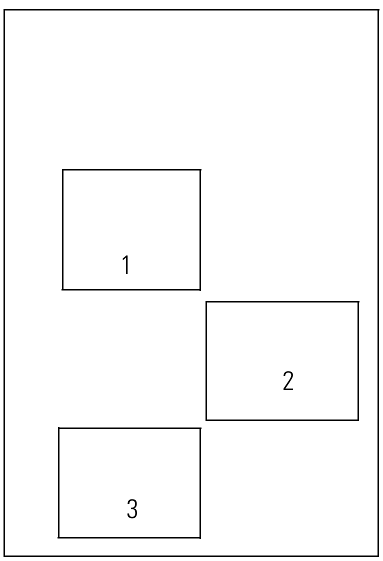

Front cover: *Photographs by Cathy Munday, U.S. Geological Survey.*

1. Mud Slough at Highway 140.

Mud Slough was one of the most significant tributary sources of nutrients, organic carbon, and chlorophyll-a to the San Joaquin River during the study.

2. Dairy in San Joaquin River Basin.

Nitrogen and oxygen isotope data suggested that animal waste was a significant source of nitrate in the San Joaquin River during this study.

3. San Joaquin River at Crows Landing.

Sources and Transport of Nutrients, Organic Carbon, and Chlorophyll-*a* in the San Joaquin River Upstream of Vernalis, California, during Summer and Fall, 2000 and 2001

By Charles R. Kratzer[1], Peter D. Dileanis[1], Celia Zamora[1], Steven R. Silva[2], Carol Kendall[2], Brian A. Bergamaschi[1], and Randy A. Dahlgren[3]

U.S. GEOLOGICAL SURVEY

Water-Resources Investigations Report 03-4127

Prepared in cooperation with the
CALFED BAY-DELTA PROGRAM and
CALIFORNIA DEPARTMENT OF WATER RESOURCES

6427-12

[1]U.S. Geological Survey, Sacramento, California
[2]U.S. Geological Survey, Menlo Park, California
[3]University of California, Davis, California

Sacramento, California
2004

U.S. DEPARTMENT OF THE INTERIOR
GALE A. NORTON, *Secretary*

U.S. GEOLOGICAL SURVEY
Charles G. Groat, *Director*

For additional information write to:

District Chief
U.S. Geological Survey
Placer Hall—Suite 2012
6000 J Street
sacramento, CA 95819-6129
http://ca.water.usgs.gov

Copies of this report can be purchased from:

U.S. Geological Survey
Information Services
Building 810
Box 25286, Federal Center
Denver, CO 80225-0286

Contents

FIGURES

TABLES

CONVERSION FACTORS, VERTICAL DATUM AND ABBREVIATIONS AND ACRONYMS

CONVERSION FACTORS

Multiply	By	To obtain
inch (in.)	2.54	centimeter (cm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
square mile (mi^2)	2.590	square kilometer (km^2)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
acre-foot (acre-ft)	1,233	cubic meter (m^3)

Vertical coordinate information is referenced to the North American Vertical Datum of 1988 (NAVD 88); horizontal coordinate information is referenced to the North American Datum of 1927 (NAD 27).

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

$$°F = (1.8)°C + 32$$

Specific conductance is given in microsiemens per centimeter at 25 degrees Celsius (µS/cm at 25°C).

Concentrations of chemical constituents in water are given either in milligrams per liter (mg/L) or micrograms per liter (µg/L).

Abbreviations and Acronyms

‰	per mil
cm	centimeter
cm^{-1}	per centimeter
kg/d	kilogram per day
L	liter
L/mg-centimeter	liter per milligram-centimeter
mg	milligram
mg/L	milligram per liter
mL	milliliter
mm	millimeter
µg/L	microgram per liter
µm	micrometer
µS/cm	microsiemens per centimeter
nm	nanometer
C	carbon
DOC	dissolved organic carbon
DWR	California Department of Water Resources

δ	delta, the relative difference between the ratio of isotopes in a sample and the ratio of isotopes in some standard
EC	electrical conductivity
EDTA	ethylenediaminetetraacetic acid
EWI	equal width increment
GFF	glass fiber filter
Hwy	Highway
N	nitrogen
NWIS	National Water Information System
NWQL	National Water Quality Laboratory of the U.S. Geological Survey
P	phosphorus
POM	particulate organic matter
QA/QC	quality assurance and quality control
QC	quality control
RPD	relative percent difference
SJR	San Joaquin River
SOC	suspended organic carbon
STORET	STOrage and RETrieval database of the U.S. Environmental Protection Agency
SUVA	specific ultraviolet absorbance
TDN	total dissolved nitrogen
TMDL	Total Maximum Daily Load
UCD	University of California at Davis
UCDBL	University of California at Davis's Biogeochemistry Laboratory
USGS	U.S. Geological Survey
VAMP	Vernalis Adaptive Management Plan
VPDB	Vienna Pee Dee Belemnite
VSS	volatile suspended solids

Sources and Transport of Nutrients, Organic Carbon, and Chlorophyll-*a* in the San Joaquin River Upstream of Vernalis, California, during Summer and Fall, 2000 and 2001

By Charles R. Kratzer, Peter D. Dileanis, Celia Zamora, Steven R. Silva, Carol Kendall, Brian A. Bergamaschi, and Randy A. Dahlgren

ABSTRACT

Oxidizable materials from the San Joaquin River upstream of Vernalis can contribute to low dissolved oxygen episodes in the Stockton Deep Water Ship Channel that can inhibit salmon migration in the fall. The U.S. Geological Survey collected and analyzed samples at four San Joaquin River sites in July through October 2000 and June through November 2001, and at eight tributary sites in 2001. The data from these sites were supplemented with data from samples collected and analyzed by the University of California at Davis at three San Joaquin River sites and eight tributary sites as part of a separate study. Streamflows in the San Joaquin River were slightly above the long-term average in 2000 and slightly below average in 2001. Nitrate loads at Vernalis in 2000 were above the long-term average, whereas loads in 2001 were close to average. Total nitrogen loads in 2000 were slightly above average, whereas loads in 2001 were slightly below average. Total phosphorus loads in 2000 and 2001 were well below average. These nutrient loads correspond with the flow-adjusted concentration trends—nitrate concentrations significantly increased since 1972 ($p < 0.01$), whereas total nitrogen and total phosphorus concentrations did not ($p > 0.05$). Loading rates of nutrients and dissolved organic carbon increased in the San Joaquin River in the fall with the release of wetland drainage into Mud Slough and with increased reservoir releases on the Merced River. During August 2000 and September 2001, the chlorophyll-*a* loading rates and concentrations in the San Joaquin River declined and remained low during the rest of the sampling period. The most significant tributary sources of nutrients were the Tuolumne River, Harding Drain, and Mud Slough. The most significant tributary sources of dissolved organic carbon were Salt Slough, Mud Slough, and the Tuolumne and Stanislaus Rivers. Compared with nutrients and dissolved organic carbon, the tributaries were minor sources of chlorophyll-*a*, suggesting that most of the chlorophyll-*a* was produced in the San Joaquin River rather than its tributaries. On the basis of the carbon-to-nitrogen ratios and the $\delta^{13}C$ of particulate organic matter in the San Joaquin River and tributaries, the particulate organic matter in the river was mostly phytoplankton. On the basis of the $\delta^{15}N$ values of the particulate organic matter, and of total dissolved nitrogen and nitrate, the nitrate in the San Joaquin River probably was a significant nutrient source for the phytoplankton. The range of $\delta^{15}N$ and $\delta^{18}O$ values of nitrate in the San Joaquin River and tributaries suggest that animal waste or sewage was a significant source of nitrate in the river at the time the samples were collected.

INTRODUCTION

The Stockton Deep Water Ship Channel (ship channel) was dredged to a depth of about 35 ft to allow ocean-going ships to reach the inland Port of Stockton (fig. 1). Immediately upstream of the ship channel, the San Joaquin River is about 8 to 10 ft deep. At the beginning of the ship channel and for about 7 mi downstream to Turner Cut (fig. 1), the San Joaquin River annually experiences episodes of low dissolved oxygen (Lee and Jones-Lee, 2003). These episodes are most prolonged and acute in the summer and fall months, but also have been observed in other months. Dissolved oxygen levels typically fall as low as 2.0 to 2.5 mg/L (Christopher Foe, California Regional Water Quality Control Board, Central Valley Region, written commun., 2002). The oxygen deficit can stress and kill resident aquatic life and could inhibit the upstream migration of fall-run Chinook salmon (Lee and Jones-Lee, 2003).

The State's basin plan for the Sacramento-San Joaquin Delta contains a water quality objective requiring oxygen levels to be maintained above 6 mg/L in the San Joaquin River between Stockton and Turner Cut during September through November and above 5 mg/L at all other times (California Regional Water Quality Control Board, 1998). The 6 mg/L objective was adopted to protect the upstream migration of fall-run Chinook salmon. The State of California placed the San Joaquin River on the 303(d) list of impaired water bodies in 1998 because of low dissolved oxygen levels (California State Water Resources Control Board, 1998). The problem was classified as a high priority for correction, and the State committed to complete a technical Total Maximum Daily Load (TMDL) in 2003 and an implementation plan in 2004 (Mark Gowdy, California Regional Water Quality Control Board, Central Valley Region, written commun., 2003). A technical advisory committee was formed to advise the State on the development of the TMDL and to oversee projects funded by the CALFED Bay-Delta Program related to the low dissolved oxygen problem in the lower San Joaquin River.

The conceptual model of the dissolved oxygen impairment in the ship channel incorporates two primary factors—hydrology and upstream loads of oxidizable material. Deepening the river decreased the efficiency of atmospheric reaeration and increased water residence time allowing a larger fraction of the imported organic material to be oxidized. If streamflows from upstream could be increased, it would have two counteracting effects on the problem—it would increase the load of upstream oxidizable material, but it would reduce the water residence time (Mark Gowdy, California Regional Water Quality Control Board, Central Valley Region, written commun., 2003). The main sources of upstream material are the City of Stockton Wastewater Treatment Plant (“WWTP” on fig. 1) about one mile upstream of the ship channel and the upstream San Joaquin Basin (fig. 1). The upstream loads from the San Joaquin Basin appear to have the greatest impact on dissolved oxygen in the ship channel in summer, and they decline in significance in the fall and winter to the City of Stockton discharges of treated wastewater containing high concentrations of ammonia.

The primary purpose of this study was to define the sources and transport of nutrients, organic carbon, and chlorophyll-*a* in the upstream San Joaquin Basin, above Vernalis. A secondary purpose was to compare nutrient loads and concentrations from the 1970s and 1980s to the present (Kratzer and Shelton, 1998). This study was funded by the CALFED Bay-Delta Program. The sampling in this study was coordinated with an independent study conducted in the study area by the University of California at Davis (UCD). The UCD study was funded by the U.S. Fish and Wildlife Service to evaluate the food resources to the Sacramento-San Joaquin Delta from the Sacramento and San Joaquin Basins.

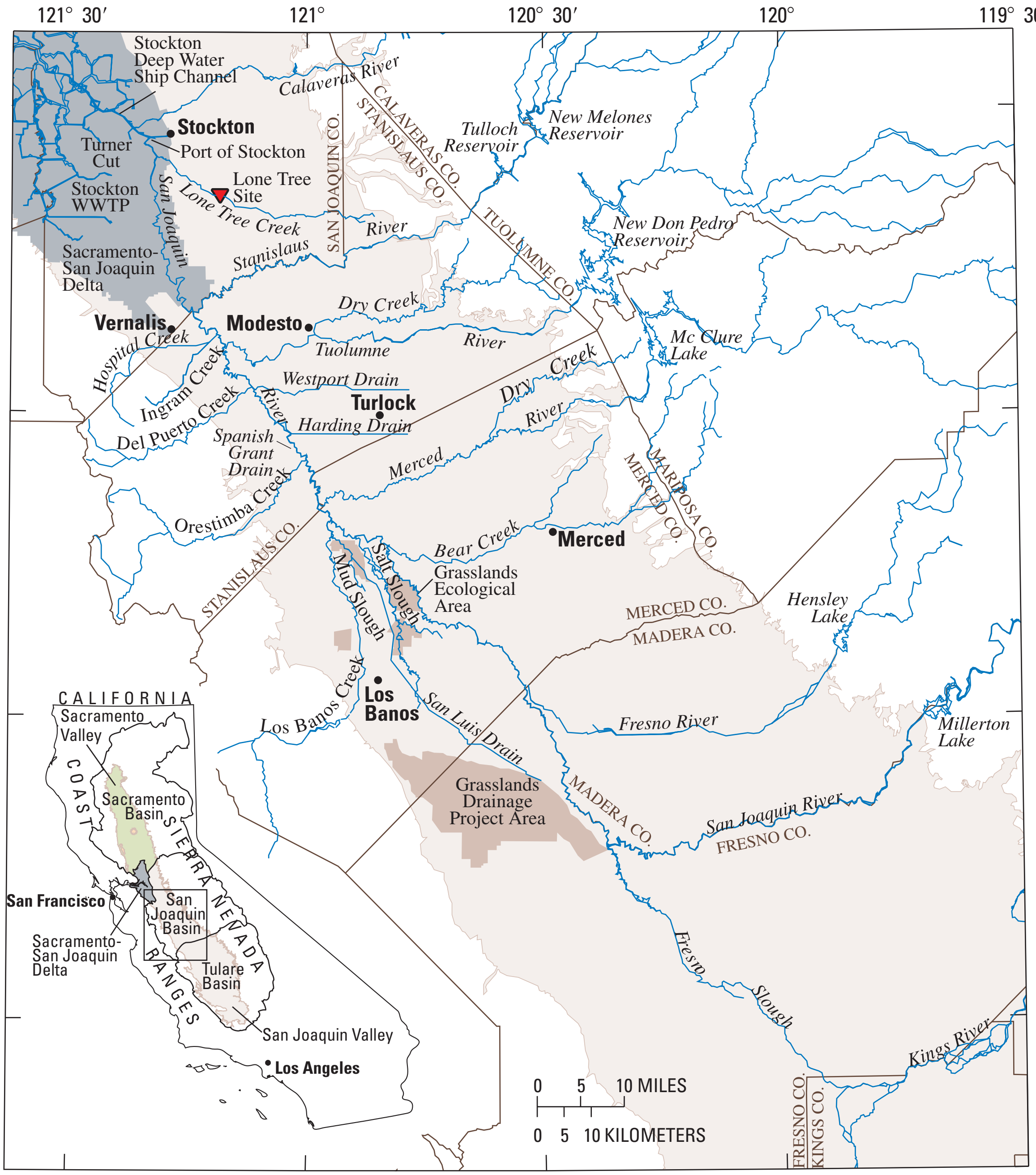

Figure 1. Portion of the San Joaquin Valley and the Sacramento-San Joaquin Delta.

Ammonia, nitrate, and orthophosphate are major plant nutrients, and their concentrations are often limiting factors in the growth of algal and aquatic plant populations. Other forms of nitrogen and phosphorus, such as organic compounds containing these elements, can be converted to plant nutrients in the aquatic environment by microorganisms that use organic material as metabolic substrates and release nitrate, ammonia, and phosphate as byproducts of aerobic and anaerobic respiration. Chlorophyll-*a* is often used as a gross measure of living algal populations and pheophytin-*a* of dead algal populations; these populations often account for much of the organic carbon in the aquatic system. Samples were collected by both the U.S. Geological Survey (USGS) and UCD for analysis of biochemical oxygen demand. These samples were delivered to either the California Regional Water Quality Control Board (Central Valley Region) or their contract laboratory and the resulting data are not analyzed in this report.

For the sake of brevity, many site names are abbreviated in this report from the official names given in table 1. For example, the "San Joaquin River at Maze Road Bridge near Modesto" (site 24 in table 1) is referred to as "SJR at Maze Road," or sometimes simply as "Maze Road." Tributary sites where there is only one site on the tributary will usually be referred to by the tributary name; for example, "Hospital Creek below confluence of Ingram Creek near Grayson" (site 23 in table 1) is referred to simply as "Hospital Creek."

The authors thank Dr. Peggy Lehman of the California Department of Water Resources (DWR) for her patience and support on contractual issues related to this project. Finally, we acknowledge the steering and technical committees of the San Joaquin River dissolved oxygen TMDL stakeholder process for their technical reviews of this study.

