are known to occur in the reservoir. The fall-run chinook salmon is the most important and abundant anadromous fish in the lower Yuba River system.

Downstream from Folsom Dam and 30 miles upstream from the mouth of the American River is the Lake Natoma-Nimbus Dam afterbay complex. Anadromous fish cannot pass Nimbus Dam. The Nimbus Salmon and Steelhead Hatchery is located on the downstream side of Nimbus Dam. The lower American River aquatic habitat includes a meandering streambed in a broad flood plain which is delineated from surrounding urban areas by 30 foot levees. The waters' edge is bordered by native riparian vegetation, backwaters, dredge ponds, and urban recreational areas such as parks and golf courses. The river and backwater areas support at least 41 species of fish, including chinook salmon, steelhead trout, striped bass, and American shad. Common resident fish include the Sacramento sucker, black bass, carp, squawfish, and hardhead.

Species which occur in the Sacramento Valley basin that are either federally or State listed as threatened or endangered include the greater sandhill crane, bank swallow, least Bell's vireo, Swainson's hawk, western yellow billed cuckoo, California black rail, willow flycatcher, bald eagle, American peregrine falcon, Aleutian Canada goose, giant garter snake, valley elderberry longhorn beetle, and winter-run chinook salmon. Six candidate species occur in the area (California tiger salamander, tricolored blackbird, white-faced ibis, snowy plover, Sacramento anthicid beetle, and Sacramento splittail), as well as five species recommended for candidate species (western spadefoot toad, vernal pool fairy shrimp, California linderiella, conservancy fairy shrimp, and vernal pool shrimp). The California hibiscus is a species of special concern that occurs in the area.

Land Use and Economy. The economy of the Sacramento River basin is based primarily on irrigated agriculture and livestock production. Related industries include food packing and processing, agricultural services and the farm equipment industry. Another important segment of the economy in the Sacramento River basin consists of military and other federal government establishments, the State government, and the aerospace industry. Lumber industries are centered in the Sierra, Nevada, Cascade Range, Modoc Plateau, and a portion of the Coast Range. Other industries are engaged in extraction or mining and production of natural gas, clay, limestone, sand, gravel, and other minerals. Population growth has given rise to many service industries. The 1985 population for the Sacramento Valley region exceeded 1.8 million people. Major urban areas include Sacramento, West Sacramento, Redding, Chico, Davis, Placerville, Woodland, Roseville, Yuba City, Auburn, Marysville, Oroville, Willows, Red Bluff, Quincy, Nevada City, and Alturas.

Along the Sacramento River between Keswick and Red Bluff, soils are deep and fine-textured and are suitable for growing a wide variety of field and orchard crops. Crops presently grown are corn, sugar beets, safflower, strawberry plants, alfalfa, and hay. Orchards of apples, olives, walnuts, almonds, prunes, and peaches are planted. In addition, large farming areas are devoted to the raising of beef and dairy cattle.

Along the Sacramento River between Red Bluff and the Delta, alluvial soils eroded from the surrounding mountains are well suited for a variety of agricultural uses, and historically supported extensive riparian forests. Riparian woodland and grass lands have largely been converted to agricultural uses, with orchards predominating in the upper portion of this reach and row crops dominating in the lower portion. Typical agricultural crops include almonds, pears, peaches, rice, tomatoes, sugar beets, wheat, corn, and seed crops such as melons and sunflowers. Thousands of acres of wetlands and refuges also occur in the area.

Many individual residences and small communities exist along the upper river between Red Bluff and the Delta, such as Tehama, Los Molinos, Hamilton City, Princeton, and Butte City. Further from the river, larger towns and cities include Chico, Willows, and Colusa. Along the lower river, major urban development from the City of Sacramento fronts the river, with minor residential and commercial development at Knights Landing, Rio Vista, Isleton, Walnut Grove, Locke, Hood, Clarksburg, and Freeport. Marinas are common along the river in this reach, especially between Clarksburg and just upstream of Discovery Park. Agriculture is the most important segment of the economy for the smaller communities, while manufacturing and services are more important for the economy of the larger towns.

Recreation. Over 2 million visitors participate in recreational activities along the Sacramento River annually. Fishing and relaxation are the most popular recreational activities. Other types of recreation include boating, swimming, camping, picnicking, hiking, and outdoor sports. Winter-run chinook salmon fishing was very popular prior to the severe decline in the population and current State restrictions. Steelhead trout and spring, fall, and late-fall salmon runs remain popular among recreational anglers along the river. Ocean sport fishing also accounts for a large percentage of the Sacramento River anadromous fish catch.

Numerous public and private facilities provide recreational access along the Sacramento River between Keswick Dam and Red Bluff. Fishing is excellent in the river between Keswick Dam and Red Bluff. Rafting, kayaking, and canoeing are also popular because the river is fast flowing and there are a number of riffle areas. Picnicking, camping, and sightseeing are other important recreational activities.

Fishing and hiking occur throughout the year, while picnicking and camping are limited to the spring through fall months. Water contact sports, such as swimming, kayaking, and canoeing, are generally restricted to the summer months where the daytime temperatures are often over 100°F.

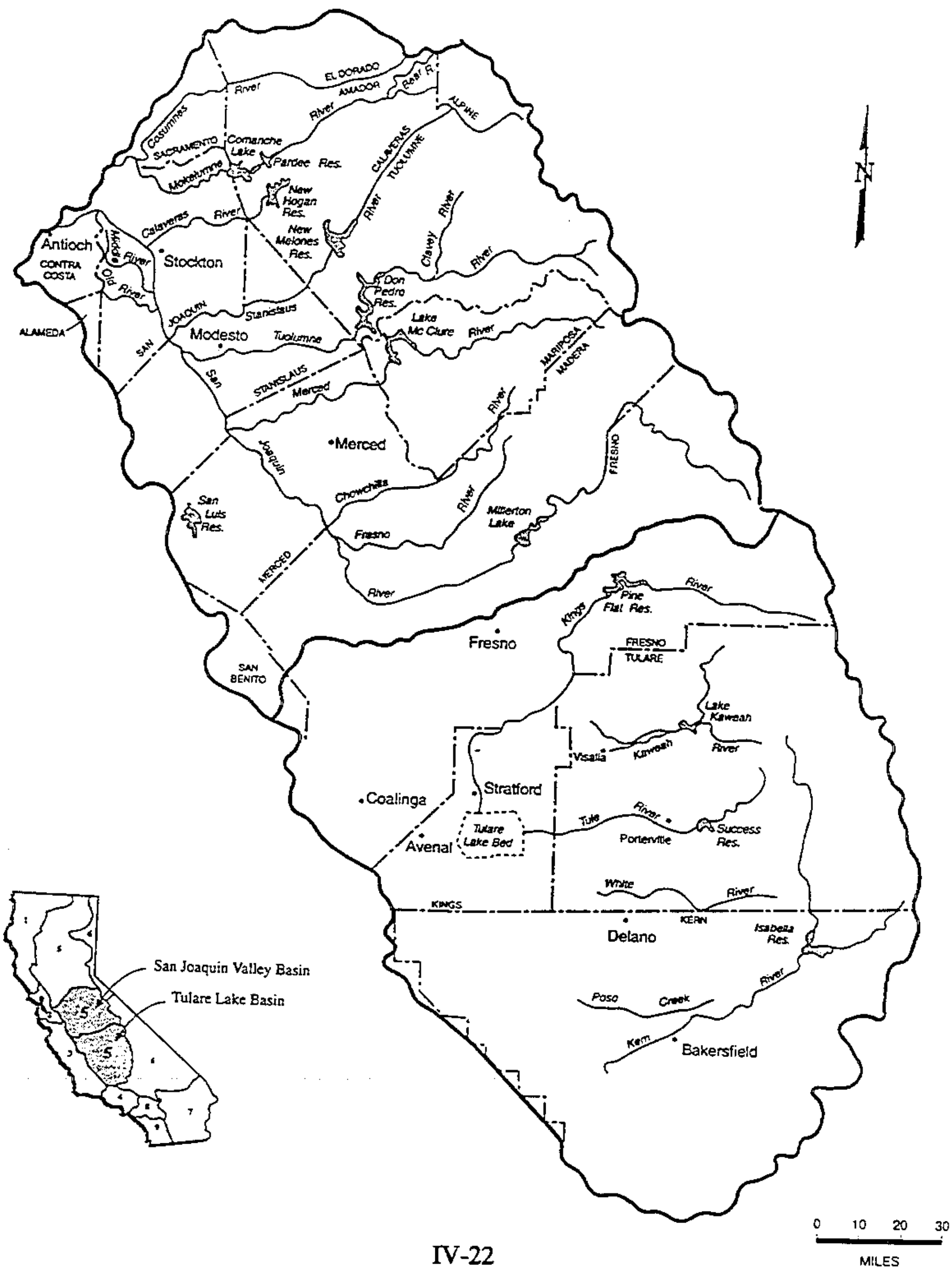
Little recreation land is available in the Sacramento Valley floor outside of riparian corridors between Red Bluff and the Delta. The Sacramento River environment is the primary remnant riparian corridor in the valley, providing the most important recreational resource for local residents. Public access to the river for recreational use is limited by the amount of public lands along the river. About 65 percent of the total recreational use on the river at and above Sacramento is by people living in counties adjacent to the river. Ninety percent of the summer day use activity is by local residents. Popular uses include fishing, boating, water skiing, picnicking, camping, and bird watching.

2. San Joaquin Valley (San Joaquin River Basin and Tulare Lake Basin)

The San Joaquin Valley extends from the Bay-Delta Estuary in the north to the Tehachapi Mountains in the south, and from the crest of the Sierra Nevada in the east to the Coast Range in the west. The valley is comprised of two hydrologic regions: the San Joaquin River basin and Tulare Lake basin (Figure IV-5). The San Joaquin River basin, located just south of the Sacramento River basin, comprises the northern part of the San Joaquin Valley. The Tulare Lake basin comprises the southern part of the valley.

The San Joaquin Valley is semiarid, characterized by hot, dry summers and mild winters except for the highest altitudes. In the mountains, summer days are warm and nights cool, but winter temperatures are often severe with heavy snowfall. The valley floor is free of frost during the growing season, with the average frost-free period being from eight to nine months. A frost-free belt extends along the Sierra Nevada foothills from Fresno County southward, providing a suitable area for citrus and other frost sensitive crops. Maximum

Figure IV-5 SAN JOAQUIN RIVER AND TULARE LAKE BASINS



summer temperatures are in the neighborhood of 110 °F and minimum winter temperatures may fall below 25°F. Relative humidities are low in the summer.

The year is divided into distinct wet and dry seasons. The major portion of the precipitation occurs in the winter season from November to April, with rain at the lower elevations and snow in the higher regions. Topography and latitude are the major factors controlling precipitation in the basin. Heaviest precipitation occurs on the west slope of the Sierra Nevada and, in general, increases with altitude up to about 7,000 feet, and then tends to decrease with increased elevation. Precipitation also decreases from north to south with lower means in the southern portion of the watershed areas. Precipitation is scanty on the valley floor.

