WATER-QUALITY ASSESSMENT OF CACHE CREEK, YOLO, LAKE, AND COLUSA COUNTIES, CALIFORNIA

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U.S. GEOLOGICAL SURVEY

Water-Resources Investigations

Open-File Report 81-677

Prepared in cooperation with the

CALIFORNIA STATE WATER RESOURCES CONTROL BOARD

Menlo Park, California
July 1981

UNITED STATES DEPARTMENT OF THE INTERIOR

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CONVERSION FACTORS

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
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)
in (inches)	2.54	cm (centimeters)
in (inches)	25.4	mm (millimeters)
mi (miles)	1.609	km (kilometers)
mi^2 (square miles)	2.590	km^2 (square kilometers)
tons (short)	0.9072	Mg (megagrams)
μmho/cm (micromhos per centimeter)	1.000	μS/cm (microsiemens per centimeter)

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

$$(\text{Temp } ^\circ F - 32)/1.8 = \text{temp } ^\circ C$$

Explanation of other abbreviations

JTU	Jackson turbidity units
μg/L	micrograms per liter
μg/g	micrograms per gram
mg/L	milligrams per liter
mL	milliliters
rm	river miles

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.

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ABSTRACT

Cache Creek and its tributaries from Clear Lake to Yolo Bypass have been the subject of water-quality and water-quantity studies by several governmental agencies since the early 1900's. Water-quality data gathered from all these studies of Cache Creek showed that water in the basin is of good quality for most of the beneficial uses defined by the California State Water Resources Control Board. Concentrations of dissolved constituents are substantially higher in the water in the two largest tributaries than in the water in Cache Creek. Seasonal variations in dissolved constituents are also greater in the tributaries than in Cache Creek. Clear Lake has a major effect on water quality, resulting in little seasonal fluctuation in water quality in Cache Creek. Excessive boron and suspended-sediment concentrations are the greatest water-quality problems, according to existing data. Both of these problems are from natural sources. Water-quality monitoring is presently being conducted monthly at four sites by the California Department of Water Resources and at several other sites by other governmental agencies. Modifications in current water-quality monitoring are proposed to gain further information on diurnal dissolved oxygen cycles, pesticides, and biological constituents that may adversely affect beneficial uses.

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 Cache Creek.

Current and historical water-quality data were gathered from all known sources including the U.S. Environmental Protection Agency and Geological Survey computer files, California Department of Water Resources, and county and local water agencies. Representatives of all Federal, State, and local agencies that have control or interest in Cache Creek 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 Cache Creek basin drains 1,150 mi^2 on the eastern slope of the northern part of the California Coast Ranges in Lake, Colusa, and Yolo Counties (pl. 1). The basin extends from the tributaries of Clear Lake to the Yolo Bypass, 10 mi northwest of Sacramento. The Yolo Bypass is a channel used to divert floodflows from the Sacramento River. The assessment discussed in this report pertains only to Cache Creek and its tributaries below Clear Lake Dam. The studied part of Cache Creek begins at an altitude of 1,300 ft at the outlet of Clear Lake and flows to Cache Creek settling basin before entering the Yolo Bypass, at 25 ft. The studied reach is 81 mi in length, with the distance to the drainage divide ranging from 2 to 4 mi from each bank. The two main tributaries, North Fork Cache Creek and Bear Creek, drain about 350 mi^2 north of Cache Creek's upper reach from Clear Lake Dam to Capay Valley.

The climate of the Cache Creek basin is characterized by mild, wet winters, warm, dry summers, and long frost-free periods. Precipitation occurs mostly from October to April, in the form of rain. The higher altitudes in the west receive 50 to 60 inches per year, and the valley regions receive about 20 inches. California Department of Water Resources Bulletins 90 (1961) and 94-13 (1965) present a comprehensive description of the basin's climate, including precipitation and temperature data at sites throughout the basin.

The geology of Cache Creek basin is described by Lustig and Busch (1967). The most important aspects of geology with respect to water quality are the large areas of Cretaceous and Jurassic marine sedimentary rocks drained by Bear Creek and by Cache Creek from near the confluence with North Fork to Capay Valley. These rocks are the primary source of high concentrations of dissolved solids and boron found in the water.

A general cultural and economic history of the Cache Creek basin is described by the U.S. Army Corps of Engineers (1979). Land use in much of the Cache Creek basin has remained nearly the same since the time of the Spanish land grants. The lower basin, downstream from Rumsey, has traditionally been agriculturally oriented. The upper basin, including the North Fork and Bear Creek drainages, is almost completely undeveloped. Vegetation consists mainly of chaparral and oak woodland.

The upper reach of Cache Creek has had little human impact. Cache Creek Canyon, from Clear Lake Dam to Capay Valley, is accessible to vehicles along Highway 16 from Capay Valley to the confluence with Bear Creek. Other access to the creek is by dirt roads and jeep trails. One small valley area in Cache Creek Canyon (Wilson Valley) was once settled and cultivated for pasture but now is used only as rangeland. Cache Creek Canyon Regional Park (fig. 1), along Highway 16, was developed in 1978 to provide public recreational facilities along the creek.

FIGURE 1.--Westernmost section of Cache Creek Canyon Park. View is downstream. This is the starting point for many of the rafting activities and the halfway point for the raft trips that start at Buck Island.

The North Fork Cache Creek drainage has a similar terrain and level of development. Little Indian Valley was used for pasture and farming until 1975 when it was inundated by Indian Valley Reservoir. Upstream from the present reservoir the creek drains forested highlands with a maximum altitude of about 4,000 ft. Downstream from the reservoir is a small valley containing a few houses and pasture (fig. 2).

In Bear Creek basin, Highway 16 follows adjacently the first 10 mi of the creek from its confluence with Cache Creek. Near the junction of Highway 16 with Highway 20 is an open valley used for grazing. The area to the southwest of this junction is an elk preserve maintained by the U.S. Bureau of Land Management. Upper Bear Creek runs through Bear Valley, a broad valley used primarily for grazing. Mining for mercury has taken place in the Sulfur Creek basin, which contributes 9.5 mi^2 of drainage to Bear Creek, but none of the mercury mines were in operation in 1978 (California Division of Mines and Geology, 1979).

FIGURE 2.--North Fork Cache Creek. View is downstream. Highway 20 is at the right.

The middle and lower reaches of Cache Creek, in Capay Valley and the Central Valley, are lined with dryland and irrigated land used for agriculture and pasture. The amount of irrigated land is increasing as more water is being withdrawn from the creek and from ground-water supplies. The major population center is Woodland, 3 mi southeast of Cache Creek at Yolo (rm 1.1). It has a population of about 30,000 and is growing.

HYDROLOGY

The discussion of hydrology is based on five segments of the Cache Creek system. The first three segments are reaches on the main fork of Cache Creek: (1) The upper reach from Clear Lake Dam (rm 80.7) to Rumsey (rm 48.1), (2) Capay Valley from Rumsey to Capay Dam (rm 29.0), and (3) the lower reach from Capay Dam to Yolo Bypass (rm 0.0). The last two segments are the principal tributaries to Cache Creek: (4) North Fork Cache Creek (rm 72.8) and (5) Bear Creek (rm 56.5) (pl. 1).

Channel Description, Impoundments, and Diversions

A longitudinal profile of the Cache Creek channel is shown in figure 3. The upper reach of Cache Creek, from Clear Lake Dam to Rumsey, is 30 mi long with an average gradient of 28 ft/mi. Cache Creek Canyon, through which the creek flows, is a steep-sided narrow canyon which opens into a few small valleys or terraces. Much of the streambed consists of bedrock and large boulders. The stream flows in a series of rapids interspersed with shallow gravelly bottomed pools. Clear Lake Dam (rm 80.7) (fig. 4) at the head of this reach was constructed in 1914 to provide flood control and irrigation storage in addition to the natural storage in Clear Lake. The Gopcevic, Hotaling Estate Co., and Ruddick (1920) and Bemmerly and Bemmerly (1940) decrees limit the lake's controlled storage capacity to 314,000 acre-ft. Yolo County Flood Control and Water Conservation District, the controlling agency, releases water from April through October for irrigation use downstream. No other diversions or impoundments occur along this reach of Cache Creek.

From Cache Creek Canyon, the creek enters Capay Valley near Rumsey (fig.5). The creek hugs the Capay Hills on the east side of the valley. Slumping and badland topography are typical features along the creek in this reach (fig. 6). Riparian vegetation is intermittent. The streambed is braided in some areas and consists mostly of gravel. Along the valley, a few small diversions of irrigation water are made from the creek. Several small intermittent creeks, not easily identified, drain the agricultural land to the west. In the 20-mi reach in Capay Valley, the creek descends with an average gradient of 11.5 ft/mi.