STUDY AREA

The perennial San Joaquin Basin drains 7,395 mi^2, of which 4,320 mi^2 are in the Sierra Nevada, 2,273 mi^2 are in the San Joaquin Valley, and 802 mi^2 are in the Coast Ranges (fig. 1 inset). On the basis of USGS streamflow data for 1951–95, 66 percent of the average streamflow in the San Joaquin River comes from the three major east-side river basins: the Merced River (15 percent), the Tuolumne River (30 percent), and the Stanislaus River (21 percent). The remaining streamflow in the San Joaquin River comes from the Bear Creek Basin; Mud and Salt Sloughs, and ephemeral creeks that drain from the west; drainage canals that flow directly to the San Joaquin River; and occasionally from the upper San Joaquin River above Bear Creek during especially high streamflow events (fig. 1).

A total of four sites were sampled by the USGS during July through October 2000 (sites 7, 12, 18, and 27 shown in fig. 2 and listed in table 1). These sites bracket the major east-side tributaries to the mainstem of the San Joaquin River. During June through November 2001, the USGS sampled the same four mainstem sites plus eight minor tributary sites, including four tributaries from the west-side and four from the east-side. The west-side sites include Mud Slough (site 5, fig. 2) that receives tile drainage from 97,000 acres (Grasslands Drainage Project Area, fig. 1) and includes wetlands (Grasslands Ecological Area) and grazing on native vegetation (fig. 3) (Quinn and others, 1998). The other three west-side sites (sites 11, 13, and 23 in fig. 2) generally represent surface runoff from row crops and orchards, although Spanish Grant Drain and Hospital Creek contain some tile drainage as well. The four east-side sites include Harding Drain (site 14, fig. 2), which receives treated effluent from the City of Turlock wastewater treatment plant in addition to excess irrigation water (operational spill) and runoff from agricultural areas (fig. 3). The Dry Creek site (site 20, fig. 2) receives operational spills and agricultural return flows from upstream of Modesto, and urban runoff from Modesto. The other two east-side sites—Lone Tree Creek (fig. 1) and Westport Drain (site 17, fig. 2)—receive only operational spill and agricultural runoff. Data for the Lone Tree Creek site will not be interpreted in this report because it discharges to the Sacramento-San Joaquin Delta downstream of Vernalis.

Table 1. Names, locations, and types of data available for sites in the San Joaquin River Basin, California

[Site locations in column 4 are in the following order unless otherwise noted: river miles from San Joaquin River; river miles from Vernalis. Water-quality samples collected and analyzed by University of California at Davis (UCD) or U.S. Geological Survey (USGS). x, data reported; —, no data reported]

Site number (See fig. 2)	Site name	Site identification number	Site location	Data at sites				
				Instantaneous streamflow	Continuous streamflow	Water quality	Historic loads	Major diversion
1	San Joaquin River near Stevinson	[1]11260815	[2]60.5	—	x	UCD	x	—
2	Salt Slough at Highway 165 near Stevinson	11261100	6.8; 64.0	—	x	UCD	x	—
3	San Joaquin River at Fremont Ford Bridge	11261500	[2]52.8	—	—	—	x	—
4	San Luis Drain, Site B, near Stevinson	11262895	[3]1.8; 9.9; 58.7	—	x	UCD	—	—
5	Mud Slough near Gustine	11262900	8.0; 56.8	—	x	UCD/USGS	x	—
6	Los Banos Creek at Highway 140	[4]371636120575200	[3]2.2; 6.0; 54.8	—	x	UCD	—	—
7	San Joaquin River upstream of Merced River, near Hills Ferry	372006120571701	[2]46.1	—	—	USGS	—	—
8	Merced River near Stevinson	[1]11272500	4.8; 50.5	—	x	—	x	—
9	Merced River at River Road Bridge near Newman	11273500	1.1; 46.8	—	—	UCD	—	—
10	San Joaquin River near Newman	11274000	[2]45.7	—	x	—	x	—
11	Orestimba Creek at River Road near Crows Landing	11274538	1.0; 37.7	—	x	UCD/USGS	—	—
12	San Joaquin River near Crows Landing	11274550	[2]35.5	—	x	USGS	—	—
13	Spanish Grant Combined Drain near Patterson	11274554	0.7; 33.4	x	—	USGS	—	—
14	Harding Drain at Carpenter Road near Patterson	[5]11274560	0.1; 31.2	—	x	USGS	—	—
15	San Joaquin River at Patterson Bridge near Patterson	[1]11274570	[2]26.3	—	x	UCD	x	—
16	Patterson Irrigation District (diversion)		[2]26.2	—	—	—	—	x
17	Westport Drain near Modesto	373232121053900	1.0; 22.1	x	—	USGS	—	—
18	San Joaquin River at Laird Park near Grayson	373324121090401	[2]16.8	x	—	USGS	—	—
19	West Stanislaus Irrigation District (diversion)		[2]11.7	—	—	—	—	x
20	Dry Creek at Gallo Bridge below Highway 132 at Modesto	373811120590001	[6]0.8; 17.2; 28.4	x	—	USGS	—	—
21	Tuolumne River at Modesto	11290000	16.2; 27.4	—	x	—	x	—
22	Tuolumne River at Shiloh Road Bridge near Grayson	11290200	3.6; 14.8	—	—	UCD	—	—
23	Hospital Creek below confluence of Ingram Creek near Grayson	373701121121100	0.7; 8.3	x	—	USGS	—	—
24	San Joaquin River at Maze Road Bridge near Modesto	[1]11290500	[2]4.9	—	x	UCD	x	—
25	Stanislaus River at Ripon	11303000	15.7; 18.2	—	x	—	x	—
26	Stanislaus River at Caswell State Park near Ripon	374209121103800	8.5; 11.0	—	—	UCD	—	—
27	San Joaquin River near Vernalis	11303500	[2]0.0	—	x	USGS	x	—

[1]Department of Water Resources gaging station.
[2]River miles from Vernalis.
[3]River miles from Mud Slough; river miles from San Joaquin River; river miles from Vernalis.
[4]Lawrence Berkeley Laboratory gaging station.
[5]Turlock Irrigation District gaging station.
[6]River miles from Tuolumne River; river miles from San Joaquin River; river miles from Vernalis.

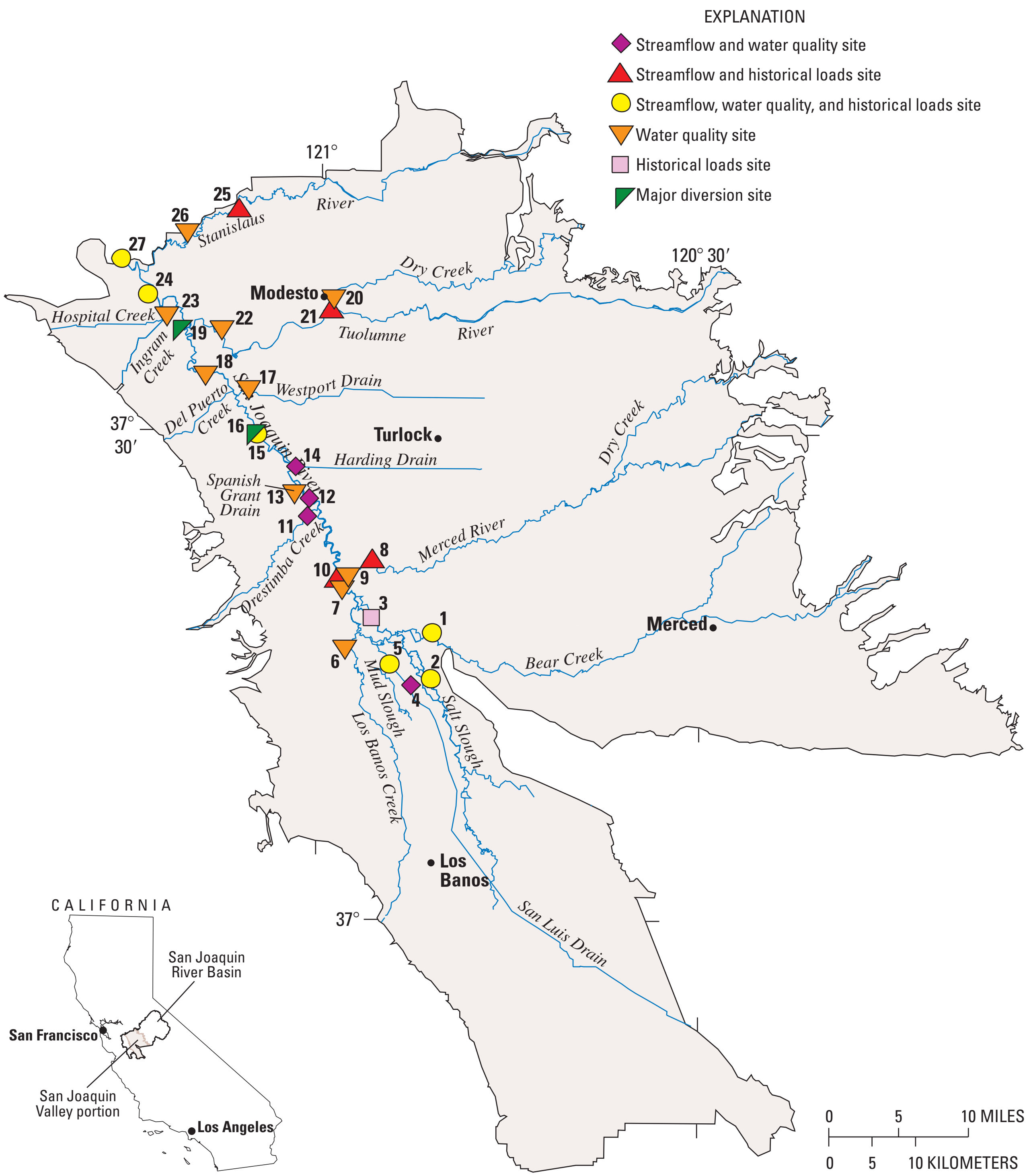

Figure 2. San Joaquin Valley portion of the San Joaquin River Basin and site locations.

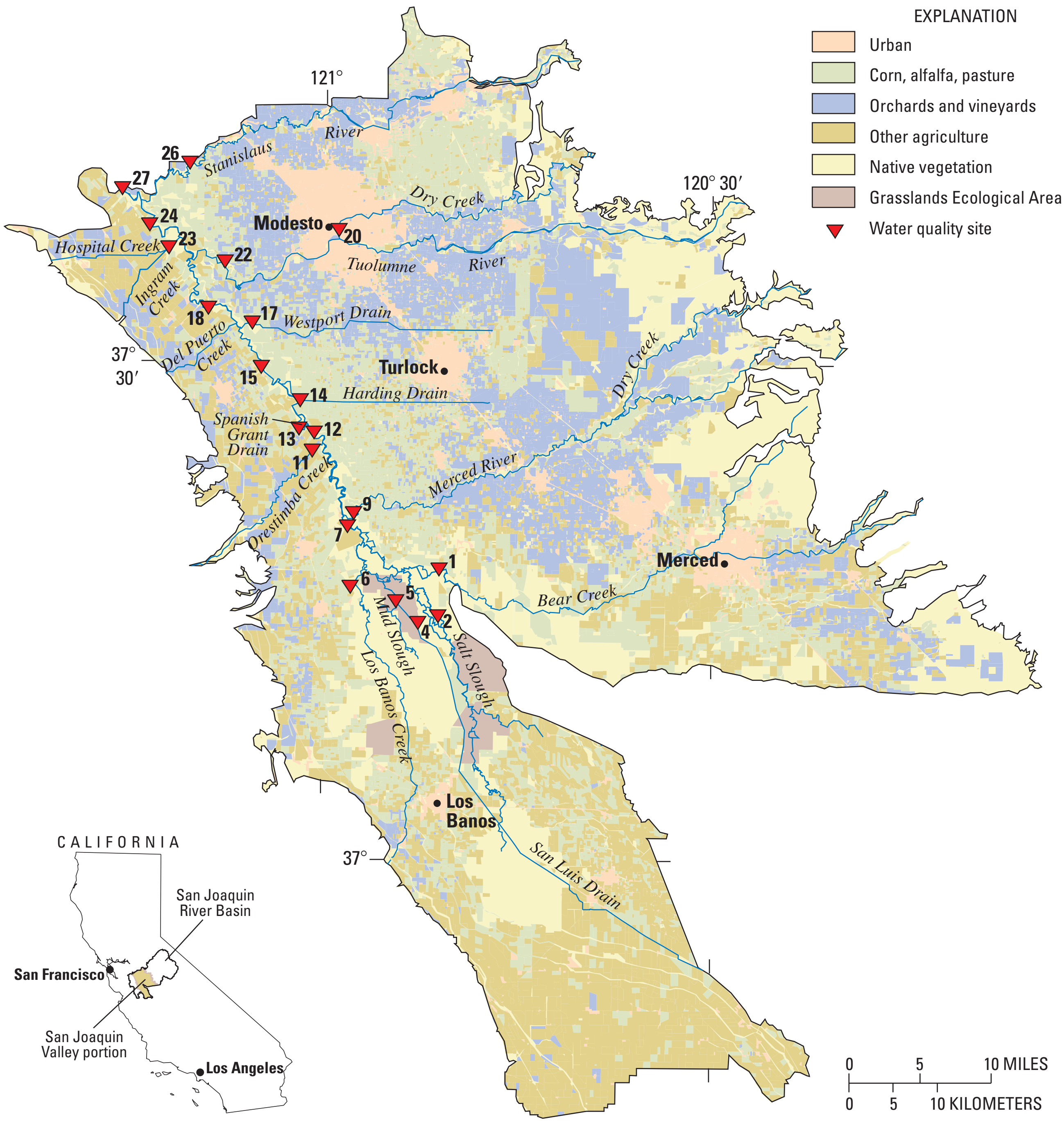

Figure 3. San Joaquin Valley portion of the San Joaquin River Basin, water quality sampling sites, and land use areas.

UCD sampled a total of 11 sites in the San Joaquin Basin (table 1) during this period, including 3 mainstem sites, the 3 main east-side tributaries, and 5 minor tributaries. In addition to sampling Orestimba Creek and Mud Slough, UCD also sampled Salt Slough (site 2, fig. 2), the San Luis Drain (site 4, fig. 2), and Los Banos Creek (site 6, fig. 2). Salt Slough and Los Banos Creek receive some releases from wetlands and tailwater runoff from agricultural areas. The San Luis Drain receives primarily tile drainage from the Grasslands Drainage Project Area and some releases from wetlands. In this report, the UCD data for these 11 sites will be presented with the USGS data (Randy Dahlgren, University of California, Davis, written commun., 2003).

The UCD water quality sampling sites on the Merced, Tuolumne, and Stanislaus Rivers (sites 9, 22, and 26, respectively; fig. 2) are downstream of gaging stations (sites 8, 21, and 25, respectively; fig. 2). Streamflows at the water quality sampling sites were estimated using travel times in the tributaries from the gaging stations (Kratzer and Biagtan, 1997). Precipitation in the study area was based on records for downtown Modesto.

The 20 sites sampled for water quality in this study by UCD or USGS along with land use are shown in figure 3. DWR prepares detailed maps of land use on the valley floor every six to seven years. The detailed categories of land use were aggregated into five general categories here for illustrative purposes: urban; corn, alfalfa, and pasture; orchards and vineyards; other agriculture; and native vegetation. The corn, alfalfa, and pasture area includes many of the dairy operations in the San Joaquin Basin. The other agriculture area on the west-side consists mainly of row crops, whereas the south consists mainly of cotton. The Grasslands Ecological Area is an area of managed wetlands. These wetlands are flooded in the fall and drained in the early spring. The percentage of land use in each sampled basin (table 1) is listed in table 2. The basin areas for the sampled tributaries are shown in figure 4.

Table 2. Basin areas and land use for valley portion of drainage basins within the San Joaquin River Basin, California

[See figure 4 for basin locations. mi^2, square mile]

Site number (See figure 4)	Site name[1]	Basin area		Land use as percentage of valley basin area					
		Total (mi^2)	Valley (mi^2)	Urban	Corn, alfalfa, and pasture	Orchards and vineyards	Native vegetation	Grasslands Ecological Area	Other agriculture
1	San Joaquin River near Stevinson	866	441	7.2	19.7	15.9	34.2	0.0	22.9
2	Salt Slough near Stevinson	492	484	2.8	14.7	1.1	19.5	4.6	57.3
5	Mud Slough near Gustine, California	492	484	2.8	14.7	1.1	19.5	4.6	57.3
6	Los Banos Creek at Highway 140	198	42	2.4	20.6	6.2	43.1	0.2	27.5
9	Merced River at River Road	1,383	245	5.5	15.5	44.0	23.9	0.0	11.1
11	Orestimba Creek at River Road	195	33.3	0.3	15.2	31.4	10.6	0.0	42.5
13	Spanish Grant Drain	33.8	23.9	3.8	26.6	18.2	2.8	0.0	48.7
14	Harding Drain at Carpenter Road	84	84	14.4	51.3	18.8	0.6	0.0	14.9
17	Westport Drain near Modesto	79	79	7.2	28.1	50.8	0.9	0.0	13.0
20	Dry Creek at Gallo Bridge	211	66.1	14.9	30.4	19.2	26.4	0.0	9.2
22	Tuolumne River at Shiloh Road	1,860	149	18.0	20.0	25.8	27.3	0.0	8.9
23	Hospital Creek below Ingram Creek	70.6	16.8	3.4	1.0	18.1	7.1	0.0	70.5
26	Stanislaus River at Caswell State Park	1,144	116	15.4	31.9	31.4	12.9	0.0	8.4
27	San Joaquin River near Vernalis	7,395	2,273	7.1	22.2	19.8	21.6	1.5	27.9

[1]To conserve space, site names are slightly abbreviated from the full versions listed in table 1.