The San Joaquin Valley is a rich agricultural region. The valley's long growing season, mild and semi-arid climate, good soils, and available water provide conditions suitable for a wide variety of crops. Major crops include cotton grapes, tomatoes, hay, sugar beets, and various orchard and vegetable crops. Agriculture and closely related industries provide the economic base that supports a large and growing population. Urban areas include Fresno, Bakersfield, Visalia, and Modesto.

Water to the San Joaquin Valley from the Sierra Nevada is limited and there is an annual overdraft of ground water. Imported water, generally consisting of 200 to 500 mg/l TDS, is used mainly on the west side. Water used on the east side is generally of better quality than that used on the west side and in the valley trough areas. In most parts of the valley, irrigation water is reused at least once, and water quality worsens progressively with each reuse.

Types of habitat in the San Joaquin Valley are similar to those of the Sacramento Valley.

a. **San Joaquin River Basin**. The San Joaquin River basin, which encompasses about 7,017,000 acres, is the primary drainage in the San Joaquin Valley. The San Joaquin River flows northward toward the Delta, draining the central southern portion. Major tributaries to the San Joaquin River include the Stanislaus, Tuolumne, Merced, Chowchilla, and Fresno rivers, which originate in the Sierra Nevada. In the Delta, the Cosumnes, Mokelumne, and Calaveras rivers, which also originate in the Sierra Nevada, flow into the San Joaquin River upstream of its confluence with the Sacramento River.

These Sierra streams provide the northern part of the San Joaquin Valley with high-quality water and most of its surface water supplies. Most of this water is regulated by reservoirs and used on the east side of the valley, but some is diverted across the valley to the Bay Area via the Mokelumne Aqueduct and the Hetch Hetchy Aqueduct.

On the west side of the basin, streams include Hospital, Del Puerto, Orestimba, San Luis, and Los Banos creeks. These streams are intermittent, often highly mineralized, and contribute little to water supplies.

The San Joaquin River basin is subjected to two types of floods: those due to prolonged rainstorms during the late-fall and winter, and those due to snowpack melting in the Sierra during the spring and early-summer, particularly during years of heavy snowfall. Major problem areas lie along valleys, foothill streams, and the San Joaquin River, where flood flows often exceed channel capacities and damage urban and highly developed agricultural areas (DWR 1986).

Surface Water Hydrology. The main stem of the San Joaquin River rises on the western slope of the Sierra Nevada at elevations in excess of 10,000 feet. From its source, the river flows southwesterly until it emerges onto the valley floor at Friant. The river then flows westerly to the center of the valley near Mendota, where it turns northwesterly to join the Sacramento River at the head of Suisun Bay. The main stream has a length of about 300 miles, one-third of which lies above Friant Dam. Surface water serves about two-thirds of the San Joaquin River basin while ground water serves the remaining areas.

Runoff from the watersheds of both the major and minor streams in the San Joaquin River basin shows wide seasonal, monthly, and daily variations modified by the effects of storage, releases from storage, diversions, and return flows. Average runoff from the basin is estimated at 7.93 MAF. Flows on the main stem of the San Joaquin River are regulated by operations of Friant Dam. There are often no flows in the mainstem itself beyond those flows originating in the three major tributaries (Merced, Tuolumne, and Stanislaus rivers) plus agricultural and municipal drainage.

Partial stream regulation of tributary streams is afforded by Pardee Dam on the Mokelumne River, New Melones, Donnells, and Beardsley dams on the Stanislaus River, Hetch Hetchy and New Don Pedro dams on the Tuolumne River, and Exchequer Dam on the Merced River. In addition, there are a number of power and irrigation developments on these streams which serve to regulate and modify the natural runoff. A list of the major reservoirs in the San Joaquin River basin is presented in Table IV-2.

Stream flows are depleted by diversions and increased by drainage and return irrigation flows along the stream courses. Stream flows in the Delta are influenced by tidal action and diversions to the Delta-Mendota Canal and the California Aqueduct. During the long dry season, the smaller streams often have no flows. Lowest flow conditions usually occur just prior to the advent of the rainy season which generally gets underway in late-November.

Surface Water Quality. The major water quality problems of streams on the San Joaquin Valley floor are large salt loads associated with irrigation and nutrients from municipal, industrial, and agricultural sources. Major portions of basin streams are reaching an undesirable state of nutrient enrichment. Prolific aquatic plant and algal growth are causing detriments to beneficial water uses. Aquatic plants have, on occasion, nearly blocked reaches of the lower Stanislaus River and have interfered with recreational uses.

Table IV-2. Major Reservoirs in the San Joaquin River Basin

Reservoir Name	Stream	Capacity (TAF)	Owner
New Melones	Stanislaus River	2,420	USBR
New Don Pedro	Tuolumne River	2,030	Turlock ID and Modesto ID
Hetch Hetchy	Tuolumne River	360	City of San Francisco
Lake McClure	Merced River	1,024	Merced ID
San Luis	N/A	2,040	USBR and DWR
Shaver	San Joaquin River	135	Southern California Edison
Pardee	Mokelumne River	210	EBMUD
Salt Springs	Mokelumne River	142	PG&E
Millerton	San Joaquin River	520	USBR
Edison	San Joaquin River	125	Southern California Edison
Lloyd (Cherry)	Tuolumne River	269	City of San Francisco
Mammoth Pool	San Joaquin River	123	Southern California Edison
Camanche	Mokelumne River	417	EBMUD
New Hogan	Calaveras River	317	USCOE
Eastman	Chowchilla River	150	USCOE
New Spicer Meadow	Tuolumne	189	CCWD

Source: DWR 1994a

Diurnal fluctuation of dissolved oxygen due to the presence of large algal concentrations and partially treated municipal and industrial wastes have contributed to fish kills in the Stanislaus, Tuolumne, and San Joaquin rivers. Other water quality problems include excessive coliform levels, pesticide concentrations, and turbidity.

Generally, water quality in the mainstem of the San Joaquin River is degraded downstream from Friant Dam during summer and fall months of all water years. High salt concentrations in the lower reaches of the San Joaquin River and its major tributaries arise from upstream diversion of the natural flow and the large volumes of drainage, waste waters, and return flows which, directly or indirectly, find their way into the surface drainage. At times, the entire flow in the river is comprised of used waters. The agricultural return water is estimated to carry a total annual salt load of 740,000 tons to the Sacramento-San Joaquin Delta. Although the water in the lower San Joaquin River is still usable for agriculture, severe crop damage has been occasionally experienced. Moreover, greater volume of applied water is needed to leach the greater amount of accumulated salts in the soil system. Increasing drainage problems have been associated with the increase in salt concentration.

Electrical conductivity (EC), boron, and other mineral concentrations are higher in dry and critical years due to a lack of dilution flows. This situation has imposed a slight to moderate degree of restriction on use of river water for irrigation. Water quality characteristics that were present during the 1991 water year are typical of critical year conditions. EC rises to 3,420 micromhos per centimeter (μmhos/cm) in the upper reaches downstream from Friant Dam. Conditions improved somewhat at the downstream end, where EC rises to 1,680 μmhos/cm. Water quality improves somewhat during a wet year, as in 1986 when EC measured up to 930 μmhos/cm in the upper portion, and to 980 μmhos/cm in the lower portion of the river.

Boron concentrations during 1991 measured up to 0.75 mg/l in the upper area, and to 1.2 mg/l in the lower reach. Among the trace elements analyzed during 1991, median selenium values frequently exceeded USEPA ambient water quality criteria of 5 micrograms per liter (μg/l) for the protection of aquatic life in the middle portions of the river, and routinely exceeded the primary drinking water standard of 10 μg/l. Elevated molybdenum concentrations in the upper river have been consistently found during the previous five critically dry years. The molybdenum is apparently derived from ground water seepage entering the river since the site where this element has been found is upstream from the discharge of tile drainage.

Generally, water quality in the Merced and Stanislaus rivers is good. Typically, water quality decreases during the late-summer as natural flows to the river decrease and poorer quality flows such as agricultural return flows increase. The Merced and Stanislaus rivers, though contributing freshwater flows year round, do not have sufficient flows during summer and fall months to dilute the poor quality of the mainstem San Joaquin River.

The Tuolumne River generally has good quality through much of the year. However, in late-summer and fall, when natural flows to the river decrease and lesser quality water such as agricultural return flows increase, water quality conditions are less than optimum. A contributor to the salt load of the basin is the saline water from abandoned gas wells on the Tuolumne River. The impact of this waste is such that the Tuolumne River at its mouth has about four times the salt concentration of similar adjacent rivers.

<u>Ground Water Hydrology</u>. In the San Joaquin River basin, 26 ground water basins and areas of potential ground water storage have been identified. Nine basins have been identified as significant sources of ground water. The total area of these nine basins is about 13,700 square miles, of which the San Joaquin Valley alone occupies 13,500 square miles and is the largest ground water basin in the State. There is an annual overdraft of approximately 209 TAF of ground water (DWR 1994a).

Subsidence in the San Joaquin Valley due to ground water extraction began in the mid-1920's. In 1942, 3 MAF were pumped for irrigation, but by 1970, pumping for irrigation exceeded 10 MAF. As a result, water levels in the western and southern portions of the valley declined at an increased rate during the 1950's and 1960's. By 1970, 5,200 square miles of valley land had been affected, and maximum subsidence exceeded 28 feet in an area west of Mendota.

Much of the Los Banos-Kettleman City subsidence area is now served by the San Luis Unit of the CVP. Since 1968, as more State and federal water has been used for irrigation, water levels have been recovering. In the future, if full contractual CVP deliveries are made, subsidence in this area is expected to cease. Since 1971, SWP deliveries to some parts of the Wheeler Ridge-Maricopa Water Storage District in Kern County have resulted in a ground water level recovery of as much as 75 feet.

Immediate problems caused by overdrafting are localized land subsidence, water quality degradation near Stockton from salt water intrusion, and higher pumping costs. Since the area will continue to rely on ground water as a source for irrigated agriculture, as well as municipal and industrial uses, water agencies are attempting to alleviate the overdraft conditions through artificial recharge and conjunctive use programs.

Ground Water Quality. Significant portions of the ground water in the basin exceed the recommended TDS concentrations in the U.S. Public Health Service Drinking Water Standards (500 mg/l). The predominant water type varies from aquifer to aquifer and the source of recharge. The character of the water on the east side of the valley is predominantly sodium-calcium bicarbonate. Water on the west side principally contains sodium sulfate. Some areas also have excessive boron concentrations.

Vegetation. Much of the native vegetation in the San Joaquin Valley has been replaced by introduced species or disturbed by cultivation or grazing. Major natural vegetation classes found within the valley include grassland, sagebrush shrub, coastal shrub, and hardwood forest-woodland.

A major portion of the CVP's San Luis service area has been developed for agriculture. On the undisturbed portions, native vegetation consists of sagebrush, saltbrush, Russian thistle, and similar cover common to semiarid regions. In years of average or better rainfall, some wild oats, brome grass, and other native grasses prevail near the foothills. Native wildflowers which previously grew within the San Luis Reservoir area were transplanted to areas above the water surface.