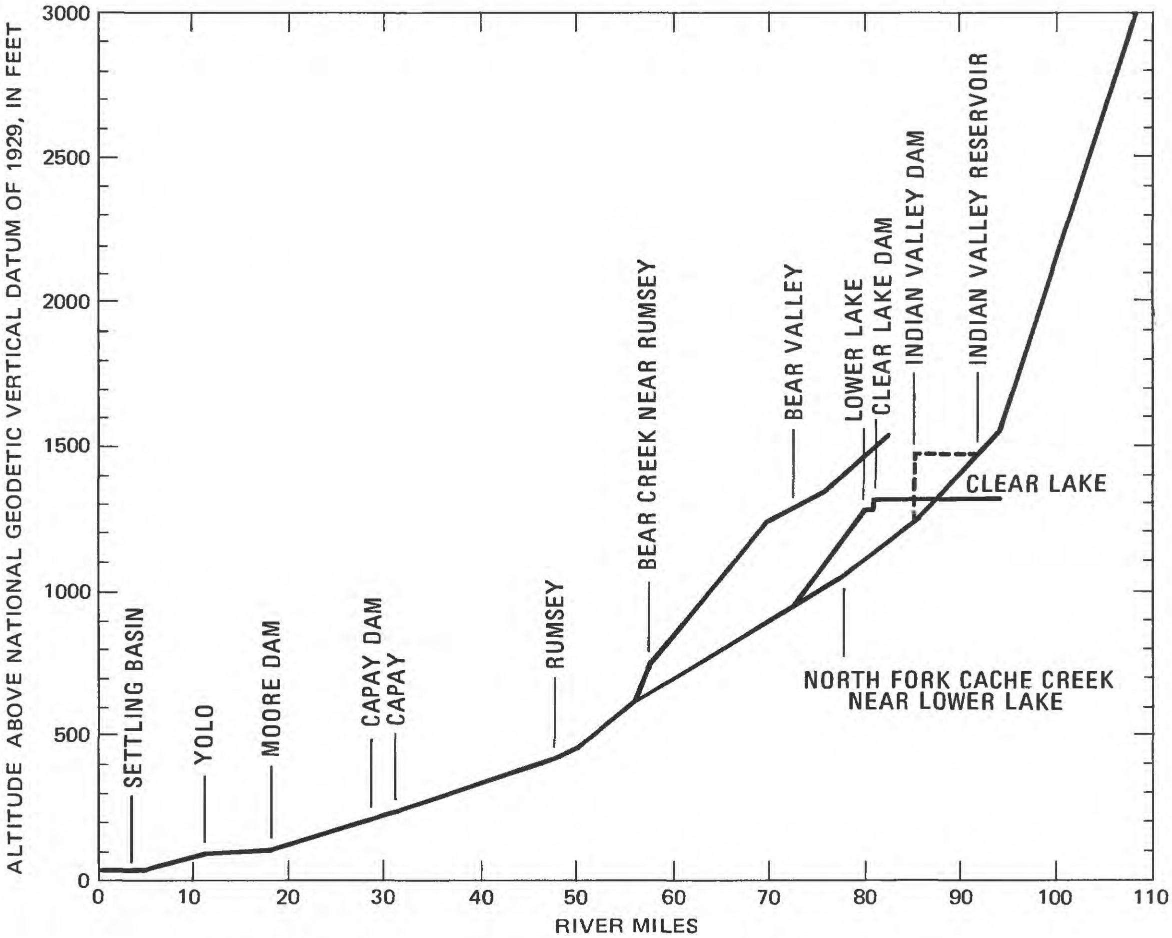


FIGURE 3.--Channel profile of Cache Creek.

The lower reach of Cache Creek has an average gradient of 7 ft/mi. Capay Dam was built in conjunction with Clear Lake Dam to divert irrigation releases south to Winters Canal and north to Adams Canal. The dam has a total diversion rate of 1,000 ft^3/s. Streamflows below the dam are intermittent during the irrigation season when diversions are at a maximum. From Capay Dam (rm 29.0) to Moore Dam (rm 18.3) the channel is very wide with a predominantly gravel bed (fig. 7). During times of water diversions at Capay Dam, much of this reach is dry with small ponded areas where ground-water tables are shallow. Gravel mining operations in this reach continue to alter the stream channel extensively. Gravel is also mined from the 5-mi reach immediately downstream from Moore Dam. This reach has a gravelly stream channel similar to the channel above the dam. Releases from Moore Dam and a spill from West Adams Canal 2 mi downstream from Moore Dam provide continuous flow in this reach during most years. Moore Dam impounds agricultural return flow from the surrounding farmlands, release water from Alder Canal, and ground-water seepage for diversion to Moore Canal. Near the town of Yolo the streambed narrows and is confined by clay banks and levees (fig. 8). The streambed in this reach is silt and gravel. The leveed stream continues to the Cache Creek settling basin, which was constructed in 1937 to collect sediment transported by Cache Creek and thereby maintain the floodway capacity of Yolo Bypass. Much of the basin is now filled and is being farmed.

FIGURE 4.--Clear Lake Dam. View is to the west. U.S. Geological Survey gaging station, Cache Creek near Lower Lake, is in the lower right corner of the photograph. (Photograph courtesy of the California State Water Resources Control Board.)

North Fork Cache Creek flows into Cache Creek at rm 72.8, about 8 mi downstream from Clear Lake Dam. The stream gradient averages 57 ft/mi over its 36-mi length. The canyon in the North Fork upstream from Indian Valley Reservoir is steep sided. The streambed along the canyon consists of boulders, cobbles, and gravel in alternating pools and riffles. Indian Valley Reservoir, formed in 1975 by Indian Valley Dam, is located 12.8 mi upstream from Cache Creek. The reservoir has a capacity of 300,000 acre-ft. Annual releases of 79,000 acre-ft are made by Yolo County Flood Control and Water Conservation District from April through October. Downstream from Indian Valley Dam is an area of greatly eroded badlands (fig. 9). Farther downstream the drainage opens into a flat valley which contains a small housing development and some land irrigated from the creek. The streambed in this area is mostly gravel.

FIGURE 5.--Capay Valley. View is downstream. The gaging station, Cache Creek near Rumsey, is located at the bridge. Highway 16 is at the right. This is the ending point for most of the raft trips.

Bear Creek enters Cache Creek at the Highway 16 bridge about 6 mi upstream from the end of Cache Creek Canyon. The lower 13.5 mi of Bear Creek is in a canyon. This reach of Bear Creek has a gradient of 45 ft/mi and a streambed of mostly bedrock and sand. The upper 12 mi flow through the broad, flat Bear Valley with an average gradient of 22 ft/mi. The streambed in the valley is mostly sand and gravel. There are a few storage reservoirs on ephemeral streams in the side canyons to Bear Valley.

FIGURE 6.--Bank erosion along the left bank of Cache Creek in Capay Valley.

Streamflow

The magnitudes and some of the variations of monthly flows in Cache Creek and its major tributaries are shown by the hydrographs on plate 1. Discussion of discharge in the drainage will be confined mainly to water years 1961-75. During this period, continuous records of streamflow were collected at most of the major gaging stations, and releases from Indian Valley Reservoir had not yet begun.

FIGURE 7.--Lower Cache Creek. View is east (downstream) from a point 1 mile downstream from Capay Dam. The channel along this reach is very wide and extensively modified by flooding and gravel mining.

Prior to 1975, flow was unregulated in the major tributaries, Bear Creek and North Fork Cache Creek, and therefore reflected natural climatic influences. The highest flows occur from November through April when most of the precipitation occurs. The maximum mean monthly flow occurs in January at both stations. Lowest flows occur from July through October. The flow patterns at the four stations on Cache Creek show the effect of regulation and diversion at Clear Lake Dam and Capay Dam. The patterns of flow are similar to those of unregulated streams from October through April, when little water is released for irrigation. From April through September when natural flow would drop sharply, releases from Clear Lake keep the flow relatively uniform. Most of the released water is diverted at Capay Dam, as shown by the hydrograph of Cache Creek at Yolo, where summer mean monthly flows are less than 5 ft^3/s.

FIGURE 8.--Cache Creek near the Yolo gaging station. View is upstream. The creek is confined by levees along this reach.

FIGURE 9.--Badland topography along North Fork Cache Creek about 5 miles downstream from Indian Valley Dam.

Since 1975 a series of atypical water years has occurred. A record drought in 1976 and 1977 resulted in monthly mean flows of less than 3 ft^3/s for all but 2 months from October 1975 through January 1978 at Cache Creek near Lower Lake. Irrigation releases were maintained in North Fork Cache Creek during 1976, with water stored in Indian Valley Reservoir, but dropped to less than 6 ft^3/s in 1977 when the reservoir was emptied. Except for 2 months in 1976, no flow was recorded from October 1975 to November 1977 at Cache Creek near Yolo station. Since the 1976 drought, flow conditions have returned to a more normal pattern, except that summer flows in North Fork have become considerably higher than before due to an increase in releases from Indian Valley Reservoir.

Duration curves of daily flow (fig. 10) indicate the percentage of days a given daily mean discharge is equaled or exceeded during some selected periods of time. The curve for Cache Creek near Lower Lake shows a flow pattern indicative of a station directly influenced by storage and release from a reservoir. The flattened parts of the curve indicate periods when discharge is relatively constant for an extended period. At this station, discharge was between 250 and 740 ft^3/s for about 27 percent of the days. This is the period when irrigation releases were occurring. The lower part of the curve flattens out again, representing base flow conditions in late autumn and early winter, after irrigation releases stop and before winter high flows start. Cache Creek near Lower Lake has a median discharge (daily mean discharge equaled or exceeded 50 percent of the time) of 180 ft^3/s. The curve from Cache Creek near Capay shows the same pattern of flattening at the 200 to 600 ft^3/s range. However, the flow from the major tributaries causes the curve to be much less steep, from 40 to 90 percent, with the result that the median discharge near Capay was 340 ft^3/s.