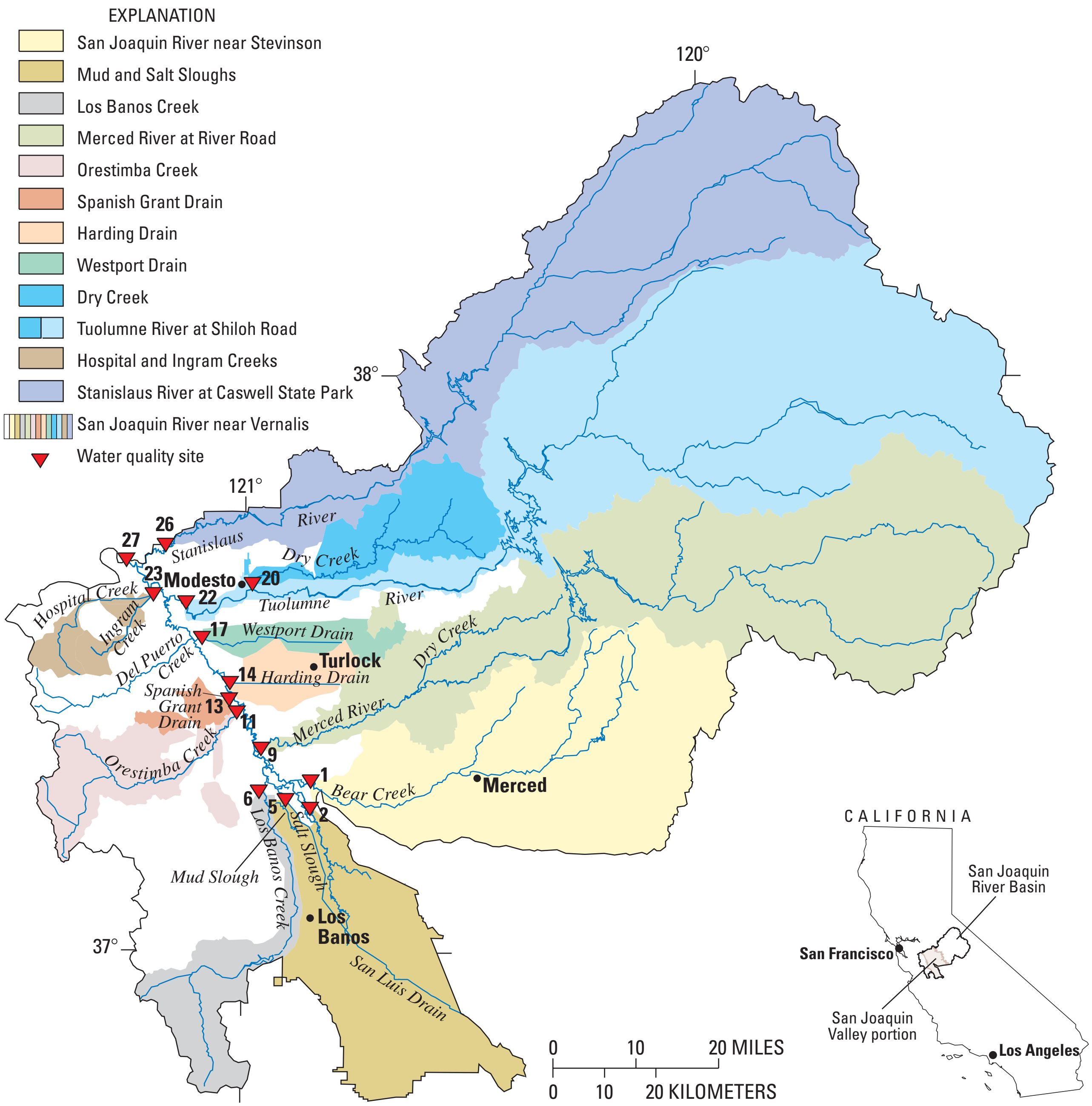

Figure 4. San Joaquin River Basin and drainage basins for water quality sites.

METHODS OF DATA COLLECTION AND ANALYSIS

Sample Collection and Processing

The frequency of sampling during July through October 2000 and June through November 2001 by USGS at the San Joaquin River sites was every two weeks (sites 7, 12, 18, and 27; fig. 2), and every four weeks for the minor tributary sites (sites 5, 11, 13, 14, 17, 20, and 23; fig. 2). UCD generally sampled every two weeks throughout the year at their sites (sites 1, 2, 4, 5, 6, 9, 11, 15, 22, 24, and 26; fig. 2). The sample collection times in 2000 relative to precipitation and streamflow are shown in figure 5 for the mainstem of the San Joaquin River and major east-side tributary sites, and in figure 6 for minor tributary sites. The equivalent information for 2001 is shown in figures 7 and 8, respectively.

Samples were collected during this study using six different methods, depending on the site location and streamflow conditions: (1) width- and depth-integrated using a D-77 isokinetic sampler with a Teflon nozzle and a 3-L (liter) Teflon bottle (Webb and others, 1999); (2) width- and depth-integrated using a DH-81 isokinetic sampler with a Teflon nozzle and a 3-L Teflon bottle (Webb and others, 1999); (3) an equally spaced three-point integrated surface grab using a 3-L Teflon bottle strapped into a metal cage suspended from a rope; (4) a midpoint surface grab using the same sampler; (5) a dip sample collected at the centroid of flow or at multiple locations along the cross section using a 3-L Teflon bottle; and (6) a midstream surface grab sample using a collection bucket.

U.S. Geological Survey Methods

Samples collected at the SJR near Vernalis (site 27) and the SJR at Laird Park (site 18) sites were width- and depth-integrated using the D-77 isokinetic sampler, whereas the DH-81 isokinetic sampler was used at the San Joaquin River upstream of Merced River site (site 7). At the SJR near Crows Landing site (site 12), samples were collected as equally spaced, three-point, integrated surface grabs in a 3-L Teflon bottle using the cage sampler suspended from a boat. Samples at the minor tributary sites were collected as integrated grab samples from a bridge using a 3-L Teflon bottle in the cage sampler at Mud Slough (site 5) and Harding Drain (site 14), and as wading multivertical integrated grabs or midpoint grabs depending on streamflow conditions at the other minor tributary sites.

Samples were processed in the field using the following protocol. Nine liters was collected at each site in three separate 3-L Teflon sample bottles using sampling techniques specific to that site. The samples were split for analysis of target constituents using a cone splitter in 2000 (Radtke and others, 1999), and a churn splitter in 2001 (Radtke and others, 1999). Sample water for whole-water analyses was poured directly from the splitter into the appropriate bottle types for analysis of suspended sediment, nutrients, volatile suspended solids (VSS), pH, and electrical conductivity (EC). The nutrient sample was preserved using 1 mL of 4.5N sulfuric acid. Sample water for dissolved nutrients and alkalinity was filtered through a 0.45-µm capsule filter and collected in the appropriate bottle types. For chlorophyll-*a* and pheophytin-*a*, a known volume of sample (ranged from 50 to 150 mL) was filtered through a 25-mm glass fiber filter (GFF); the filter was placed in a sterile Petri dish, wrapped in aluminum foil, and stored and shipped on dry ice. Three liters of the total 9-L sample were used for the analysis of suspended organic carbon (SOC), dissolved organic carbon (DOC), ultraviolet absorbance at 254 nanometer (nm) wavelength, and stable isotopes. The churn splitter used in 2001 was made of polyethylene, which could potentially affect the concentrations of organic constituents (Wilde and others, 1999). Thus, the 3-L Teflon sample bottle used for these analytes was not composited in the churn splitter, but was poured directly into the appropriate bottles for analysis. For SOC and DOC, a 100-mL aliquot of sample was filtered through a silver filter. For the SOC analysis, the silver filter was retained, folded, and placed in aluminum foil and stored on ice with the corresponding filtered sample (DOC). A 100-mL aliquot was filtered through a GFF for the ultraviolet absorbance and immediately chilled. The remaining sample water was poured into two 1-L amber glass bottles for analysis of stable isotopes of carbon, nitrogen, and oxygen.

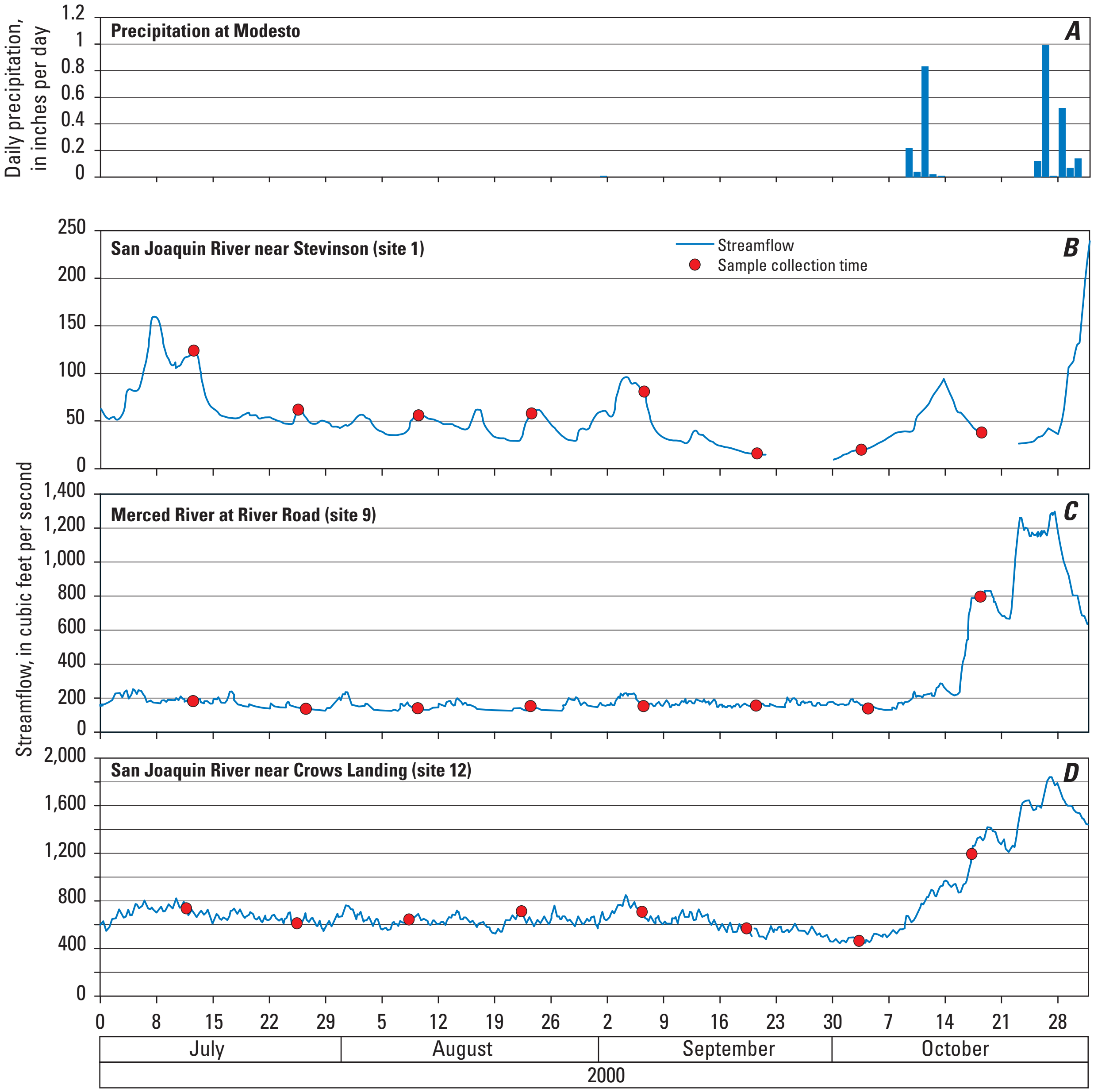

Figure 5. Precipitation at Modesto, California, streamflow for San Joaquin River sampling sites and major east-side tributaries from upstream to downstream, and sample collection times, July to October 2000.

(A) Precipitation at Modesto, (B) Streamflow and collection times for San Joaquin River near Stevinson (gaps in streamflow indicate missing data), (C) Streamflow and collection times for Merced River at River Road, (D) Streamflow and collection times for San Joaquin River near Crows Landing,

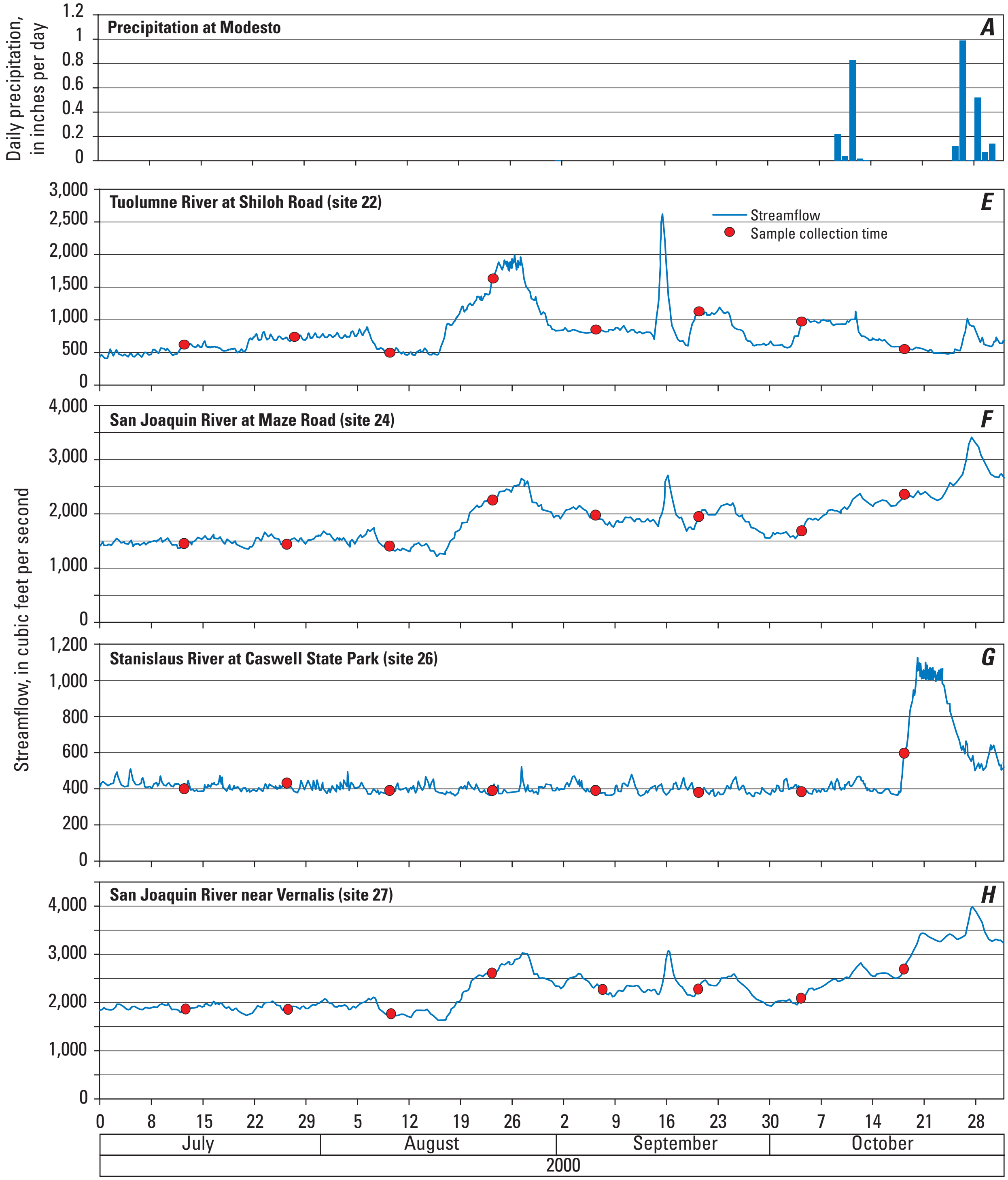

Figure 5.—*Continued.* (E) Streamflow and collection times for Tuolumne River at Shiloh Road, (F) Streamflow and collection times for San Joaquin River at Maze Road, (G) Streamflow and collection times for Stanislaus River at Caswell State Park, (H) Streamflow and collection times for San Joaquin River near Vernalis.