Wildlife and Fish. Food and cover for native wildlife are limited. The hot, dry climate of the west side of the San Joaquin Valley limits vegetation on the valley floor mostly to sagebrush, tumbleweed, and some grasses, except in a few draws and creek channels. The foothills of the Coast Range are also dry and mostly treeless except in a few creek bottoms.

Some wildlife cover plantings along the San Luis Canal have provided additional wildlife habitat.

In the trough of the San Joaquin Valley between Mendota and Gustine are tens of thousands of acres of excellent waterfowl land which constitute an important station along the Pacific Flyway. Drainage flows are an appreciable percentage of the water supply for this area and are used to grow feed and cover crops, and to provide resting ponds for the waterfowl using this area. While drainage seems to be an attractive source of water for wetland use, selenium levels in the drainage water have been toxic to waterfowl.

Most native fish populations have been eliminated by drainage projects and modifications of natural watercourses. They are now confined to farm ponds, drainage canals, and aqueducts. The only anadromous fishery in the San Joaquin River is a fall run of chinook salmon to the Merced, Tuolumne, and Stanislaus river tributaries; no spawning occurs on the mainstem.

The only rare or endangered species known to be in the general area affected by the San Luis Unit are the San Joaquin kit fox, California condor, blunt-nosed leopard lizard, and giant garter snake.

Land Use and Economy. Historically, the economy of the San Joaquin River region has been based on agriculture. By far, agriculture and food processing are still the major industries. Other major industries include the production of chemicals, lumber and wood products, glass, textiles, paper, machinery, fabricated metal products, and various other commodities.

The valley's long growing season, mild and semi-arid climate, good soils and available water provide conditions suitable for a wide variety of crops. Major crops include cotton, grapes, tomatoes, hay, sugar beets, and various orchard and vegetable crops. Agriculture and closely related industries provide the economic base that supports a large and growing population. The population in the valley grew from 1.7 million in 1970 to 2.5 million in 1985. Urban areas include Fresno, Bakersfield, Visalia, and Modesto.

Public lands amount to about one third of the region. The national forest and park lands encompass over 2,900,000 acres of the region; state parks and recreational areas and other State-owned property account for about 80,000 acres; and Bureau of Land Management and military properties occupy some 221,000 and 37,000 acres, respectively (DWR 1994a).

Most of the lands in the San Luis service area of the CVP occupy the gently sloping coalescing alluvial fans laid down by creeks emerging from the Coast Range. These soils rank among the highest in the San Joaquin Valley in potential productivity and adaptability to a wide variety of high valued crops. The excellent soils coupled with a long, hot growing season make the area ideal for farming operations. The predominant crops are irrigated grain, cotton, alfalfa seed, field crops, melons, and small but increasing acreage of deciduous orchards. Some of the non-irrigated lands are used for dry farm grain and native pasture.

Most of the area is in large landholding, and large scale farming prevails. Except for packing sheds, cotton gins, auction yards, and similar activities directly related to the marketing of agricultural products, there are no industrial or commercial enterprises of significance. South of the service area, several oil fields have been developed. The communities of Avenal and Coalinga exist chiefly to support the oil operations in the immediate vicinity.

Agriculture and the oil industry are the primary economic activities in the SWP service area. Crops raised in the region include alfalfa, barley, safflower, sugar beets, fruits, vegetables, nuts, cotton, sweet potatoes, cantaloupe, and grapes. Beef cattle, dairy products, and poultry are also significant. Other sources of income include manufacturing, trade, services, and government. Despite substantial variations in annual SWP deliveries, total acreage in the San Joaquin service area does not normally fluctuate. Farmers rely heavily on ground water pumping in dry years and local surface water diversions in wet years to maintain the same irrigated acreage.

Recreation. San Luis Reservoir, O'Neill Forebay, Los Banos, New Melones, New Don Pedro, and New Exchequer reservoirs offer good boating and fishing most of the year. Other recreational opportunities are available elsewhere in the Basin, including fishing along the basin's rivers and streams, and boating and whitewater rafting on major tributaries. Beach developments, particularly on the forebay, have been popular. Picnicking, swimming, waterskiing, hunting, and camping are activities afforded by the reservoir. Recreational development is jointly funded by the federal and State governments, but is managed by the State Department of Parks and Recreation.

Along the California Aqueduct, many miles of walk-in fishing sites have been provided, and a stock of many kinds of fish has developed from fish and eggs surviving the CVP and SWP pumps. There are also 170 miles of bikeways along the Aqueduct.

b. Tulare Lake Basin. The Tulare Lake basin is one of the richest agricultural regions in the United States. The highly developed agricultural economy of the basin is dependent upon runoff from the Sierra Nevada, import from basins to the north, and ground water to supply its water needs.

The Tulare Lake basin, which has a land area of 11,076,000 acres, includes all San Joaquin Valley stream basins between Fresno and Bakersfield that drain into Tulare Lake rather than northward into the San Joaquin River. Located at the southern half of the San Joaquin Valley, the basin is comprised of the Kings, Kern, Tule, and Kaweah river basins. These four rivers drain westward from the southern Sierra Nevada and terminate in the Tulare Lake or Buena Vista Lake beds. Dams on each of these rivers provide flood control and water supply for ground water recharge and for urban and agricultural uses. No large streams enter the basin from the coastal ranges or the Tehachapi Mountains.

__Surface Water Hydrology__. Tulare Lake tributaries are heavily used for irrigation, with little water reaching the lake. Water entering Tulare Lake basin that forms Tulare Lake is from excess flood water from the Kings, Kaweah, and Tule rivers, and, to some extent, the Kern River. Floods are not an uncommon occurrence, but are variable in intensity and frequency. Levees have been built to contain the water in cells to maximize farming possibilities in the basin. Flood waters collected in the basin are used for irrigation. Other means of disposal include evaporation, some ground water recharge, and recently by pumping out of the basin. In extreme flood conditions, water can flow out of the basin through the Kings River to the San Joaquin River.

The Kings River, which drains the Sierra Nevada mountains in eastern Fresno County, is impounded by Pine Flat Reservoir. The reservoir can store about 1 MAF. The reservoir regulates water for irrigation and flood control. The Kings River interconnects with the Friant-Kern Canal east of Fresno, where it divides into the South Fork and Kings River North. The South Fork flows into the Tulare Lake basin. Kings River North flows in a northwesterly direction and can connect with the San Joaquin River through Fresno Slough, a man-made channel. Historically, the Kings and San Joaquin rivers connected in most years during heavy runoff. More recently, this event occurs only during extreme flooding, but is more commonly hydraulically connected by virtue of irrigation practices. Before irrigation development, Tulare Lake overflowed into the San Joaquin River during periods of extreme flood. The Kings River, which carries eroded material from the Sierra Nevada, has built up a low, broad ridge across the trough of a valley so that the Tulare Lake basin has essentially no natural surface water outlet.

The Kaweah River is impounded by Terminus Dam to form the 143 TAF Lake Kaweah. This reservoir provides flood control, irrigation water, ground water recharge, and recreation. During late-spring, summer, and early-fall, most Kaweah River water controlled by the dam is diverted for irrigation, leaving little flow left in the river. The Kaweah Delta Water Conservation District distributes water from the reservoir to the service area encompassing almost 340,000 acres, of which 256,000 acres are used for agriculture. Most industrial, municipal, and domestic water in the service area is supplied from ground water. All water in the Kaweah drainage is utilized within the basin except during heavy flood years. When flood releases are made from Kaweah Reservoir, all possible water is diverted for irrigation use; any excess water flows into Tulare Lake.

The Tule River drainage serves over 400,000 acres of agricultural land. About six miles east of Porterville in Tulare County, Success Dam impounds the Tule River to form the 82 TAF Lake Success. The reservoir regulates flows for flood control and irrigation.

About half the agricultural lands in the Tule River basin are upstream from Success Dam and are served by local irrigation districts. The Lower Tule River Irrigation District and Tulare Irrigation District control most diversions downstream from the dam. Numerous ponding and ground water recharge basins controlled by local irrigation districts and non-public entities also occur along the river. The numerous diversions downstream from the dam, and percolation into the river bed and flood plain, result in discontinuous flow and intermittent pools throughout the lower river. The river interconnects with the Friant-Kern Canal. During extremely wet years, water in the Tule River flows to Tulare Lake.

Lake Isabella, in northwestern Kern County east of Bakersfield, impounds water from the Kern and South Fork Kern rivers draining eastern Tulare County. The reservoir has a storage capacity of 570 TAF. As a result of numerous diversions and regulation of flow at Isabella Dam, the natural river flow is virtually nonexistent and most flows are depleted before reaching Tulare Lake in all but exceptionally large runoff years.

Surface Water Quality. The perennial streams which arise in isolated parts of the Sierra Nevada are not subject to major manmade waste loads since most discharges are applied to the land. Irrigation return water forms a major portion of the summer base flow in the lower reaches of the larger streams. Saline water from oil wells is a contributor to the basin salt load.

The salt content of Tulare Lake (about 570 mg/l TDS) is due mainly to soil salts historically in the basin and introduced fertilizers. Poso Creek also contributes salt to the southern portion of the basin, but the proportional quantity of water from this drainage is small.

Ground Water Hydrology. The ground water overdraft in the Tulare Lake basin is a significant unresolved water resource problem in California. The average annual rate of ground water overdraft was calculated to be about 341 TAF in 1990 (DWR 1994a). This is a reduction in overdraft, due to the importation of SWP water and the availability of surplus supplies, from a level of about 1.3 MAF in 1972.

Numerous public and private water agencies are engaged in the acquisition, distribution, and sale of surface water to growers in the Tulare Lake basin. Since most of the agencies overlie usable ground water and use ground water conjunctively with surface water, some of their operational practices, such as artificial recharge and use of "non-firm" surface supplies in lieu of ground water, can be viewed as elements of a ground water management program. The agencies do not, however, have the power to control ground water extractions. Such authority is a requisite to comprehensive ground water management.

Ground Water Quality. Ground water near Tulare Lake has experienced an increase in dissolved solids concentrations over the years. In some locations, ground water has been abandoned as a water source as a result of quality degradation from salt loading. Suitable salt levels in the root zone have been maintained by the practice of leaching dissolved solids downward. Significant portions of the ground water exceed the recommended TDS concentration in the U.S. Public Health Service Drinking Water Standard (500 mg/l).

Nitrogen concentrations in some ground water in the Tulare Lake basin approach or exceed the levels recommended by the drinking water standards (10 mg/l). High nitrogen concentrations are usually attributed to sewage effluent and leaching or naturally occurring nitrogen and fertilizers.

Vegetation. Plant species along the tributaries to the basin are typical of those found on the west slope of the Sierra Nevada foothills. Grassland-oak savannah and oak woodland communities are typical of this region. Valley oak savannah dominates in the valley area, but in the foothills is replaced by live oaks in progressively denser stands. Around streams and lakes, riparian habitats occur. Plants found outside the riparian area are mainly grasses and wildflowers.