The flow-duration curve for Cache Creek near Yolo shows a median daily discharge equal to zero. Flow at this station occurred only 45 percent of the days during the 1961-75 period. Flow diversions at Capay Dam are responsible for the lack of flow at Yolo.

North Fork Cache Creek and Bear Creek have duration curves of daily flow indicative of unregulated streams with large yearly fluctuations in flow. Both curves flatten near the lower end, indicating base flow, probably from springs in the upper basins; however, both curves show almost no flow for at least 1 percent of the days of record. Median flows at North Fork Cache Creek and Bear Creek are 34 and 5 ft^3/s, respectively.

Flow duration for North Fork Cache Creek for the 2 years after the 1976-77 drought is also shown in figure 10. This curve, although based on only 2 years of record, shows how flow regulation in the creek has changed since the filling of Indian Valley Reservoir. The curve shows that periods of low flow were reduced as flows of less than 10 ft^3/s occurred only about 7 percent of the time. Prior to Indian Valley Reservoir, flows less than 10 ft^3/s occurred about 35 percent of the time. The percentage of time that high flows (greater than about 300 ft^3/s) occurred also decreased, indicating that high flows were impounded by the dam. The median flow at the North Fork Cache Creek station in 1978-79 was 61 ft^3/s.

Floods in Cache Creek basin result from short-term runoff during major winter rainstorms. The largest flood for the period of record was in February 1958, when a peak discharge of 41,400 ft^3/s was recorded at Cache Creek at Yolo. The levees along the lower end of the creek held, but the creek overflowed its banks upstream, causing an estimated $520,000 damage. Other floods in 1940 (28,700 ft^3/s measured plus an estimated, by indirect measurement, 10,000 ft^3/s discharge at Yolo), 1956 (27,400 ft^3/s), 1965 (37,800 ft^3/s), and 1970 (34,600 ft^3/s) have caused varying amounts of damages in the study area and in areas around Clear Lake.

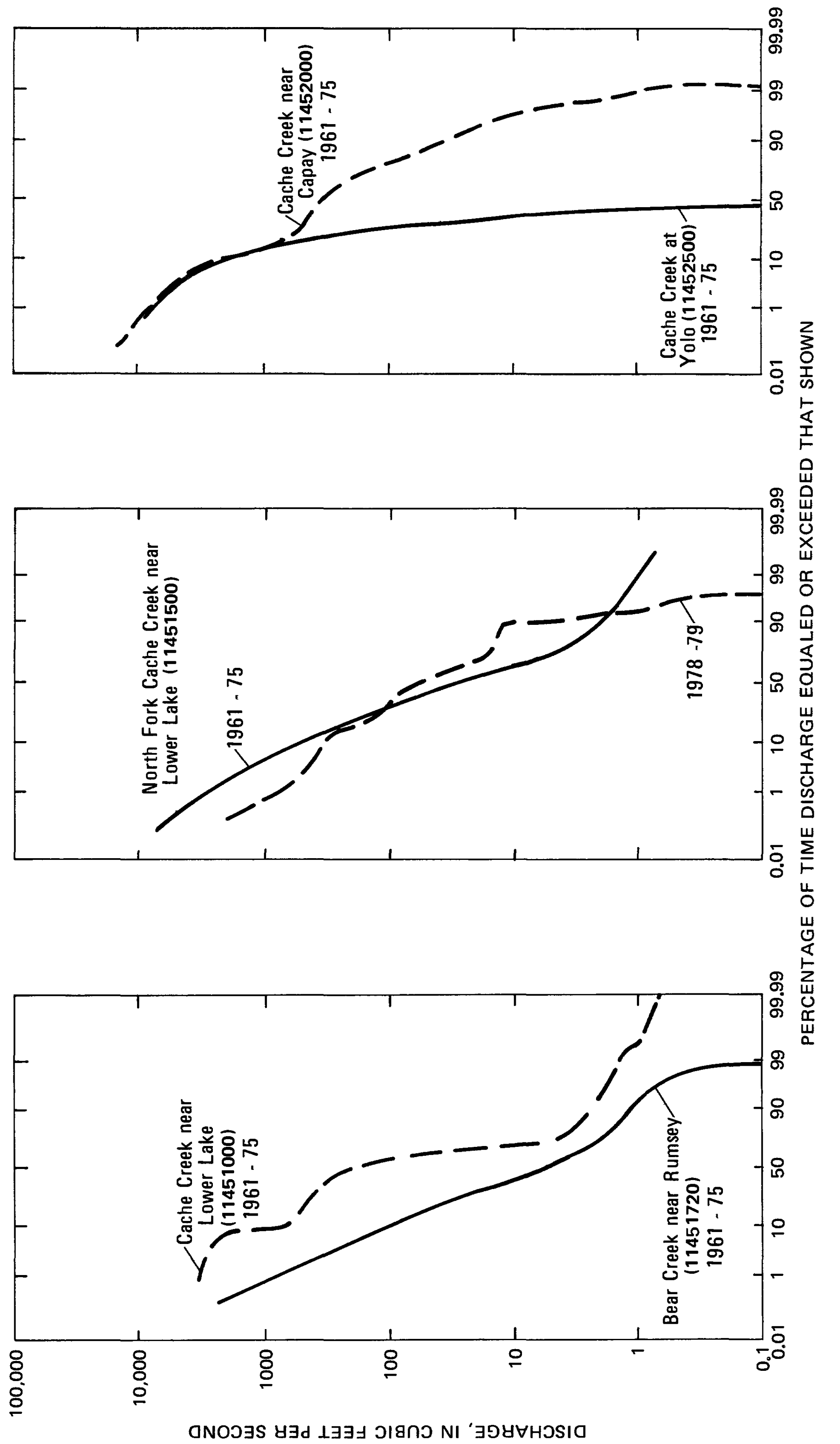


FIGURE 10.--Duration curves of daily flow for selected stations on Cache Creek.

Flooding problems and proposed flood control projects are described by the U.S. Army Corps of Engineers (1979). In 1961, improvements to the levees downstream of Yolo increased the capacity of Cache Creek to 30,000 ft^3/s. Gravel mining has widened and deepened the channel from Capay to Yolo and, hence, increased the capacity in this reach. Indian Valley Dam and Clear Lake Dam limit the discharge of Cache Creek at Rumsey to a maximum of 20,000 ft^3/s, except in extreme floods.

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 Cache Creek 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 the detriment of other beneficial uses. All reasonable or desirable uses may not be beneficial. A description of the beneficial uses identified for Cache Creek and the extent to which each is currently used follows.

Irrigation.--Irrigation is the main use of Cache Creek water. The management of flow in Cache Creek is designed to maximize availability of irrigation water. The first diversions of water for irrigation are made in Capay Valley where farmers pump creek water for orchard and row crop irrigation. It is estimated that they divert less than 3,000 acre-ft per year (W. L. McAnlis, Yolo County Flood Control and Water Conservation District, oral commun., 1980). At Capay Dam virtually all the flow is diverted during the months from April to October by Yolo County Flood Control and Water Conservation District. District canals extend north and south with most of the service area southwest of Woodland. The Yolo District also operates Moore Dam (rm 18.3) as a channel crossover for Alder Canal, which runs south into Moore Canal, and as a diversion point for agricultural return flows and ground-water seepage.

Stock watering.--Livestock and poultry was a $9.3 million industry in Yolo County in 1979 (Yolo County Department of Agriculture, 1980). The extent to which Cache Creek water was used for stock watering is unknown but is probably insignificant compared to irrigation usage.

Industrial supply.--Industrial process supply includes water used directly for manufacturing products. No water from Cache Creek 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 Cache Creek is currently used for these purposes. The gravel mining industry uses ground water for gravel washing. Other mining activities in the basin are no longer in operation.

Contact water recreation.--Contact water recreation includes all recreational uses involving actual body contact with water, such as swimming, wading, and sport fishing. Swimmers and sport fishermen use Cache Creek in Canyon Park and at other public access sites in Capay Valley and the Central Valley. Indian Valley Reservoir is used for boating and fishing. North Fork Cache Creek is used on a limited basis by fishermen in the 5-mi reach immediately downstream from Indian Valley Reservoir. This reach supports a trout fishery in the cool water released from the bottom of the reservoir.

Canoeing and rafting.--The lower part of Cache Creek Canyon has become a popular stretch for white-water rafting, kayaking, and innertubing in the past 4 years. A concessionaire has organized 1- and 2-day raft trips from Buck Island (rm 60.9) and Canyon Park (rm 53.9) to Rumsey (rm 48.1). During the summer about 500 people a week take these trips (Earl Balch, Yolo County Planning Department, oral commun., 1980).

Noncontact recreation.--Noncontact recreational activities involve the presence of water but do not require contact with it, such as picnicking, sunbathing, hiking, and camping. These activities are confined mostly to Canyon Park and other areas of the creek that are accessible from Highways 16 and 20. Indian Valley Reservoir also provides an area for noncontact recreation. Dirt roads, jeep trails, and hiking trails provide access to the creek at more remote locations.