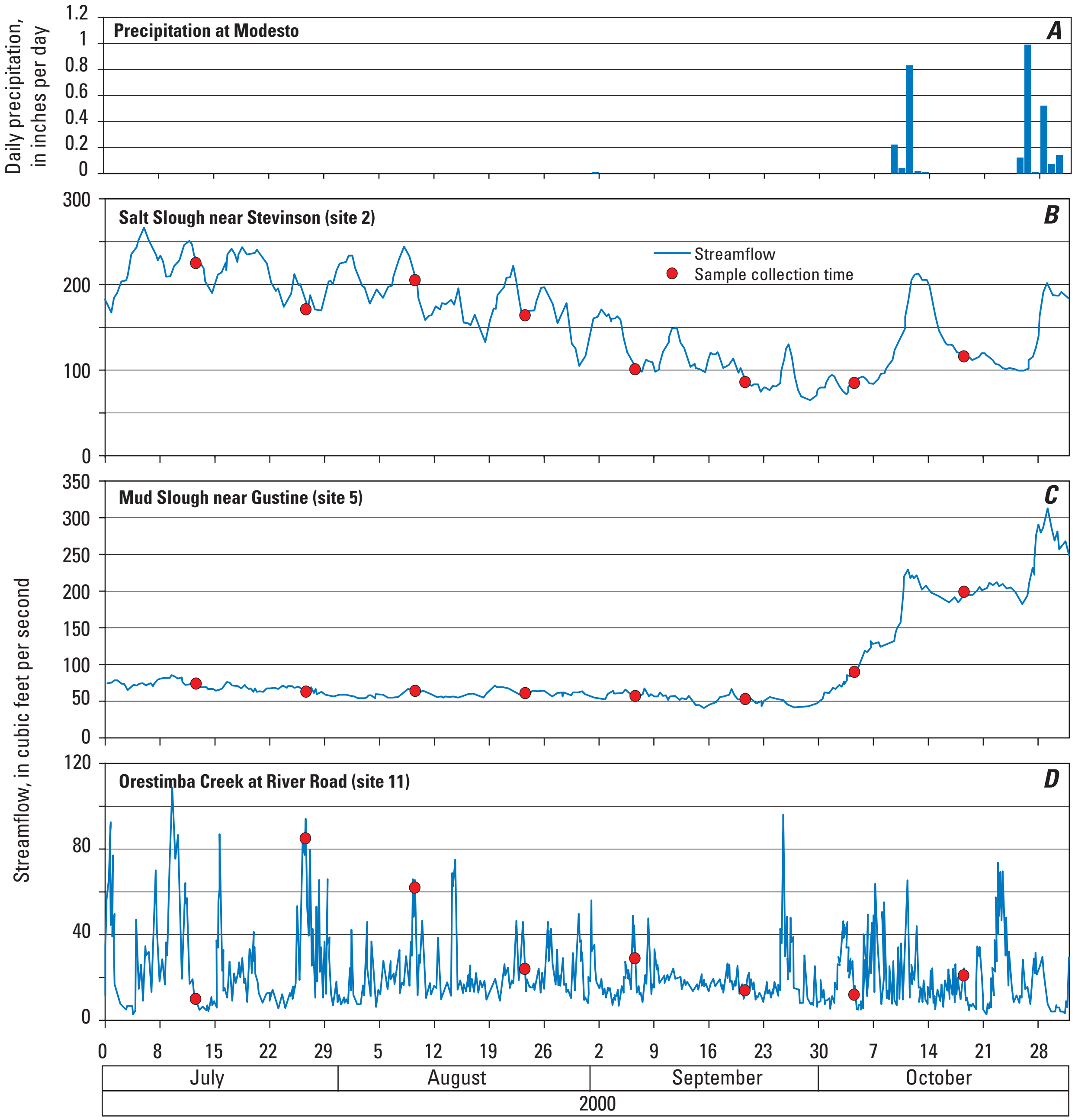

Figure 6. Precipitation at Modesto, California, streamflow for minor tributaries with gaging stations, and sample collection times, July to October 2000.

(A) Precipitation at Modesto, (B) Streamflow and collection times for Salt Slough near Stevinson, (C) Streamflow and collection times for Mud Slough near Gustine, (D) Streamflow and collection times for Orestimba Creek at River Road.

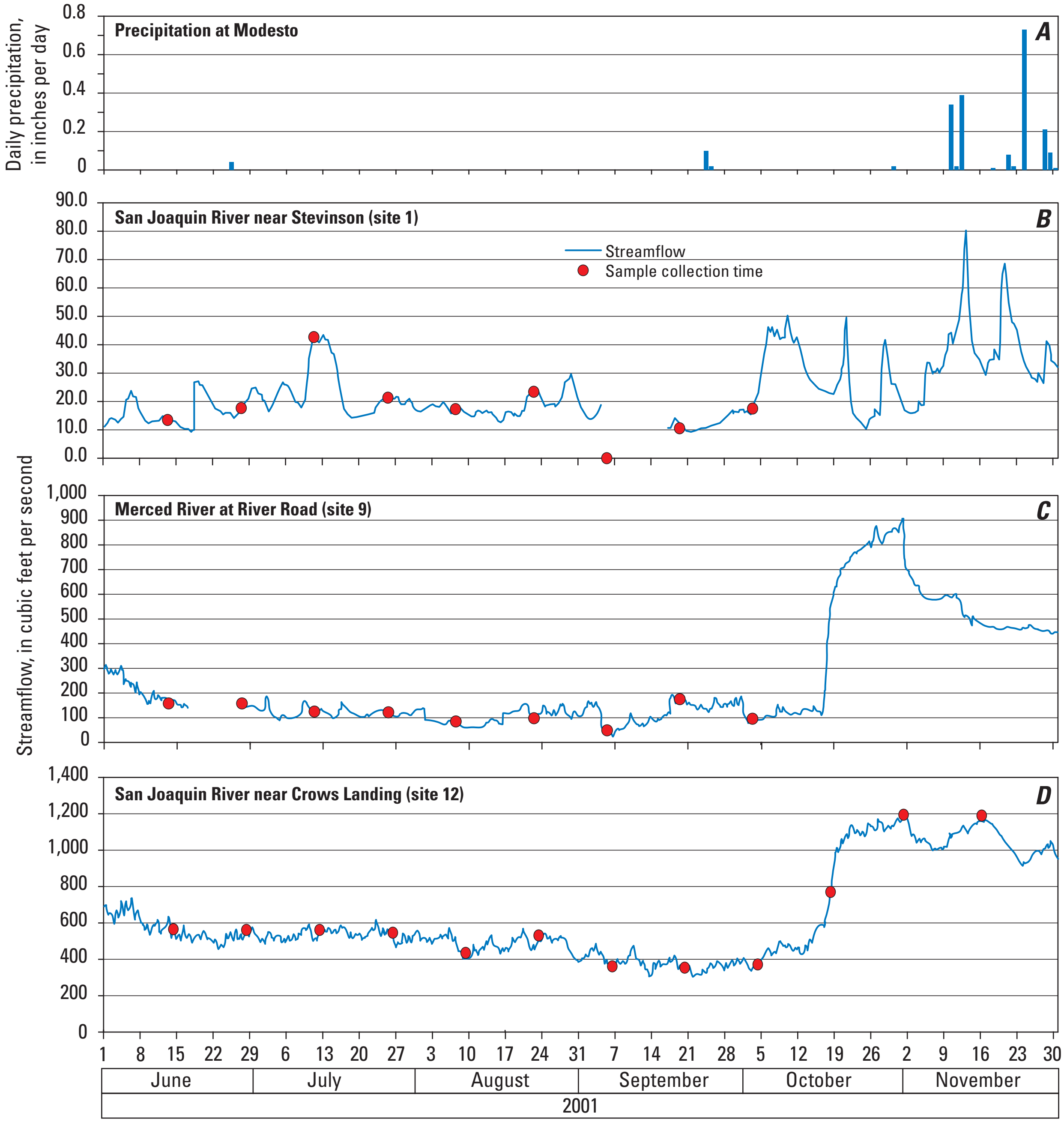

Figure 7. Precipitation at Modesto, California, and streamflow for San Joaquin River sampling sites and major east-side tributaries from upstream to downstream, and sample collection times, June to November 2001 (gaps in streamflow in 7B, C, E, F, and H indicate missing data).

(A) Precipitation at Modesto, (B) Streamflow and collection times for San Joaquin River near Stevinson, (C) Streamflow and collection times for Merced River at River Road, (D) Streamflow and collection times for San Joaquin River near Crows Landing.

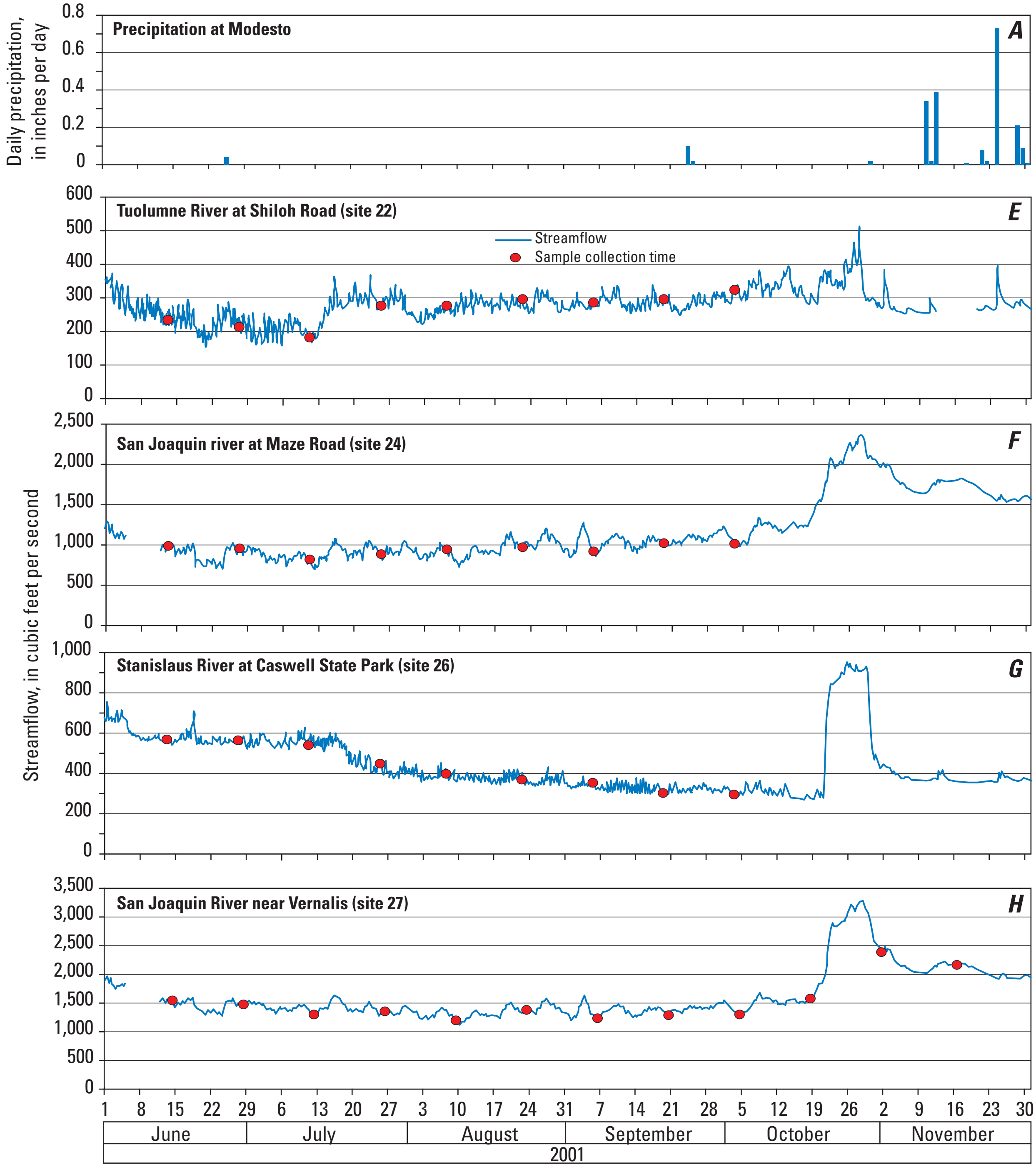

Figure 7.—*Continued.* (E) Streamflow and collection times for Tuolumne River at Shiloh Road, (F) Streamflow and collection times for San Joaquin River at Maze Road, (G) Streamflow and collection times for Stanislaus River at Caswell State Park, (H) Streamflow and collection times for San Joaquin River near Vernalis.

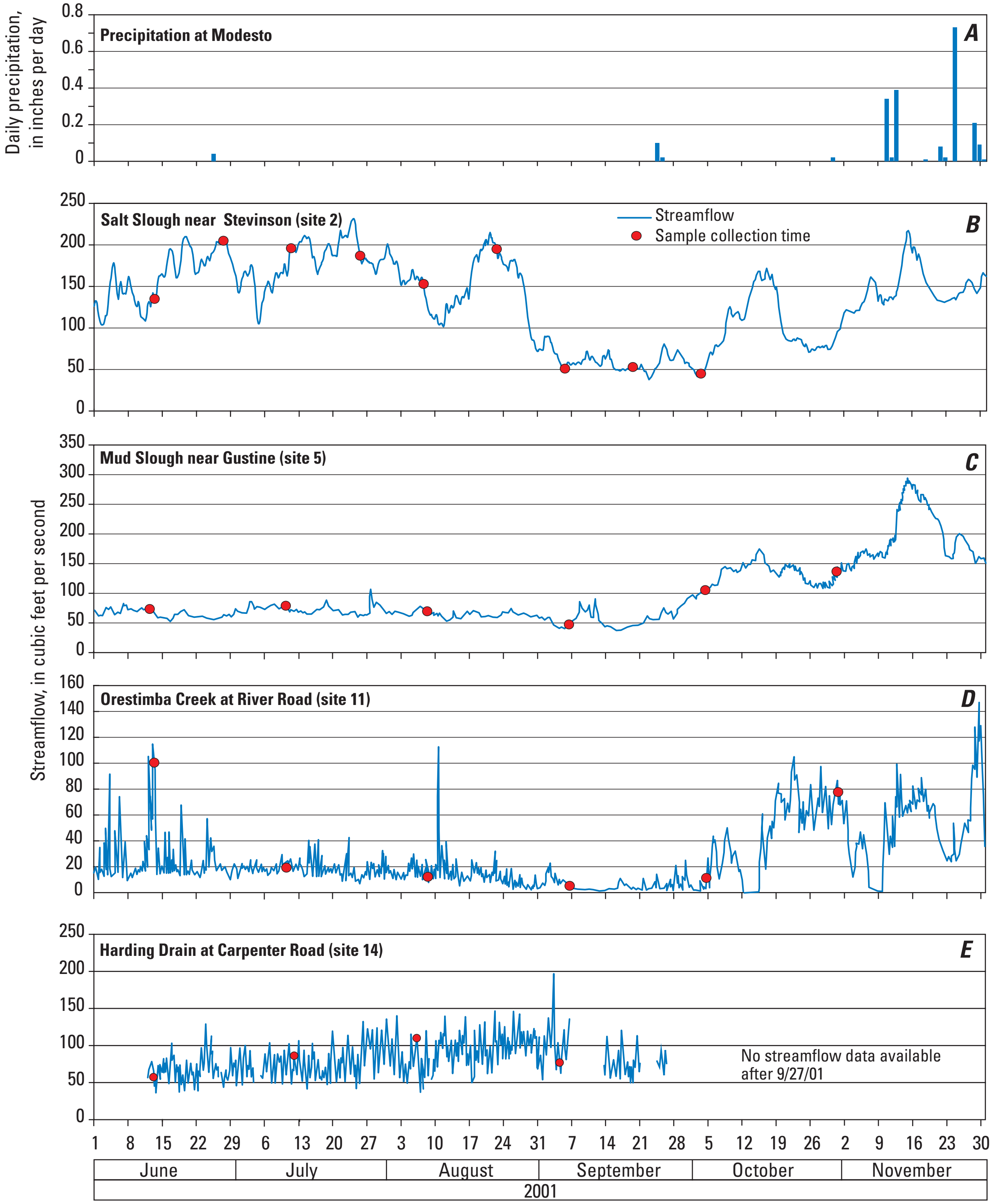

Figure 8. Precipitation at Modesto, California, streamflow for minor tributaries with gaging stations, and sample collection times, June to November 2001.

