WATER-QUALITY ASSESSMENT OF THE MERCED RIVER, CALIFORNIA

By Stephen K. Sorenson

U.S. GEOLOGICAL SURVEY

Open-File Report 82-450

Prepared in cooperation with the

CALIFORNIA STATE WATER RESOURCES CONTROL BOARD

November 1982

UNITED STATES DEPARTMENT OF THE INTERIOR

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For readers who prefer to use International System (SI) units rather than inch-pound units, the conversion factors for the terms used in this report are listed below:

Multiply	By	To obtain
acres	0.4047	hectares
acre-ft (acre-feet)	1233	m^3 (cubic meters)
ft (feet)	0.3048	m (meters)
ft/mi (feet per mile)	0.1894	m/km (meters per kilometer)
ft^3/s (cubic feet per second)	0.02832	m^3/s (cubic meters per second)
inches	2.54	cm (centimeters)
mi (miles)	1.609	km (kilometers)
mi^2 (square miles)	2.590	km^2 (square kilometers)
µmho/cm (micromhos per centimeter)	1.000	µS/cm (microsiemens per centimeter)

Degree Fahrenheit is converted to degree Celsius by using the formula:

$$(\text{temp } °F-32)/1.8 = \text{temp } °C$$

Explanation of other abbreviations

µg/L	micrograms per liter
µg/kg	micrograms per kilogram
mg/L	milligrams per liter
mL	milliliters
rm	river miles from mouth

National Geodetic Vertical Datum of 1929 (NGVD of 1929): A geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called mean sea level.

Water year is a 12-month period ending September 30 and is designated by the year in which it ends.

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ABSTRACT

The Merced River and its major tributaries have been the subject of water-quality and quantity studies by local, State, and Federal agencies since before 1900. Data have been compiled and analyzed, and even though water-quality problems exist in the basin, the water generally is of good quality for most of the beneficial uses defined by the California State Water Resources Control Board. Water-quality objectives for dissolved oxygen, pesticides, and pH were violated in some parts of the basin. The most likely cause of the dissolved-oxygen and pesticides violations is the return of agricultural irrigation water to the river in the lower 30 miles of the river. Violations of pH objectives occurred only in the upper drainage and were likely due to naturally occuring, poorly buffered water.

Water-quality monitoring is currently being done at three stations in the basin by the California Department of Water Resources, at one station by the U.S. Geological Survey, and at several sites by the National Park Service. Modifications to the current water-quality monitoring program are proposed to gain further information on dissolved-oxygen fluctuations and pesticide concentrations in the lower river and to investigate nutrient inputs to Lake McClure.

INTRODUCTION

Purpose and Scope

This water-quality assessment is one in a series being prepared as part of a cooperative program between the U.S. Geological Survey and the California State Water Resources Control Board (State Board). The purpose of this assessment is to define water-quality problems and determine monitoring needs in the Merced River.

Current and historical water-quality data were gathered from all known sources including the U.S. Environmental Protection Agency and U.S. Geological Survey computer files, California Department of Water Resources, and county and local water agencies. Representatives of Federal, State, and local agencies that have control or interest in the Merced River were contacted to obtain information on land use, known water-quality problems, and current monitoring programs. Analyses of past, present, and possible future water quality were made on the basis of available data. Water-quality problems, as defined by impairment of stated beneficial uses, and possible causes and solutions to the problems were identified.

Description of Study Area

The Merced River is on the western slope of the Sierra Nevada in central California (pl. 1). It is one of the major watersheds contributing to the San Joaquin River. The 1,280-square-mile drainage covers parts of Madera, Mariposa, and Merced Counties. The South Fork Merced River (the Merced River's major tributary) drains 241 miles of the southern basin and enters the main river 101 miles upstream from the mouth.

The upper basin in the Sierra Nevada is mostly granitic, part of the Sierra Nevada batholith. The foothill areas contain a variety of sedimentary and metamorphic formations, while the lower basin in the Central Valley consists of tertiary and quaternary alluvial deposits. A detailed description of the geology of the basin is presented by the California Division of Mines and Geology (1962).

The climate in the basin varies with elevation. High elevation areas are characterized by mild, dry summers and cold, wet winters with heavy snowfall. Mean annual precipitation at the high elevations is about 45 inches. Lower elevations are characterized by hot, dry summers and mild, wet winters. Mean annual rainfall at the lower elevations is about 10 inches. Anderson and others (1966) present a detailed overview of climate in Mariposa County, which covers a large part of the Merced River basin.

Most of the Merced River basin upstream from river mile 110 is within Yosemite National Park. This generally pristine environment is extensively used by thousands of visitors to the park every year. The majority of development is in Yosemite Valley where most of the visitor and park facilities are located. Several back-country camps and ranger stations are located in the upper drainage. River mile 110 to 95 and all the South Fork basin not included in Yosemite National Park are in Sierra (south side of the river) and Stanislaus (north side of the river) National Forests (pl. 1). Recreational activities in the national forests are minimal because of the steep terrain and lack of access to most of the area.

No logging has occurred in the drainage south of the Merced River for at least the last 6 years (Dick Hambrock, U.S. Forest Service, oral commun., 1981). Some areas in the Devil Gulch area (tributary to the South Fork Merced River) may be logged in the next 10 years. Commercial timber in the Sierra National Forest is mixed conifer (white fir, ponderosa and sugar pine, and incense cedar). The potential for large-scale logging is low because of the lack of good timber stands and the rugged terrain. The Stanislaus National Forest has much more logging activity with five or six areas currently being logged in the Grizzly and Anderson Creek areas of the North Fork basin (not on map) (Dennison, U.S. Forest Service, oral commun., 1981). Most of this timber is ponderosa pine.

The upper reaches of the South Fork Merced River have some development around the town of Wawona. Development near Wawona includes some park and visitor facilities, a campground, and a waste-treatment plant that does not discharge into the Merced River.

Much of the Merced River basin from the granitic areas in Yosemite National Park downstream to the Central Valley has scattered deposits of gold. This area was extensively worked for placer gold, with many mines being opened in the middle to late 1800's. Most of the activities were dormant after the boom period in the late 1800's until the late 1970's when the price of gold made it profitable for some of the marginal mines to reopen and for small dredging operations to recover gold from the river. Numerous small mines have opened or reopened but most are very small operations located on dry or occasionally running streams in the North Fork, Maxwell Creek (tributary to Lake McClure at Horseshoe Bend), and Whites Gulch basins (tributary to Lake McClure at rm 76) (pl. 1). Sweetwater Mine on Sweetwater Creek (south side of the Merced River) is the largest mine currently active. Sweetwater Creek drains into the Merced River at about rm 95.

The Merced River drainage downstream from Lake McClure is used mostly for seasonal pasture for livestock. The river downstream from rm 42 is lined mostly with irrigated cropland (beyond the riparian vegetation). Two small towns, Snelling and Cressey, are adjacent to the river, and numerous farm and ranch houses and barns are at various points along the lower river.

FIGURE 1.--New Exchequer Dam and Lake McClure.

CHANNEL DESCRIPTION, IMPOUNDMENTS, AND DIVERSIONS

The Merced River is hydrologically divided into four major segments for the purposes of this discussion (see pl. 1). The furthest upstream segment is from the river's origin, on the west slope of 13,114-foot Mount Lyell, to the Happy Isles Bridge gaging station at the head of Yosemite Valley. The average stream gradient in this segment is 327 ft/mi. Flow in the river alternates between reaches of rapid and turbulent flow over bare granite with a series of spectacular waterfalls, and slower, more uniform flow through low-gradient, sandy-bottomed meandering reaches in subalpine meadows. Numerous tributaries, most of which are perennial, flow into the river along this segment. Washburn and Merced Lakes (rm 131 and 127, respectively) are glacial impoundments along this upper segment of the river. Both lakes have surface areas of about 54 acres and are about 65 feet deep.

The second segment is the 12 miles of river that flows through Yosemite Valley. In this segment the river falls 600 feet for an average gradient of 50 ft/mi. The Yosemite Valley segment flows through dense coniferous forests and open meadows. Along this reach the mean annual discharge for the period of record increased from 377 ft^3/s at Happy Isles Bridge to 664 ft^3/s at Pohono Bridge due to inflow from numerous tributaries.

FIGURE 2.--Merced River in Merced River Canyon near Briceburg, looking downstream. Highway 140 is along the left bank of the river (arrow indicates direction of flow).

In the third segment, the Merced River flows 54 miles through Merced Canyon from Yosemite Valley to New Exchequer Dam (fig. 1). The first 35 miles of this segment, to the headwaters of Lake McClure, drops 2,590 feet for an average gradient of about 80 ft/mi (fig. 2). The remaining 19 miles of this segment is now inundated by Lake McClure. The Merced River's largest tributary, the South Fork Merced River, joins along this segment at rm 101. The Merced River Canyon is lined with chaparral vegetation that results in little shading on the river except that provided by the surrounding hills. The channel in this segment is composed mostly of gravel and boulders. State Highway 140 follows the river from Yosemite Valley to Briceburg. The downstream 11 miles of the canyon are inaccessible by road. A sewage-treatment plant at El Portal treats sewage from Yosemite National Park and El Portal. This plant is allowed to discharge secondary treated effluent to the river under National Pollution Dischargers (NPDES) permit number CA0119057. The main method of effluent disposal at the treatment plant is percolation ponds. However, since the plant opened in 1976, effluent has frequently been discharged directly to the river due to poor percolation and high ground-water levels in the El Portal area at certain times of the year.

FIGURE 3.--McSwain Dam and Reservoir.

Lake McClure presently covers the downstream 19 miles of the third segment. It was enlarged to its present size in 1967 by New Exchequer Dam. From 1929 until 1967, Exchequer Dam just upstream from New Exchequer Dam impounded a 10-mile long reservoir. Lake McClure presently has a gross capacity of 1,025,000 acre-ft. The hydrologic residence time of the water in the lake is 1.1 years (California Department of Water Resources, 1978).

The fourth segment of the Merced River from New Exchequer Dam to the San Joaquin River is 62 miles long and drops 330 feet for an average stream gradient of 5.3 ft/mi. The river channel varies considerably along this segment. The upper 3.5 miles flow through a steep-sided canyon between New Exchequer Dam and McSwain Reservoir. Downstream from McSwain Dam (a flow-regulating structure built in conjunction with New Exchequer Dam) (fig. 3), the river is impounded by two large diversion dams at rm 52 and 54.

The upstream diversion dam, Merced Falls Dam, diverts water into the Merced Irrigation District's North Side Canal. Snelling Diversion Dam at river rm 52 (fig. 4) diverts the bulk of the flow in the river during the irrigation season to the Merced Irrigation District's Main Canal. The riverbed in this area consists of coarse gravel. Dredger tailings from past goldmining operations line the river. The 6-mile reach downstream from Snelling Diversion Dam flows over dredger tailings that extend as far as three-quarters of a mile to either side of the river (fig. 4). Along this area there are a number of off-river ponds and short sloughs, some of which are fed by small diversion dams on the main river (fig. 5). These small diversions are erected

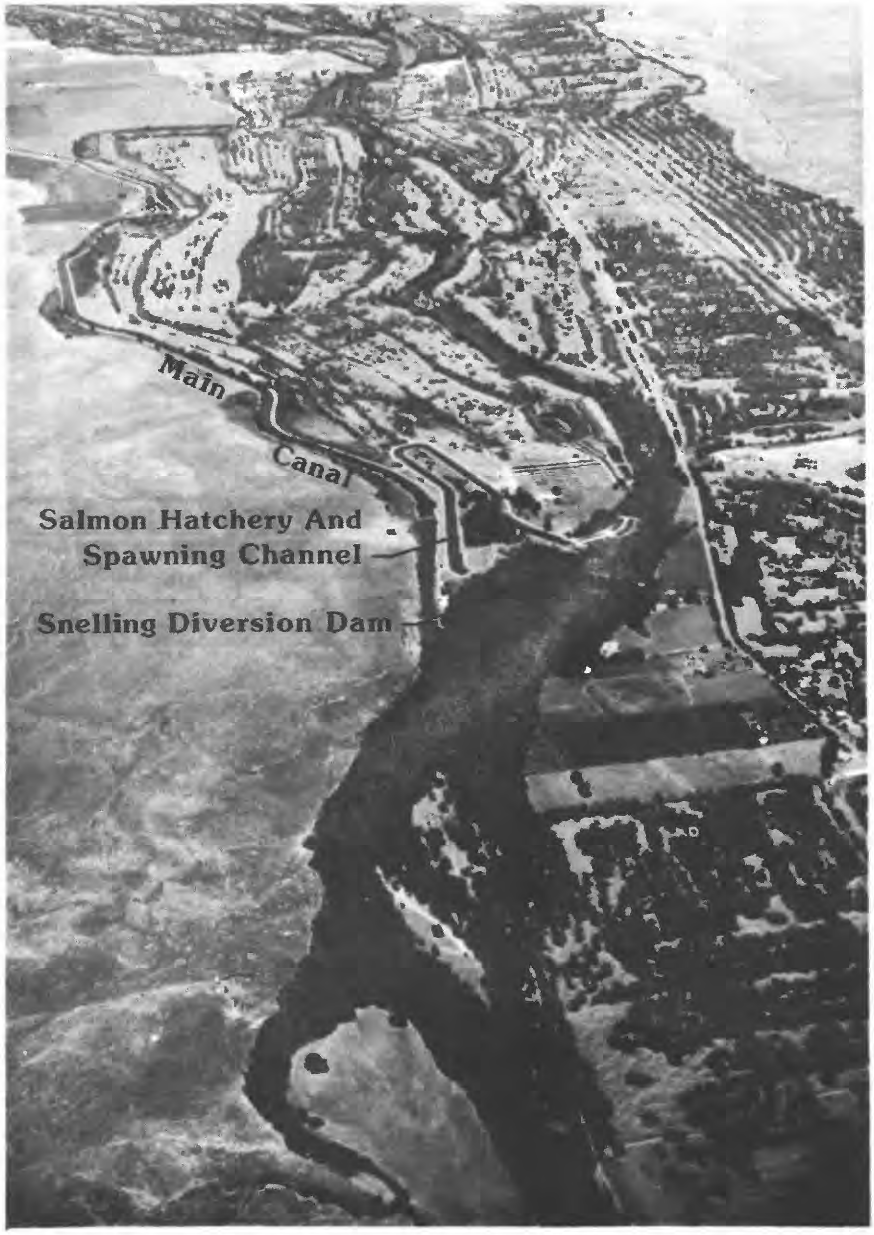


FIGURE 4.--Merced River from over McSwain Dam, looking west. Near the middle of the photograph is Snelling Diversion Dam with Main Canal leading away to the left. The salmon hatching and spawning channel is located below the dam. The longitudinal striped pattern is trees along dredger tailings.

each year after high winter flow to provide water to riparian areas. The river channel is composed mostly of cobbles and coarse sand in this reach. From rm 27 to 44 there are several gravel-mining operations adjacent to the river. All but three of these appeared to be abandoned during an aerial survey made in May 1981. The active gravel operations are dredging gravel from off-stream ponds adjacent to the river (fig. 6). Some of the numerous old gravel ponds in this area are now connected to the river and form wide spots in the river channel (fig. 7). Most of the channel is lined with natural levees which enclose a flood plain as much as a mile wide. Some areas of the river are protected by manmade levees.