Warm freshwater habitats.--Warm freshwater habitats are for warm-water native and introduced game and nongame fishes and other aquatic plants and animals. All of Cache Creek and its major tributaries provide good warm-water habitats, except Cache Creek downstream from a point about 3 mi below Capay Dam, where the stream dries up during the summer, and the reach downstream from Indian Valley Dam, which is a cold-water habitat. A list of fish species found in Cache Creek downstream from Capay Dam is presented by Environ (1980).

Cold freshwater habitats.--The only year-round cold freshwater habitats in Cache Creek are in the reach downstream from Indian Valley Reservoir which receives cool release water from the bottom of the reservoir. Other areas of Cache Creek provide cold water habitats during the winter months. The Water-Quality Control Plan (California Regional Water Quality Control Board, Central Valley Region, 1975) lists cold-water habitats as a potential beneficial use.

Spawning (warm water).--Areas suitable for warm-water fish spawning are found along the entire length of Cache Creek that receives flow year-round. Because the creek is shut off from the Sacramento River and Yolo Bypass except during high flow, Cache Creek does not provide spawning for a significant number of anadromous fish. Striped bass are believed to be present in Cache Creek (Environ, 1980) but probably do not spawn successfully.

Spawning (cold water).--Cold-water fish (predominantly brown trout) apparently have established a self-sustaining population in the reach of North Fork Cache Creek below Indian Valley Dam, indicating the presence of a suitable cold-water spawning habitat. Much of Cache Creek would probably be suitable for anadromous cold-water fish spawning if direct access to the Sacramento River was provided. Steelhead trout and king salmon have been collected in Cache Creek between Capay and Yolo (Environ, 1980) but the number that spawn in Cache Creek is probably very small.

Wildlife habitats.--Much of the upper basin of Cache Creek and its tributaries is in a natural state due to the ruggedness of the terrain and lack of easy access. The area, therefore, provides an excellent habitat for native wildlife. Agricultural development in Capay Valley limits wildlife habitats, but the hills on both sides of the valley and riparian areas along the stream provide valuable wildlife habitats. Wildlife habitats below Capay Valley are restricted to small areas of riparian vegetation and to agricultural fields.

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 were produced on an interim basis until sufficient information becomes available to establish specific objectives. A key consideration in setting objectives is the policy of nondegradation. The policy (defined in 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 Cache Creek:

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.--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 habitats	5.0 mg/L
Water designated as cold-water habitats	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 freshwaters 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.

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 cold-water intrastate waters be increased more than 5°F above natural receiving water temperature. At no time or place shall the temperature of warm-water intrastate waters 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 JTU, increases shall not exceed 20 percent; where natural turbidity is between 50 and 100 JTU, increases shall not exceed 10 JTU; and where natural turbidity is greater than 100 JTU, increases shall not exceed 10 percent.

WATER QUALITY

Water-quality data have been collected on a regular basis at several sites on Cache Creek and its tributaries for many years. Table 1 shows a list of the water-quality and streamflow stations in the studied Cache Creek basin. Most of the data were collected and analyzed by the California Department of Water Resources. Most of the data are stored in the computer files of the Environmental Protection Agency (STORET) and the Geological Survey (WATSTORE). For this assessment, the stored data were retrieved and reviewed for completeness and technical accuracy. Conflicting data were selectively omitted from the analyses and interpretation presented in this report.

Most of the discussion on water quality in this report is based on data collected in 1961-75 water years, the same base period used in reporting flow duration and hydrographs. Where change is apparent, reference is made to water quality in the years before 1961 and since 1975.

TABLE 1. - Water-quality sampling stations in Cache Creek drainage

[DWR, California Department of Water Resources; USGS, U.S. Geological Survey; YCFC&WCD, Yolo County Flood Control and Water Conservation District]

Station name	Station identification No.	Collecting agency	Years water quality was sampled: Physical	Chemical	Boron	Sediment	Years of discharge record
Lower reach							
Willow Slough at Highway 113.	383610122455801	YCFC&WCD	1969-current	---	1969-current	---	---
Cache Creek at Yolo	11452500	USGS	1957-67, (temperature)	---	---	1957-67	1903-current
West Adams Canal at Salisbury Spill.	384026121521201	YCFC&WCD	1969-current	---	1969-current	---	---
Alder Canal near Moore Dam.	AOC84171542	DWR	Apr 59 (once)	Apr 59 (once)	Apr 59 (once)	---	---
Moore Canal near Moore Dam.	AOC84091530	DWR	Apr 59 (once)	Apr 59 (once)	Apr 59 (once)	---	---
Cache Creek at Moore Dam.	384110121540401	YCFC&WCD	1969-current	---	1969-current	---	---
Cache Creek at County Road 85, at Capay.	A0854010	DWR	Jan-Apr 1959	Jan-Apr 1959	Jan-Apr 1959	---	---
Middle reach							
Salt Creek below Taylor Canyon, near Capay Dam.	A0885010	DWR	June 41 (once)	June 41 (once)	June 41 (once)	---	---
Salt Creek at Highway 16, above Capay.	A8102101	DWR	Apr 52-	Apr 52-	Apr 52-	---	---

Cache Creek at Capay Diversion Dam.	384248122050202	Yolo County farm advisor	1930-38	1930-38	1930-38	---	---
		YCFC&WCD	1969-current	---	1969-current	---	---
	A0894500	DWR	Apr 52 (once)	Apr 52 (once)	Apr 52 (once)	---	---
Taylor Canyon at Highway 16, in Capay Valley.	A8112210	DWR	Apr 52 (once)	Apr 52 (once)	Apr 52 (once)	---	---
Alder Spring Creek at Taylor Canyon, near Capay Valley.	A8112240	DWR	Apr 52-Apr 53	Apr 52-Apr 53	Apr 52-Apr 53	---	---
Cache Creek near Capay	11452000	USGS	---	---	---	---	1942-77
	A8112000	DWR	1951-77	1951-77	1951-77	---	---
Brooks Creek at Highway 16, near Brooks.	A8112380	DWR	Apr 52 (once)	Apr 52 (once)	Apr 52 (once)	---	---
Brooks Creek at Old Toll Road, near Brooks.	A8112330	DWR	Apr 53 (once)	Apr 53 (once)	Apr 53 (once)	---	---
McKinney Canyon below Smith Canyon, near Guinda.	A8112410	DWR	Apr 53 (once)	Apr 53 (once)	Apr 53 (once)	---	---
Cobbey Canyon at Highway 16, near Guinda.	A8112510	DWR	Apr 53 (once)	Apr 53 (once)	Apr 53 (once)	---	---
Pierce Canyon near Indian School, near Guinda.	A8112620	DWR	Apr 53 (once)	Apr 53 (once)	Apr 53 (once)	---	---
Pierce Canyon at County Road 53 Bridge, near Guinda.	A8112622	DWR	Apr 52-Apr 53	Apr 52-Apr 53	Apr 52-Apr 53	---	---
Cache Creek tributary below Rumsey Bridge.	A8113480	DWR	Apr 52	Apr 52	Apr 52	---	---
Cache Creek at Rumsey (published as "above	11451760	USGS	---	---	---	1960-76	1960-62, 65-current
Rumsey" pre-1973).	A8113500	DWR	1976-current	1976-current	1977-current	---	---
Rumsey Canyon at Highway 16, near Rumsey.	A8113610	DWR	Apr 52-Apr 53	Apr 52-Apr 53	Apr 52-Apr 53	---	---

TABLE 1. - Water-quality sampling stations in Cache Creek drainage--Continued

Station name	Station identification No.	Collecting agency	Years water quality was sampled				Years of discharge record
			Physical	Chemical	Boron	Sediment	
			Upper reach				
Cache Creek at Highway 16, near Rumsey.	A8120010	DWR	Apr 52-Apr 59	Apr 52-Apr 59	Apr 52-Apr 59	---	---
Bear Creek near Rumsey	11451720	USGS	---	---	---	1960-67	1958-current
	A8125000	DWR	1968-current	1968-current	1968-current	---	---
Sulfur Creek	5 sites	USGS	Sept 59	Sept 59	Sept 59	---	---
Bear Creek below Wilbur Springs Bridge.		DWR	1938-39	1938-39	1938-39	---	---
N. Fork Cache Creek near Lower Lake.	11451500	USGS	---	---	---	1957-66	1930-current
	A8205000	DWR	1938-41, 1951-current	1938-41, 1951-current	1938-41, 1951-current	--- ---	--- ---
N. Fork Cache Creek below Indian Valley Dam.	A8206000	DWR	Apr 78 (once)	Apr 78 (once)	Apr 78 (once)	---	---
	390435122320102	YCFC&WCD	1975-current		1975-current	---	---
Indian Valley Reservoir at Dam.	A8R90502322	DWR	1975-current	1975-current	1975-current	---	---
	390457122321102	YCFC&WCD	1975-current	---	1975-current	---	---
Indian Valley Reservoir at Boat Ramp.	A8R90502318	DWR	March 78 (once)	March 78 (once)	March 78 (once)	---	---
N. Fork Cache Creek at Hough Springs.	11451100	USGS	---	---	---	---	1971-current
		YCFC&WCD	1975-current	1975-current	1975-current	---	---
Cache Creek near Lower Lake.	11451000	USGS	---	---	---	---	1944-current
	A8135000	DWR	1951-current	1951-current	1951-current	---	---

Areal Variations in Water Quality

Discussion of areal variations in water quality is based on data collected at Cache Creek near Lower Lake (station 11451000), North Fork Cache Creek near Lower Lake (11451500), Bear Creek near Rumsey (11451720), and Cache Creek near Capay (11452000). These stations are used because they have long-term records of discharge and water quality, and are considered representative of most of the Cache Creek drainage.