(A) Precipitation at Modesto, (B) Streamflow and collection times for Salt Slough near Stevinson, (C) Streamflow and collection times for Mud Slough near Gustine, (D) Streamflow and collection times for Orestimba Creek at River Road, (E) Streamflow and collection times for Harding Drain at Carpenter Road (gap in streamflow indicates missing data).

The 3-L Teflon sample collection bottles and the churn splitter were cleaned between each site using the following protocol. After sampling at a site, the collection bottles and the splitter were rinsed with deionized water. Approximately 30 mL of dilute Liquinox solution was then placed into the bottles and splitter, and both were capped and shaken. The Liquinox solution was then completely rinsed with deionized water. Approximately 30 mL of 5-percent hydrochloric acid solution was then added to the bottles and splitter, and both were capped and shaken. The acid rinsate was emptied into a waste container. The final step in the cleaning procedure was to thoroughly rinse the collection bottles and churn splitter with deionized water. The cone splitter followed the same cleaning procedure as the churn splitter, except that the appropriate solutions are passed through the splitter. At the next site, the 3-L Teflon sample collection bottles and splitter were rinsed three times with stream water (native water) before collecting or splitting the sample.

University of California at Davis Methods

All samples were collected as midstream grab samples using a collection bucket that sampled the upper two feet of the water column. The processing method for samples collected by UCD included holding individual 125-mL amber glass bottles under the water being poured from the bucket immediately after collection for the analysis of pH, EC, alkalinity, nutrients, particulate organic matter (POM), and DOC; and a 2-L bottle for collecting the chlorophyll-*a*, pheophytin-*a*, and total suspended solids samples. The cleaning procedure for the collection bucket included an 8-percent hydrochloric acid wash and three rinses with deionized water. The bucket was also rinsed three times with native water prior to sample collection at each site.

Field Measurements and Streamflow

Water temperature, dissolved oxygen concentrations, and secchi disk (measures water transparency) readings were recorded prior to actual sample collection at USGS sites. Sample water for the determination of pH, EC, and alkalinity was split from the cone or churn, and these parameters were measured in the field. Water temperature was determined in the field at each UCD site, but EC, pH, and alkalinity were determined in the laboratory within 24 hours of collection.

For most water quality sampling sites, streamflows were from gaging stations operated and maintained by the USGS, DWR, Lawrence Berkeley Laboratory, or Turlock Irrigation District. Of the 20 water quality sites sampled by USGS and UCD, 11 have a gaging station at the site, 3 have a gaging station upstream of the site, 1 has a gaging station downstream, and 5 required instantaneous streamflow measurements during each site visit. The sites at gages included three DWR gaging stations—SJR near Stevinson, SJR near Patterson, and SJR at Maze Road (sites 1, 15, and 24; fig. 2); six USGS gaging stations—Salt Slough near Stevinson, San Luis Drain at Site B, Mud Slough near Gustine, Orestimba Creek at River Road, SJR near Crows Landing, and SJR near Vernalis (sites 2, 4, 5, 11, 12, and 27; fig. 2); a gage operated by Lawrence Berkeley Laboratory for the minor tributary site, Los Banos Creek at Highway 140 (site 6; fig. 2); and a gage operated by Turlock Irrigation District for the minor tributary site, Harding Drain at Carpenter Road (site14; fig. 2). Three water quality sampling sites—Merced River at River Road, Tuolumne River at Shiloh Road and Stanislaus River at Caswell State Park—are located downstream of gaging stations and streamflows were estimated on the basis of travel times to the water quality sampling sites (sites 9, 22, and 26; fig. 2) (Kratzer and Biagtan, 1997). Streamflows for the San Joaquin River upstream of Merced River site were estimated using two downstream gages. The SJR at Laird Park (site 18; fig. 2) and four minor tributary sites—Spanish Grant Drain, Westport Drain near Modesto, Dry Creek at Gallo Bridge, and Hospital Creek (sites 13, 17, 20, and 23; fig. 2)—do not have gaging stations. During three water quality sampling visits (September 19, October 3, and November 15) to the SJR at Laird Park in 2001, the streamflow measurement equipment malfunctioned, and streamflow values were estimated using the ratio of the measured streamflows at Laird Park to the measured streamflows at the upstream DWR gage near Patterson for the same parcel of water (using the travel time from Kratzer and Biagtan, 1997). The average of these ratios was multiplied by the measured streamflow at Patterson for the sampling visits when the streamflow equipment was malfunctioning.

Analytical Methods

All samples collected by USGS other than isotopes and suspended sediment were shipped overnight to the USGS National Water Quality Laboratory (NWQL) in Denver, Colorado, for analysis. The isotope samples were first processed and prepared at the USGS California District Laboratory in Sacramento, California, and then sent to the USGS Menlo Park Stable Isotope Laboratory in Menlo Park, California, for final analysis. The suspended sediment samples were sent to the USGS California District Sediment Laboratory in Marina, California, for analysis. Samples collected by UCD were analyzed at UCD's Biogeochemistry Laboratory (UCDBL) in Davis, California.

U.S. Geological Survey Methods

The USGS analytical methods for analysis of nutrients, organic carbon, ultraviolet absorbance, VSS, chlorophyll-*a* and pheophytin-*a*, suspended sediment, and isotopes are briefly described here.

Nutrients

The analysis of nutrients at the NWQL included the following forms of nitrogen and phosphorus: dissolved ammonia, dissolved nitrite, dissolved nitrite plus nitrate, dissolved ammonia plus organic nitrogen, total ammonia plus organic nitrogen, dissolved phosphorus, dissolved orthophosphate, and total phosphorus. Ammonia was determined by reacting the sample with sodium salicylate, sodium nitroprusside, and sodium hypochlorite in an alkaline medium and measuring the concentration colorimetrically (Fishman and Friedman, 1989). Nitrite was determined from the reaction of nitrite ions with sulfanilamide under acidic conditions; the concentration was measured colorimetrically. The determination of nitrite plus nitrate included reducing nitrate to nitrite using a copper-cadmium column. The sample was then treated with sulfanilamide under acidic conditions, and the concentration was measured colorimetrically. The final result is the sum of the nitrite originally present plus that formed by the reduction of the nitrate (Fishman and Friedman, 1989). The determination of ammonia plus organic nitrogen included reducing organic nitrogen compounds to ammonium ion by digestion using sulfuric acid in the presence of mercuric sulfate and potassium sulfate. The ammonium ion produced by digestion, as well as the ammonium ion originally present, was determined by reaction with the same reagents as in the ammonia determination previously described in an alkaline medium, and the concentration was measured colorimetrically (Fishman and Friedman, 1989). Orthophosphate was determined by first converting all forms of phosphorus to orthophosphate by an acid-persulfate digestion. The orthophosphate ions were then reacted with ammonium molybdenate in acidic solution to form phosphomolybdic acid, which upon reduction with ascorbic acid produces an intensely colored blue complex that is measured colorimetrically (Fishman and Friedman, 1989). Total phosphorus was determined by the U.S. Environmental Protection Agency persulfate-digestion method 365.1 (U.S. Geological Survey, 1999).

Organic Carbon, Ultraviolet Absorbance, and Volatile Suspended Solids

The DOC sample was acidified, purged to remove inorganic forms of carbon, and oxidized with persulfate in an autoclave at 116–130ºC. The resultant carbon dioxide was measured by nondispersive spectrometry (Wershaw and others, 1987). The procedure that was used with DOC also was used to determine SOC on the silver filter. The determination of ultraviolet absorbance involved passing a 1-cm light path from a spectrophotometer, set at 254-nm wavelength, through the sample and measuring the mean ultraviolet absorbance (Eaton and others, 1995). The determination of VSS begins with thoroughly mixing the unfiltered sample and pouring an appropriate volume into a graduated cylinder. This volume is then filtered through a glass-fiber filter, and the suspended solids are dried, weighed, and ignited at 550ºC for 1 hour. The loss to ignition corresponds to the amount of VSS (Fishman and Friedman, 1989).

Chlorophyll-*a* and Pheophytin-*a*

The NWQL schedule 1508 was used for the determination of chlorophyll-*a* in 2000, whereas the NWQL schedule 1637 was used for the determination of chlorophyll-*a* and pheophytin-*a* in 2001. The laboratory procedures for these two schedules vary slightly. The procedure for schedule 1508 included placing the filter that contained the phytoplankton into a tissue grinder and extracting the chlorophylls from the algal cells by centrifuging. The chlorophylls were then separated from each other and from chlorophyll degradation products by thin-layer chromatography. The chlorophylls were eluted and measured using a spectrofluorometer (Britton and Greeson, 1987). The procedure for schedule 1637 included extracting the phytoplankton in 100-percent methanol with the aid of a tissue grinder and allowing the mixture to steep to ensure thorough extraction of the chlorophyll-*a*. The filter slurry was then centrifuged to clarify the solution and fluorescence was measured before and after acidification with 0.01 N hydrochloric acid. Solutions of known concentrations of both chlorophyll-*a* and pheophytin-*a* were used as calibration factors to calculate concentrations (U.S. Environmental Protection Agency, 1997). Pheophytin-*a* was not analyzed for samples collected in 2000.

Suspended Sediment

The water-sediment mixture was weighed, then the sediment was allowed to settle to the bottom of the bottles, and clear water was carefully decanted off to leave a water-sediment slurry. At this point, the slurry was washed with deionized water through a 0.062-mm sieve and put into two crucibles-one for the < 0.062-mm fraction and one for the > 0.062-mm fraction. These two fractions were then filtered separately through GFFs, and the two filters were placed into evaporating dishes, oven dried, cooled, and weighed (Guy, 1973). The total weight of the two fractions was used to calculate the suspended sediment concentration (in mg/L), and the weight of the < 0.062-mm fraction was divided by the total weight to calculate the percentage less than 0.062 mm.

Isotopes

Duplicate 1-L samples were collected for isotope analysis of POM and total dissolved nitrogen (TDN) at four mainstem San Joaquin River sites (sites 5, 10, 16, and 25; fig. 2) in 2000 and 2001 and six tributary sites (sites 9, 11, 12, 15, 18 and 21; fig. 2) in 2001. These samples were first prepared at the USGS California District Laboratory and sent to the USGS Menlo Park Stable Isotope Laboratory for final analysis. The initial processing at the USGS California District Laboratory included filtration through a 0.7-µm pore-size GFF within 24 hours of collection into 1-L baked amber glass bottles. The filters were folded into quarters, wrapped in aluminum foil, sealed in plastic bags, and stored in a freezer until further processing. The filtered water was acidified to pH 2 using concentrated hydrochloric acid and stored in a refrigerator at 4ºC until further processing.

Further processing of the POM samples began with thawing the filters, scraping with a spatula while wet, and collecting the scraped material in clean glass vials. This removes the POM along with a thin layer of the glass fiber filter materials. Hence, because each sample contains an unknown amount of glass, the absolute elemental values are not representative of the organic material and C:N (atomic) ratios are reported instead. The samples were then freeze-dried in the vials to remove water. After freeze-drying, the samples were ground and homogenized in an agate mortar and pestle and 20-mg aliquots were weighed into silver cups. The open cups were placed in a ceramic rack in a glass dessicator jar (with no dessicant and no vacuum grease to seal the jar). One drop of organic-free water was added to each cup and an open beaker of concentrated hydrochloric acid was placed in the bottom of the jar. The jar was closed for 6 to12 hours to allow vapor-phase acidification to remove carbonates from the samples. The rack of samples was then dried at 60ºC in a convection oven, folded closed and placed in 96-well trays for shipment to Menlo Park for final analysis.

The further processing of the filtered samples for isotope analysis of TDN began with 200-mL aliquots being poured into 1-L flasks and reduced to 25 to 50 mL by rotary evaporation. This process also removes dissolved carbonate from the samples. After reduction by rotary evaporation, the samples were adjusted to pH 7 by drop-wise addition of sodium hydroxide solution. The neutralized samples were poured into clean, glass flasks, then frozen and freeze dried. The freeze-dried samples were scraped out of the flasks with a clean steel spatula and collected in clean glass vials. The collected material was divided into 40-mg aliquots (using a microbalance), which were placed in tin cups. The cups were folded, closed, crimped, and placed in 96-well trays for shipment to Menlo Park for analysis.

Upon arrival at the USGS Menlo Park Stable Isotope Laboratory, the POM samples were analyzed for carbon and nitrogen isotopic and elemental composition on a Carlo Erba 1500 or 2500 elemental analyzer attached to a Micromass Optima or Micromass Isoprime mass spectrometer, in computer-controlled runs of 50 to 100 analyses each. A working standard material, ethylenediaminetetraacetic acid (EDTA), was analyzed with every run. The standard material samples that were analyzed ranged in size in order to bracket the environmental sample yield in terms of nitrogen and carbon, allowing for correction for sample-size linearity of the instrument. The EDTA was also analyzed at ten-sample intervals to correct for instrument drift over time. Empty silver or tin capsules were analyzed as blanks at the beginning and end of the run. About 10 percent of the samples were analyzed in duplicate. The EDTA standard was calibrated through a set of international standards to atmospheric air for $\delta^{15}N$ and to Vienna Pee Dee Belemnite (VPDB) for $\delta^{13}C$. Nitrogen and carbon isotopic compositions are expressed in per mil (‰) relative to atmospheric air and VPDB, respectively. The calculations are as follows:

$$\delta^{15}N_{Air} = \{[(^{15}N/^{14}N)_s/(^{15}N/^{14}N)_{Air}] - 1\} \times 1{,}000$$

$$\delta^{13}C_{VPDB} = \{[(^{13}C/^{12}C)_s/(^{13}C/^{12}C)_{VPDB}] - 1\} \times 1{,}000$$

where

N_{Air} =	the international nitrogen standard
$^{15}N/^{14}N$, $^{13}C/^{12}C$ =	ratio of heavy to light isotope in the sample or standard
s =	sample; and
C_{VPDB} =	the international carbon standard.

Analytical precision (1 standard deviation) for the standards was about ±0.15‰ for $\delta^{13}C$ and $\delta^{15}N$. In 2002, the USGS Menlo Park Stable Isotope Laboratory initiated a new automated system for simultaneous analysis of $\delta^{15}N$ and $\delta^{18}O$ of nitrate, using a method in which bacterial cultures reduce aqueous nitrate to N_2O (Sigman and others, 2001; Casciotti and others, 2002). This development allowed a subset of frozen archived 2001 samples to be analyzed directly for $\delta^{15}N$ and $\delta^{18}O$ of nitrate.

University of California at Davis Methods

The laboratory quality assurance and quality control (QA/QC) for the UCDBL involves standard laboratory protocols for spikes, replicates, reference standards, setting of control limits, and methods for criteria for rejection and data validation. Spikes were run at the onset of the project until consistent, and acceptable recoveries were obtained. Acceptable recovery was set at 85 percent. Approximately 5 to 10 percent of the UCD samples were replicates. Within an analytical run, if replicates were not within 10 to 20 percent of one another, the samples were reanalyzed. Certified nutrient and mineral reference standards were used for the determination of nitrate, ammonium, and orthophosphate. The reference standard was run immediately after instrument calibration. The limit of acceptability was ±10 percent from the certified value. At the onset of an analytical run, a series of distilled-deionized and (or) digested matrix blanks were run, after which a standard curve was developed from a series of standards defining the working range of analysis. The standard curve was verified by running the reference standards. The standard curve was rejected if it did not determine the values of the reference standards within ±10 percent and was reanalyzed every 20 to 30 samples to verify that no instrument drift had occurred. Drift in excess of 10 percent resulted in rejection of all values determined since the previous standardization. Standards were also analyzed at the end of each analytical run.

The UCD water quality samples were analyzed for the same constituents as those analyzed by the NWQL with the exception of ultraviolet absorbance and isotopes. The UCDBL analytical method for determination of POM is very similar to the NWQL method for determination of VSS. The UCDBL analytical methods for analysis of nutrients, organic carbon, POM, chlorophyll-*a* and pheophytin-*a*, and total suspended solids are briefly described here.