FIGURE 5.--Temporary diversion dam near river mile 36. This dam diverts water to a slough along the left bank (arrow indicates direction of flow).

FIGURE 6.--Active gravel-mining operation near river mile 40. Gravel is being dredged from the oblong pond whose levees extend into the river.

FIGURE 7.--Old gravel pits along the Merced River near Snelling. These pits are part of the main channel.

Along this lower reach, 23 pumps were observed in May 1981 (fig. 8), 17 of them downstream from the State Highway 99 bridge (rm 27). These pump water for irrigation into the surrounding fields. Water is returned to the river through 19 spills (observed in May 1981) (fig. 8). These spills ranged in size from the large overflows from Livingston Canal at rm 22, to several pipes extending through the levee. Twelve of the 19 spills observed were downstream from the State Highway 99 bridge. The salmon fish hatchery below Snelling Dam (fig. 4) is the only discharger along this reach that requires an NPDES permit. The hatchery discharges water from rearing ponds into a slough which discharges into the main river. The channel configuration and floodflow characteristics in the lower Merced River are described by Blodgett and Bertoldi (1968).

FIGURE 8.--Irrigation pump and irrigation return discharge along the south bank of the Merced River near river mile 17 (arrow indicates direction of flow).

STREAMFLOW

Hydrographs of mean monthly flow at gaging stations on the Merced River (pl. 1) show the highly seasonal nature of the runoff from the basin. The 1967-80 period represents a time when all the major gaging stations on the river had a nearly complete discharge record and during which the majority of water-quality data were collected. The hydrographs at Happy Isles Bridge, Briceburg on Merced River, and South Fork Merced River near El Portal (pl. 1) show unregulated runoff that closely matches the precipitation pattern in the basin. Peak runoff occurs in May and June when the snowpack at higher elevations is melting. Low runoff occurs in September and October after snowmelt and before winter rains increase discharge.

Hydrographs for Happy Isles Bridge (rm 128) representing the mean monthly flow for the two highest discharge years (1967 and 1969) and the two lowest discharge years (1976-77) during the base period of 1967-80 are also plotted on plate 1. Discharge patterns for the high discharge years are similar to those found in the composite hydrograph. The low flow years, however, did not follow the composite hydrograph. Minimum discharge occurred in January and August, and peak runoff, in May, decreased from 2,550 ft^3/s in the composite hydrograph to 650 ft^3/s during the low flow years.

The hydrograph of mean monthly discharge at South Fork Merced River near El Portal is nearly identical in shape to the hydrograph at the Briceburg station. The mean monthly discharge at the South Fork station is about one-third the corresponding mean at the Briceburg station.

Hydrographs for the two stations downstream from New Exchequer Dam (pl. 1) have similar seasonal flow patterns to those above the dam, except for a decrease in seasonal variation due to the reservoir system. At the station below Merced Falls Dam, discharge was highest in May and June in the average year between 1967 and 1980. Discharge was lowest during November and December instead of during September and October as at the stations upstream from the dam.

Peak discharge occurred at the station near Stevinson in February and March. Discharge declines during the spring and summer months when irrigation diversions direct flow away from the stream.

Flow-duration curves (fig. 9) show the integrated effect of the various factors (climate, topography, geology, and others) that affect runoff (Searcy, 1959). The steep slope of the Merced River at Happy Isles Bridge is typical of an unregulated stream that is fed by highly seasonal precipitation. The slope of the curve decreases at both ends. The decrease at the upper end is due to the storage of runoff in the snowpack and, at the lower end to springs and lakes in the high country that sustain a relatively constant low flow. The median flow (daily mean flow equaled or exceeded 50 percent of the time) at Happy Isles Bridge was 110 ft^3/s.

The duration curve for South Fork Merced River near El Portal is similar in slope to the one at Happy Isles Bridge. The slope at the top of the curve decreases less than at Happy Isles Bridge curve because the South Fork drainage is lower in elevation and therefore has less snowpack. The median flow at this station was 160 ft^3/s.

The curve for Merced River below Merced Falls Dam has a flat slope near the top of the curve showing that higher flows were maintained for a greater period of the year than at other stations. The longer duration of higher flows results from the release of water from New Exchequer Dam during irrigation season. The median discharge at this station was 1,200 ft^3/s, which is more than double the median discharge at the next upstream station (Merced River near Briceburg).

The flow-duration curve for Merced River near Stevinson has an irregular slope near the middle of the curve, showing that discharge was relatively constant, between 60 to 200 ft^3/s, during 35 percent of the days. The nearly vertical slope at about the 97-percent duration point indicates discharge averaged between 30 and 60 ft^3/s for only a few days. The relatively flat slope near the curve's bottom represents a fairly constant flow, probably caused by irrigation return flows.

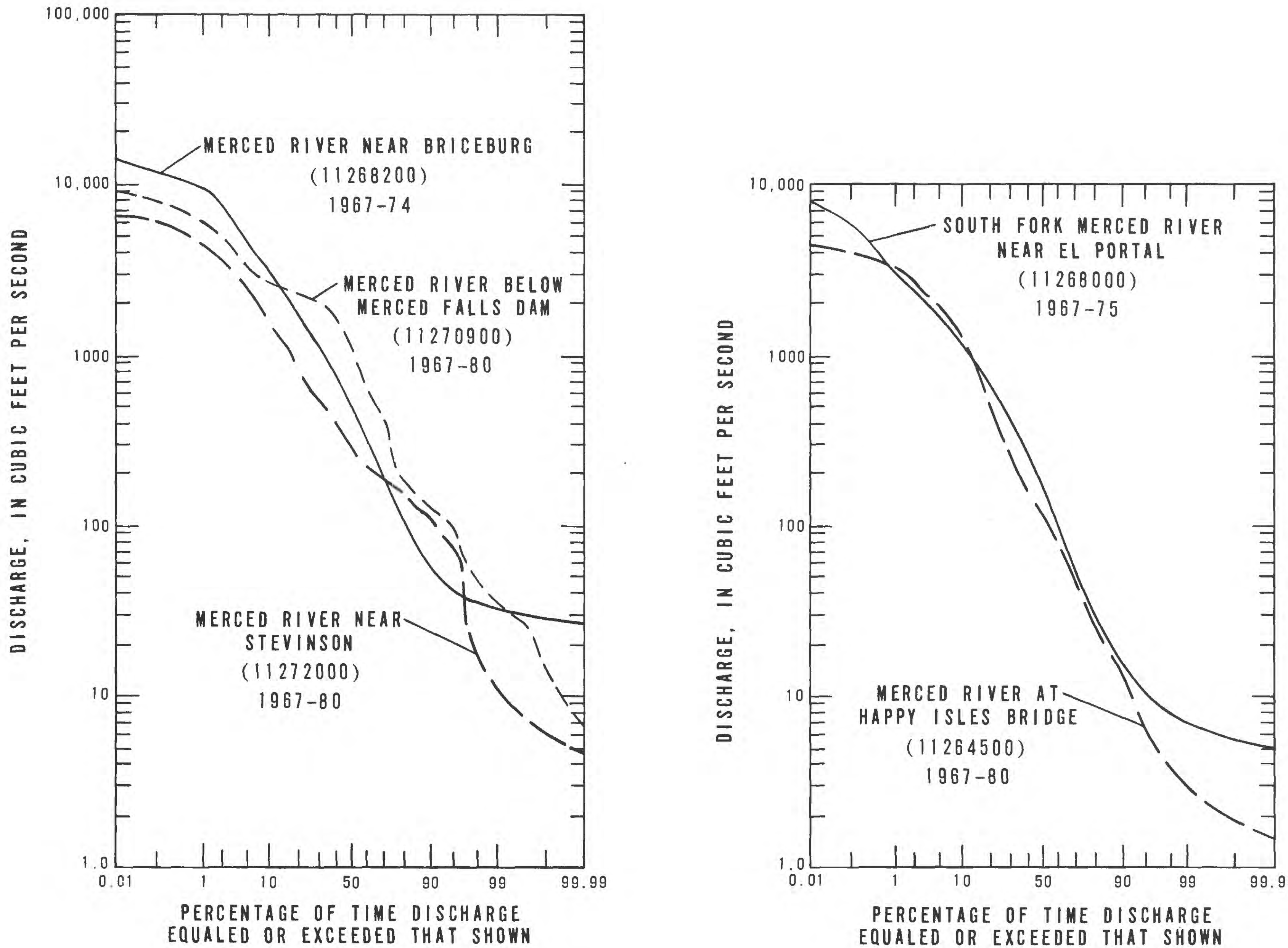


FIGURE 9.--Flow-duration curves at five stations in the Merced River basin.

BENEFICIAL USES AND WATER-QUALITY OBJECTIVES

The California Regional Water Quality Control Boards are commissioned to set objectives for the quality of water in California. The Regional Boards also have specified beneficial uses for each basin. The combination of these beneficial uses and the water-quality objectives constitutes a water-quality standard under section 303 of the 1972 amendments to the Federal Water Pollution Control Act. The beneficial uses and water-quality objectives for the Merced River are found in the report "Water Quality Control Plan Report for the Sacramento River, the Sacramento-San Joaquin Delta, and the San Joaquin Basins" (California Regional Water Quality Control Board, Central Valley Region, 1975).

Beneficial Uses

Water-quality management plans are aimed toward the protection and enhancement of beneficial uses. These can be any uses by fish, wildlife, and humans which can be satisfied without detriment to other beneficial uses.

Beneficial uses in the Merced River are defined for four segments: (A) source to Lake McClure, (B) Lake McClure, (C) McSwain Reservoir, and (D) from McSwain Dam to the San Joaquin River. These segments are different from the segments defined for the channel description discussion (see pl. 1). The beneficial uses and the segments to which each applies are given in table 1. This is taken directly from the Water Quality Control Plan Report and has some discrepancies. For instance, irrigation is a use of river water in segment D but it is not shown as such in table 1. A description of each beneficial use and the extent of each use follows.

Municipal and domestic water supply.--This beneficial use is shown for segment D and as a potential use for the other three segments. Currently, however, the National Park Service operates the only public drinking water system that takes water from the Merced River. The main source of water for the park's drinking water comes from a diversion below Illilouette Creek (rm 128) in segment A. Water is also taken, in lesser amounts, from Merced River near Vernal Falls and Tenaya Creek near Mirror Lake.

Irrigation.--Irrigation is shown as a beneficial use for segments A, B, and C and not for segment D. Much of the water in the river is controlled by the Merced Irrigation District, which owns New Exchequer, McSwain, Merced Falls, and Snelling Dams. The Merced Irrigation District controls the discharge of the river to provide water, mostly for irrigation, to its service area. Two diversions of water to Merced Irrigation District canals are downstream from McSwain Dam. The first is at Merced Falls diversion dam, which diverts water to the North Side Canal. Between 1969 and 1979 this dam diverted an average of 23,080 acre-ft/yr. The second diversion is at Snelling diversion dam, which diverts water to the Main Canal. An average of 530,519 acre-ft/yr was diverted between 1969 and 1979. During this same period of time, an average of 418,282 acre-ft/yr was allowed past the diversions to maintain flow in the Merced River. About 97 percent of the diversion occurs during the irrigation season, which is variable, starting in March or early April and lasting until about mid-October.