The relative percentages of major cations and anions over the 1961-75 base period are shown in pie diagrams on plate 1. At Cache Creek near Lower Lake, calcium and magnesium are the predominant cations and bicarbonate is the predominant anion. This is also true at North Fork Cache Creek near Lower Lake, but the relative percentages of sodium plus potassium (sodium and potassium are combined on the pie diagrams, however, potassium makes up less than 1 percent of the dissolved solids at all stations) and chloride are greater than at Cache Creek near Lower Lake. Water from Bear Creek has predominantly sodium plus chloride ions. The small percentage of calcium relative to the percentage of magnesium at this station is particularly noteworthy because this condition is unusual in California streams. The relative percentages of cations and anions at Cache Creek near Capay are very similar to the percentages found at North Fork Cache Creek. The percentages of cations are nearly equal for calcium, magnesium, and sodium plus potassium, while bicarbonate is the predominant anion. The mean concentration of dissolved solids for the base period is listed below each pie diagram on plate 1. Because only a few determinations of dissolved-solids concentrations were made at most stations, a ratio between dissolved solids and specific conductance was calculated for each station. This ratio was used to calculate dissolved-solids concentrations from all available specific conductance measurements. The mean concentration of dissolved solids shown on plate 1 is the mean of the calculated concentrations. Cache Creek near Lower Lake had the lowest mean dissolved-solids concentration of 163 mg/L. Bear Creek, with 1,520 mg/L, had the highest mean dissolved-solids concentration.

Other constituents for which a substantial number of samples have been taken are boron and nitrate. Mean boron concentrations were highest at North Fork Cache Creek near Lower Lake (2,520 μg/L), followed by Bear Creek near Rumsey (2,500 μg/L), Cache Creek near Capay (1,510 μg/L), and Cache Creek near Lower Lake (810 μg/L). Mean nitrate concentrations were highest at Bear Creek (1.4 mg/L as N), followed by Cache Creek near Capay (0.60 mg/L as N), Cache Creek near Lower Lake (0.44 mg/L as N), and North Fork Cache Creek near Lower Lake (0.2 mg/L as N). Boron and nitrate will be discussed in more detail in the water-quality problems section of this report.

Water samples for trace metal analyses were taken at Cache Creek near Lower Lake, North Fork Cache Creek near Lower Lake, and Bear Creek on several dates from 1974-76 and twice a year from 1952-66 at Cache Creek near Capay. Most of the samples were analyzed for cadmium, copper, iron, lead, manganese, and zinc, and some for aluminum, arsenic, and hexavalent chromium. Trace metal concentrations were within Environmental Protection Agency and California water-quality criteria for irrigation and aquatic life, with only a few exceptions. The April 4, 1974, sample at North Fork Cache Creek near Lower Lake had a total iron concentration of 12,000 μg/L, in excess of the Environmental Protection Agency recommended irrigation-water limit of 5,000 μg/L for continuous use on crops (National Academy of Sciences and National Academy of Engineering, 1973). The total manganese concentration of 250 μg/L, in the same sample, also exceeded the Environmental Protection Agency irrigation water standard (200 μg/L). At Cache Creek near Lower Lake, three samples (May 4, 1972; April 4, 1974; and May 6, 1975) had total iron concentrations of 1,000, 1,400, and 1,600 μg/L, respectively. These samples and the North Fork sample exceed the Environmental Protection Agency recommended limit of 1,000 μg/L for aquatic life (U.S. Environmental Protection Agency, 1976).

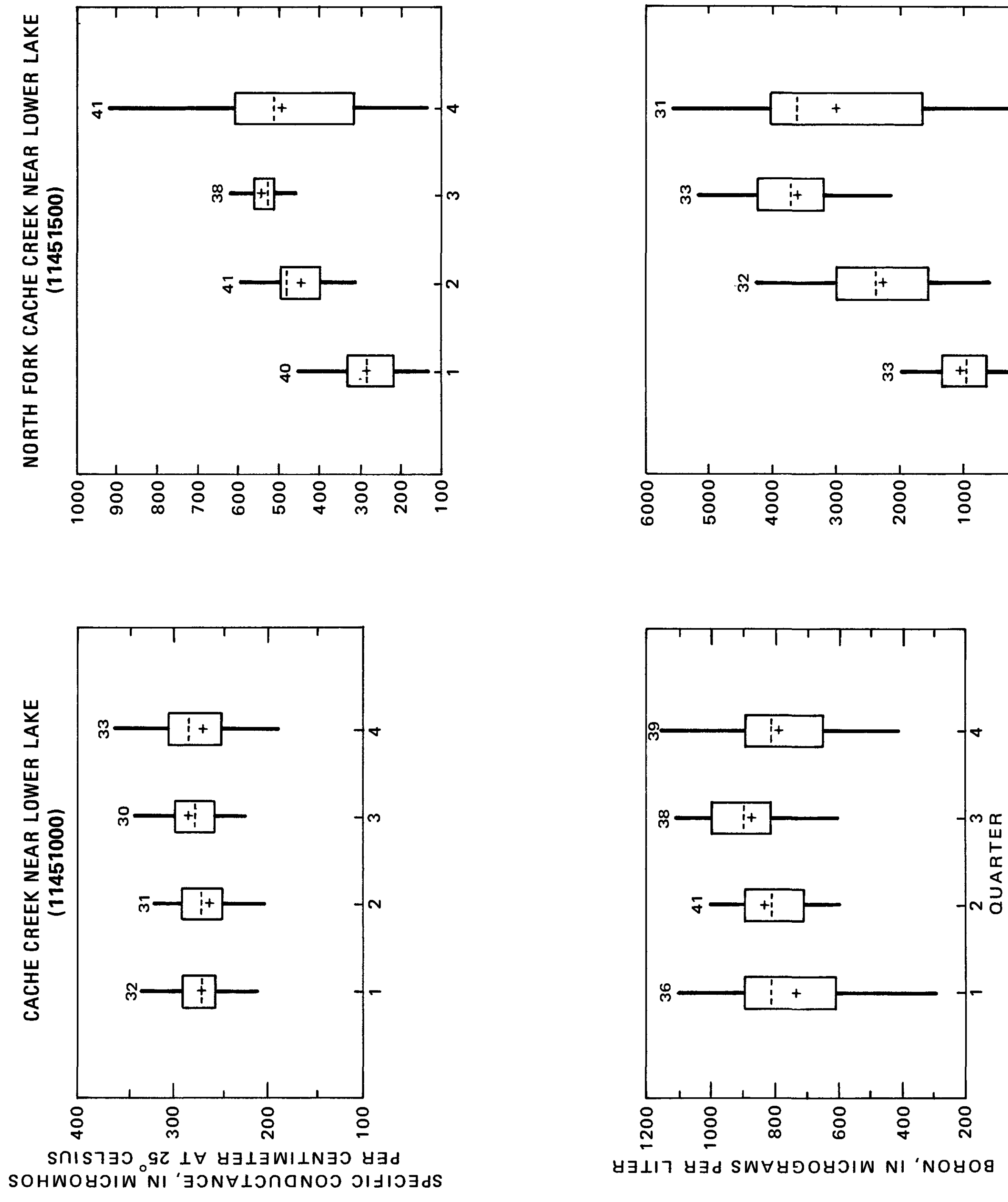
Changes in Water Quality Resulting from Indian Valley Reservoir

Several effects on water quality in North Fork Cache Creek have been noted since the filling of Indian Valley Reservoir. Water temperature decreased in the 5-mi reach below the dam as a result of the release of cool deep water in the reservoir. These temperature decreases have been sufficient to provide suitable cool temperatures for cold-water aquatic habitats and to allow for the establishment of a trout fishery (Phil Baker, California Department of Fish and Game, oral commun., 1980). Comparison of water-quality constituents and physical properties at North Fork near Lower Lake for the period, 1952-75, with data obtained after filling the reservoir, 1978-79 (the drought years of 1976-77 were considered too atypical to use in the comparison), using Student's *T* test, showed a significant decrease in specific conductance and in concentrations of alkalinity, calcium, magnesium, sodium, chloride, sulfate, and boron at the 5-percent level. There were no statistically significant (5-percent level) differences in pH, dissolved oxygen, water temperature (the sampling station is located downstream from the area affected by the cool reservoir waters), or nitrate.

Differences in water quality in North Fork Cache Creek did not result in significant changes in water quality in Cache Creek downstream from the confluence with North Fork. A comparison of data from 1970-75, 1965-75, and 1952-75 at Cache Creek near Capay with data from 1978-79 at Cache Creek near Rumsey (the Cache Creek near Capay station was discontinued in 1976 and replaced by Cache Creek near Rumsey) showed no significant differences in mean concentrations at the 5-percent level. Comparison of data from the Capay and Rumsey stations may not be applicable due to the distance between them (17.3 mi) and the lack of any simultaneous water-quality data; but, because there are no major inflows between the stations, it is assumed that no significant water-quality changes occur.