A large part of the natural plant life, including that in riparian areas below the reservoirs, has been lost due to extensive agricultural encroachment and other development. However, there is a mature riparian forest on both sides of the Kaweah River immediately below Terminus Dam. Most natural vegetation below the reservoirs remains only in small disjunct patches. Further downstream, plant life becomes similar to that of the Tulare Lake basin. Plant life of the lower Kern River is characterized as valley mesquite habitat, which is uniquely found in southwestern Kern County.

There are four plants within the general area that are listed by California as either rare or endangered. The one rare species listed is Greene's Orcutt grass. Endangered species include the Kaweah brodiaea and Springville clarkia, and San Joaquin Valley Orcutt grass which is presumed to be extirpated from the recorded site.

Wildlife and Fish. A majority of the native wildlife has been extirpated from the Tulare Lake basin. The land historically was marshlands and a swamp or a lake. Many species that occurred historically in the lake basin have been greatly reduced in number due to habitat deterioration and destruction from farming and urban development in the area. Birds known to inhabit the area, at least seasonally or when the lake exists, include most species of waterfowl, wading birds, and many types of gulls. Birds that are not water oriented occur in riparian areas adjacent to the lake in rivers or canals with riparian zones.

Fish habitat downstream from tributary reservoirs is primarily warmwater. A fishery for trout exists immediately below some of the dams during the fall and winter seasons and is supported by trout moving out of the lakes. Summer water temperatures in these reaches of the rivers are too warm to sustain coldwater fish species on a year-round basis. The rivers are commonly dewatered where there is no irrigation or flood control needs, so that fish are only found seasonally and are usually from upstream areas. When intermittent pools do exist, the more hearty and well adapted species (such as carp, Sacramento blackfish, bullhead, green sunfish, bluegill, mosquitofish, hitch, golden shiner, log perch, and Mississippi silverside) can usually be found. During irrigation deliveries, many game and non-game fish migrate up from the Tulare Lake basin through ditches and canals emanating from the river.

Water diversions, channelization, and construction of canals and levees have dramatically altered aquatic and riparian habitats in the Tulare Lake area. The vast lake bottom and marsh areas of Tulare Lake and much of its native flora and fauna have also been lost. Normal irrigation and farming practices dictate that these canals often dry up seasonally. In spite of this, several species of fish occur (seasonally or perennially) in Tulare Lake. Native fish species include rainbow trout (found only infrequently as they are incidentally transported from upstream areas), tule perch, Sacramento sucker, Sacramento perch, tule perch, riffle sculpin, and endemic minnows. Most of these still exist in the area, although Sacramento perch and tule perch have not been reported recently from the drainage, and the extent and diversity of native minnow populations have diminished. Non-native species of both game and non-game fish have been introduced throughout the basin.

At least 10 endangered or threatened species may occur within the area, including the Sierra red fox, wolverine, San Joaquin kit fox, San Joaquin antelope squirrel, blunt-nosed leopard lizard, giant kangaroo rat, giant garter snake, bald eagle, California condor, peregrine falcon, Tipton kangaroo rat, black-shouldered kite, great blue heron, and spotted owl. The yellow-billed cuckoo has not been reported in this area for a number of years though it was formerly widespread in San Joaquin Valley riparian areas. Its disappearance from the area is probably due to the lack of adequate habitat since it requires relatively large areas of undisturbed riparian areas. No rare or endangered fish species are known to be present in the drainage.

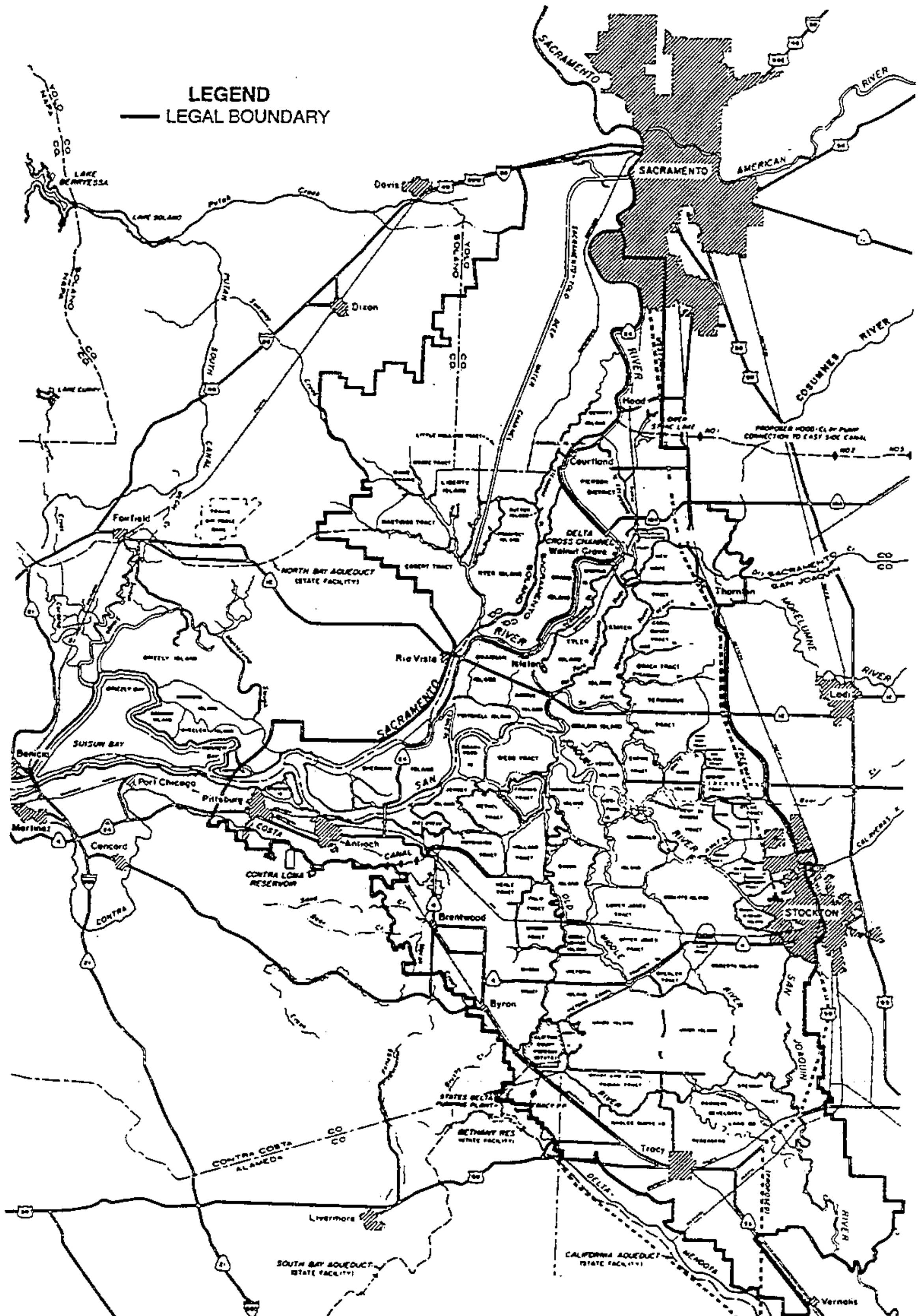
D. SACRAMENTO-SAN JOAQUIN DELTA (and Central Sierra Area)

The Delta-Central Sierra area includes the Sacramento-San Joaquin Delta and the Cosumnes, Mokelumne, and Calaveras river basins, totaling 3,109,000 acres. The Delta area forms the lowest part of the Central Valley bordering and lying between the Sacramento and San Joaquin rivers and extending from the confluence of these rivers inland as far as Sacramento and Stockton.

The Delta, which has legal boundaries established in California Water Code Section 12220 (Figure IV-6), comprises a 738,000-acre area generally bordered by the cities of Sacramento, Stockton, Tracy, and Pittsburg. This former wetland area has been reclaimed into more than 60 islands and tracts, of which about 520,000 acres are devoted to farming. The Delta is interlaced with about 700 miles of waterways. An approximate 1,110-mile network of levees protects the islands and tracts, almost all of which lie below sea level, from flooding. Prior to development, which began in the mid-19th century, the Delta was mainly tule marsh and grassland, with some high spots rising to a maximum of about 10 to 15 feet above mean sea level. The low dikes of early Delta farmers became a system of levees that now protect about 520,000 acres of farmland on 60 major islands and tracts. There are now about 1,100 miles of levees, some standing 25 feet high and reaching 200 feet across at the base.

Behind the levees, peat soils have subsided over the years due to oxidation, shrinkage, and soil loss by wind erosion. As a result, some of the island surfaces now lie more than 20 feet

Figure IV-6 SACRAMENTO-SAN JOAQUIN RIVER DELTA



below mean sea level and as much as 30 feet below high tide water levels in surrounding channels. All the major tracts and islands have been flooded at least once since their original reclamation, and a few have been allowed to remain flooded. Delta lands in the areas of deep peat soil, where subsidence has been greatest, are expensive both to protect from inundation and to reclaim from inundation once flooded.

The Delta is an important agricultural area. Historically, the area was noted for its truck crops, such as asparagus, potatoes, and celery, but since the 1920's, there has been a shift toward lower valued field crops. Corn, grain, hay, and pasture currently account for more than 75 percent of the region's total production. The shift has been attributed mainly to market conditions, although changes in technology and growing conditions have also played a role. Delta farming produces an average gross income of about $375 million.

The population of the Delta is about 200,000 people, most of which is in upland areas on the eastern and western fringes. Most Delta islands are sparsely populated, though some, including Byron Tract and Bethel Island, have large urban communities.

The Delta area has a Mediterranean climate with warm, rainless summers and cool, moist winters. The annual rainfall varies from about 18 inches in the eastern and central parts to about 12 inches in the southern part. Ocean winds, which enter the Delta through the Carquinez Strait, are very strong at times in the western Delta.

The Sacramento-San Joaquin Delta is situated near the center of the Central Valley at the confluence of the Sacramento and San Joaquin rivers.

Surface Water Hydrology. The Sacramento and San Joaquin rivers unite at the western end of the Sacramento-San Joaquin Delta at Suisun Bay. The Sacramento River contributes roughly 85 percent of the Delta inflow in most years, while the San Joaquin River contributes about 10 to 15 percent. The minor flows of the Mokelumne, Cosumnes, and Calaveras rivers, which enter into the eastern side of the Delta, contribute the remainder. The rivers flow through the Delta and into Suisun Bay. From Suisun Bay, water flows through the Carquinez Strait into San Pablo Bay, which is the northern half of San Francisco Bay, and then out to sea through the Golden Gate.

Tidal influence is important throughout the Delta. Historically, during summers when mountain runoff diminished, ocean water intruded into the Delta as far as Sacramento. During the winter and spring, fresh water from heavy rains pushed the salt water back, sometimes past the mouth of San Francisco Bay.