TABLE 1. - Beneficial uses and the segment of the Merced River to which each applies

[X, designated beneficial use; 0, potential beneficial use]

Segment	Municipal and domestic supply	Irrigation	Stock watering	Industrial process	Industrial service supply	Power	Water-contact recreation	Canoeing and rafting	Noncontact recreation	Warm freshwater habitats	Cold freshwater habitats	Warm-water migration	Cold-water migration	Warm-water spawning	Cold-water spawning	Wildlife habitat
A. Source to Lake McClure.	0	X	--	--	--	X	X	X	X	X	X	--	--	--	--	X
B. Lake McClure	0	X	--	--	--	X	X	--	X	X	X	--	--	--	--	X
C. McSwain Reservoir	0	X	--	--	--	X	X	--	X	X	X	--	--	--	--	X
D. McSwain Dam to San Joaquin River.	X	--	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Water is pumped directly from the river at a series of points along the lower Merced River (segment D). These privately operated pumps are not connected with the Merced Irrigation District or the Turlock Irrigation District. The quantity of water diverted by these pumps is not known. Fifty-seven percent of the water delivered to irrigators in 1979 was applied to permanent pasture, almonds, and rice. Other major crops in the Merced Irrigation District service area are alfalfa, corn, peaches, and grapes.

Stock watering.--Stock watering is shown as a beneficial use for segment D. The extent to which the river is used for stock watering is unknown but some of the river below McSwain Dam is lined by open pasture. Aerial observations in May 1981 indicated some cattle along the banks.

Industrial process and service supply.--These beneficial uses are shown for segment D. Industrial process supply includes water used directly for manufacturing products. No water from the Merced River is currently used for this purpose. Industrial service supply includes water for mining, gravel washing, fire protection, and cooling. Water quality is usually not a consideration for industrial service supply. Little, if any, water from the Merced River is currently used for these purposes. The gravel-mining industry uses ground water for gravel washing.

Power.--Power production is shown as a beneficial use for all four segments. There are currently four hydroelectric powerplants on the river. In Yosemite Valley, a diversion at rm 118 diverts water through a 1.1-mile pipe along the north wall of the valley to a point where it plunges to a powerplant. This plant is operated by the National Park Service and provides much of the power to the park facilities in the valley. The powerplant was closed in the winter of 1980-81 due to damage to the penstock from a landslide, but will be repaired soon.

The Merced Irrigation District operates powerplants at New Exchequer Dam and McSwain Dam. The electricity is sold to Pacific Gas and Electric Company. The fourth powerplant is run by Pacific Gas and Electric Company at Merced Falls Diversion Dam.

Water-contact recreation.--Water-contact recreation includes all recreational uses involving actual body contact with water, such as swimming, wading, sport fishing, and boating. This beneficial use is shown for all four segments of the river. Fishing and swimming are popular pastimes along most of segment A. Thousands of visitors each year come in contact with the Merced River both in Yosemite Valley and upstream from the valley in the back country. The sport fishery in Yosemite National Park is for rainbow, brook, and brown trout. These are now self-sustaining populations since the California Department of Fish and Game stopped planting in the mid-1970's.

The Merced River downstream from the park is stocked with about 36,000 catchable rainbow trout a year. Most of these fish are planted in the reach from El Portal to Indian Flat in a section that has the most suitable trout habitat. Because most of this segment is easily accessible by highway, it is heavily used for fishing and swimming. From about Indian Flat to Lake McClure the river provides a good sport fishery for smallmouth bass. The South Fork Merced River is managed as a wild trout stream by the California Department of Fish and Game. Due to limited access along most of the South Fork, it is not used extensively for fishing or other water-contact recreation.

Lake McClure is extensively used for boating and fishing. Many houseboats are moored on the lake. Several boat launches, and picnic and campgrounds are maintained by Merced Irrigation District and by concessionaires. Regular plants of rainbow trout are made by Murrison Trout Farm under contract with Merced Irrigation District and California Department of Fish and Game. Lake McClure also provides a good warm-water fishery for large and smallmouth bass and other warm-water game fish.

McSwain Reservoir has one recreation area maintained by the Merced Irrigation District that is the center for most of the boating, fishing, and swimming activities on the lake. This reservoir is planted with catchable trout from California Department of Fish and Game and Murrison Trout Farm on a regular basis.

The Merced River downstream from McSwain Dam is used for water-contact recreation mainly at the four State and county parks (fig. 10) located along this segment. Other points of access are at the various bridges that cross the river. The 3-mile segment of river downstream from Snelling Dam is a popular trout fishing area for local fishermen. This area has cool water from

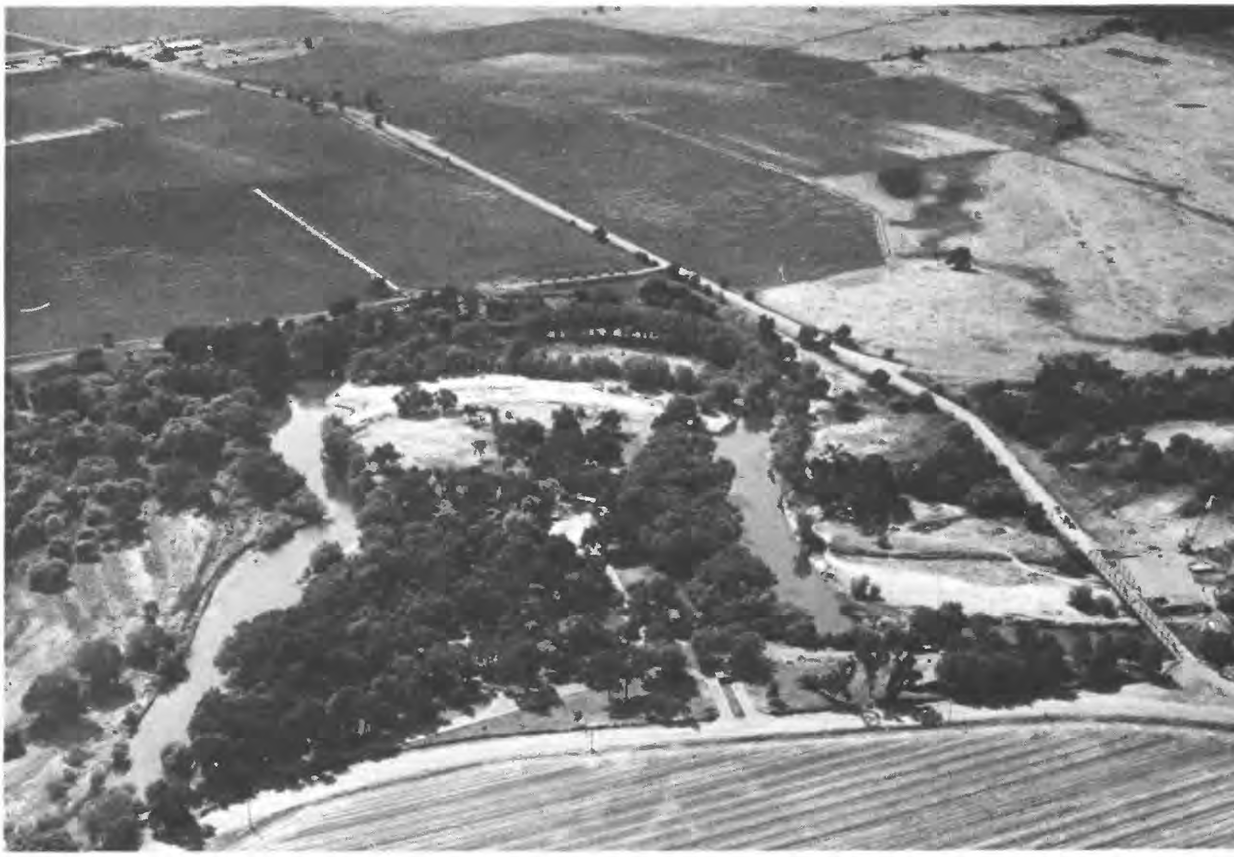


FIGURE 10.--George J. Hatfield State Park at river mile 1.3. Riparian vegetation is typical of the lower 30 miles of the Merced River.

the reservoirs upstream and although trout are not planted here, enough are washed downstream from McSwain Reservoir and Murrison Trout Farm to provide a good fishery. Downstream from the cool-water segment, there is a good fishery for large and smallmouth bass, channel and white catfish, and sunfishes. The lower river is closed to fishing each year during the autumn salmon run.

Canoeing and rafting.--This beneficial use is shown for segments A and D. Rafting and canoeing are not as large an activity on the Merced River as they have become on other Sierra Nevada rivers. There are no commercial rafting operators offering raft rides. Aerial observations made in May 1981 showed three rafts on the entire river. Two of these were in the segment between El Portal and Briceburg and one was along the dredger tailing area below Snelling Diversion Dam. These activities may become more popular in the future as usage increases on other rivers.

Noncontact water recreation.--These are activities that involve the presence of water but do not require contact with it, such as picnicking, sunbathing, hiking, and camping. These activities are shown as a beneficial use on all four segments of the river. Noncontact recreation is popular along the entire river where access is provided.

Warm freshwater habitats.--Warm freshwater habitats are a beneficial use on all four segments of the river. There is little warm-water habitat in the upper river upstream from about Indian Flat (rm 104) because the water temperature is too low most of the year. From Indian Flat to Lake McClure and particularly downstream from Briceburg, the river provides a good smallmouth bass fishery.

Lake McClure is a warm-water lake providing good habitat for warm-water fish such as large and smallmouth bass, crappie, sunfish, and catfish. McSwain Reservoir and the part of the river between this reservoir and New Exchequer Dam is a poor warm-water habitat due to releases of cool water from the lower part of Lake McClure. The cool-water release also affects the river downstream from McSwain Dam for a few miles. From this reach downstream to the San Joaquin River is good warm-water habitat. The side sloughs and old gravel ponds that are connected with the stream provide excellent habitats for native and introduced game and nongame fish and other warm freshwater organisms.

Cold freshwater habitats.--This beneficial use is shown for all four segments of the river. The entire river upstream from about Indian Flat including the South Fork Merced River is good cold-water habitat. Lake McSwain and the river for 3 miles downstream from McSwain Dam are also good cold-water habitat that support a trout fishery. Lake McClure supports a cold-water fishery in its deeper cooler waters.

Warm- and cold-water migration.--This beneficial use is shown for segment D of the river. The lower Merced River downstream from Snelling Diversion Dam supports an annual run of King Salmon. This migration occurs in the autumn from about mid-October to December. No other fish are known to migrate in and out of the Merced River. Due to the operation of the California Department of Fish and Game hatchery just downstream from Snelling Dam, the salmon run has increased in the last few years. In 1980, 3,008 fish were counted entering the hatchery (Laird Marshall, California Department of Fish and Game, oral commun., 1981). The Merced Irrigation District is required to maintain a minimum flow of 200 ft^3/s in the lower Merced River during the salmon run.

Warm- and cold-water spawning.--The salmon that migrate each autumn into the Merced River spawn in the natural channel, in a manmade spawning channel just downstream from Snelling Diversion Dam or in the hatchery at Snelling Diversion Dam. The gravelly substrate and cool water in the area of Snelling Dam make good spawning habitat for cold-water fish. Much of the rest of the lower river provides excellent warm-water spawning habitat to support both game and nongame fish.

Wildlife habitats--Good wildlife habitats exist along the entire river. The Merced Irrigation District maintains water diversions to several side sloughs in the lower river to maintain riparian habitats.

Water-Quality Objectives

The objectives for the quality of inland surface water as defined in the Water-Quality Control Plan (California Regional Water Quality Control Board, Central Valley Region, 1975) are very generalized. They are interim objectives that will remain in effect until sufficient information becomes available to establish more specific objectives. A key consideration in setting objectives is the policy of nondegradation. The policy (defined in State Board Resolution Number 68-16) is to regulate the quality of the State's water so as to achieve the highest water quality consistent with maximum benefit to the population of the State and that water quality will not be degraded from present conditions, even if the present conditions are better than the objectives. A few rivers and lakes have specific numerical objectives based on knowledge of existing conditions and potential for degrading beneficial uses.

The following objectives apply to the Merced River:

Bacteria.--Concentrations of fecal-coliform bacteria, based on a minimum of five samples for any 30-day period, shall not exceed a geometric mean of 200 colonies per 100 mL, nor shall more than 10 percent of the total number of samples taken during any 30-day period exceed 400 colonies per 100 mL.

Biostimulatory substances.--Water shall not contain biostimulatory substances in concentrations that promote aquatic growth to the extent that such growth causes nuisance or adversely affects beneficial uses.

Chemical constituents.--Water shall not contain chemical constituents in concentrations that adversely affect beneficial uses.

Color.--Water shall be free of discoloration that causes nuisance or adversely affects beneficial uses.

Dissolved oxygen.--Dissolved oxygen shall be greater than 8.0 mg/L at all times from the source to Lake McClure and from New Exchequer Dam to Cressey (rm 28). In other sections of the river the monthly median of daily mean dissolved-oxygen concentrations shall not fall below 85 percent of saturation in the main water mass and the 95th percentile concentration shall not fall below 75 percent of saturation. Dissolved-oxygen concentrations shall not be reduced below the following minimum levels at any time:

Water designated as warm-water habitat	5.0 mg/L
Water designated as cold-water habitat	7.0 mg/L
Water designated for warm- or cold-water spawning	7.0 mg/L

Floating material.--Water shall not contain floating material in amounts that cause nuisance or adversely affect beneficial uses.

Oil and grease.--Water shall not contain oils, greases, waxes, or other materials in concentrations that cause nuisance, result in a visible film or coating on the surface of the water or on objects in the water, or otherwise adversely affect beneficial uses.

pH.--The pH shall not be depressed below 6.5 nor raised above 8.5. Changes in normal ambient pH levels shall not exceed 0.5 in freshwater designated as cold- or warm-water habitats.