Seasonal Changes in Water Quality

The extent of seasonal changes in water quality in the Cache Creek basin varies greatly from station to station. Seasonal changes in water quality were evaluated based on grouped quarters (February-April, quarter 1; May-July, quarter 2; August-October, quarter 3; and November-January, quarter 4) during the 1961-75 water years. Figure 11 represents seasonal variations in specific conductance and boron concentrations. The smallest seasonal variations occurred at Cache Creek near Lower Lake just downstream from Clear Lake. This was expected because the station is the only one directly downstream from a reservoir. North Fork Cache Creek near Lower Lake, and Bear Creek near Rumsey had much higher seasonal variability, typical of free-flowing streams. North Fork Cache Creek now has considerably less seasonal variation in water quality, due to regulation at Indian Valley Reservoir. All stations except Cache Creek near Capay had the highest seasonal mean specific conductance and boron concentrations during the third quarter. At Cache Creek near Capay, the highest means occurred during the fourth quarter. Because the fourth quarter is after the irrigation season, releases from Clear Lake are minimal and a larger percentage of the flow at Cache Creek near Capay during these months is contributed by North Fork and Bear Creek. Because these sources have higher specific conductance and higher boron concentrations than the water released from Clear Lake, specific conductance and boron at Cache Creek near Capay are higher in the fourth quarter than in other seasons of the year. The greatest variation in specific conductance and boron concentrations within a quarter occurred during the fourth quarter at all stations due to large fluctuations in runoff during this quarter.


NORTH FORK CACHE CREEK NEAR LOWER LAKE
(11451500)
CACHE CREEK NEAR LOWER LAKE
(11451000)
SPECIFIC CONDUCTANCE, IN MICROMHOS
PER CENTIMETER AT 25° CELSIUS
BORON, IN MICROGRAMS PER LITER
QUARTER

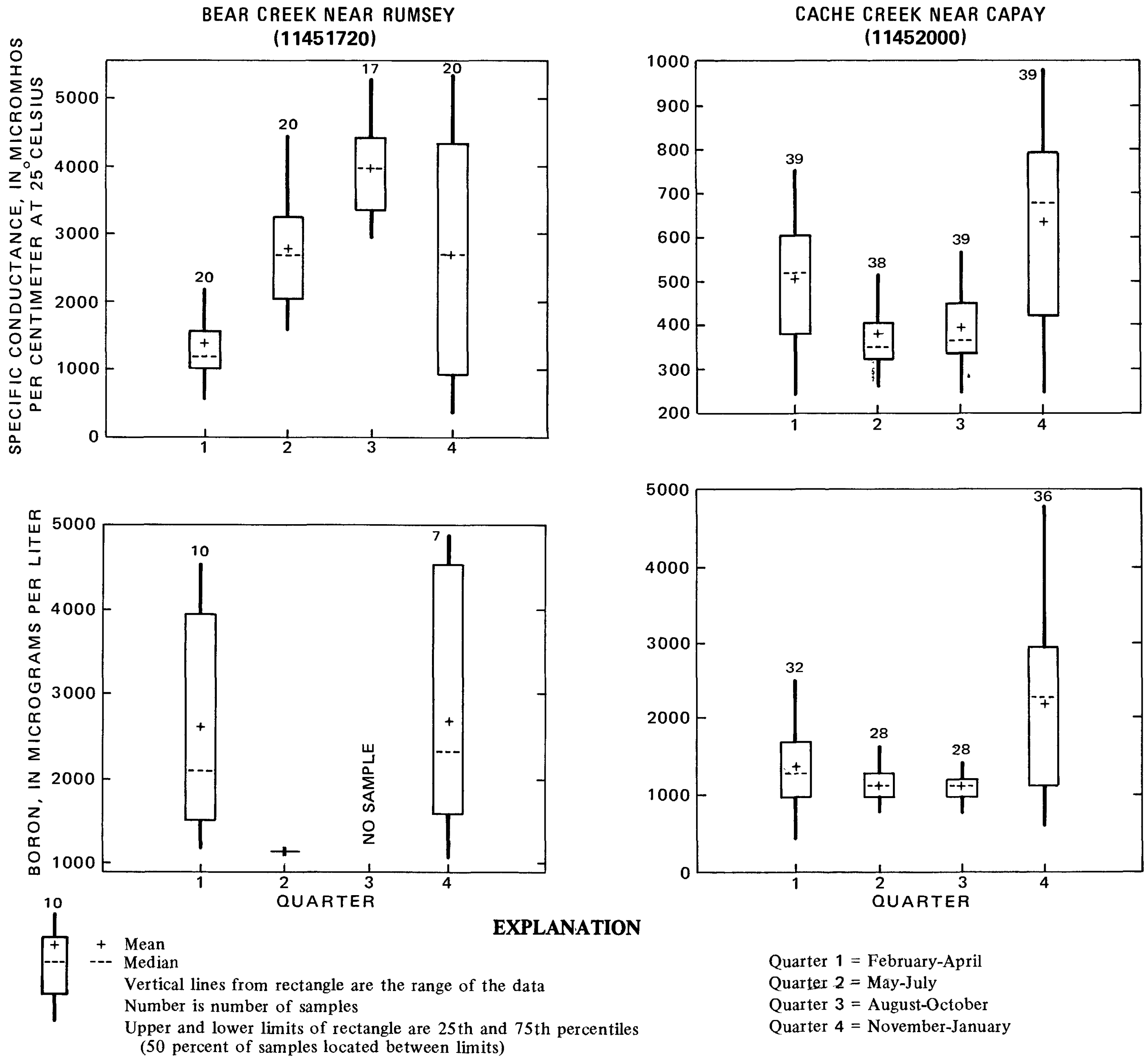


FIGURE 11.--Seasonal variation in specific conductance and boron from 1961-75 at selected stations on Cache Creek.

ASSESSMENT OF WATER-QUALITY PROBLEMS

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 Cache Creek and several of the most common water-quality problems found in surface waters are given in table 2. Included also in table 2 for each beneficial use is an indication whether the stated problems exist in Cache Creek, 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 at all important to another industry. With these limitations in mind, two water-quality problems are indicated in table 2.

High boron concentrations limit the water's use for irrigation because boron is toxic to plants in varying concentrations. Boron is a natural constituent derived from the marine sediments that are drained by Cache Creek and its tributaries. The mean 3-month boron concentration in Cache Creek near Capay ranged from 1,200 μg/L during March, April, and May to 2,200 μg/L during December, January, and February. Highest concentrations of boron occur during the winter when water is not being used for irrigation. Crops that are boron sensitive (defined by the U.S. Salinity Laboratory Staff, 1954) are adversely affected by boron concentrations between 500 and 1,000 μg/L and generally cannot be grown using Cache Creek water. This problem is well known and the Yolo County Flood Control and Water Conservation District monitors it closely. Farmers who use Cache Creek water have compensated for high boron concentrations by avoiding boron-sensitive crops or by using irrigation techniques that minimize the problem.

The second water-quality problem in Cache Creek is high sediment loads. The only substantial sediment study conducted on Cache Creek was reported by Lustig and Busch (1967). Suspended-sediment samples were collected at several stations on Cache Creek, North Fork Cache Creek, and Bear Creek during the 1960-63 water years. Lustig and Busch concluded that the land drained by Capay Valley contributed 2.04 times as much suspended sediment per square mile of drainage area as did the drainage upstream from Capay Valley. Cache Creek near Capay had the largest mean annual suspended-sediment discharge (830,000 tons) during the study. The mean annual suspended-sediment discharge at Cache Creek at Yolo during the study was 533,000 tons, indicating that 36 percent of the suspended sediment was deposited or diverted between Capay and Yolo. The remainder was discharged to Cache Creek settling basin. The U.S. Army Corps of Engineers (1979) estimated that an average of 675 acre-ft of sediment was transported to Cache Creek settling basin annually. Since the settling basin is now nearly full, an estimated 340 acre-ft per year of sediment that was formerly deposited in the settling basin now flows into Yolo Bypass (U.S. Army Corps of Engineers, 1979). The Corps of Engineers report describes a proposed program to expand the settling basin to accommodate more sediment.