With the addition of Shasta, Folsom, and Oroville dams, saltwater intrusion into the Delta during summer months has been controlled by reservoir releases during what were traditionally the dry months. Typically, peaks in winter and spring flows have been dampened, and summer and fall flows have been increased. In very wet years, such as 1969, 1982, 1983, and 1986, reservoirs are unable to control runoff so that during the winter and spring the upper bays become fresh; even at the Golden Gate, the upper several feet of water column consisted of fresh water.

On the average, about 21 MAF of water reaches the Delta annually, but actual inflow varies widely from year to year and within the year. In 1977, a year of extraordinary drought, Delta inflow totaled only 5.9 MAF, while inflow for 1983, an exceptionally wet year, was about 70 MAF. On a seasonal basis, average natural flow to the Delta varies by a factor of more than 10 between the highest month in winter or spring and the lowest month in fall. During normal water years, about 10 percent of the water reaching the Delta would be withdrawn for local use, 30 percent would be withdrawn for export by the CVP and SWP, 20 percent would be needed for salinity control, and the remaining 40 percent would become Delta outflow in excess of minimum requirements. The excess outflow would occur almost entirely during the season of high inflow.

Hydraulics of the Estuary system are complex. The influence of tide is combined with freshwater outflow resulting in flow patterns that vary daily. Delta hydraulics are further complicated by a multitude of agricultural, industrial, and municipal diversions for use within the Delta itself, and by exports by the SWP and CVP.

Water Supply Developments. The Delta-Central Sierra area is the hub of the major State and federal water development facilities, and numerous local water supply projects. Water projects divert water from Delta channels to meet the needs of about two-thirds of the State's population and to irrigate 4.5 million acres. Delta agricultural water users divert directly from the channels, using more than 1,800 unscreened pumps and siphons, which vary from 4 to 30 inches in diameter, and with flow rates of 40 to about 200 cfs. These local diversions vary between 2,500 and 5,000 cfs during April through August, with maximum rates in July.

In the Delta near Walnut Grove, the federal Delta Cross Channel diverts water, by gravity, from the Sacramento River into the North and South forks of the Mokelumne River. Sacramento River water moves down these channels through the central Delta and into the San Joaquin River. Flows in the Delta Cross Channel reverse as the tide changes and, at certain stages, there is considerable flow from the channel into the Sacramento River. Flows in the Delta Cross Channel can be controlled by two radial gates. The channel is closed for flood control purposes when Sacramento River flows exceed about 25,000 cfs. Other channels that convey water across the Delta include Georgiana Slough, and the San Joaquin, Old, and Middle rivers.

In addition to the principal CVP and SWP diversions into the Delta-Mendota Canal and the California Aqueduct, respectively (which are described under the previous sections on these water projects), the CVP also diverts water into the Contra Costa Canal, and the SWP diverts water into the North Bay Aqueduct and the South Bay Aqueduct, as described below.

Contra Costa Water District Service Area. CVP water is delivered through the Contra Costa Canal to the Contra Costa Water District (CCWD). The CCWD delivers water throughout eastern Contra Costa County, including a portion of the district in the San Joaquin River region. The current contract with the USBR is for a supply of 195 TAF per year. The CCWD also has a right to divert almost 27 TAF from Mallard Slough on Suisun Bay. Most of the CCWD's demands are met through direct diversions from the Delta through the Contra Costa Canal. The CCWD has very little regulatory or emergency water supply storage to replace Delta supplies when water quality is poor. As a result, CCWD service area voters authorized funding for Los Vaqueros Reservoir in 1988. The reservoir will improve supply reliability and water quality by allowing the CCWD to pump and store water from the Delta during high flows. The Los Vaqueros Project has received all the required environmental and water rights permits, and construction has begun. The first stage of the project will be operational in the spring of 1997.

A diversity of industry is located in Contra Costa County. With its miles of waterfront linking ocean, river, and overland transportation facilities, the area offers many advantages to heavy industries requiring large supplies of cooling and processing water, large land areas, and access to a deepwater ship channel. Major industry groups in the county that require the greatest amounts of water are manufacturers of petroleum and coal products, paper and allied products, chemicals and allied products, primary metal products, and food and related products. Presently, the exceptionally high water needs of the petroleum refineries are largely met with brackish supplies from the south shores of San Pablo and Suisun bays.

The CCWD provides the municipal water needs of about 400,000 county residents. Of the nine bay area counties, Contra Costa is projected to experience the most rapid future population growth. The growing trend toward municipal water use increases the need for both improved water quality to meet State and federal standards and improved system reliability to meet peak water demands.

North Bay Service Area. The SWP delivers water through the North Bay Aqueduct to the Solano County Water Agency and the Napa County Flood Control and Water Conservation District. The aqueduct extends over 27 miles from Barker Slough to the Napa Turnout Reservoir in southern Napa County. Maximum SWP entitlements are for 67 TAF annually. The North Bay Aqueduct also conveys water for the City of Vallejo, which purchased capacity in the aqueduct.

With an estimated population of 95,000, Napa County is known for its substantial wine, livestock, and dairy industries. The industries of Solano County, with a population of about 303,500, include field, fruit, and nut crops, livestock, and several heavy water-using industries (a cannery, refinery, brewery, food processing, and meat packing). In addition to the North Bay Aqueduct, Solano County obtains its water supply from Lake Berryessa, Lake Solano, several small reservoir and stream projects, ground water, agricultural return flows, and reclaimed waste water.

South Bay Service Area. From Bethany Reservoir, up to 300 cfs of Delta water is lifted by the South Bay Pumping Plant into the South Bay Aqueduct, which serves Alameda and Santa Clara Counties around the southern half of San Francisco Bay. Along the South Bay Aqueduct near Livermore, water is pumped into Lake Del Valle on Alameda Creek, which provides aqueduct flow regulation and flood protection.

Alameda County has some natural runoff from Alameda Creek, but only Santa Clara County has significant surface water supplies. Water is imported from the Tuolumne River via the Hetch Hetchy Aqueduct, and from the Delta via the South Bay Aqueduct and the San Felipe Project.

Ground water basins have been intensively developed for domestic, industrial, and irrigation uses and have been overdrawn, with resultant seawater intrusion and land subsidence problems. Extensive recharge programs using local and imported water supplies have allowed substantial recovery of the ground water basins.

Historically, Santa Clara County's economy was dominated by agriculture. However, the rapid urban development of the county has displaced much of the farming, which is now carried out in the less populated southern part of the county. The South Bay is northern California's leading business center. The economy of the area is diversified, with manufacturing, commerce, services, and government sectors employing significant numbers of people.

Surface Water Quality. The existing water quality problems of the Delta system may be categorized by toxic materials, eutrophication and associated dissolved oxygen fluctuations, suspended sediments and turbidity, salinity, and bacteria.

Many Delta waterways have impaired water quality due to toxic chemicals (SWRCB 1994). High concentrations of some metals from point and non-point sources appear to be ubiquitous in the Delta. Tissues from fish taken throughout the Delta exceed the National Academy of Sciences/Food and Drug Administration guidelines for mercury. There is currently a health advisory in effect for mercury in striped bass. High levels of other metals (i.e., copper, cadmium, and lead) in Delta waters are also of concern. Also, in localized areas of the Delta (e.g., near Antioch and in Mormon Slough), fish tissues contain elevated levels of dioxin as a result of industrial discharges.

Pesticides are found throughout the waters and bottom sediments of the Delta. High levels of chlordane, toxaphene, and DDT from agricultural discharges impair aquatic life beneficial uses throughout the Delta, while diazinon can be found in elevated concentrations at various locations (SWRCB 1994). The more persistent chlorinated hydrocarbon pesticides are consistently found throughout the system at higher levels than the less persistent organophosphate compounds. The sediments having the highest pesticide content are found in the western Delta. Pesticides have concentrated in aquatic life in the Delta. The long-term effects of pesticide concentrations found in aquatic life of the Delta are not known. The effects of intermittent exposure of toxic pesticide levels in water and of long-term exposure to these compounds and combinations of them are likewise unknown.

Much of the water in the Delta system is turbid as a result of an abundance of suspended silts, clays, and organic matter. Most of these sediments enter the tidal system with the flow of the major tributary rivers. Some enriched areas are turbid as a result of planktonic algal populations, but inorganic turbidity tends to suppress nuisance algal populations in much of the Delta. Continuous dredging operations to maintain deep channels for shipping has contributed to turbidity of Delta waters and is a factor in the temporary destruction of bottom organisms through displacement and suffocation.

The most serious enrichment problems in the Delta are found along the lower San Joaquin River and in certain localized areas receiving waste discharges, but having little or no net freshwater flow. These problems occur mainly in the late-summer and coincide with low river flows and high temperatures. Dissolved oxygen problems are further aggravated by channel deepening for navigational purposes. The resulting depressed dissolved oxygen levels have not been sufficient to support fish life and, therefore, prevent fish from moving through the area. In the autumn these conditions, together with reversal of natural flow patterns by export pumping, have created environmental conditions unsuitable for the passage of anadromous fish (salmon) from the Delta to spawning areas in the San Joaquin Valley.

Warm, shallow, dead-end sloughs of the eastern Delta support objectionable populations of planktonic blue-green algae during summer months. Floating and semi-attached aquatic plants, such as water primrose and water hyacinths, frequently clog waterways in the lower San Joaquin River system during the summer. Extensive growths of these plants have also been observed in localized waterways of the Delta. These plants interfere with the passage of small boat traffic and contribute to the total organic load in the Delta-Bay system as they break loose and move downstream in the fall and winter months.

Salinity control is necessary because the Delta is contiguous with the ocean, and its channels are at or below sea level. Unless repelled by continuous seaward flow of fresh water, sea water will advance up the Estuary into the Delta and degrade water quality. During winter and early-spring, flows through the Delta are usually above the minimum required to control salinity. At least for a few months in the summer and fall of most years, however, salinity must be carefully monitored and controlled. The monitoring and control is provided by the CVP and SWP, and regulated by the SWRCB under it water rights authority.

At present, salinity problems occur mainly during years of below normal runoff. In the eastern Delta, these problems are largely associated with the high concentrations of salts carried by the San Joaquin River into the Delta. Operation of the State and federal export pumping plants near Tracy draws high quality Sacramento River water across the Delta and restricts the low quality area to the southeast corner. Localized problems resulting from irrigation returns occur elsewhere, such as in dead-end sloughs. Salinity problems in the western Delta result primarily from the incursion of saline water from the San Francisco Bay system. The extent of incursion is determined by the freshwater flow from the Delta to the Bay.

Bacteriological quality of Delta waters, as measured by the presence of coliform bacteria, varies depending upon proximity of waste discharges and significant land runoff. The highest concentration of coliform organisms is generally found in the western Delta. Local exceptions to this can be found in the vicinity of major municipal waste discharges.