Pesticides.--No individual pesticide or combination of pesticides shall be present in concentrations that adversely affect beneficial uses. There shall be no increase in pesticide concentrations found in bottom sediments or aquatic life that adversely affects beneficial uses. Total identifiable chlorinated hydrocarbon pesticides shall not be present at concentrations detectable within the accuracy of analytical methods prescribed in Standard Methods for the Examination of Water and Wastewater, latest edition, or other equivalent methods approved by the Executive Officer. Water designated for use as domestic or municipal supply (segment D) shall not contain concentrations of pesticides in excess of the limiting concentrations set forth in California Administrative Code, Title 22, Chapter 15, Section 64435, Table 3.

Radioactivity.--Radionuclides shall not be present in concentrations that are deleterious to human, plant, animal, or aquatic life, or that result in the accumulation of radionuclides in the food web to an extent that presents a hazard to human, plant, animal, or aquatic life.

Sediment.--Suspended-sediment discharge of surface waters shall not be altered in such a manner as to cause nuisance or adversely affect beneficial uses.

Settleable material.--Waters shall not contain substances in concentrations that result in the deposition of material that causes nuisance or adversely affects beneficial uses.

Suspended material.--Waters shall not contain suspended material in concentrations that cause nuisance or adversely affect beneficial uses.

Tastes and odors.--Waters shall not contain taste or odor-producing substances in concentrations that impart undesirable tastes or odors to domestic or municipal water supplies or to fish flesh or other edible products of aquatic origin, or that cause nuisance, or otherwise affect beneficial uses.

Temperature.--The natural receiving water temperature of intrastate waters shall not be altered unless it can be demonstrated to the satisfaction of the presiding California Regional Water Quality Control Board that such alteration in temperature does not adversely affect beneficial uses. At no time or place shall the temperature of any cold-water intrastate water be increased more than 5°F above natural receiving water temperature. At no time or place shall the temperature of any warm-water intrastate water be increased more than 5°F above natural receiving water temperature.

Toxicity.--All waters shall be maintained free of toxic substances in concentrations that are toxic to or that produce detrimental physiological responses in human, plant, animal, or aquatic life. Compliance with this objective will be determined by use of indicator organisms, analyses of species diversity, population density, growth anomalies, bioassays of appropriate duration, or other appropriate methods as specified by the Regional Board.

Turbidity.--Waters shall be free of changes in turbidity that cause nuisance or adversely affect beneficial uses. Increases in turbidity attributable to controllable water-quality factors shall not exceed the following limits: Where natural turbidity is between 0 and 50 Jackson turbidity units, increases shall not exceed 20 percent; where natural turbidity is between 50 and 100 Jackson turbidity units, increases shall not exceed 10 Jackson turbidity units; and where natural turbidity is greater than 100 Jackson turbidity units, increases shall not exceed 10 percent.

WATER QUALITY

Water-quality and water-discharge data have been collected for many years at several sites in the Merced River basin. Table 2 presents a summary of all known water-quality and discharge data on the Merced River and its tributaries. Discharge data date back to 1901 at Merced River below Merced Falls Dam (rm 54). Another long-term discharge station is Merced River at Happy Isles Bridge (rm 127) (data from 1916). The earliest water-quality records available are a series of weekly composites taken at Merced River below Exchequer Dam (rm 62) in 1906. No records exist from 1906 to 1951. In 1951 the California Department of Water Resources started sampling at Merced River below Exchequer Dam (rm 62) and Merced River near Stevinson (rm 5). Most of the water-quality data available were collected between 1967 and 1981. The U.S. Geological Survey has monitored water quality monthly at Merced River at Happy Isles Bridge (rm 127) since 1968 as part of the National Hydrological Benchmark Network. The California Department of Water Resources has regularly sampled at Happy Isles Bridge (rm 127), Merced River near Briceburg (rm 95), Merced River below Exchequer Dam (rm 62)(1951-76), Merced River below Merced Falls Dam (rm 54) (1976-81), and Merced River near Stevinson (rm 5) (1951-69).

The U.S. Geological Survey did a series of water-quality studies between 1973 and 1977 to appraise the effect of the new sewage-treatment plant at El Portal (Hoffman and others, 1976; Hoffman, 1979), to determine the source of mercury in the upper Merced River basin (no report has been published), and to assess water quality in the entire river in the 1977 water year (Hoffman, 1978; Sorenson and Hoffman, 1981). The California Department of Water Resources did a study of Lake McClure in 1975-76. The results of the Lake McClure study are in a memorandum report of the California Department of Water Resources (1978).

The National Park Service did a reconnaissance study of water quality at 22 sites in Yosemite National Park in the summer of 1979. These stations are not included in table 2 because of the limited number of samples taken at each site. Measurements were made for biochemical oxygen demand, fecal coliform and fecal streptococcal bacteria, pH, temperature, nitrogen, phosphorus, and suspended solids. The data are available from the National Park Service.

The U.S. Geological Survey collected water samples for major ion and nutrient analyses at several streams and lakes in the upper Merced River drainage in the autumn of 1981. These samples are part of an ongoing Yosemite Park water-quality reconnaissance. The results of these analyses were not available at time of publication.

Few biological samples have been taken from the river. All known biological samples were collected between 1973 and 1979. Samples were for phytoplankton, periphyton, and benthic invertebrates.

Most of the water-quality and water-discharge data are in the computer files of the U.S. Geological Survey (WATSTORE) and the U.S. Environmental Protection Agency (STORET). All data were reviewed for completeness and accuracy for the purposes of this report and conflicting data were selectively deleted. The discussions that follow are based on data collected between 1967 and 1981. This is the same base period used in the hydrology discussion. When changes in water quality are apparent, data from other periods will be discussed. Unfortunately, most of the data were not collected for the purposes of a basinwide assessment of water quality. The only data that were collected as part of a basinwide sampling program were those by the U.S. Geological Survey during the record 1976-77 drought (Hoffman, 1978). At some stations most of the existing data base was collected in 1976-77.

TABLE 2. - Water-quality and water-discharge stations in the Merced River basin

[USGS, U.S. Geological Survey; DWR, California Department of Water Resources]

Station name	Station number	River mile (Merced River stations)	Collecting agency	Discharge	Water quality			
						Biological		
					Physical/ chemical	Phytoplankton	Periphyton	Benthic invertebrates
Merced River above Washburn Lake.	374240119215800	142	USGS	--	1977 (one sample)	--	--	--
Washburn Lake above Lewis Creek.	374257119221500	142	USGS	--	1977 (one sample depth profile)	--	--	--
Merced Lake above Echo Creek.	374408119244500	138	USGS	--	1976-77 (depth profile)	--	--	--
Merced River above Sunrise Creek.	374403119302700	132	USGS	--	1976-77	--	--	--
Merced River below Vernal Falls.	374335119330000	130	USGS	--	1972 (one sample)	--	--	--
Tenaya Creek below Tenaya Lake.	374934119280100	--	USGS	--	1972 (one sample)	--	--	--
Tenaya Creek below Mirror Lake.	374431119332500	--	USGS	--	1972 (one sample)	--	--	--
Tenaya Creek near Yosemite.	11265000	--	USGS	1904-09 1912-58	--	--	--	--
Merced River at Happy Isles Bridge.	11264500	128	USGS	1916 to 1981	1968 to 1981	1977	1974	1973-74, 1977
	B5170000	--	DWR	--	1972-80			

Illilouette Creek above mouth.	374331119332200	--	USGS	--	1972 (one sample)	--	--	--
Yosemite Valley sewage treatment plant.	11266450	--	USGS	--	1973-74	--	--	--
	B5152130	--	DWR					
Merced River at El Capitan Bridge.	11266400	122	USGS	--	1972 and	--	1974	1973-74
					1974	--	1974	1973-74
	B5154010	--	DWR	--	--	--	--	--
Merced River at Pohono Bridge.	11266500	119	USGS	1917 to 1981	1971-72	--	--	--
Merced River at Junction Big Oak Flat Road and 140.	B5151950	118	DWR	--	1974-75 and 1977	--	--	--
Tamarack Creek at Tamarack Flat Campground.	11266700	--	USGS	--	1977	--	--	--
Merced River at Big Oak Flat.	11266750	116	USGS	--	1975-77	--	--	--
Merced River at Rancheria Flat (below El Portal).	11267050	109	USGS	--	1973-77	--	1974	1973-74
	B5151710	--	DWR	--	1972, 1974-75,	--	--	--
					and 1977	--	--	--
South Fork Merced River at Wawona.	11267300	--	USGS	1958-75	--	--	--	--
	B5432000	--	DWR	--	1976 (one sample)	--	--	--
South Fork Merced River near El Portal.	11268000	--	USGS	1950-75	1973-75 and 1977	--	1974	1973-74
	B5410000	--	DWR	--	1977	--	--	--
Merced River below South Fork near Briceburg.	11268100	102	USGS	--	1975 and 1977	--	--	--
Merced River near Briceburg.	11268200	96	USGS	1965-74	1971-77	1977	--	1977
	B5139500	--	DWR	--	1966-67, 1972 to 1981	--	--	--

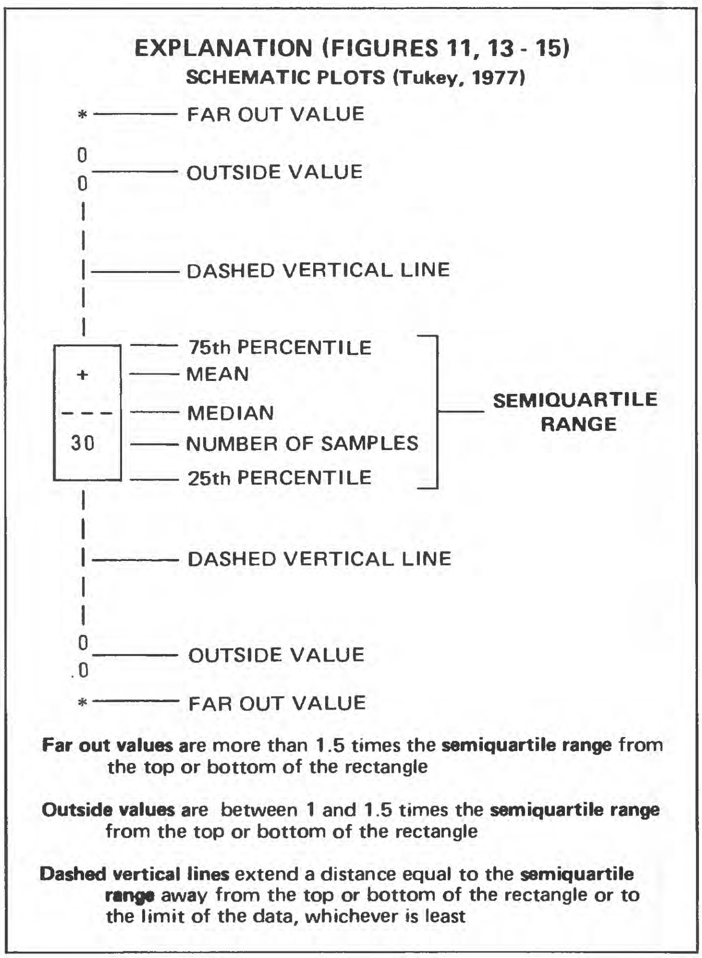
TABLE 2. - Water-quality and water-discharge stations in the Merced River basin--Continued

Station name	Station number	River mile (Merced River stations)	Collecting agency	Discharge	Water quality: Physical/chemical	Water quality: Biological: Phytoplankton	Water quality: Biological: Periphyton	Water quality: Biological: Benthic invertebrates
Lake McClure at inlet	B5R736200611	82	DWR	--	1975-77	1975-76	--	--
Lake McClure at Bagby	B5R736700791	79	DWR	--	1975	--	--	--
Merced River at Bagby	11268500	79	USGS	1922-66	--	--	--	--
	B5132000	--	DWR	--	1972-75, and 1977	1975-76	--	--
Merced River above Lake McClure.	B5140000	82	DWR	--	1967 (one sample)	--	--	--
Lake McClure at Upper Horseshoe Bend.	B5R741601611	73	DWR	--	1975-76	1975-76	--	--
Lake McClure at Lower Horseshoe Bend.	B5R740501381	72	DWR	--	1975-76	1975-76	--	--
Maxwell Creek at Coulterville.	B5125000	--	DWR	1958 to 1981	1975-77, and 1980	--	--	--
North Fork Merced River near Coulterville.	B5260000	--	DWR	1958-69	1975-76	--	--	--
Bean Creek near Coulterville.	B5258000	--	DWR	1965 to 1981	--	--	--	--
Lake McClure at Barrett Cove.	B5R738810731	67	DWR	--	1975-76	1975-76	--	--

Lake McClure near McClure Point.	B5R735701621	64	DWR	--	1975-77	1975-76	--	--
Lake McClure at Exchequer.	11269500	63	USGS	--	1976-77	1976-77	--	--
Merced River below Exchequer Dam.	11270000	62	USGS	1914-65	1906	--	--	--
	B5120000	--	DWR		1951-76	--	--	--
Merced River below Merced Falls Dam.	11270900	55	USGS	1901 to 1981	1966, 76-77	1977	--	1977
	B0518400	--	DWR	--	1976 to 1981	--	--	--
Merced River below Snelling.	B0517000	47	DWR	1928 to 1981	--	--	--	--
Dry Creek near Snelling	B0516500	--	DWR	1966 to 1981	--	--	--	--
Merced River at Shaffer Bridge.	11271290	32	USGS	1965 to 1981	--	--	--	--
Merced River at Cressey	11271350	28	USGS	--	--	--	--	--
	B0515500	--	DWR	1941 to 1981	--	--	--	--
Merced River at Milliken Bridge.	11272000	12	USGS	--	--	--	--	--
	B0513100	--	DWR	--	1965 to 1981	--	--	--
Merced River near Stevinson.	11272500	5	USGS	1940 to 1981	1976-77	--	--	1977

Areal Variations in Water Quality

Concentrations of dissolved constituents in the Merced River generally increase from the headwaters to the mouth. The water is generally low in specific conductance, and calcium and bicarbonate are the predominant cation and anion, respectively. Mean specific conductance (fig. 11) ranges from 18 μmho/cm at Merced River at El Capitan Bridge (rm 120) to 219 μmho/cm at Merced River near Stevinson (rm 5). Mean specific conductance does not exceed 56 μmho/cm (mean at Merced River near Bagby, rm 77) until downstream of Merced Falls Dam where specific conductance increases from 44 μmho/cm at Merced Falls Dam (rm 54) to 219 μmho/cm at Stevinson (rm 5). This large increase in specific conductance at the downstream station is most likely due to excess water from irrigation use being discharged into the river at several points.