Nutrients

Samples for nitrate and ammonia were filtered through a 0.45-µm Nuclepore membrane filter, and the dissolved concentrations were quantified simultaneously using an automated membrane diffusion and conductivity detection method (Carlson, 1978; Carlson, 1986). TDN was determined by oxidizing a filtered sample (0.45-µm Nuclepore membrane) with a 1-percent persulfate oxidant solution and then using the same analytical method as for nitrate and ammonia (Yu and others, 1994). Dissolved organic nitrogen was calculated as the difference between TDN and ammonia and nitrate. Samples for total nitrogen analysis were analyzed with the same method as TDN. Dissolved orthophosphate was determined by a spectroscopic method using the stannous chloride standard method (Eaton and others, 1995) after the sample had been filtered through a 0.45-µm Nuclepore membrane. Total phosphorus was determined on whole-water samples using the stannous chloride standard method following persulfate digestion as described for TDN. Total dissolved phosphorus was determined on a filtered sample (0.45-µm Nuclepore membrane) using the same method as for total phosphorus. Dissolved organic phosphorus was calculated as the difference between total dissolved phosphorus and orthophosphate (Eaton and others, 1995).

Organic Carbon and Particulate Organic Matter

DOC was analyzed by ultraviolet-enhanced, persulfate digestion with infrared detection using a Dohrmann 180 DOC instrument (Randy Dahlgren, University of California, Davis, written commun., 2003). For POM samples, a known volume of water sample was filtered through a GFF, weighing the filter before and after filtration. Following filtration, the filter was dried in a desiccator for 24 hours and then weighed again. The filter was then ignited at 525ºC for four hours and the loss in mass was subtracted from the precombusted mass to determine the POM present in the original sample (Eaton and others, 1995).

Chlorophyll-*a* and Pheophytin-*a*

The analytical method for determining chlorophyll-*a* and pheophytin-*a* concentrations were the same as that used in the chlorophyll-*a* and pheophytin-*a* analyses at the NWQL during the 2001 study period (laboratory schedule 1637), with the exception of the use of 90-percent ethanol instead of the 100-percent methanol to extract the pigment (Eaton and others, 1995).

Total Suspended Solids

Total suspended solids were quantified by filtration of a known volume of water sample through a GFF and weighing the filter before and after filtration. Following filtration, the filter was dried in a desiccator for 24 hours and then weighed again (Randy Dahlgren, University of California, Davis, written commun., 2003).

U.S. Geological Survey Quality Control Samples

The collection of quality control (QC) samples is necessary to evaluate the quality of the data. QC samples are collected, usually at the field site, in order to identify, quantify, and document bias and variability in data resulting from the collection, processing, shipping, and handling of samples by field and laboratory personnel (Wilde and others, 1999). A total of 33 QC samples were collected out of a total of 158 samples (including six environmental samples collected at Lone Tree Creek) collected in this study (Appendix A). Four different types of field QC samples were collected in this study: 9 field blanks, 12 split replicates, 8 sequential replicates to compare sampling methods (width- and depth-integrated versus midpoint grab), and 4 sequential replicates to compare laboratory methods (NWQL versus UCDBL). In addition to the above QC samples, 15 samples were collected in 2001 at Mud Slough (4 samples), Orestimba Creek (4 samples), and SJR near Vernalis (7 samples) by USGS and UCD within 2 days of each other. Although not truly a replicate, these samples should be close in value. A relative percent difference (RPD) is used to describe the variability found in replicates. The RPD is calculated by taking the absolute value of the difference between the environmental and replicate samples and dividing by the average of the two samples.

The primary purpose of the field blanks was to identify potential sources of sample contamination and to assess the magnitude of contamination with respect to environmental concentrations of target analytes (Wilde and others, 1999). Of the nine field blanks collected, three had detections of DOC above the laboratory reporting limit of 0.3 mg/L (Appendix A). The field blanks used blank water distributed by the NWQL that contained 0.1 mg/L of DOC and the analytical reproducibility at this level is about ±0.2 mg/L. Thus, blanks having concentrations of 0.3 mg/L or less for DOC are acceptable (U.S. Geological Survey, 2000). The blanks with DOC above 0.3 mg/L had concentrations about an order of magnitude below the corresponding environmental samples (Appendix A).

Split replicates were samples divided into two equal subsamples, each of which were submitted for identical analyses in order to assess variability from sample processing and preservation (Wilde and others, 1999). The split replicate samples were split from the cone splitter in 2000 and from the churn splitter in 2001. One of the 3-L Teflon sample bottles was poured into two sets of bottles directly for SOC, DOC, and ultraviolet absorbance analyses in 2001 instead of splitting with the plastic churn splitter.

Sequential replicate samples were collected in 2000 to assess the variability in the UCD grab sampling method against the USGS width- and depth-integrated sampling method as well as in laboratory performance between the NWQL and the UCDBL. The sampling design for the collection of sequential replicate samples was as follows. During the USGS collection of a water quality sample using the width- and depth-integrated method, a second sample was collected using the UCD midpoint grab method. This second midpoint grab sample was considered to be the sequential replicate. Both samples were sent to the NWQL for analyses. For four of these eight sequential replicates, an additional volume of water was collected by midpoint grab and was analyzed for the same constituents at the UCDBL. Therefore, the sequential replicates were not only used to compare the variability in sampling methods, but also to compare variability in laboratory methods.

Table 3. Summary of quality-control replicate data for samples collected in the San Joaquin River Basin, California, 2000–2001

[NWQL, National Water Quality Laboratory; EWI, equal width increment; UCD, University of California at Davis; USGS, U.S. Geological Survey; n, number of samples; RPD, relative percent difference; VSS, volatile suspended solids; POM, particulate organic matter. %, percent; —, no data reported]

	Split replicates, both analyzed at NWQL			Sequential replicates collected by EWI and grab, both analyzed at NWQL				Sequential replicates, one analyzed at NWQL and the other at UCD				Samples collected and analyzed within 2 days of each other by USGS and UCD			
Constituent	n	Range of RPDs (%)	Median RPDs (%)	n	Range of RPDs (%)	Median RPDs (%)	% with EWI higher	n	Range of RPDs (%)	Median RPDs (%)	% with NWQL higher	n	Range of RPDs (%)	Median RPDs (%)	% with USGS higher
Dissolved nitrate	12	0.0– 4.5	0.6	7	0.5–1.4	0.7	43	4	1.7–10.6	7.8	0	15	1.5–31.9	5.5	53
Total nitrogen	12	0.0– 9.5	2.6	7	0.0–6.7	1.8	57	4	0.7–15.5	1.9	75	15	0.3– 46.0	9.0	20
Dissolved orthophosphate	12	0.0– 8.0	0.0	8	0.0– 8.0	0.0	50	4	3.7–8.6	6.7	25	13	0.0–147.1	14.7	50
Total phosphorus	12	0.0–5.3	0.9	8	2.3–10.2	4.8	63	4	31.3–54.6	48.9	100	15	2.9–116.2	17.3	53
Dissolved organic carbon	11	0.0–92.7	3.1	7	0.0– 4.6	2.4	29	4	4.0–77.4	38.8	50	15	0.0–40.0	9.8	54
Suspended organic carbon	10	0.0–86.4	14.4	7	0.0–82.4	23.5	43	0	—	—	—	0	—	—	—
Chlorophyll-*a*	11	5.0–77.8	16.1	8	2.3–193	11.9	25	4	12.7–190	48.2	50	15	2.0–133.3	19.4	47
Pheophytin-*a*	10	0.8–78.8	19.4	0	—	—	—	0	—	—	—	15	29.8–149.0	102.4	100
VSS/POM	0	—	—	0	—	—	—	2	30.3–53.3	41.8	0	15	2.5–117.0	49.5	13

The samples collected for the split replicates and the sequential replicates to compare sampling methods were all analyzed at the NWQL. The median RPDs for these samples were less than 5 percent for nutrients and DOC and from 10 to 25 percent for SOC, chlorophyll-*a*, and pheophytin-*a* (table 3). For the four sequential replicates split between the NWQL and the UCDBL, the median RPDs were less than 10 percent for nitrate, total nitrogen, and orthophosphate, and between 35 and 50 percent for total phosphorus, DOC, and chlorophyll-*a*. Only two of these four samples had detections to compare the NWQL values for VSS with the UCD values for POM. These samples had a median RPD of 41.8 percent. Because there were so few sequential replicates for laboratory comparisons, the differences between samples collected by USGS and UCD within 2 days of each other also were evaluated. These 15 samples were used to address concerns raised by the four sequential replicates about mixing USGS and UCD data for total phosphorus, DOC, and VSS/POM. The concern with total phosphorus analyses and potential laboratory bias was somewhat alleviated by the additional data as the median RPD dropped from 49 to 17 percent and the percentage of samples analyzed at the NWQL with higher values dropped from 100 to 53 percent (table 3). Concerns over DOC comparability also were reduced as the median RPD dropped from 39 to 10 percent. The additional data did not alleviate concerns regarding mixing VSS and POM data however, as the median RPD increased from 42 to 50 percent and the bias of higher values for POM remained. The additional data also pointed out a serious problem with mixing USGS and UCD data for pheophytin-*a* as the median RPD was 102 percent and all USGS values were higher.

In conclusion, the nitrogen constituents had low variability when analyzed at the NWQL (median RPD less than 5 percent) and relatively low variability between the NWQL and the UCDBL (median RPD less than 10 percent). For the phosphorus constituents and for DOC, the variability at the NWQL was also less than 5 percent (median RPD), and the variability between laboratories was between 10 and 20 percent (median RPD). SOC and chlorophyll-*a* had a variability at the NWQL of about 15 percent (median RPD), and chlorophyll-*a* had a variability between laboratories of about 20 percent. The variability between laboratories for pheophytin-*a* and VSS/POM is unacceptably high (about 100 percent for pheophytin-*a* and 50 percent for VSS/POM). In addition, whereas the variability between USGS and UCD laboratories appears to be fairly random for nutrients, organic carbon, and chlorophyll-*a*, there was a consistent bias for pheophytin-*a* and the comparison of USGS VSS values with UCD POM values. Thus, the pheophytin-*a* values from UCD will not be presented in this report and the VSS and POM data will be presented as two separate constituents.

HYDROLOGIC CONDITIONS DURING THE STUDY PERIOD

The long-term mean annual precipitation in the study area is about 10 to 12 in. (Kratzer and Shelton, 1998). The monthly precipitation in the study area for the 30-year period of 1972 to 2001 shown in figure 9 is based on precipitation in downtown Modesto. The six-month June through November period accounted for 21 percent of the annual precipitation during the 30-year period. Some significant precipitation events did occur during the 2000 and 2001 sampling periods: 1.09 in. during October 9–11, 2000, and 0.75 in. during November 10–12, 2001.

The streamflow at SJR near Vernalis during June through November is much less variable than during the rest of the year (fig. 10). In the highly manipulated San Joaquin Basin, this time of year is generally a low-flow period influenced primarily by agricultural diversions and return flows and hydropower releases from the reservoirs. In recent years, significant reservoir releases were made during late October to attract spawning fall-run Chinook salmon as part of the Vernalis Adaptive Management Plan (VAMP) (San Joaquin River Group Authority, 2002). The median June through November average streamflow near Vernalis for the 30-year period was 2,156 ft^3/s, with a low of 198 ft^3/s in 1977 and a high of 14,943 ft^3/s in 1983. During June through November of 2000, the average streamflow near Vernalis was 2,419 ft^3/s; in 2001 it was 1,624 ft^3/s (fig. 10B). Thus, the June through November San Joaquin River streamflows in 2000 were about 50 percent higher than in 2001.

Water availability in the San Joaquin Basin is defined by a water year hydrologic classification system known as the 60-20-20 water year index. This represents the percentage weight given to three variables: the forecasted, unimpaired runoff from April through July (60 percent); the forecasted, unimpaired runoff from October through March (20 percent); and the reservoir carryover storage from the previous water year constrained by a maximum allowable value (20 percent) (California Department of Water Resources, accessed February 20, 2003). Using this index, water years 1972–2001 were classified as wet, above normal, below normal, dry, or critical (fig. 11). "Unimpaired flow" represents the runoff from a basin if flow had not been altered (California Department of Water Resources, 1987). The total unimpaired streamflow to the valley floor in the San Joaquin Basin is the sum of unimpaired flows from SJR at Millerton Lake, Merced River at Lake McClure, Tuolumne River at New Don Pedro Reservoir, Stanislaus River at New Melones Reservoir, and outflow from the Tulare Basin by way of Fresno Slough (fig. 1). The unimpaired flow provides an estimate of the total water that would be expected to reach Vernalis under natural conditions. The actual outflow from the San Joaquin Basin is about 40 percent less than the unimpaired flow to the valley, mostly because of consumptive agricultural water use in the basin (Kratzer and Shelton, 1998). The timing of actual outflow is more evenly distributed throughout the year than the unimpaired flow to the valley because of the storage and release schedules of the four major upstream reservoirs. Reservoir development and water use in the basin have shifted the peak outflow from May to March and cut this peak flow about in half (Kratzer and Shelton, 1998).

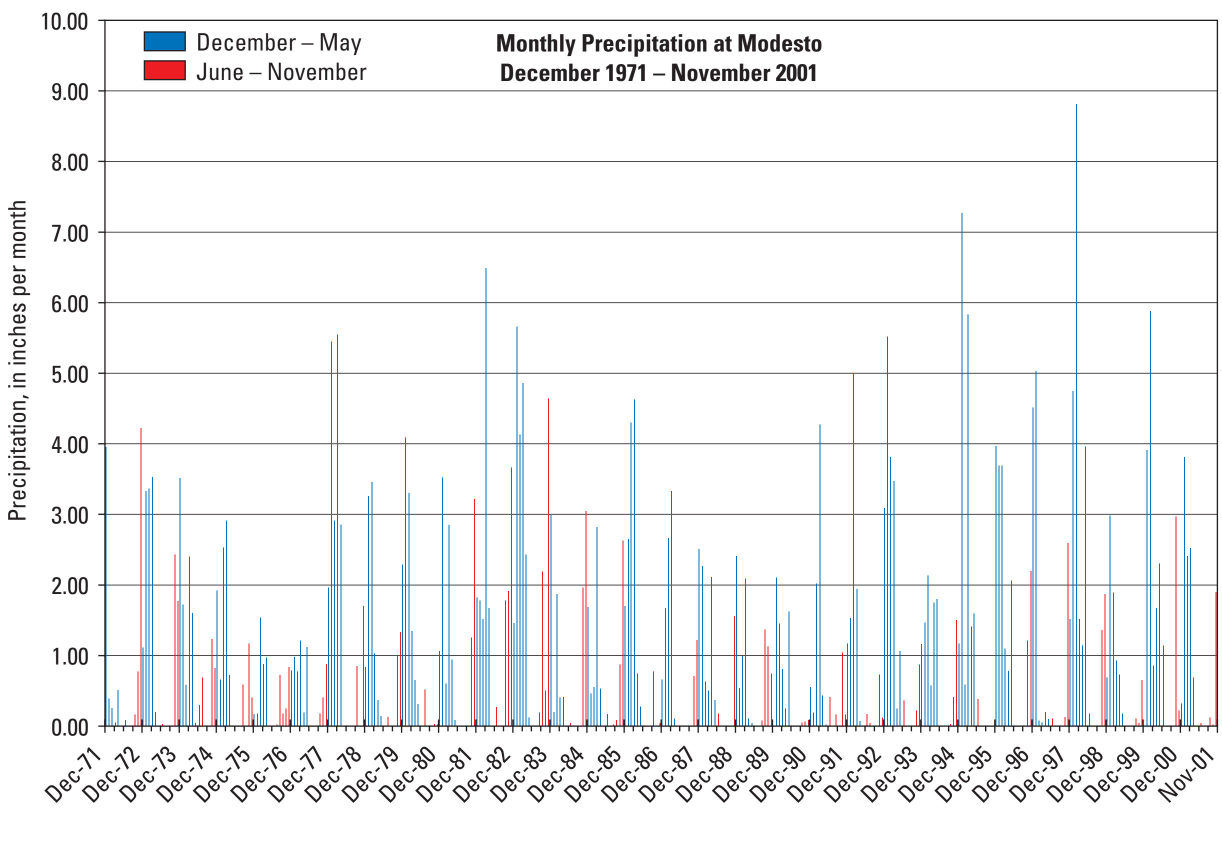

Figure 9. Monthly precipitation in downtown Modesto, California, December 1971–November 2001.