Another human health concern is that Delta water contains precursors of trihalomethanes (THMs), which are suspected carcinogens produced when chlorine used for disinfection reacts with natural substances during the water treatment process. Dissolved organic compounds that originate from decayed vegetation act as precursors by providing a source of carbon in THM formation reactions. During periods of low Delta outflow, tidal mixing of salts from the ocean (including bromides) extends farther into the Delta, increasing the bromide concentrations at municipal drinking water intakes. When bromides are present in water along with organic THM precursors, THMs are formed that contain bromine as well as chlorine. Drinking water supplies taken from the Delta are treated to meet current THM standards. However, more restrictive standards are being considered which, if adopted, will increase the cost and difficulty of treating present Delta water sources.

Discharges from municipal and industrial wastewater treatment plants affect the quality of surface waters. However, the increased use of secondary treatment facilities has resulted in reduced nutrient loadings, which has reduced the impact of these discharges on surface water quality in recent years.

Ground Water Quality. A major restriction on the use of ground water, particularly for municipal and industrial needs, is the variable and uncertain quality. Ground water salinity levels in the Suisun-Fairfield area typically range from 300 to 6,000 mg/l TDS, with average values generally exceeding 900 mg/l TDS. Putah Plain ground water is of somewhat better quality, with average TDS levels generally under 600 mg/l. However, the Putah Plain aquifer is distant from municipal and industrial water demand centers, so water transport facilities would have to be incorporated into any project developing ground water on a major scale.

Ground water quality is generally poor north of St. Helena and south of Napa, where it is frequently degraded by brackish water from San Francisco Bay. Because most of any additional demand for water would be for municipal and industrial use, where both quality and quantity are crucial, ground water will probably continue to be used as a supplemental source, mainly for agriculture.

Vegetation. The complex interface between land and water in the Estuary provides rich and varied habitat for wildlife, especially birds. Habitat or cover types in the Delta are agriculture, forest, riparian forest, riparian scrub-shrub, emergent freshwater marsh, and heavily shaded riverine aquatic.

Wildlife and Fish. The Delta supports many birds and mammals in the riparian and upland habitats. The area also serves as a feeding and resting area for millions of ducks, geese, swans, and other migrant waterfowl.

The wildlife and fish diversity is high due to the extensive mudflats and riparian vegetation, and gradation of aquatic habitats from freshwater (in the upper reaches of the Delta), to brackish (in the Suisun Bay region), to saline (in portions of San Francisco Bay). These three aquatic habitat zones historically graded gradually into one another. The zones move upstream or downstream, depending on the amount of freshwater outflow. Important groups of wildlife dependent on the Delta and Bay estuarine environment are waterfowl and other migratory waterbirds, game birds such as pheasant and quail, numerous nongame birds, furbearers, and other mammals.

The Delta is particularly important to waterfowl migrating via the Pacific Flyway. The principal attraction for waterfowl is winter flooded agricultural fields, mainly cereal crops, which provide food and extensive seasonal wetlands. The Delta, along with the principal wetlands that support Central Valley waterfowl, is winter habitat for 60 percent of the waterfowl on the Pacific Flyway, and for 90 percent of all waterfowl that winter in California. More than a million waterfowl are frequently in the Delta at one time.

The Estuary supports about 90 species of fish. The Delta, which is basically a freshwater environment, serves as a migratory route and nursery area for chinook salmon, striped bass, sturgeon, American shad, and steelhead trout. All of these anadromous fishes spend most of their adult lives either in the lower bays of the Estuary or in the ocean. The Delta is a major nursery area for most of these species. Other fishes in the Estuary include Delta smelt, Sacramento splittail, Sacramento perch, catfish, largemouth bass, black bass, crappie, and bluegill.

The Delta has a large number of fishery habitat types, including estuarine, fresh, and marine water environments. The amounts of the various habitat types depend, in part, upon outflow regimes and water year hydrology. Habitats vary from dead-end sloughs to deep open water areas of the lower Sacramento and San Joaquin rivers and Suisun Bay. There are also a scattering of flooded islands offering submerged vegetative shelter. The banks of the channels are varied, and include riprap, tules, emergent marshes, and native riparian habitats. Water temperatures generally reflect ambient air temperatures. However, riverine shading may moderate summer temperatures in some areas.

Food supplies for Delta fish communities consist of phytoplankton, zooplankton, benthic invertebrates, insects, and forage fish. General productivity in the Delta is in constant flux and an evaluation of the interrelationships of the food web is now underway by the

Interagency Ecological Program. There are indications that overall productivity at the lower food chain levels has decreased during the past 15 or so years.

Biological production in the Estuary may be higher in the entrapment zone where freshwater Delta outflows meet and mix with more saline waters of the bay. The entrapment zone concentrates sediments, nutrients, phytoplankton, striped bass larvae, and fish food organisms. It is considered advantageous that outflows be sufficient to keep the entrapment zone in the upper reaches of Suisun Bay, where it can spread out over a large area, rather than in the narrower Delta channels upstream from Suisun Bay.

Numerous listed or candidate rare, threatened, or endangered vertebrate species are known to live in the Delta, but none is confined exclusively to that area. Seven listed species are birds (bald eagle, American peregrine falcon, Swainson's hawk, California black rail, Aleutian Canada goose, tricolored blackbird, and western yellow-billed cuckoo), two are mammals (salt marsh harvest mouse and San Joaquin kit fox), two are reptiles (giant garter snake and southwestern pond turtle), two are amphibians (California tiger salamander and California red-legged frog), and four are fish (winter-run chinook salmon, Delta smelt, Sacramento splittail, and Sacramento perch). There are five listed or candidate endangered or threatened invertebrate species in the Delta (valley elderberry longhorn beetle, Lange's metalmark butterfly, Delta green ground beetle, Sacramento anthicid beetle, and curve-foot hygrotus diving beetle). Twelve rare or endangered plant species, most of which are associated with freshwater marshes, can also be found in the Delta.

Land Use and Economy. Although no major cities are entirely within the Delta, it does include a portion of Stockton, Sacramento, and West Sacramento. In addition, the small cities of Antioch, Brentwood, Isleton, Pittsburg, and Tracy, plus about 14 unincorporated towns and villages, are located within the Delta. Most of the population in the legal Delta is in the upland areas on the eastern and western fringes. The Stockton area on the east and the Antioch-Pittsburg area on the west have undergone steady industrialization and urbanization. Most Delta islands are sparsely populated; however, some, including Byron Tract and Bethel Island, have large urban communities.

Recreation. Although the Delta environment has been extensively altered over the past 125 years by reclamation and development, natural and aesthetic values remain that make it a valuable and unique recreational asset. Waterfowl and wildlife are still abundant, sport fishing is still popular, and vegetation lining the channels and islands are still attractive. As a result, the miles of channels and sloughs that interlace the area attract a diverse and growing number of people seeking recreation.

With its unique and numerous recreational opportunities, the Delta will continue to support large numbers of recreationists. Motor boating and fishing are the leading activities. The extensive riparian vegetation of the Delta area is conducive to sight seeing, bird watching, and relaxing. Overnight camping, picnicking, swimming, and waterskiing are enjoyed by many people. Photography, bicycling, hunting, and sailing also occur in the Delta, although less frequently.

There are about 20 public and more than 100 commercial recreational facilities in the Delta. These facilities provide rentals, services, camping guest docks, fuel, supplies and food. Demand for and use of these facilities continue to grow.

E. SUISUN MARSH

Suisun Marsh is one of the few major marshes remaining in California and the largest remaining brackish wetland in Western North America. Located at the northern edge of Suisun Bay, just west of the confluence of the Sacramento and San Joaquin rivers and south of the City of Fairfield, the marsh consists of a unique diversity of habitats, including tidal wetlands, sloughs, managed diked wetlands, unmanaged seasonal wetlands, and upland grasslands. Most of Suisun Marsh consists of managed diked wetlands; however, numerous studies have established that tidal marshlands can have significant geomorphic and ecological values, including flood control, shoreline stabilization, sediment entrapment, water quality improvement, and food chain support for aquatic, semi-aquatic, and terrestrial plants and animals (Williams and Josselyn 1987).

Land Use. The primary managed area of Suisun Marsh contains 58,600 acres of marsh, managed wetlands, and adjacent grasslands, plus 29,500 acres of bays and waterways. An additional 27,900 acres of varying land types act as a buffer zone. Most of the managed wetlands are enclosed within levee systems. About 70 percent of the managed wetlands are privately-owned by more than 150 duck clubs. The DFG owns and manages 14,700 acres. The Solano County Farmlands and Open Space Foundation owns 1,050 acres of tidal wetlands and a 78 acre diked managed wetland. The U.S. Navy administers 1,400 acres of tidal wetlands on the channel islands of Suisun Bay.

Vegetation. Elevation and salinity are the principal factors controlling the distribution of tidal marsh plants in San Francisco Bay (NHI 1992). Vascular vegetation and the flow of tidal water maintain and ultimately control the distribution and abundance of the marshlands. The plants influence the quality and quantity of habitats for many species of wildlife. The ecological values and function of tidal marshland are largely determined by the nature of the plant community. The structure of the plant communities in tidal marshland is strongly correlated to salinity regime (Schubel 1993). Within the diked managed wetlands of the Suisun Marsh, water management, and the resulting controlled wetland hydroperiod, has been shown to have the most significant effect on the vegetation type used by several sensitive fish including delta smelt, longfin smelt, chinook salmon, and splittail.

Under a 1984 plan of protection for the marsh and a 1985 preservation agreement to mitigate the effects of upstream water projects on the marsh, the staged construction of extensive marsh water control facilities was planned. To date, the salinity control structure on Montezuma Slough, a major waterway in the marsh, has been constructed. This facility helps to ensure that a dependable supply of suitable salinity water is available to preserve marsh habitat, including food plants for waterfowl (DWR 1986).

Wildlife and Fish. Suisun Marsh supports 45 species of mammals, 230 species of birds, and 15 species of reptiles and amphibians. The marsh is a major wintering ground for waterfowl of the Pacific Flyway. Ducks, geese, swans, and other migrant waterfowl use the marsh as a feeding and resting area. As many as 25 percent of California's wintering waterfowl inhabit the marsh in dry winters. Waterfowl are attracted to the marsh by the water and the abundance of natural food plants, most valuable of which are alkali bulrush, fat hen, and brass buttons. The growth of such plants depends on proper soil salinity, which is affected by salinity of applied water. Freshwater flows from the Delta into Suisun Bay and marsh channels from October through May affect marsh salinities and waterfowl food production.

Most fish in marsh channels are striped bass, for which the marsh is an important nursery area. Other anadromous species sometimes found in the marsh include chinook salmon, sturgeon, American shad, and steelhead trout. Catfish, providing a sport fishery, are also found in Suisun Marsh.

Resident breeding populations of two endangered species (the salt marsh harvest mouse and the California clapper rail), one threatened species (the California black rail), and two candidate species (the California Suisun song sparrow and Suisun ornate shrew) have been documented in Suisun Marsh. Two state listed plant species (Mason's lilaeopsis and softbird's beak) occur in Suisun Marsh in addition to three federal candidate plant species (Suisun Slough thistle, Suisun aster, and Delta tule pea) (DWR 1994b).