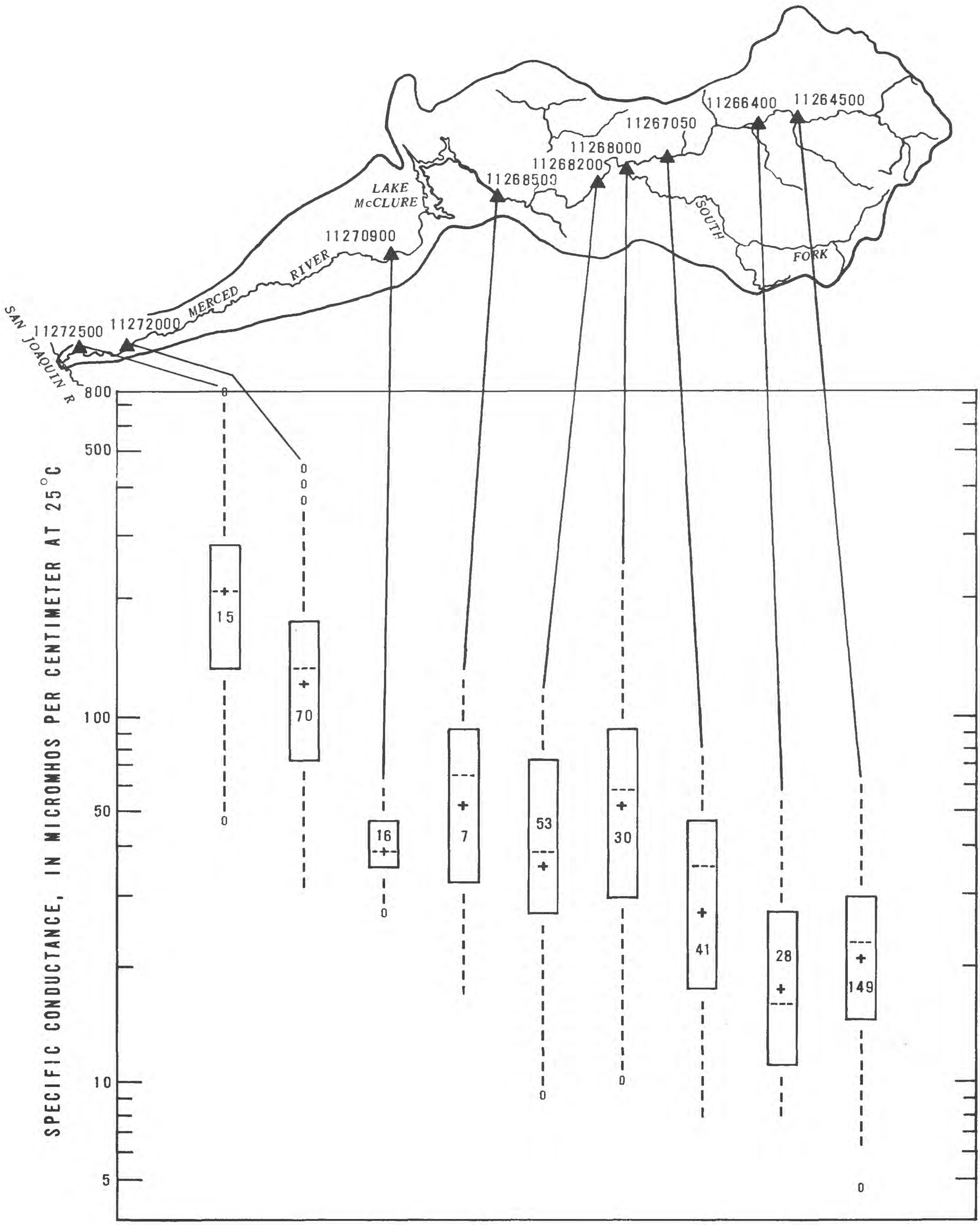


FIGURE 11.--Changes in specific conductance at nine stations in the Merced River basin for 1967-80 water years.

The predominant anion and cation are calcium and bicarbonate at all the sampled stations on the river but the relative concentrations change as the water flows downstream. The pie diagrams on plate 1 indicate the relative concentration of the major ions at several stations. Sodium and potassium are combined in the diagrams but potassium makes up less than 1 percent of the dissolved solids at each station. The trilinear diagram (fig. 12) shows the progression of major ion changes among stations. Starting at Happy Isles Bridge (rm 127) and going downstream to Merced Falls Dam (rm 54), the percentage of sodium and potassium, and chloride decreases while the percentage of magnesium and bicarbonate correspondingly increases. The addition of irrigation return water in the lower reach causes a decrease in the percentage of calcium and bicarbonate and an increase in sodium and potassium and chloride at the two downstream stations.

Mean values of pH are nearly constant along the river except at the stations near both ends (fig. 13). Mean pH is 6.8 and 6.6, respectively, at Happy Isles Bridge (rm 127) and El Capitan Bridge (rm 120). Mean pH along the middle section of the river ranges from 7.2 to 7.3. Mean pH was 7.6 at the Stevinson station (rm 5).

Except for high concentrations of dissolved nitrate along the lower reach of the river, plant nutrient concentrations are generally low. Mean total nitrogen upstream from and including Merced Falls Dam (rm 54) ranges from 0.13 mg/L at South Fork Merced River near El Portal (rm 107) to 0.40 mg/L at Happy Isles Bridge (rm 127)(fig. 14). Mean total nitrogen increased to 1.7 mg/L at Milliken Bridge (rm 12) and Stevinson (rm 5). The largest number of total nitrogen samples were taken at Milliken Bridge (rm 12). Figure 14 shows that nitrogen concentrations varied greatly over the period of record. This variation indicates periodic slugs of nitrogen input at various times of the year. Sampling at the stations upstream from Lake McClure (rm 77) detected occasional nitrogen concentrations that seem anomalously high when compared to other samples (far-out values in fig. 14). These high concentrations were all taken at low flow, indicating that the river is subject to occasional slugs of nitrogen that are not well diluted. The source of nitrogen at the upstream stations is unknown but it is probably associated with visitor use in the upper river basin.

The type of nitrogen detected in the river varies between the upstream and downstream stations. In the upper basin (Happy Isles Bridge, rm 127), most of the nitrogen present in the water is in the form of organic nitrogen (table 3). At Milliken Bridge (rm 12), the concentration of organic nitrogen is greater than at Happy Isles Bridge (rm 128) but the predominant nitrogen species is nitrate. The source of the nitrate in the lower river is most likely agricultural return flow.

Phosphorous concentrations follow a similar pattern to nitrogen concentrations (fig. 15). The upper stations are generally low in phosphorus with occasional high concentrations. The lower stations had higher mean phosphorous concentrations with greater variability in the samples.

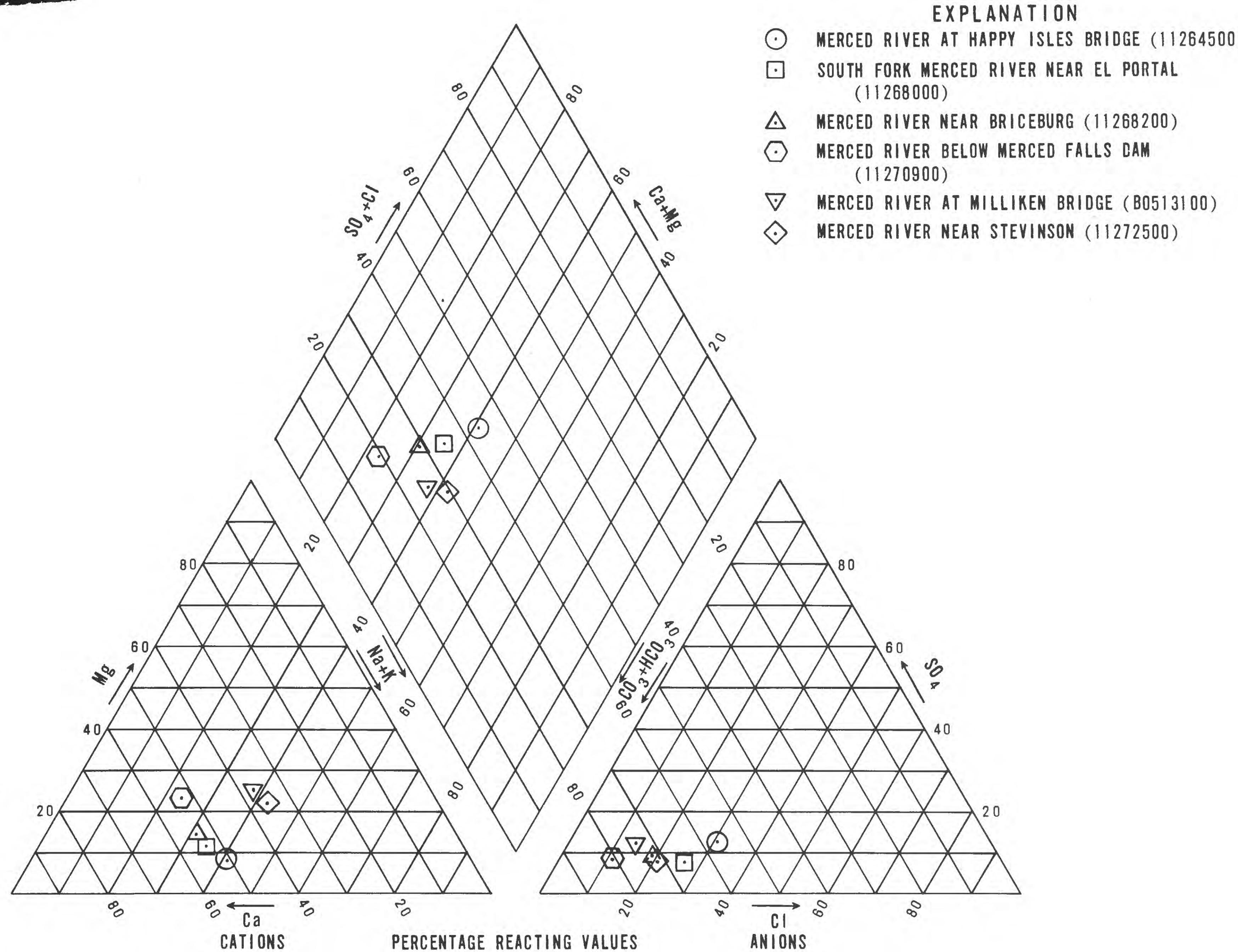


FIGURE 12.--Major ion composition at six stations in the Merced River basin for 1967-80 water years.

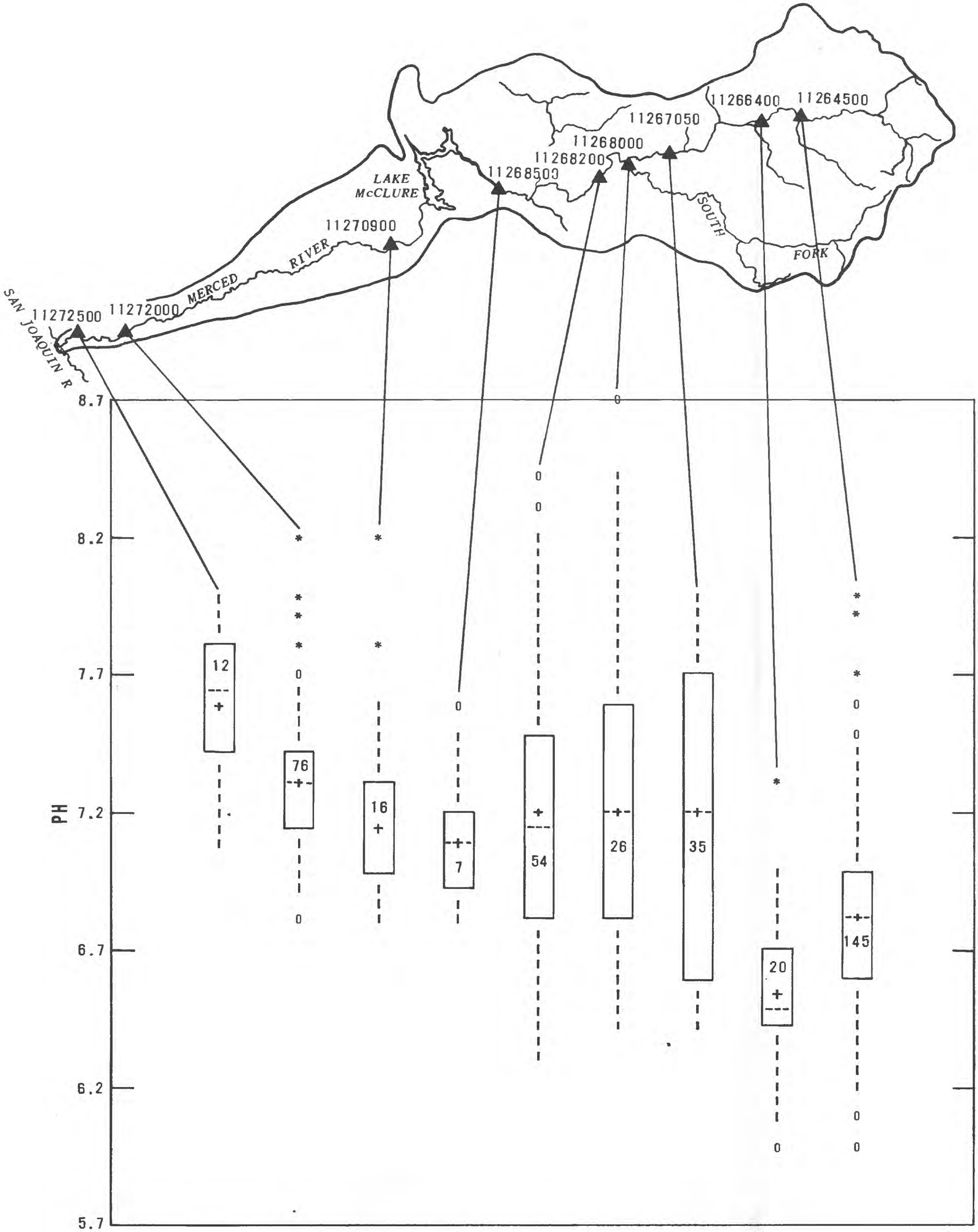


FIGURE 13.--Changes in pH at nine stations in the Merced River basin for 1967-80 water years.