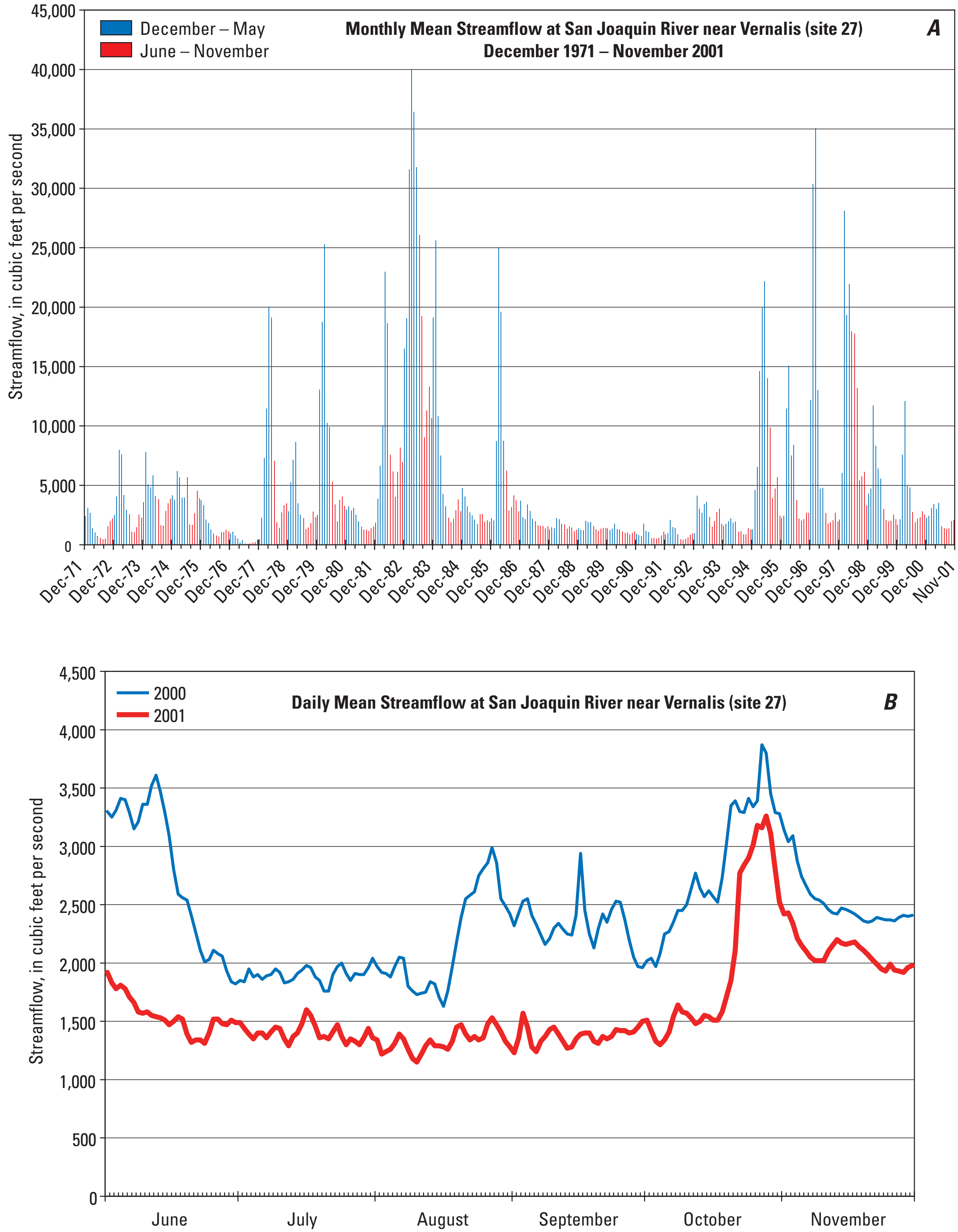

Figure 10. Streamflow at San Joaquin River near Vernalis, California.

(A) Monthly for December 1971–November 2001, and (B) Daily for June through November 2000 and 2001.

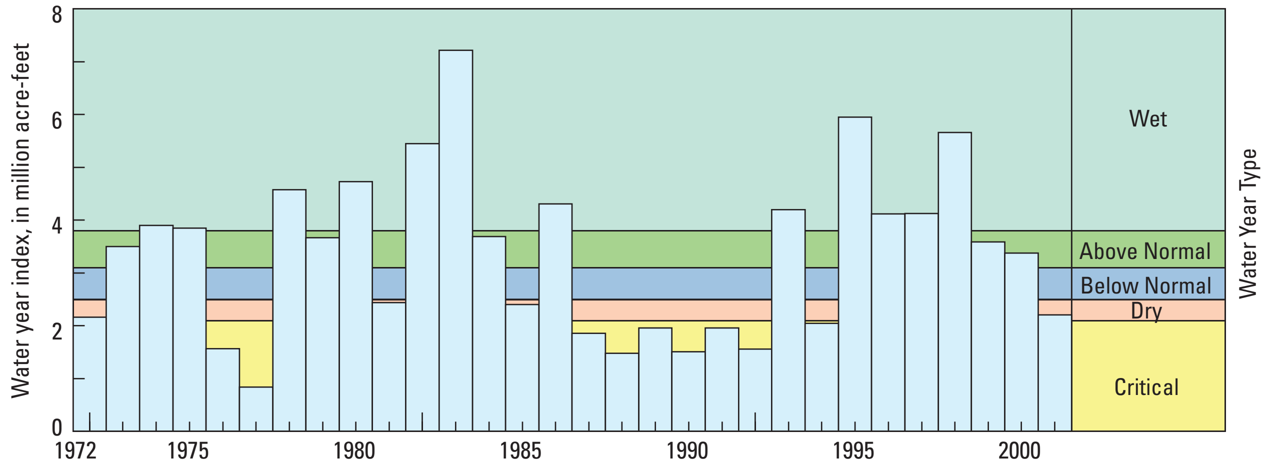

Figure 11. Water year indexes and corresponding water year types for San Joaquin Basin, California, 1972–2001.

During the 1972–2001 period, there were 12 wet, 5 above normal, 4 dry, and 9 critical water years (fig. 11. The periods of wet and dry were cyclical during the 30-year period. The first six water years of the period were balanced—two wet, one above normal, one dry, and two critical. The drought of 1976–1977 was followed by a 9-year period dominated by wet water years, including the extremely wet water year of 1983. Overall, this 9-year period included five wet, two above normal, and two dry water years. Following that 9-year wet period were six consecutive critical water years. The last 9 years of the period were again dominated by wet water years with 5 wet, 2 above normal, a dry, and a critical water year. The 2000 and 2001 water years were above normal and dry, respectively. On the basis of the numeric 60-20-20 water year index, 2000 (3.38 million acre-ft) was close to the 30-year average index of 3.33 million acre-feet, while 2001 (2.20 million acre-ft) was considerably below the average.

CONCENTRATIONS OF NUTRIENTS, ORGANIC CARBON, AND CHLOROPHYLL-*A*

Concentrations will be interpreted here in terms of the range of values and the median values, some temporal trends over the sampling period, and some upstream to downstream trends. More in-depth analysis of tributary sources to the San Joaquin River will be presented in the section "Loads of Nutrients, Organic Carbon, and Chlorophyll-*a*." It is important to note that considering only concentrations can sometimes be misleading with respect to their significance to the overall river system because of the magnitude of streamflows. For example, SJR near Stevinson had some very high concentrations of nutrients, organic carbon, and chlorophyll-*a* on occasion. However, the streamflows associated with these high concentrations were extremely low, and the river was essentially ponded at the site with very low velocities. Further, concentrations that were based on individual monthly or every two week sampling are connected in the plots presented in this section. This connection is made merely for the purpose of indicating trends in concentrations and should not be implied to represent a continuous record of concentrations. Streamflow for SJR near Vernalis is shown in each plot to indicate streamflow variations in the entire basin. To see the relation of concentrations to streamflow at a given site, the reader should refer to figures 5 to 8.

Concentrations of nutrients, organic carbon, and chlorophyll-*a* in water samples, collected from July through October 2000 and from June through November 2001, are presented in Appendixes B and C. Appendix B provides laboratory results at sites on the San Joaquin River and Appendix C provides laboratory results from sites on major and minor tributaries to the San Joaquin River. The instantaneous streamflows during sampling at the San Joaquin River sites are plotted in figure 12. These plots help to show the progressive increases in streamflows in the San Joaquin River as one moves downstream and that the Merced, Tuolumne, and Stanislaus Rivers greatly increase the streamflows.

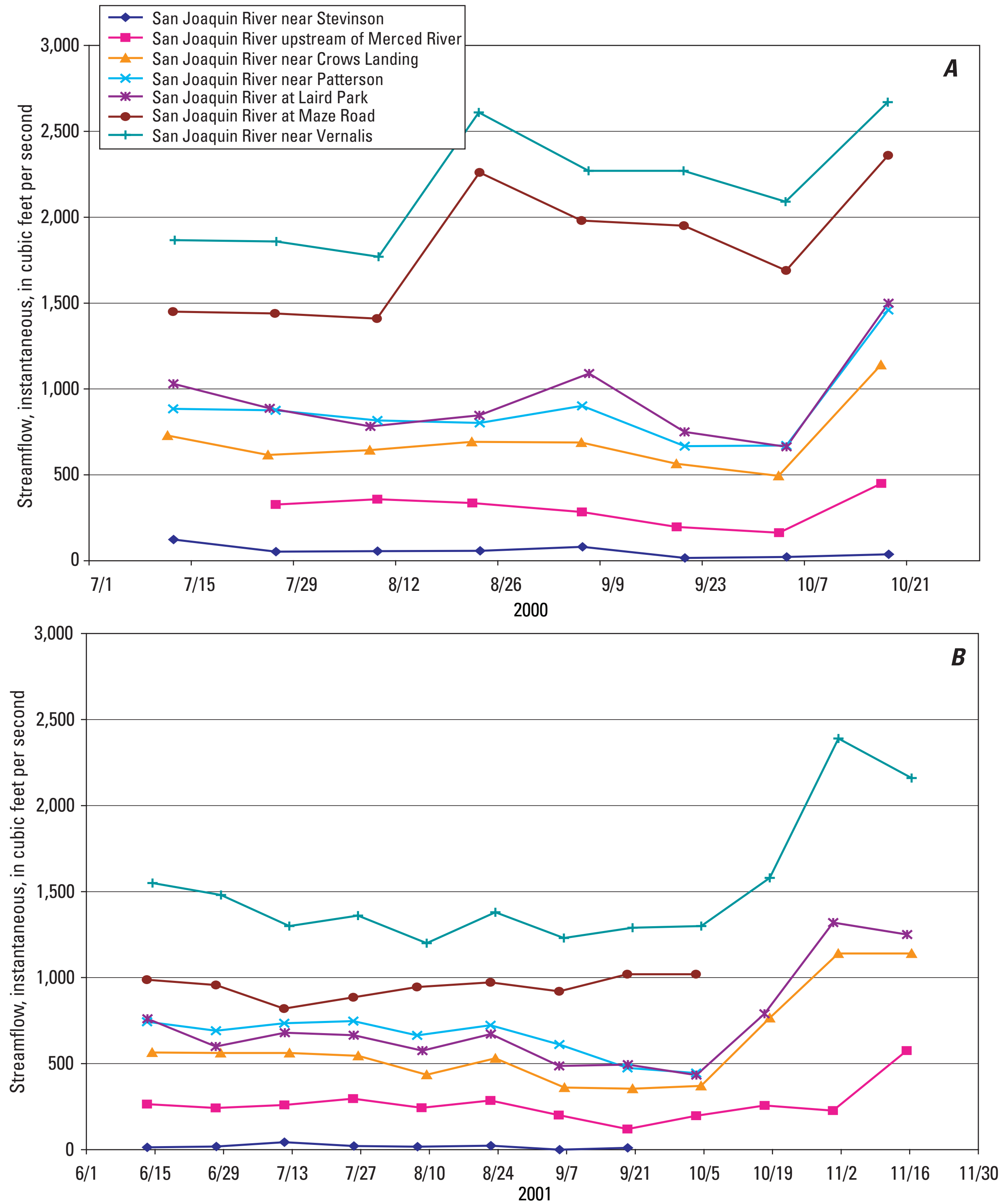

Figure 12. Instantaneous streamflow at time of sampling at San Joaquin River sites in California.

(A) July through October 2000, and (B) June through November 2001.

Nitrogen

Ammonia concentrations were below the laboratory reporting levels in 59 of the 130 samples collected at San Joaquin River sites and in 16 of the 168 samples collected from tributaries. The median concentration of ammonia in the San Joaquin River was 0.02 mg/L in 2000 and 0.04 in 2001, with maximum concentrations of 0.58 and 0.53 mg/L, respectively. The median concentration of ammonia in samples collected at tributary sites in 2000 and 2001 was 0.05 mg/L, with a maximum of 2.43 mg/L. The highest concentrations observed were in Harding Drain, which receives effluent from the City of Turlock Wastewater Treatment Plant.

Nitrate concentrations in the San Joaquin River ranged from 0.01 to 8.06 mg/L in 2000 and from 0.02 to 5.55 mg/L in 2001, with medians of 2.67 and 2.60 mg/L, respectively. Concentrations at the tributary sites ranged from 0.02 to 19.7 mg/L, with a median of 2.66 mg/L. Concentrations of total nitrogen in the San Joaquin River ranged from 1.04 to 11.7 mg/L in 2000 and from 1.29 to 7.23 mg/L in 2001, with medians of 3.48 and 3.96 mg/L, respectively. Concentrations in the tributaries ranged from 0.37 to 22.9 mg/L, with a median of 3.39 mg/L.

With the exception of SJR near Stevinson, most nitrogen in the San Joaquin River and the tributaries was in the form of nitrate. On average, nitrate accounted for 97 percent of the dissolved inorganic nitrogen and 72 percent of the total nitrogen in the river samples collected downstream of Stevinson. At SJR near Stevinson, more of the nitrogen was in the form of organic compounds. Dissolved inorganic nitrogen at SJR near Stevinson averaged only about 12 percent of the total nitrogen. Dissolved organic nitrogen accounted for about 67 percent of the total dissolved nitrogen and 35 percent of the total nitrogen. At the downstream sites in the San Joaquin River, the dissolved organic nitrogen accounted for only 16 percent of the total nitrogen.

Concentrations of nitrate, inorganic nitrogen, and total nitrogen generally decreased throughout the sampling period at upstream sites in 2000 and 2001 (figs. 13 and 14). Nitrate concentrations at the Crows Landing, Patterson, and Laird Park sites decreased from about 4 mg/L to about 2 mg/L; total nitrogen decreased from about 6 mg/L to about 2 mg/L. Nitrogen concentrations at the two downstream sites, Maze Road and Vernalis, did not have a general trend over the study period, although concentrations fluctuated quite a bit at Maze Road. These sites are greatly affected by dilution flows from the Tuolumne and Stanislaus Rivers. The dilution of Maze Road concentrations in 2001 was not nearly as great as in 2000 because of relatively high nitrate concentrations in the Tuolumne River in 2001.

Nitrogen concentrations usually decreased in the San Joaquin River from Laird Park to Maze Road to Vernalis. At the end of the sampling periods in 2000 and 2001, the concentrations at SJR near Crows Landing were actually lower than those at SJR near Vernalis. This probably was due to VAMP-related reservoir releases on the Merced River and wetland releases from the Grasslands Ecological Area to Mud Slough. These releases diluted the nitrogen concentrations at SJR near Crows Landing. A significant precipitation event preceded the last sampling visit in 2000 and 2001 as well.

Phosphorus

Concentrations of orthophosphate in the San Joaquin River ranged from 0.04 to 0.34 mg/L in 2000 and from 0.02 to 0.29 mg/L in 2001, with a median of 0.12 mg/L for both years. Concentrations at tributary sites ranged from below laboratory reporting levels to 2.27 mg/L, with a median of 0.08 mg/L for both years. Total phosphorus concentrations in the San Joaquin River ranged from 0.15 to 0.50 mg/L in 2000 and from 0.18 to 0.56 mg/L in 2001, with medians of 0.26 and 0.30 mg/L, respectively. Concentrations at tributary sites ranged from 0.02 to 2.58 mg/L, with a median of 0.17 mg/L for both years.

Both orthophosphate and total phosphorus concentrations were highly variable throughout the monitoring period and did not show any overall temporal trends (figs. 15 and 16). Concentrations were similar between years for San Joaquin River sites downstream of the Merced River. Orthophosphate concentrations ranged from about 0.1 to 0.3 mg/L; total phosphorus ranged from about 0.2 to 0.5 mg/L.