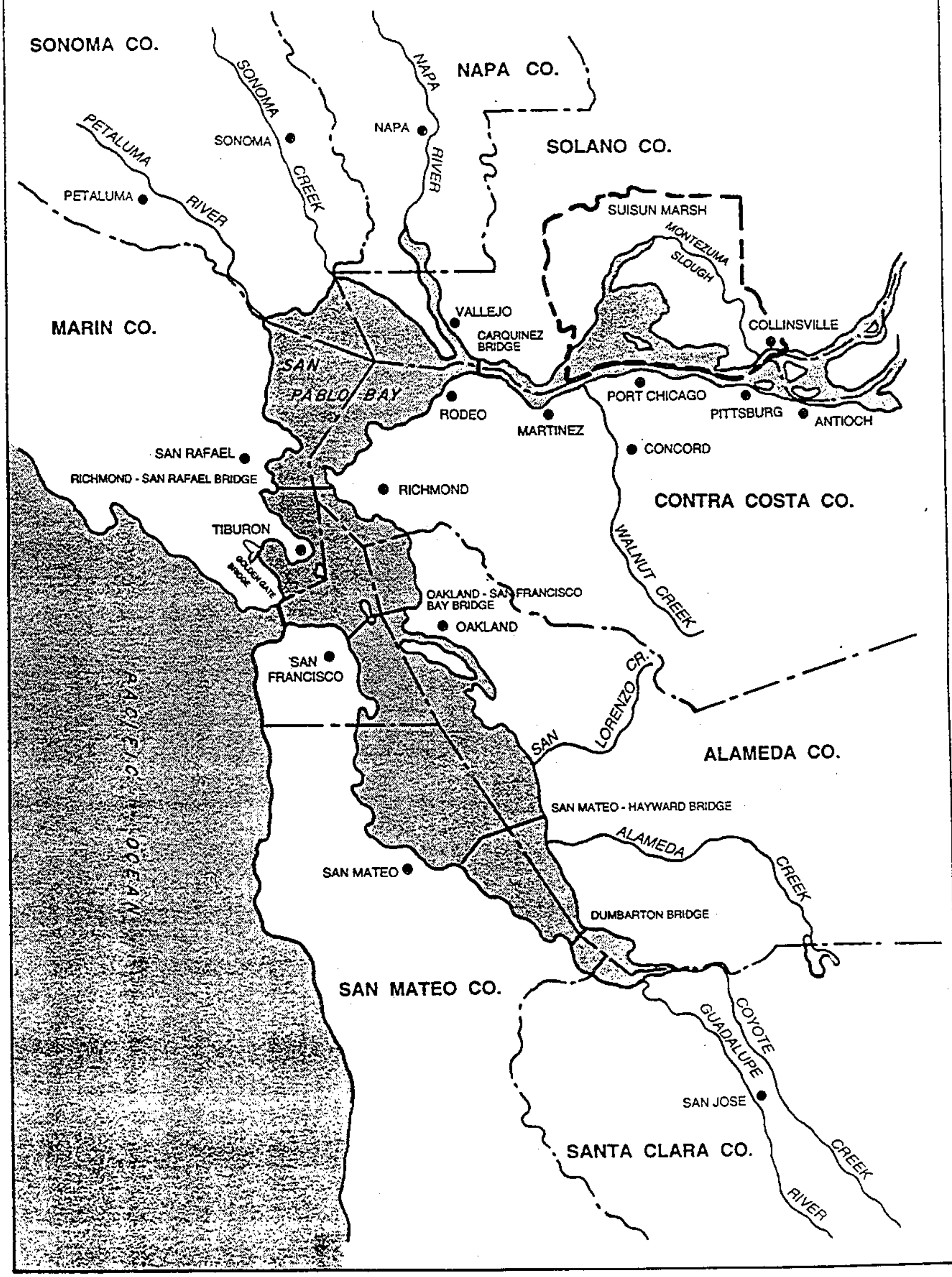
F. SAN FRANCISCO BAY

The San Francisco Bay system (Figure IV-7) is an integral part of the Central Valley and Delta ecosystems. Runoff from the northern and southern Central Valley converges in the Delta prior to discharging to the ocean through the Bay. Anadromous fish traveling to Central Valley streams to spawn or returning to the ocean travel through the Bay.

Surface Water Hydrology. San Francisco Bay, which includes Suisun, San Pablo, Central, and South bays, extends about 85 miles from the east end of Chipps Island (in Suisun Bay near the City of Antioch) westward and southward to the mouth of Coyote Creek (tributary to South Bay near the City of San Jose). The Golden Gate connects San Francisco Bay to the Pacific Ocean.

The surface area of San Francisco Bay is about 400 square miles at mean tide. This is about a 40 percent reduction, due to fill, from its original size. Most of the bay's shoreline has a flat slope, which causes the intertidal zone to be relatively large. The volume of water in the bay changes by about 21 percent from mean higher-high tide to mean lower-low tide. The depth of the bay averages 20 feet overall, with the Central Bay averaging 43 feet and the

Figure IV-7 SAN FRANCISCO BAY COMPLEX (INCLUDING SUISUN MARSH)



South Bay averaging 15 feet (DWR 1986). San Francisco Bay is surrounded by about 130 square miles of tidal flats and marshes.

The principal source of fresh water in San Francisco Bay is outflow from the Delta. Delta outflows vary greatly according to month and hydrologic year type. Historical Delta outflows have dropped to zero during critically dry periods such as 1928 and 1934. Present summer outflows are maintained by upstream reservoir releases. Although annual Delta outflow has averaged 24 MAF from 1977 to 1986, it has varied from less than 2.5 MAF in 1977 to more than 64 MAF in 1983.

Other significant sources of freshwater inflow to San Francisco Bay are the Napa, Petaluma, and Guadalupe rivers, and Alameda, Coyote, Walnut, and Sonoma creeks. These tributaries make up a total average inflow of about 350 TAF. Stream flow is highly seasonal, with more than 90 percent of the annual runoff occurring during November through April. Many streams often have very little flow during mid- or late-summer.
The surface hydrology of the bay can be divided into two distinct patterns. The northern part of the bay, including San Pablo and Suisun bays, receives freshwater outflow from the Delta and functions as part of the Estuary. The South Bay receives little runoff and behaves like a lagoon. Circulation in and flushing of the bay depend on tides and Delta outflow. Circulation is primarily a tidal process, while flushing is believed to depend on tidal action, supplemented by periodic Delta outflow surges following winter storms (USBR and DWR 1986).

Freshwater outflow from the Delta to San Francisco Bay is believed to be important in maintaining desired environmental conditions in the bay, but no standards govern such outflow. High-volume, uncontrolled outflow surges during the winter cause freshwater to penetrate well into the central bay, from which it can enter the southern bay by tidal exchange. Such events cause salinity stratification in much of the South Bay that can persist for several weeks or months following the initial appearance of freshwater.

Water requirements in the San Francisco Bay area are met by local surface and ground water supplies, and imported surface water. The conveyance systems that bring the majority of the water to the area are: the Hetch Hetchy, South Bay, North Bay, Mokelumne, Petaluma, and Santa Rosa-Sonoma aqueducts; Contra Costa and Putah South canals; Cache Slough Conduit; and the San Felipe Project. More than 60 percent of the water is imported from Delta supplies.

Surface Water Quality. Water quality in the San Francisco Bay system is impacted by several factors. For example, the presence of elevated concentrations of toxic pollutants in the bays, from both point and non-point sources, has caused them to be listed as impaired water bodies. The State Department of Health Services has issued health advisories on the consumption of the bays' fish and certain waterfowl due to their elevated levels of selenium and other metals (SWRCB 1994).

Pesticides in the San Francisco Bay system originate from municipal storm sewers and sanitary sewerage systems, urban runoff, and agricultural drainage from the Central Valley. The presence of these pesticides is a threat of unknown magnitude to the fisheries and wildlife resources. Fish kills have occurred in the San Francisco Bay system as a result of accidental spills of toxic materials, and discharges of inadequately treated sewage and industrial wastes. Localized fish kills involving large numbers of striped bass have occurred in Suisun Bay from unknown causes.

The San Francisco Bay area has experienced oil pollution problems mainly localized at refinery docks, ports, marinas, and near storm sewer outlets. These problems are attributable to accidental spills, deliberate discharges, pipeline leaks, and pumping of oil bilge or ballast water.

Depressed levels of dissolved oxygen in the extreme portion of South San Francisco Bay occur during the late-summer and early-fall months due to municipal waste discharges. Dissolved oxygen deficiencies also occur in the Petaluma and Napa rivers. Algal growths have caused complete lack of dissolved oxygen in the extreme reaches of some tidal sloughs, creeks, and rivers. Recent years have brought red water discoloration caused by marine ciliates, a phenomenon probably aggravated by high nutrient concentrations.

Water in much of San Francisco Bay contains coliform bacteria levels greater than those recommended for water contact sports. Substantial improvement has been reported since the initiation of chlorination of the discharge from a large municipal sewerage system.

<u>Wildlife and Fish</u>. The bays and surrounding lands support a wide variety of fish, migratory birds, and mammals. Open water, tidal mudflats, and marshland are used by various species, especially shorebirds and waterfowl.

The anadromous species of fish which occur in San Francisco Bay system include chinook salmon, striped bass, sturgeon, American shad, and steelhead trout. Marine fish, found mainly in the lower bays, include flatfish, sharks, and surf perch. Shellfish include mussels, oysters, clams, crabs, and shrimp. Seasonal variations in salinity in the bays, due to varying Delta outflows, affect the seasonal distribution of fish and invertebrates. Benthic invertebrates, such as clams, are limited to areas where conditions are favorable year-round. Once a thriving business, there is at present no commercial oyster industry in San Francisco Bay. There is sport clamming, although coliform bacteria concentrations are higher than the U.S. Public Health Service and State allowable limits.

Rare, threatened, or endangered animal species found in the area include the Alameda striped racer, salt marsh harvest mouse, San Francisco garter snake, California clapper rail, and California yellow-billed cuckoo.

<u>Land Use and Economy</u>. Nine counties surround San Francisco Bay: Marin, San Francisco, San Mateo, Santa Clara, Alameda, Contra Costa, Solano, Napa, and Sonoma. In

1987, the San Francisco Bay area, whose economy is based on commerce and industry, became the fourth largest metropolitan area in the United States.

Recreation. Mild temperatures and brisk winds make San Francisco Bay one of the world's favorite recreational boating areas. Other water-oriented recreation includes sight-seeing, picnicking, fishing, nature walking, and camping.

G. CENTRAL COAST REGION

Construction of Phase II of the Coastal Branch of the California Aqueduct will provide SWP water to the Central Coast region. The Central Coast service area, which encompasses approximately 3.9 million acres, consists of San Luis Obispo and Santa Barbara counties.