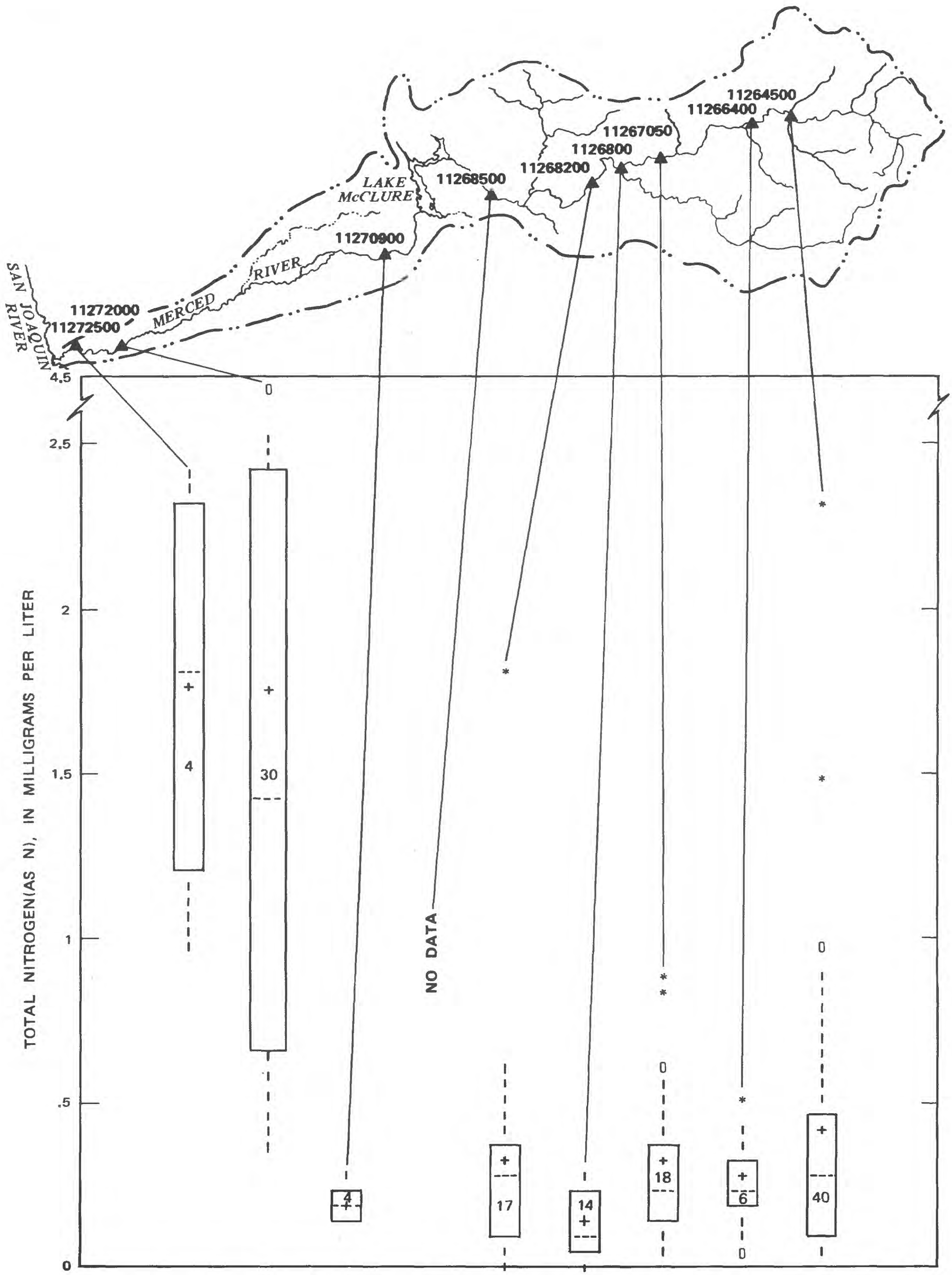


FIGURE 14.--Changes in total nitrogen at nine stations in the Merced River basin for 1967-80 water years.

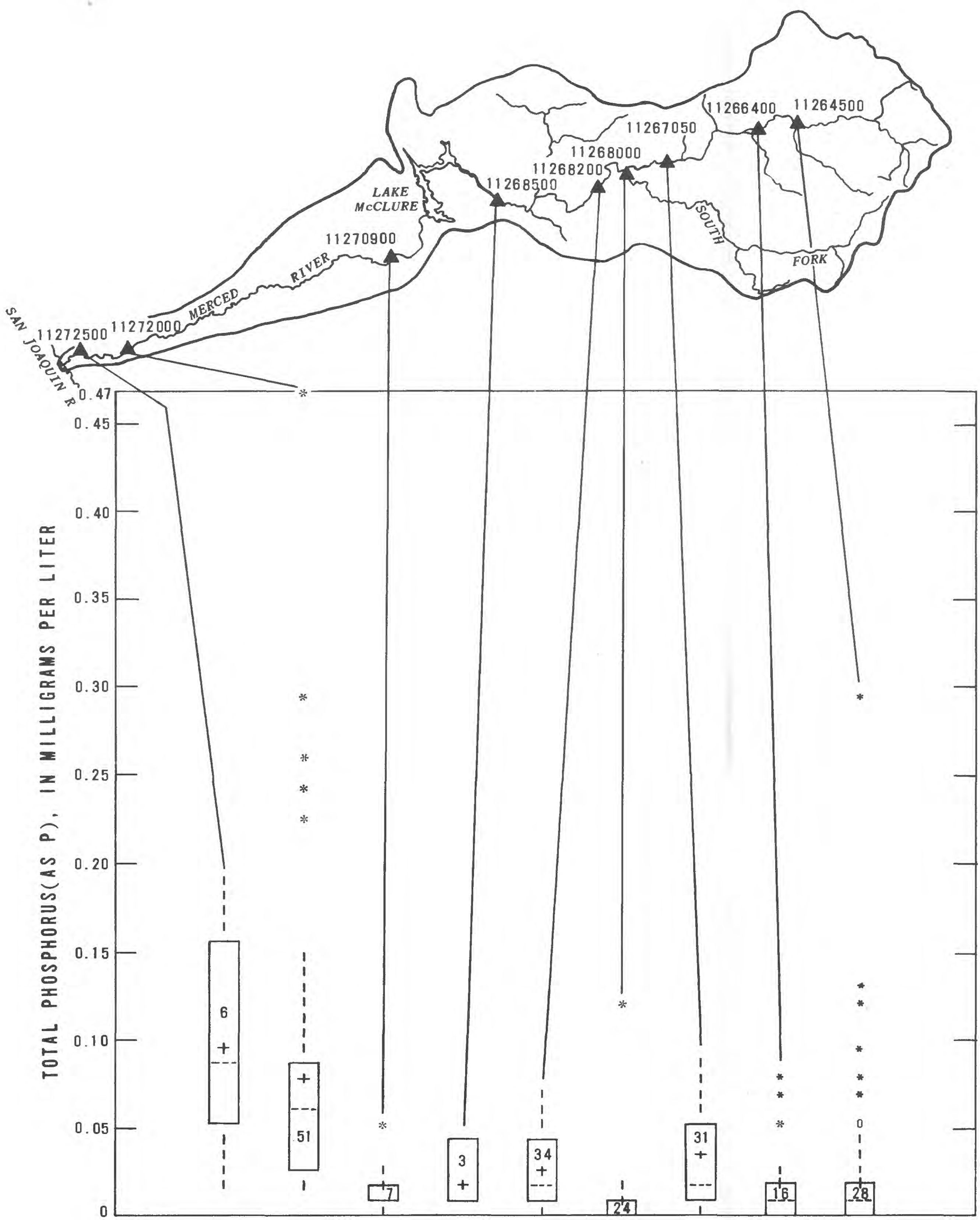


FIGURE 15.--Changes in total phosphorus at nine stations in the Merced River basin for 1967-80 water years.

Seasonal Variations in Water Quality

Seasonal changes in water quality were evaluated on the basis of grouped quarters (February-April, quarter 1; May-July, quarter 2; August-October, quarter 3; and November-January, quarter 4) during the base period of 1967-80. Figure 16 shows the mean quarterly specific conductance at seven stations along the river. At all the stations upstream from Lake McClure, mean specific conductance was lowest during the second quarter, which is when most of the snowmelt occurs. The station below Merced Falls Dam (rm 54) had almost the same mean specific conductance during each quarter due to the compositing effect of Lake McClure. The large increase in specific conductance at the Milliken Bridge (rm 12) (fig. 17) and Stevinson (rm 5) stations is smallest during the fourth quarter when irrigation is at a minimum.

Only two stations have sufficient data to determine seasonal variation in nutrients (table 3). At Happy Isles bridge (rm 127), the mean concentration of the different nitrogen species and phosphorus sampled was lowest in the second quarter during snowmelt. The concentrations of nutrients were highest during the fourth quarter when the stream discharge was increasing after the low flow period. At Milliken Bridge (rm 12), the mean concentration of nitrogen and phosphorus except for ammonia was lowest in the fourth quarter. This is the off-season for irrigation with little return flow. The mean nutrient concentration was highest during the first quarter when early season irrigation was starting.

TABLE 3. - Mean concentration of selected nutrients at Happy Isles Bridge and Milliken Bridge for 1967-80 water years

Location and nutrient	Concentration, in milligrams per liter (number in parentheses is number of samples) for indicated quarter-year periods			
	1 (Feb.-Apr.)	2 (May-July)	3 (Aug.-Oct.)	4 (Nov.-Jan.)
Merced River at Happy Isles Bridge:				
Total nitrogen	0.50(11)	0.22(11)	0.29(8)	0.58(10)
Total ammonia plus organic nitrogen (as N)	.21(18)	.15(21)	.21(21)	.33(19)
Total ammonia (as N)	.03(12)	.02(17)	.03(14)	.03(11)
Dissolved nitrate (as N)	.03(7)	.03(8)	.08(14)	.06(9)
Total phosphorus (as P)	.03(28)	.01(36)	.02(35)	.02(29)
Merced River at Milliken Bridge:				
Total ammonia plus organic nitrogen (as N)	.53(10)	.35(17)	.30(15)	.24(8)
Total ammonia (as N)	.09(6)	.07(13)	.03(10)	.08(6)
Dissolved nitrate (as N)	1.41(9)	.96(17)	1.37(14)	.71(8)
Total phosphorus (as P)	.12(10)	.09(19)	.06(13)	.06(9)