TABLE 2. - Assessment of water-quality problems in Cache Creek basin

[X, possible problem in Cache Creek but more data are needed to determine extent; E, problem exists for this beneficial use in Cache Creek; 0, possible problem for this beneficial use but not a problem in Cache Creek; --, not a problem for this beneficial use]

Beneficial use	Common water-quality problems in surface water								
	Dissolved solids	Plant nutrients	Low dissolved oxygen	Boron	Suspended sediment	Toxic sub-stances	High temper-atures	Pesti-cides	Indicator bacteria
Irrigation	0	--	--	E	E	0	--	X	--
Stock watering	0	--	--	0	--	0	--	X	X
Industrial process supply.	0	0	--	0	0	0	--	--	--
Industrial service supply.	--	0	--	0	0	0	--	--	--
Contact water recreation	--	X	0	--	E	0	0	X	X
Canoeing and rafting	--	X	--	--	E	--	--	--	--
Noncontact water recreation.	--	X	--	--	E	--	--	--	--
Warm freshwater habitats.	--	X	0	--	E	0	0	X	--
Cold freshwater habitats.	--	X	0	--	0	0	0	X	--
Warm-water spawning	--	X	0	--	E	0	0	X	--
Cold-water spawning	--	X	0	--	0	0	0	X	--
Wildlife habitats	--	--	--	--	0	0	--	X	--

High suspended-sediment loads affect several beneficial uses. Irrigation is affected by the accumulation of fine sediment in conveyance systems. High suspended-sediment loads are esthetically unappealing for contact and noncontact water recreation. High sediment loads may also affect warm- and cold-water aquatic habitats where sediment is deposited on the stream bottom, thus restricting the diversity of substrate habitats that would otherwise be found. Although high sediment loads are considered an impairment to freshwater habitats, the extent to which they are a problem can only be determined by a study of aquatic habitats in the creek. High sediment loads are mostly a natural occurrence in the basin and are probably not significantly increased by man's activities.

Excessive plant nutrients (nitrogen and phosphorus) are considered a potential problem in Cache Creek. Large amounts of plant nutrients induce heavy phytoplankton and periphyton growth in streams, causing a visual nuisance that impairs recreational uses. Heavy algal growth can also lead to other water-quality problems such as low dissolved oxygen at night when the plant community is respiring. Available data show that the concentrations of nutrients from Clear Lake and Bear Creek are high enough to cause algal growth. However, no data on the amount of plankton or other aquatic plants in the creek are available to assess the problem. Aerial observations in summer 1980 showed extensive growths of aquatic plants (periphyton and macrophytes) in Bear Creek and lesser ones along Cache Creek. North Fork Cache Creek was relatively free of plant growth.

Dissolved-oxygen concentrations in Cache Creek do not appear to be a problem but there have been a few measurements lower than the 7 mg/L objective for spawning, a beneficial use. Because a maximum of one sample was taken per month, it is not possible to detect violations of the objective for percent saturation of dissolved oxygen. At Cache Creek near Lower Lake, 12 measurements of dissolved-oxygen concentrations of less than 7 mg/L were recorded during 1951-79. All but two of these measurements were at low flow (less than 10 ft^3/s) during late autumn.

At North Fork Cache Creek near Lower Lake, three measurements of dissolved oxygen of less than 7 mg/L were reported during 1951-79. Two of these measurements (4.8 and 5.6 mg/L) were reported in November and December 1965 during a low flow period. These observations may indicate a considerable period of time during which the dissolved-oxygen objective was violated.

At Bear Creek near Rumsey, nine dissolved-oxygen concentrations lower than 7 mg/L were reported during 1968-79. Five of these nine were during the 1976-77 drought and all occurred at flows less than 4 ft^3/s.

No dissolved-oxygen concentration lower than 7 mg/L was reported at Cache Creek near Rumsey for the 1976-79 period. Two measurements of less than 7 mg/L were reported at Cache Creek near Capay during 1951-76, in October 1964 and September 1976.

The greatest potential for dissolved-oxygen problems appears to be at Cache Creek near Lower Lake. This probably is caused by discharge of water low in dissolved oxygen from Clear Lake just upstream. With once monthly sampling, it is not possible to tell the length of time that dissolved-oxygen concentrations lower than 7 mg/L occur, so it is possible that low dissolved-oxygen concentrations could occur for 3 to 4 weeks without being detected. Nothing is known about nighttime dissolved oxygen because all existing measurements were taken during the day.

Data on trace elements and synthetic organic compounds in the water of Cache Creek show concentrations not presently harmful to beneficial uses. Fish flesh samples taken from a largemouth bass at Cache Creek near Rumsey did contain a mercury concentration of 0.61 μg/g in the 1978 sample, 0.68 μg/g in the 1979 sample, and 0.34 μg/g in the 1980 sample. The 1978 and 1979 samples had concentrations of mercury exceeding the Environmental Protection Agency guideline of 0.5 μg/g (for protection of predator species) but is below the 1.0-μg/g U.S. Department of Agriculture guideline for consumption by man. The California State Water Resources Control Board toxics monitoring program that reported this finding attributed this mercury content to mercury naturally occurring in the geologic formations in the Cache Creek basin (California State Water Resources Control Board, 1979). Consistently high mercury concentrations in fish flesh could considerably impair warm water habitats and spawning and may eventually impair water contact recreation in the form of sport fishing.

Naturally occurring temperature fluctuations in Cache Creek are not a problem to any beneficial use. The reach of North Fork Cache Creek below Indian Valley Dam is now a cold-water habitat that would be adversely affected if water temperatures were to increase substantially over the present range.

Little data are available for indicator bacteria (fecal coliform and fecal streptococcal) in Cache Creek. Due to the remoteness of much of the creek, a significant bacteria problem is unlikely. However, as contact recreation increases in the creek, this aspect of water quality may become of more concern.

Sources of Potential Water-Quality Problems

Clear Lake

Clear Lake has problems with excessive algal blooms from high nutrient concentrations and temperatures. Pesticides entering the food chain have also been a problem in the lake. The algal blooms near the lake's outlet to Cache Creek are sometimes very intense and result in large quantities of phytoplankton spilling into Cache Creek. The fate of these algae is unknown, although they probably contribute to the observed turbidity in the upper part of the creek during the summer and autumn (fig. 12).

FIGURE 12.--Confluence of North Fork Cache Creek (upper left) with Cache Creek (lower left), showing the difference in water clarity.

Minor Tributaries

Much of the sediment load in Cache Creek is contributed by the small intermittent streams along Cache Creek Canyon and Capay Valley. No data are available to determine the annual sediment loads of these streams. Heavily eroded badland areas along the stream canyons indicate a great potential for sediment input. Sulfur Creek (tributary to Bear Creek), drains heavily mineralized deposits that are the source of high concentrations of nitrogen, sulfate, and chloride (Roberson and Whitehead, 1961). Several abandoned mercury mines are located in this drainage. Seepage along the hillside downhill from the farthest upstream mine was observed during an aerial reconnaisance in November 1980.

Sulfur Creek was milky white from a point just downstream from another abandoned mine shaft located about 2 mi upstream from the old Wilber Springs resort. This cloudiness persisted until about 600 ft downstream from the resort. The water-quality analyses done by Roberson and Whitehead (1961) are the only recorded analyses done on water from Sulfur Creek. The California Department of Water Resources took 17 water samples in Bear Creek just below Sulfur Creek in 1938-39. The very high sodium, chloride, hardness, and boron in these samples was attributed to inflow to Sulfur Creek (California Department of Water Resources, 1961). No analyses for trace metals in Sulfur Creek have been located.

Agricultural Return Flow

The reach of Cache Creek downstream from Moore Dam (rm 18.3) receives irrigation return flow from the surrounding farmlands. These returns contribute most of the flow in the creek during the irrigation season. No data are available on the quality of this irrigation return water, but aerial observations in 1980 showed turbid and green conditions (fig. 8), caused by phytoplankton and other aquatic plants, indicating the presence of biostimulatory substances in excess of the stated water-quality objectives. Some irrigation return flows occur in Capay Valley, but adverse effects from these flows were not visually detectable.

Gravel Mining

Gravel mining occurs mostly in the creekbed downstream from Capay Dam (rm 12.6 to rm 26.9) (fig. 13). The operations are conducted only during the irrigation season when the creekbed is dry. Sediment-laden gravel-washing water is impounded in lagoons off the main creek channel (fig. 14). During an aerial reconnaissance in summer 1980, some deposition of fine-sized sediment was observed in the main channel adjacent to the Yolo Flyers Golf Course downstream from Moore Dam. The presence of the gravel operations detracts from the beneficial use, wildlife habitat. The resultant widening of the channel has destroyed much of the natural riparian habitat. In addition, the noise and activity associated with the gravel operation make the remaining riparian areas less desirable to wildlife.

FIGURE 13.--Gravel mining operations along Cache Creek near Woodland. Cache Creek channel is in the upper part of the photograph. (Photograph courtesy of the California State Water Resources Control Board.)

Solutions to Water-Quality Problems

The most serious water-quality problems in Cache Creek are from natural sources. Therefore, solutions are difficult, if not realistically impossible, to accomplish. High boron concentrations are derived from marine sediments in the drainage basin. Impoundments have been proposed at several locations on Cache Creek and its tributaries. One of the projected benefits of these impoundments was a reduction in boron concentration. Indian Valley Reservoir has significantly reduced mean boron concentrations in North Fork Cache Creek from 2,400 µg/L before the reservoir to 1,100 µg/L after the reservoir. This reduction, however, did not cause a significant reduction in mean boron concentration downstream at Cache Creek near Rumsey. If a reservoir were constructed on Bear Creek, a similar reduction in boron from this tributary might also occur.

FIGURE 14.--Lagoon along Cache Creek channel that holds gravel-washing water. Similar lagoons are numerous along the reach of Cache Creek being mined for gravel. (Photograph courtesy of the California State Water Resources Control Board.)

However, this reduction would not signficantly affect concentrations in Cache Creek because Bear Creek contributes less than 7 percent of the average annual runoff from Cache Creek. The most practical way to deal with the high boron problem is to continue current practices which use the water for irrigating only boron-tolerant crops or mix the water with lower boron waters from other sources.