The Phase II facilities will transport 52.7 TAF of water to the area, though full SWP entitlement is 70.5 TAF per year for these areas. Santa Barbara County has the option to buy back an additional 12.2 TAF per year of SWP water. The proposed Coastal Branch Phase II, and local pipeline projects such as the Mission Hills Extension, would transect western Kern, San Luis Obispo, and Santa Barbara counties. An environmental impact report and an advance planning study were completed in May 1991.

Phase II of the Coastal Aqueduct in Kern County would be located in the northeastern portion of Antelope Valley and eastern foothill regions of the Coast Range. The area is relatively barren with few streams or other drainage. Elevation of the valley floor is about 500 feet, while hills near the project area range from 1,000 to 2,500 feet at Bluestone Ridge.

San Luis Obispo and Santa Barbara counties consist of three broad physiographic regions: a coastal plain, coastal mountains and valleys, and interior mountains and valleys. Elevations in San Luis Obispo County range from sea level along the coastal plain to 5,106 feet at the summit of Caliente Mountain in the south-east corner of the county. The seven cities in the county are Arroyo Grande, Atascadero, Grover City, Morro Bay, Paso Robles, Pismo Beach, and San Luis Obispo. The topography of Santa Barbara County is dominated by the Sierra Madre, San Rafael, and Santa Ynez mountain ranges. Elevations within Santa Barbara County vary from sea level to 6,828 feet at the summit of Big Pine Mountain. The six cities in the county are Santa Barbara, Santa Maria, Lompoc, Carpinteria, Solvang, and Guadalupe. Unincorporated communities include Goleta, Buellton, Mission Hills, Montecito, Orcutt, Santa Ynez, and Vandenberg Village. Vandenberg Air Force Base dominates the western coastal area of the county.

The climate of the Central Coast area, like much of coastal Southern California, is Mediterranean. Typically, winters are mild and moist, and summers are warm and dry. Mountain ranges intercept much of the rain, producing drier climates, and even deserts, in eastern San Luis Obispo and western Kern counties. The wettest areas occur in the Santa Lucia and Sierra Madre; the Antelope Valley in Kern County is one of the driest areas.

Precipitation varies considerably from year to year, with most occurring during November through April. Fog occurs frequently along a 2- to 15-mile-wide coastal strip.

Surface Water Hydrology. The Santa Ynez, Santa Maria, and Salinas rivers constitute the major drainage of the Central Coast service area, although numerous lesser streams exist. Dams and canals have been constructed on those rivers to conserve runoff. The Salinas River, the largest single watershed in the Central Coast area, flows northward into Monterey County and discharges into Monterey Bay. Currently, no water is imported into the Central Coast area. Ground water is the main source of water supply. Over-use of the ground water resources has led to overdrafting and water quality problems in some locations, such as the Santa Maria Valley and southern coastal Santa Barbara County.

Vegetation. Much of the natural vegetation in the two counties remains relatively undisturbed. Those areas that have been developed have mainly been the valleys, alluvial fans and plains, and terraces. Plant communities found in the area include grasslands, chaparral, scrub, riparian, marsh, woodland, and forest. Numerous sensitive plant species occur in these communities.

Wildlife and Fish. Due to the wide variety of plant communities in the area, animal populations are extremely diversified. Because of the overlap between the northern and southern floristic elements, many rare and endangered species inhabit the Central Coastal service area.

Land Use and Economy. The economy of San Luis Obispo and Santa Barbara counties depends on agriculture and related activities. In the coastal lowlands, there is considerable high value fruit and vegetable farming. In the drier lowlands, which are inland from the coast, livestock and dry-farmed grains are produced. Manufacturing is limited, but heavy water-using industries, such as petroleum production, food processing, and stone, clay, and glass products manufacturing, are present. Some mining and military installations also contribute to the region's economy. Recreation and retirement activities are increasing in the coastal communities.

H. SOUTHERN CALIFORNIA

The Southern California service area of the SWP includes Ventura, Los Angeles, and Orange counties, and parts of San Diego, Riverside, Imperial, San Bernardino, and Kern counties. The estimated population of this highly urbanized area in 1986 was over 15 million, with Los Angeles County being the most populous county in the State. SWP water is delivered to the contractors in the Southern California service area through both the East and West branches of the California Aqueduct.

Surface Water Hydrology. Due to the highly seasonal precipitation, there are no major rivers in the desert plateau region of this service area. The intermittent streams that flow from the mountains primarily percolate into groundwater basins. A limited surface water supply has been developed, and most local water supplies have been developed for flood control, groundwater recharge, and water supply. Because local water supplies are limited, imported water has played a significant role in meeting the area's growing water demands. Supplemental water is imported from three sources: (1) Los Angeles Aqueduct from the Owens Valley and Mono Lake basin, on the eastern side of the Sierra Nevada, to the City of Los Angeles; (2) Colorado River via the Colorado River Aqueduct; and (3) the SWP. Imported water was first brought into the area from Owens Valley via the Los Angeles Aqueduct by the City of Los Angeles in 1913. As development on the coastal plain increased, the Colorado River was tapped as a second imported supply in 1941 by the Metropolitan Water District, which constructed the Colorado River Aqueduct to carry this water. Both of these import facilities have been operating at or near capacity. A third major source of imported water, the SWP, first made deliveries to the Southern California area in 1972.

In Ventura and Los Angeles counties, some SWP supplies are released into natural stream channels. Piru Creek, a tributary to the Santa Clara River, serves as a conveyance to Ventura County users. In Los Angeles County, SWP water is released into Gorman Creek for recreational use. Additional opportunities exist for streamflow augmentation where the East Branch of the California Aqueduct crosses natural streams.

Surface Water Quality. Many water quality problems exist in this service area. In the coastal area, thermal discharges from electrical generation plants and nutrient overloading of streams cause local problems. In the desert areas, the problems are more general and relate to increasing salinity of both ground water and lakes. Salinity of imported water ranges from less than 220 mg/l TDS for SWP supplies to 750 mg/l TDS for Colorado River water. In some areas, SWP water is blended with imported Colorado River water to provide a better overall quality.

The quality of streams in the Antelope Valley area is good to excellent. TDS content is usually less than 300 mg/l and ranges from about 50 to 450 mg/l. The water is moderately hard, but ranges from soft to very hard, and is calcium bicarbonate in character.

The quality of water from the intermittent streams of the Mojave River area near the aqueduct is also generally good to excellent. The water is soft to moderately hard and suitable for most uses. Stormwater flow in the Mojave River is calcium bicarbonate in character and has a TDS level of less than 300 mg/l.

Ground Water Hydrology. Ground water supplies a significant portion of the water in the Southern California service area. The South Coastal hydrologic basin, which encompasses this service area, has at least 44 major groundwater basins. Although further development is possible in a few local areas, some of the basins have been over-used. Seawater barrier and artificial recharge programs have been developed to correct seawater intrusion problems, resulting from groundwater overdraft, in some areas along the coast.

Ground Water Quality. Ground water quality in the immediate vicinity of the aqueduct in the Antelope Valley is excellent. TDS concentrations of about 150 to 300 mg/l dominate, with a few smaller areas around the communities of Littlerock and Pearblossom having TDS concentrations of about 300 to 500 mg/l.

The ground water quality in the Mojave River area is fair. TDS concentrations range from about 300 to 1,000 mg/l and are predominantly calcium or sodium bicarbonate in character, with calcium predominating in the recharge area of the foothills, and sodium in the middle and lower discharge areas of the playas.

Vegetation. While some of the naturally-occurring vegetation in the Southern California service area has been altered significantly by urban and agricultural development, a large part of the region, mostly uplands, retains it native cover. The dominant natural vegetation type in the non-urbanized portion of the Southern California service area is a mixture of coastal sage scrub and chaparral communities, covering 46 percent of the land area. Chaparral has little commercial value, but it forms a valuable watershed cover and wildlife habitat.

Wildlife and Fish. The Southern California service area supports a great diversity of wildlife. Though several mammal species are found here, most of the wildlife in this area are birds. Reservoirs along the aqueduct provide habitat for numerous geese, ducks, and shore birds, including several hundred Canada geese that winter in the upper Antelope Valley.

Fish found in the California Aqueduct include largemouth bass, striped bass, green sunfish, bluegill, and catfish. In addition to these species, rainbow trout are stocked in Silverwood Lake.

The diversity of habitats available in the area, combined with the impacts of a rapidly developing human population, has resulted in a large number of rare and endangered species. Steps have been taken to preserve habitats that have unique biological significance. One endangered fish, the unarmored three-spine stickleback, exists in the service area but is no longer found in the Los Angeles, San Gabriel, and Santa Ana rivers. The population in the Santa Clara River is threatened by increased recreational use and development.

Land Use and Economy. Since the 1940's, Southern California has changed from a largely rural community with an agricultural economy to a highly urban-industrial society. This region, the State's leading center of business, contains several major industries, including aerospace, petroleum, fabricated metals, chemical production, food processing, and paper production.

In the coastal areas of Southern California, agriculture remains important economically, despite urbanization. Farms generally produce high value crops on small irrigated parcels. Agriculture is also important in the Colorado Desert, especially in the Coachella and Imperial valleys, where livestock, field crops, truck crops, sugar beets, and cotton are produced. Poultry, livestock, and field crops are produced in the Mojave Desert. On agricultural lands in the Antelope and Mojave basins, the principal crops are alfalfa and grain products. Almond, apple, apricot, pear, irrigated pasture, and some truck crops are also grown.

Recreation. Recreational facilities along the aqueduct include a bicycle trail with attendant rest facilities and fishing sites. The bikeway extends 105 miles from Quail Lake, near Interstate Highway 5, to a point near Silverwood Lake in the San Bernardino National Forest. It is available to bicycle riders, hikers, and anglers.

The U.S. Forest Service anticipates routing a portion of the Pacific Crest National Scenic Trail along the aqueduct. This would establish a hiking and equestrian route intersecting the aqueduct, moving east for 1 mile along the East Branch right-of-way to the Los Angeles Aqueduct, then north along that aqueduct, and eventually connecting with the Sequoia National Forest portion of the trail. Five fishing access sites are available along the East Branch.

The four SWP reservoirs in Southern California receive heavy year-round recreational use. Castaic Lake offers boating, swimming, fishing, waterskiing, and picnicking. Camping facilities are available in the adjoining Angeles National Forest. Facilities at Castaic Lake and Lagoon are operated by Los Angeles County Department of Parks and Recreation. Lake Perris, where recreational facilities are run by the Department of Parks and Recreation, offers swimming, boating, waterskiing, picnicking, camping, fishing, hiking, hunting, scuba diving, and rock climbing.

The other two Southern California reservoirs are farther from population centers, but are, by no means, remote. Pyramid Lake, in northwestern Los Angeles County, has facilities operated by the U.S. Forest Service. It offers boating, fishing, picnic sites, waterskiing, and swimming. Silverwood Lake, in the San Bernardino Mountains, has a State Recreation Area run by the State Department of Parks and Recreation. Recreation possibilities are fishing, picnicking, camping, hiking, swimming, bicycling, waterskiing, and boating.

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