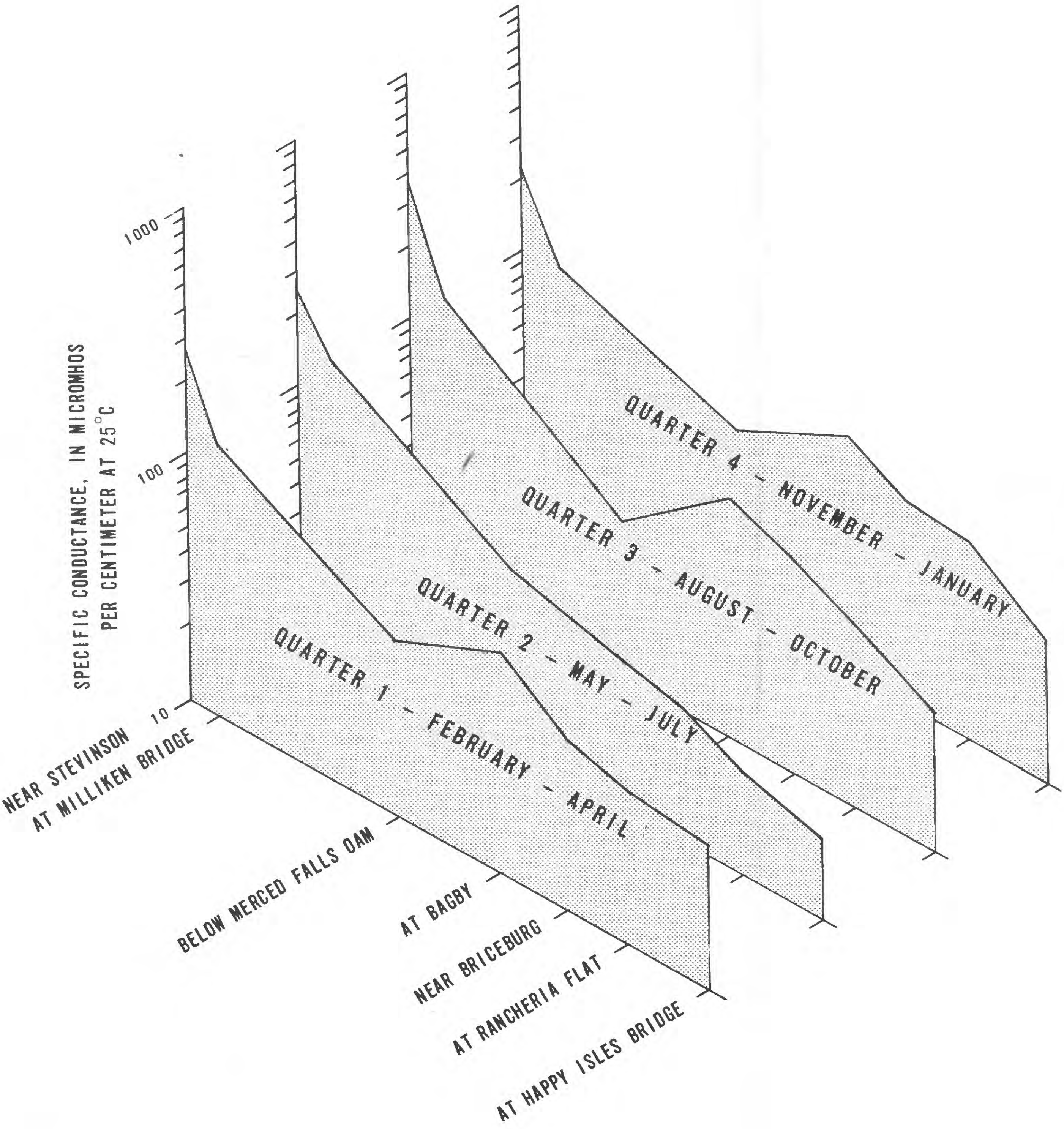


FIGURE 16.--Mean quarterly specific conductance at seven stations on the Merced River for 1967-80 water years.

FIGURE 17.--California Department of Water Resources sampling station at Milliken Bridge (river mile 12). (Arrow indicates the direction of flow.)

A water-quality problem is defined in this report as a problem that adversely affects one or more of the beneficial uses. Some water-quality problems, such as excessively low dissolved oxygen, may impair the use of the stream for one beneficial use (aquatic habitats) but have no effect on other beneficial uses (irrigation). Water-quality problems can result from natural causes, from man's activities, or a combination of the two. The source of the problem determines, to a large extent, the corrective actions that can or should be taken. Stated beneficial uses of the Merced River and several of the most common water-quality problems found in surface waters are given in table 4. Included also in table 4 for each beneficial use is an indication whether the stated problems exist in the Merced River, or whether additional data are required to assess the potential problems.

Beneficial uses are so broadly defined that it is difficult to relate a specific water-quality problem to one beneficial use. For instance, high concentrations of dissolved solids may be critical to one type of industrial service, but not important to another industry. With these limitations in mind, three water-quality problems are indicated in table 4.

TABLE 4. - Assessment of water-quality problems in the Merced River

[E, problem exists for this beneficial use in Merced River; 0, this beneficial use might be adversely affected if these standards were exceeded but available data do not indicate a problem in the Merced River at this time; *, not a problem for this beneficial use]

Beneficial use	Common water-quality problems in surface water								
	Dissolved solids	Plant nutrients	Low dissolved oxygen	pH	Suspended sediment	Toxic substances	High temperatures	Pesticides	Indicator bacteria
Municipal and domestic supply.	0	0	*	0	0	0	*	E	0
Irrigation	0	*	*	0	*	0	*	E	*
Stock watering	0	*	*	0	*	0	*	E	0
Industrial process supply	0	0	*	0	0	0	*	*	*
Industrial service supply	*	0	*	0	0	0	*	*	*
Power	*	*	*	*	0	*	*	*	*
Contact-water recreation	*	E	E	*	0	0	0	E	0
Canoeing and rafting	*	E	*	*	0	*	*	*	*
Noncontact water recreation.	*	E	*	*	0	*	*	*	*
Warm freshwater habitats	*	E	E	0	0	0	0	E	*
Cold freshwater habitats	*	E	E	0	0	0	0	E	*
Warm-water spawning	*	E	E	0	0	0	0	E	*
Cold-water spawning	*	0	0	0	0	0	0	E	*
Wildlife habitats	*	*	*	*	0	0	*	E	*

Current Water-Quality Problems

In the lower Merced River there is an increase in plant nutrients (nitrogen and phosphorus). These increases in nutrients alone do not impair beneficial uses but they contribute to excessive plant growth that affects several beneficial uses including contact and noncontact water recreation, freshwater habitats, spawning, and canoeing and rafting. Aerial observations in May 1981 showed that the amount of aquatic plants increased rapidly near rm 36 just downstream from the first of the agricultural return discharges. From this point downstream to the mouth, water hyacinths were very numerous and at times completely covered the channel (fig. 18). In addition to the water hyacinths, other aquatic plants, both emergent and submergent, were very abundant along the lower river (fig. 19). Because aquatic plants remove much of the nutrients dissolved in the water and yet the measured dissolved-nitrogen and phosphorous concentrations remain relatively high, nutrient input to the lower river must be quite high. Excessive nutrients by themselves do not cause excessive plant growth. Temperature and sunlight are also essential to the growth of aquatic plants. The lower Merced River has a combination of temperature, sunlight, nutrients, and flow velocities that is very conducive to plant growth during the spring, summer, and autumn.

Plant nutrients may be causing eutrophication of Lake McClure. When water is impounded, the increased temperature and slower current makes conditions conducive to excess phytoplankton growth. If sufficient nutrients are present, algal blooms will occur in a lake that has the warm summer and autumn temperatures of Lake McClure. Because of the efficient use of nutrients by phytoplankton, excessive nutrient input to lakes usually does not show up in chemical analyses of the water but is usually best assessed by sampling the phytoplankton populations. The California Department of Water Resources sampled the lake at several stations three times in 1975-76 and the U.S. Geological Survey sampled one station five times in 1976-77. These samples showed that the lake is subject to blue-green algae blooms during the late summer and autumn months. Blue-green algae blooms are indicators of excessive nutrient input to the lake. The largest concentration of blue-green algae sampled was at a station about 0.8 mile downstream from the Merced River inflow to the lake (about rm 75) at the time the sample was taken. On September 3, 1975, 13,000 blue-green algae (*Anabaena*) per milliliter were sampled at this station. The location of this algal bloom in the far upstream segment of the reservoir suggests that the nutrient input to the lake is quickly utilized by the phytoplankton. Other high concentrations of blue-green algae occurred at Barret Cove recreation area on October 13, 1976 (1,800 cells per milliliter) and at Lower Horseshoe Bend on October 13, 1976 (1,600 cells per milliliter). The phytoplankton samples suggest that algal blooms in the lake are localized and do not result in large floating mats that cause nuisance conditions. It appears, however, that a potential eutrophication problem does exist, and further significant nutrient input to the lake might result in severe water-quality problems. This is supported by algal growth potential studies done in 1973 and 1974 (Hoffman and others, 1976), which showed that small increases in nitrogen and phosphorous concentrations at stations in and just downstream from Yosemite Valley resulted in large increases in algal growth potential values.

FIGURE 18.--Water hyacinths blocking Merced River channel near Cressey (river mile 27). (Arrow indicates the direction of flow.)

Dissolved-oxygen concentrations less than the 7.0 and 8.0 mg/L standards are shown in table 4 as an existing water-quality problem on the Merced River. This problem is not obvious by looking at mean dissolved-oxygen concentrations measured during the 1967-80 period. Mean dissolved-oxygen concentrations during this period were greater than the 9.0 mg/L at all stations except the South Fork Merced River near El Portal when the mean was 8.9 mg/L. However, some violations of the 7.0 and 8.0 mg/L dissolved-oxygen objectives have occurred at all stations downstream from and including Happy Isles Bridge (rm 127) except at the station at Rancheria Flat (rm 108). All the violations have been during the low flow period of July through October. Violations are few, however, and most of the values are greater than the 7.0 mg/L objective in the lower river, downstream from Cressey (segment D). The lowest dissolved-oxygen measurements were at the two furthest downstream stations (at Milliken Bridge, rm 12, and near Stevinson, rm 5). At Milliken Bridge (rm 12), three violations, the lowest 6.0 mg/L, were recorded between 1976 and 1978. Concentrations were lowest in the early morning (6.0 mg/L on August 9, 1978, at 0530 hours). At Merced River near Stevinson (rm 5), the lowest dissolved oxygen was during the night hours of a diel study done by the U.S. Geological Survey on August 23 and 24, 1977 (Hoffman, 1978). This diel study showed that the dissolved-oxygen concentrations fluctuated greatly over the 24-hour day at that station in the low-flow conditions existing at that time. The maximum dissolved-oxygen concentration was 18.0 mg/L at 1400 hours and the minimum was 3.8 mg/L at 0300 hours.

FIGURE 19.--Aquatic vegetation in Merced River near river mile 7.

Diel studies done at Happy Isles Bridge (rm 127), El Capitan Bridge (rm 120), Rancheria Flat (rm 108), Big Oak Flat (rm 115), below South Fork (rm 100), near Briceburg (rm 95), and South Fork near El Portal (rm 101) by the U.S. Geological Survey between 1973 and 1977 showed some diel fluctuations in dissolved oxygen. Dissolved oxygen dipped below the 8.0 mg/L objective at only two stations (Big Oak Flat on September 28-29, 1977, and below South Fork on September 23-24, 1975). The minimum concentrations, which occurred during the night hours, were greater than the 7.0 mg/L objective for the lower reach of the river, however.

Based on the one diel sampling of dissolved oxygen at the Stevinson station (rm 5), it appears that a problem has existed with low dissolved oxygen in the lower parts of the river. The depressed dissolved oxygen at night was probably caused by the heavy summertime growth of periphyton and other plants in the lower river. Plants that flourish in the warm, nutrient-enriched water use much of the oxygen at night for respiration. Dissolved oxygen increases during the daylight hours by photosynthesis. It is difficult to say if low dissolved-oxygen conditions exist every year during low flow or only in the extreme low flow in the summer of 1977.

Low dissolved-oxygen concentrations can impair the use of the river for warm- and cold-water habitats, spawning, and indirectly, water-contact recreation (fishing). The California Department of Fish and Game (Dennis Lee, oral commun., 1981) reported that there is a fishery for warm-water fish in the lower Merced River and that the autumn salmon run still continues. The effect of any possible nighttime dissolved-oxygen sags in the lower river is difficult to define.

The extensive use of pesticides in modern agriculture suggests that irrigation return water could contain these compounds and discharge them into receiving waters. A limited amount of pesticide sampling was done at Milliken Bridge (rm 12) in 1975 and 1978-80. These samples were analyzed for chlorinated hydrocarbon and organic phosphorous compounds in the water. None were detected in 1979 or 1980, but the October 1978 sample showed 0.02 μg/L of chlorinated hydrocarbons (sum of all chlorinated hydrocarbons from one analysis) and 0.01 μg/L of organic phosphorous compounds (sum of all organic phosphorous compounds from one analysis). California drinking water standards call for a maximum of 2 μg/L of eldrin (a chlorinated hydrocarbon compound). The 2 μg/L is the lowest maximum allowable concentration of the chlorinated hydrocarbons. Drinking water standards have not been set for organic phosphorous compounds. Samples for pesticides in water and bed material were collected in the Merced River near Stevinson (rm 5) and Briceburg (rm 95) in 1977 by the U.S. Geological Survey. None of the water samples had detectable concentrations of pesticides but the bed material from the Briceburg station (rm 95) had 1 μg/kg of PCB and the bed material at the Stevinson station (rm 5) had 0.6 μg/kg of DDE (Hoffman, 1978).

The total amount of pesticide existing in an aquatic system is not well represented by taking only water samples. Most of the pesticides are readily adsorbed onto sediment particles that are either transported downstream or are deposited in the channel. Standards for pesticides in bed materials have not been established but the presence of these compounds in the bed material creates the potential for the compounds to reenter the dissolved state.

The California State Water Resources Control Board, in conjunction with the California Department of Fish and Game, has had an ongoing program of heavy metal and pesticide sampling in aquatic organisms in major rivers in California since the 1977 water year (Woodard, 1979; McCleneghan and others, 1979, 1980). These samples have shown detectable amounts of DDT and metabolites of DDT (total DDT), toxaphene, and PCB in organisms collected at Milliken Bridge (rm 12). The highest PCB concentration (1,380 μg/kg was detected in a goldfish (*Carrasius auratus*) in 1977. No PCB above the 50-μg/kg detection limit was found in fish or benthic invertebrates in a second sample taken in 1977. Analyses for PCB were not done in 1978. In the samples collected in 1978, total DDT was detected at 1,077 μg/kg in a predator fish (*Ictalurus punctatus*). This concentration exceeded the U.S. Environmental Protection Agency guideline of 1,000 μg/kg in fish to protect predators (National Academy of Sciences and National Academy of Engineering, 1973). Lesser amounts of total DDT were found in forage fish (*Cyprinus carpio*) (445 μg/kg) and freshwater clams (*Corbicula* sp.) (69 μg/kg).