The large amount of sediment in Cache Creek is due to the highly erodable properties of the land in the basin, a natural problem for which no practical solutions are apparent. Construction of dams to trap sediment is not practical because a significant part of the sediment load in the creek is contributed by Capay Valley, where, to be effective, a sediment barrier would have to be located at the downstream end of Capay Valley. The reservoir formed by this dam would inundate the productive Capay Valley agricultural area.

Potential Future Water-Quality Problems

Irrigation will probably continue to be the largest use of Cache Creek water. Except for the boron problem, the creek water should continue to be of good quality for agriculture.

To a large degree, the water quality of Cache Creek is dependent on the water quality in Clear Lake. If increasing urbanization of the areas around Clear Lake causes further deterioration of the lake's present water quality (high plant nutrient concentrations and pesticide residue), the water quality in Cache Creek will be similarly affected.

During the last 5 years, Cache Creek has been used more and more for recreation. The increasing population of northern California will continue to put pressure on the popular recreation areas, causing development of new areas such as Cache Creek Canyon Regional Park. Canoeing and rafting on Cache Creek probably will continue to grow as facilities become more available. Other contact and noncontact recreational activities can also be expected to increase in the future. There is presently no water-quality problem identified that would detract from recreational uses with the exception of the turbidity in the water, which causes an esthetic nuisance. This turbidity is caused by suspended sediment in the winter and probably by phytoplankton in the summer when recreation is at its peak.

Increased recreational use and possible increases in human habitation along the creek may lead to problems associated with waste discharges such as excessive plant nutrients and indicator bacteria. The increased rafting presents a real possibility of significant bacterial and organic pollution if properly equipped recreation areas are not provided. One small housing development now exists on North Fork Cache Creek, and roads are in place for many more houses in the same development. Capay Valley is already becoming a popular place to live "out in the country." As population increases, waste disposal must be properly planned to avoid water-quality problems in Cache Creek.

Sport fishing in Cache Creek is now somewhat limited by lack of access and an apparently small population of game fish. Little is presently known about the numbers and types of fish in Cache Creek. However, if sport fishing increases substantially, biological inventories will be needed to determine the feasibility of stocking and maintaining suitable populations of game fish.

A recent gold find near Knoxville, Calif., in an adjacent basin to Cache Creek, could lead to similar finds in Cache Creek basin. Many mines were operated in the past in Cache Creek basin, and the increasing cost of natural resources may make it profitable to reopen some of these old mines. The physical disturbances to the landscape and often poor quality of drain water from the mining activities may become a problem if mining is increased.

WATER-QUALITY MONITORING PROGRAMS

Existing Monitoring

Currently, water-quality monitoring is being done by the California Department of Water Resources at four stations in the Cache Creek basin. Monthly samples are taken at Cache Creek near Lower Lake, North Fork Cache Creek near Lower Lake, Bear Creek near Rumsey, and Cache Creek at Rumsey (this station replaced Cache Creek near Capay after 1976) as part of a cooperative agreement with the California State Water Resources Control Board.

Samples are taken monthly at Cache Creek near Rumsey and Cache Creek near Lower Lake for temperature, pH, specific conductance, dissolved oxygen, chemical oxygen demand, suspended solids, major ions, nutrients, and fecal coliform bacteria. Trace metal samples are taken in August and February, and pesticides in September and June. Sampling at these two stations is mandated as part of the State Board's primary monitoring network and the Environmental Protection Agency's Basic Water Monitoring Program.

At North Fork Cache Creek near Lower Lake and Bear Creek near Rumsey, specific conductance, temperature, pH, dissolved oxygen, and turbidity are measured monthly. If any of these measurements are out of ordinary ranges, additional samples for major ions and nutrients may be taken.

Samples of fish flesh have been taken yearly since 1977 at Cache Creek near Rumsey. These samples are analyzed for trace metals and pesticides as part of the State Board's primary monitoring network for toxic substances.

The California Department of Water Resources samples Indian Valley Reservoir near the dam at intervals of from 3 to 6 weeks. They measure a water column profile of temperature, conductivity, pH, and dissolved oxygen and collect samples for nitrogen and phosphorus at selected depths. They also sample periodically for heavy metals and major ions.

Since 1975, Yolo County Flood Control and Water Conservation District has collected monthly samples for temperature and boron and occasionally pH and specific conductance at six sites in the basin, including two sites on canals below Capay Dam (table 1).

These samples taken by the Department and the District are the only regularly scheduled water-quality sampling in the Cache Creek basin.

There are currently six active gaging stations in the Cache Creek basin. In addition to the regular water-quality sites, there is a gaging station at Cache Creek at Yolo (station 11452500) and at North Fork Cache Creek at Hough Springs (station 11451100).

Monitoring Needs

Monitoring needs are divided into two categories: long-term periodic monitoring and special or short-term reconnaissance monitoring. A suggested approach to future long-term monitoring would include a program to monitor five stations in the Cache Creek basin. These stations are Cache Creek near Lower Lake, Cache Creek at Rumsey, North Fork Cache Creek near Lower Lake, Indian Valley Reservoir near Indian Valley Dam, and Bear Creek near Rumsey. The creek stations would be sampled twice a year, once at high flow and once at low flow. The lake station would also be sampled twice a year, once in the winter when the water is mixed and once during the summer when the reservoir is stratified. Suggested analyses include specific conductance, dissolved oxygen, temperature, pH, major inorganic constituents, nutrients including nitrate, ammonia, organic nitrogen, phosphorus and orthophosphorus, and trace metals. Analyses for pesticides in water and bed material would be taken annually at low flow at Cache Creek near Lower Lake and Cache Creek near Rumsey. Vertical profiles of temperature, dissolved oxygen, specific conductance, and pH would be taken at the reservoir station. The reason for sampling semiannually instead of monthly is that monthly changes in water quality have been well documented at several stations, and semiannual sampling would be sufficient to detect long-range changes in water quality. Fewer samples at each station would also make it possible to conduct more intensive sampling in problem locations if problems are identified. Most of this proposed monitoring is already being done by the Department of Water Resources but on a more frequent schedule than is suggested here. The only additions to existing monitoring would be to sample bed material at Cache Creek near Lower Lake and near Rumsey for analysis for pesticides.

Biological monitoring is needed to provide background information, now lacking, on aquatic communities of benthic invertebrates, periphyton, and phytoplankton. Initially, samples for benthic invertebrates, periphyton (biomass and chlorophyll content), and phytoplankton would be taken seasonally four times a year at all regular water-quality stations except Cache Creek at Yolo. Quarterly sampling would be done for 2 years, after which twice yearly samples would be taken. Artificial substrates would be used for benthic invertebrates and periphyton collections for consistency in long-term monitoring. Phytoplankton samples would be grab samples. These biological data are necessary so that the aquatic habitats listed as a beneficial use can be properly assessed and monitored.

Special short-term intensive or reconnaissance monitoring is needed in several areas. At the present time, nothing is known about diel fluctuation in water quality in Cache Creek. If large changes in dissolved oxygen and pH occur at night, these changes would not be detected during routine daytime sampling. Sampling over a 24-hour period would be done during the autumn low flow period at the four upstream stations where water samples are collected. If these stations show minimal diel fluctuation in water quality, further tests may need to be done only once every 5 years or so. If a water-quality problem (such as low dissolved oxygen that could jeopardize aquatic habitat and spawning, beneficial uses) is found as a result of this sampling, then further studies to assess the extent of the problem could be planned. Diel dissolved-oxygen measurements would also allow estimates of primary productivity.

Little is known about the quantity and quality of agricultural return flows in lower Cache Creek below Moore Dam. Aerial observations in July 1980 indicated degraded water quality in this area. The green color of the water indicated the presence of excessive aquatic plant growth. A reconnaissance sampling conducted during the summer would indicate if a water-quality problem exists that would need further study. Measurements of specific conductance, pH, and temperature, and samples for nitrogen and phosphorus would be taken at identifiable agricultural return flows and at several points along the reach of Cache Creek from Moore Dam to the settling basin. In addition, samples for analyses for pesticides and phytoplankton would be taken at selected points along this reach.

An investigation of possible bacterial contamination is needed in the reach of Cache Creek most heavily used by rafters (Buck Island to Rumsey). Bacterial contamination has become a problem on other rivers used frequently by rafters. Such an investigation would involve weekly or twice weekly samples at Buck Island, Canyon Park, and Rumsey for fecal coliform and fecal streptococcal bacteria during the summer rafting season. This sampling would be repeated as necessary if a problem was found.

At the present time, there does not appear to be a need for a sediment sampling program on Cache Creek. Conditions in the basin, with the exception of the addition of Indian Valley Reservoir, have changed little from the 1960-63 period when an intensive sediment program was conducted. Since most sediment is transported during periods of high flow, sediment sampling cannot be effectively done on a periodic basis but must be coordinated with storms. Intensive sampling would be justified in the future if a significant amount of development occurs in the basin.

All the short-term monitoring proposed by this study is aimed at filling gaps in existing knowledge and pinpointing suspected water-quality problems that cannot be confirmed by existing data or observations. Future monitoring should be problem-oriented and flexible enough to respond to changing environmental and developmental conditions in the basin.

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GPO 976-806