Toxaphene is another chlorinated hydrocarbon compound that has been found in fish and benthic-invertebrate flesh sampling by the toxic substances monitoring program. The U.S. Environmental Protection Agency guideline for toxaphene concentration in predator fish is 100 μg/kg. Toxaphene concentrations of 1,040 μg/kg and 250 μg/kg were found in predator fish (*Ictalurus punctatus*) in 1978 and 1979, respectively.

The upper Merced River, upstream from the Briceburg station (rm 95), has frequently had pH values below the minimum objective of 6.5. From 1968-80 there were 22 pH measurements (12.5 percent of the total number of measurements) less than 6.5 at Happy Isles Bridge (rm 127). The lowest recorded pH at Happy Isles Bridge was 5.7 in October 1978. At El Capitan Bridge (rm 120), seven measurements (27 percent) made in 1973-74 were less than 6.5. Other stations downstream of and including the station near Briceburg (rm 95) had occasional pH measurements of less than 6.5 during 1967-81.

The low pH in the upper Merced River is not unexpected because the bulk of the discharge comes from precipitation that has had minimal contact with geological formations that would change the water's composition. Because the average pH of precipitation is considerably less than 6.5, it is expected that the pH of the river water would be low. The pH of the upper Merced River has shown no apparent upward or downward trend over the period of record. Because low pH is a natural phenomenon in the upper reaches of the Merced River occasional drops of pH below 6.5 will continue to occur.

One station (Lake McClure at Exchequer, rm 63) had pH readings that exceeded the 8.5 maximum objective. These measurements of 8.6 were taken near the surface in a depth profile in August 1977. This same profile showed pH readings of 6.4 near the bottom of the lake.

Sources of Potential Water-Quality Problems

The increase in gold-mining activity in the foothill areas of the river and its tributaries is a potential problem because of the possibility of increased sediment transport and deposition that would impair freshwater habitats. The U.S. Forest Service (Dick Hambrock, Sierra National Forest, oral commun., 1981) identified two active mines that have processing mills on the site that are near streams in the basin. The largest of these is the Sweetwater Mine on Sweetwater Creek (connects to the Merced River at rm 98). This mine currently operates two mills. The other mine is on Neds Gulch, which flows into the Merced River from the north at rm 102. The mill at this mine operates once or twice a year. The U.S. Forest Service monitors these operations and is satisfied with the procedures to insure that excessive sediment does not enter the river.

Aerial observations in May 1981 showed numerous small mining operations in the Whites Gulch basin (tributary to Lake McClure at rm 73)(figs. 20 and 21). These mines are very small operations and are well away from the stream. No mine drainage was observed from any of the mines. The extent of mining at this time is not large enough to be a threat to water quality. Other mines sighted in May 1981 in other tributaries were either abandoned or were small operations that were not causing obvious water-quality problems.

Mining for gold using suction dredges is a popular activity in the Merced River between El Portal and Lake McClure. The California Department of Fish and Game and the U.S. Forest Service monitor these activities to make sure that the dredges do not cause increases in sedimentation that would adversely affect beneficial uses.

FIGURE 20.--Gold-mining activity along Whites Gulch.

The El Portal sewage-treatment plant has had a history of problems that have caused short-term contamination of the Merced River by improperly treated sewage. At the present time, the treatment plant is working well and the Park Service is in the process of making further modifications to have the plant comply fully with their discharger's permit (Joe Higeuria, National Park Service, oral commun., 1981). Given the past problems of the plant and the likely increase in the sewage treatment necessitated by increased visitor use, this plant is considered a potential water-quality problem.

The amount of water-quality data on inflow streams to the Merced River is minimal. The National Park Service has sampled several tributaries to the Merced River in Yosemite National Park. The California Department of Water Resources and the U.S. Geological Survey have sampled the South Fork Merced River, the North Fork Merced River, Maxwell Creek, and Bean Creek. Water quality in these streams is similar to the Merced River. The limited sampling shows no apparent water-quality problems. Aerial observations of the tributaries to the Merced River did not show obvious water-quality problems with the exception of Sherlock Creek, which joins the Merced River at rm 83. This creek appeared to be flowing at about 5 ft^3/s and had a heavy growth of aquatic

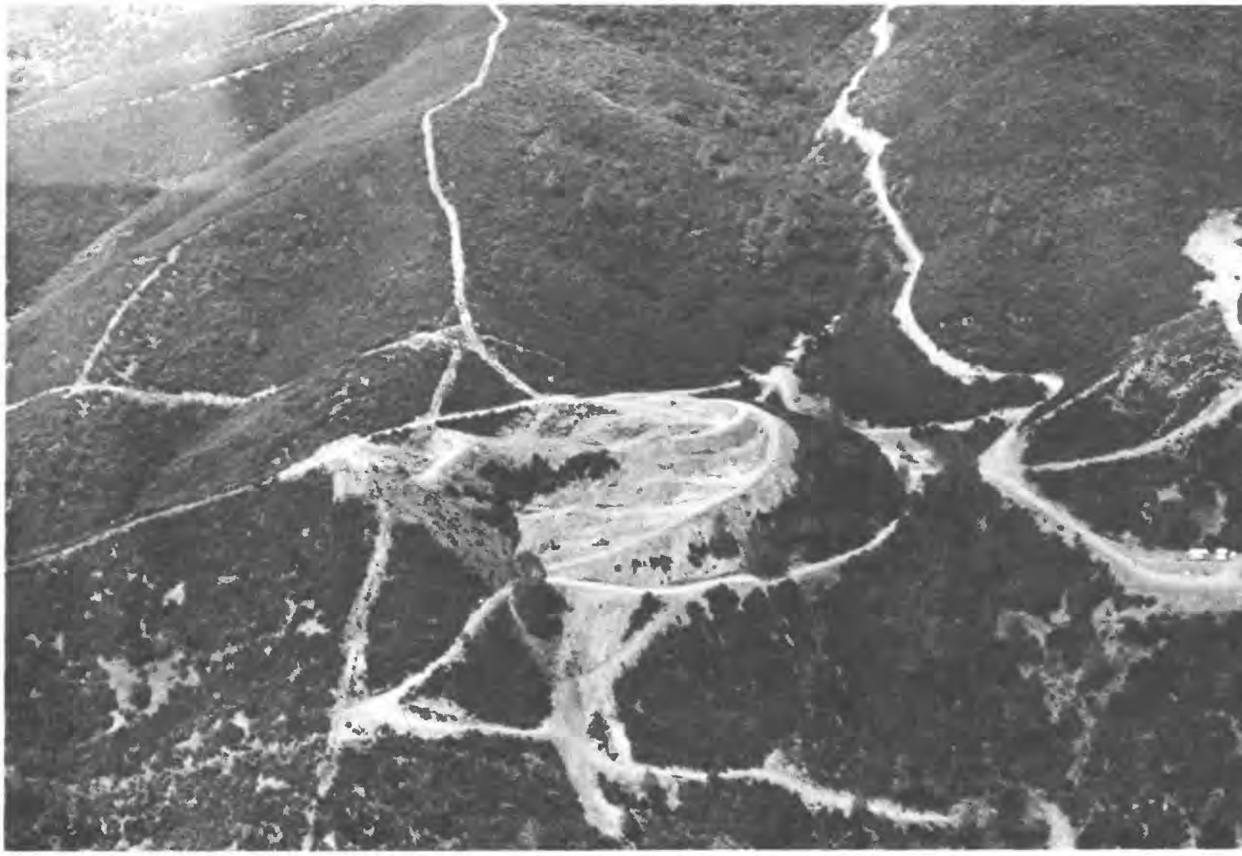


FIGURE 21.--Largest area of surface disturbance around a gold mine in Whites Gulch.

vegetation. The color of the water was a slightly yellowish brown. Some housing in the upper part of the drainage was observed and there are several abandoned mines in the drainage. The source and nature of the observed problem are not apparent. If Sherlock Creek is contributing large concentrations of nutrients, as the aquatic growth in the stream would suggest, it could be a source of nutrient input to Lake McClure.

Increased visitor use in the wilderness areas of Yosemite National Park has long been a potential water-quality problem. The Park Service has made a concerted effort to make back country users aware of possible contamination of the natural streams and lakes and has provided proper sanitary facilities at the more popular back country camping areas. The possibility of bacterial contamination in the back country still exists, however. In recent years, there has been much concern in the back-country areas about giardiasis, an often severe infection of the small intestine caused by the protozoan Giardia lamblia. Although visitors to the park are warned to avoid drinking natural water in the park because of possible Giardia contamination, very little is known about the actual occurrence of this organism in the native waters or about the occurrence of giardiasis in humans.

WATER-QUALITY MONITORING PROGRAM

Existing Monitoring

The U.S. Geological Survey currently collects samples monthly at the Hydrologic Benchmark station at Happy Isles Bridge. Monthly samples include analysis for nutrients, major ions, and indicator bacteria. Trace element samples are collected twice a year and pesticides and radiochemical constituents are sampled once a year.

The California Department of Water Resources currently monitors four stations in the Merced River basin. Merced River at Milliken Bridge is sampled monthly for nutrients and fecal coliform bacteria and quarterly for major ions. Pesticide samples were collected once a year from 1978 to 1980. Merced River at Briceburg and below Merced Falls Dam is sampled in May and December for major ions. Maxwell Creek near Coulterville (pl. 1) is sampled once a year for major ions.

The National Park Service collects samples in accordance with the NPDES discharger permit above and below the El Portal sewage-treatment plant. Weekly grab samples are analyzed for dissolved oxygen, residual chlorine, temperature, total phosphorus, and total coliform bacteria. These data are available from the California Regional Water Quality Control Board and the National Park Service.

The California State Water Resources Control Board and the California Department of Fish and Game collect fish and benthic-invertebrate samples once a year at the Milliken Bridge station for pesticide analyses as part of a toxic substances monitoring program.

Monitoring Needs

Monitoring needs in the Merced River basin are divided into two categories: long-term periodic sampling at fixed stations and short-term, intensive reconnaisance sampling to address specific problems or gaps in the existing data base.

A suggested program of routine monitoring would include monthly sampling at five stations on the Merced River. These stations are at Happy Isles Bridge, at El Portal, at Bagby, below Merced Falls Dam, and at Milliken Bridge. Suggested constituents and properties to be sampled are specific conductance, pH, temperature, dissolved oxygen, major dissolved constituents (for the first year), nutrients including nitrogen, ammonia, organic nitrogen, and phosphorus, and orthophosphorus. These samples are now being collected at Happy Isles Bridge by the U.S. Geological Survey and at Milliken Bridge by the California Department of Water Resources. The station below Merced Falls Dam would be added to determine the quality of water leaving Lake McClure and the station at Bagby would determine the quality of water just before it enters Lake McClure. The station at El Portal is now being monitored by the National Park Service in compliance with the discharger's permit at the sewage-treatment plant. The current level of monitoring, although fewer constituents are being sampled than at other locations, is probably adequate for this station. The California Department of Water Resources is currently sampling the station near Briceburg twice a year. Because of the inflow of several tributaries between Briceburg and Lake McClure, this station would be moved to a site just upstream from the reservoir near the town of Bagby.

In addition to the regular monthly sampling, pesticides in the water, bed material, and fish flesh would be collected once a year at Milliken Bridge during low flow. Samples of fish flesh are currently being collected by the California Department of Fish and Game.

In addition to the stream monitoring, Lake McClure would be sampled twice a year, once during the winter and once in the summer when the lake is thermally stratified. Samples would be collected for nutrients, chlorophyll at several depths, and phytoplankton in the photic zone. Profiles of dissolved oxygen, temperature, specific conductance, pH, and light penetration and transmission would be taken. Suggested sampling sites are near Exchequer Dam, near Barrett Cove recreation area, and near the Merced River inflow.

Special sampling programs are needed to address specific and potential problems. The low nighttime dissolved oxygen in the lower river would be studied by a diel sampling at or downstream from Milliken Bridge during low-flow conditions. If these samplings showed a dissolved-oxygen sag at night such as the one seen in the 1977 sampling (Sorenson and Hoffman, 1981), a follow-up sampling of several sites along the river from Merced Falls Dam to the San Joaquin River during the night hours would be done to determine the extent of the river affected by low dissolved oxygen. If low dissolved oxygen does prove to be a problem, further studies would be needed to determine the specific cause of the dissolved-oxygen depletion and to suggest a solution.

A reconnaissance study of water quality in the agricultural return flows is needed to understand the source of the increased dissolved solids, nutrients, and pesticides in the lower 35 miles of the river. Currently the quality or quantity of these discharges is not known

Input of nutrients to Lake McClure would be investigated by a reconnaissance study of all the tributaries that are accessible in the reach from El Portal to Lake McClure and the tributaries draining into Lake McClure. Nothing is known about the water quality of most of these streams. Included in this sampling would be Sherlock Creek, which aerial observations indicate is a source of nutrients.

Because of the potential for increased sediment transportation as a result of mining activites, an aerial survey conducted once a year during the spring is needed to observe any problem areas. The aerial surveys are a good method of detecting potential or present water-quality problems that may not be detected by routine, fixed location monitoring.

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