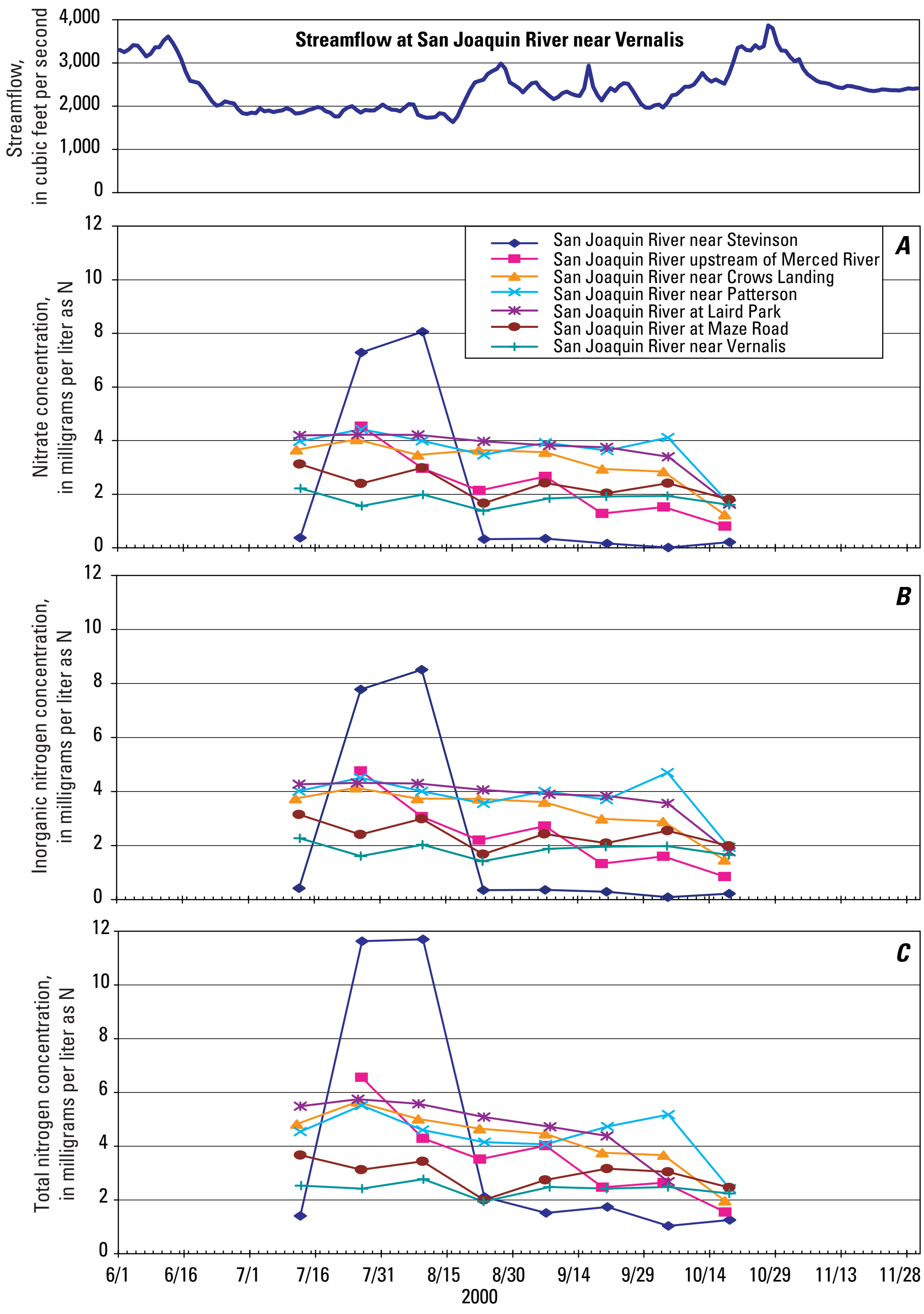

Figure 13. Concentrations of nitrate, inorganic nitrogen, and total nitrogen at San Joaquin River sites in California, from upstream to downstream for July through October 2000, with streamflow at Vernalis.

(A) Nitrate, (B) Inorganic nitrogen, (C) Total nitrogen. N, nitrogen.

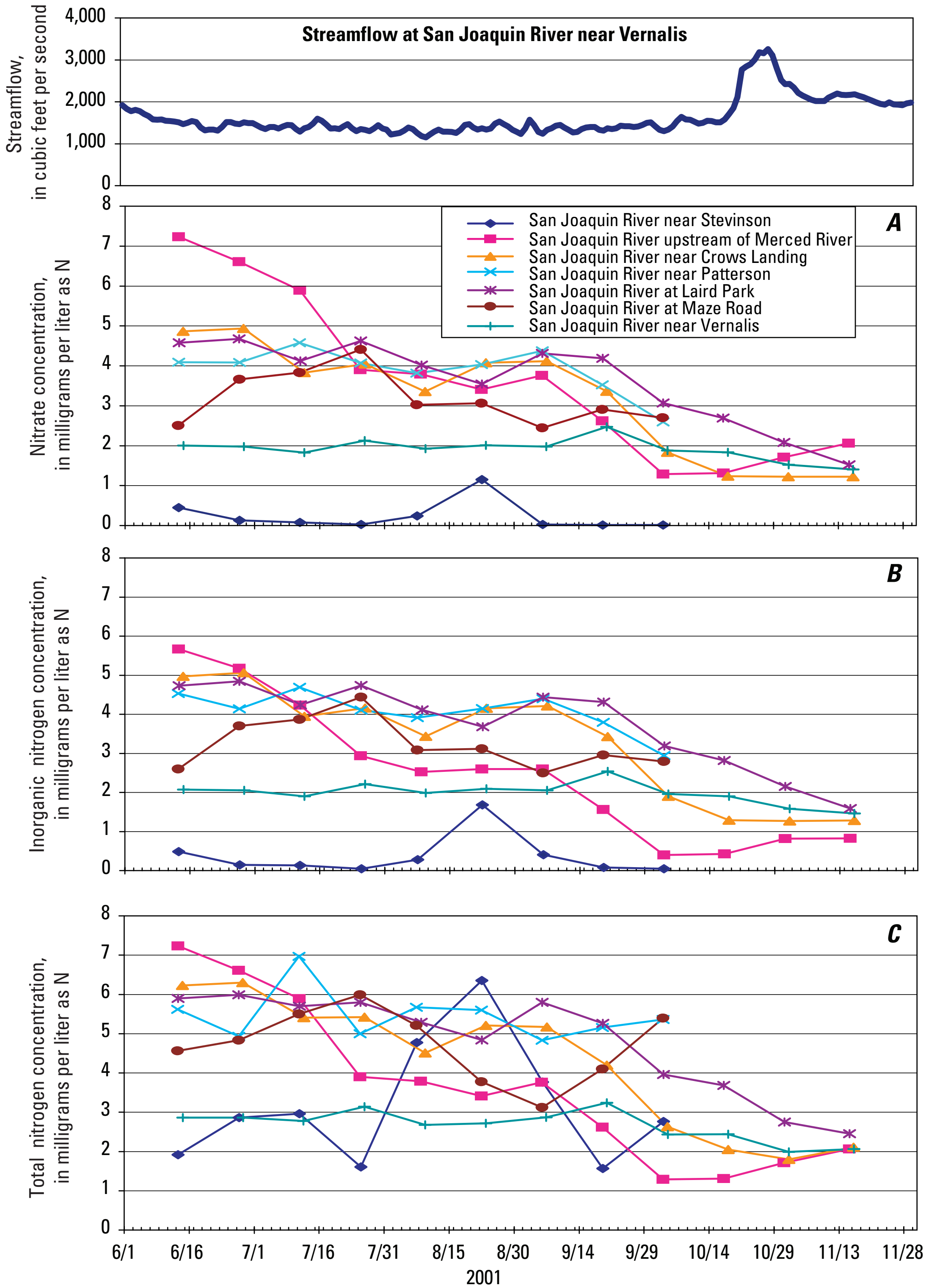

Figure 14. Concentrations of nitrate, inorganic nitrogen, and total nitrogen at San Joaquin River sites in California, from upstream to downstream for June through November 2001, with streamflow at Vernalis.

(A) Nitrate, (B) Inorganic nitrogen, (C) Total nitrogen. N, nitrogen.

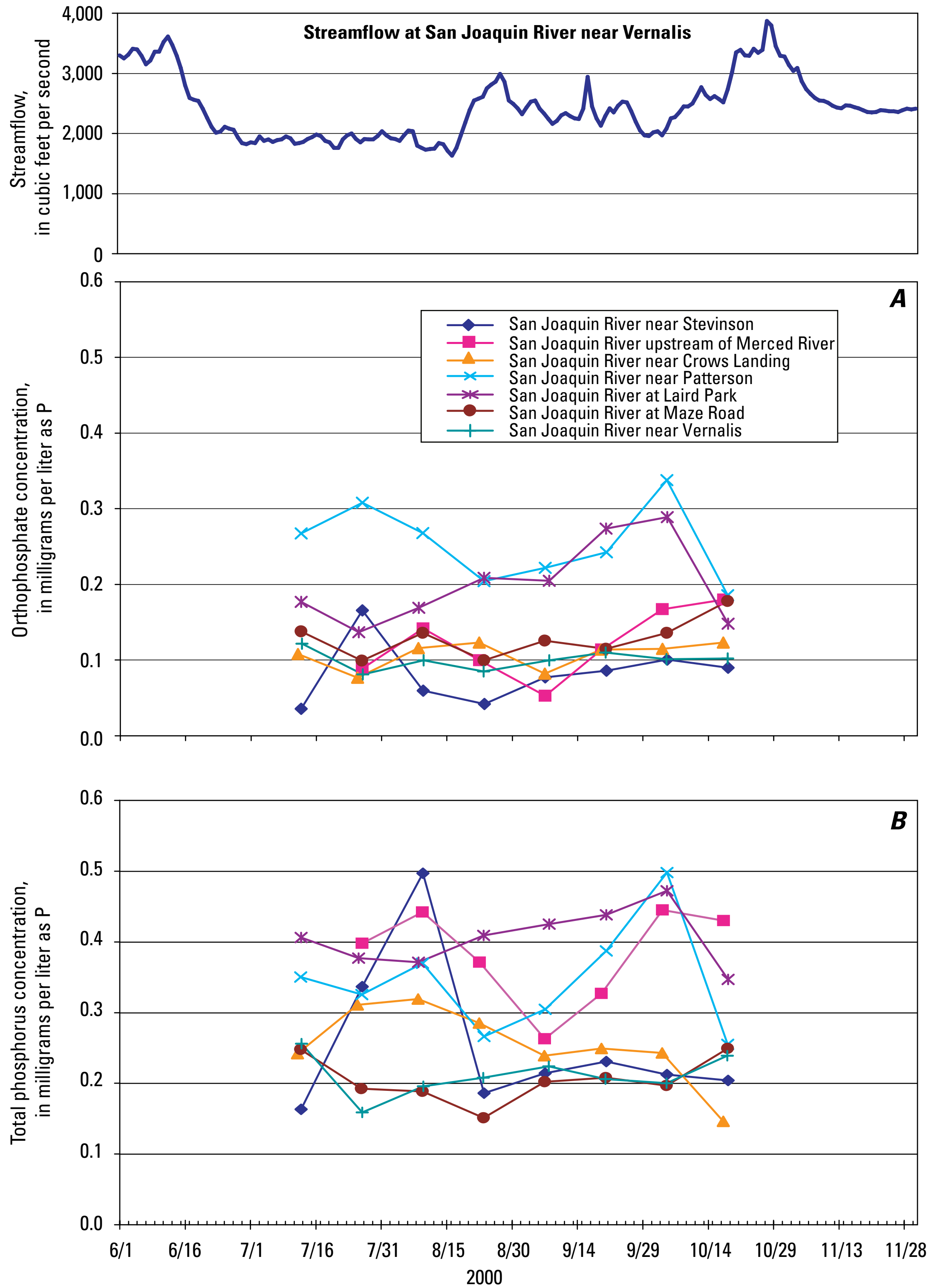

Figure 15. Concentrations of orthophosphate and total phosphorus at San Joaquin River sites in California, from upstream to downstream for July through October 2000, with streamflow at Vernalis.

(A) Orthophosphate, (B) Total phosphorus. P, phosphorus.

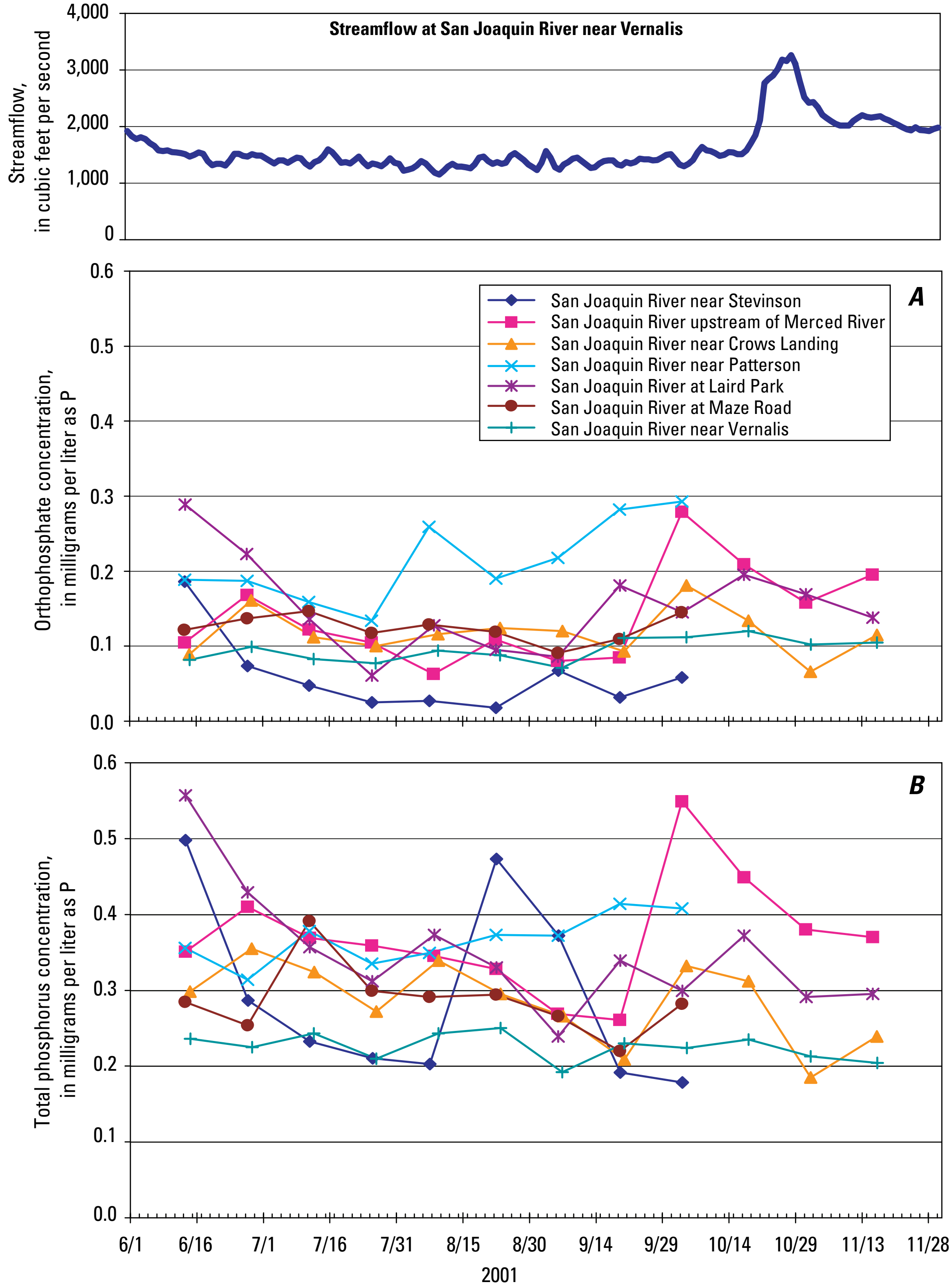

Figure 16. Concentrations of orthophosphate and total phosphorus at San Joaquin River sites in California, from upstream to downstream for June through November 2001, with streamflow at Vernalis.

(A) Orthophosphate, (B) Total phosphorus. P, phosphorus.

For San Joaquin River sites downstream of the Merced River, phosphorus concentrations were usually highest near Patterson and Laird Park, downstream of Harding Drain. Concentrations near Crows Landing were usually considerably lower than near Patterson and at Laird Park, and concentrations at Maze Road and near Vernalis were diluted by the Tuolumne and Stanislaus Rivers. As with nitrogen concentrations, the dilution at Maze Road was much less in 2001 than in 2000 because of higher phosphorus inputs from the Tuolumne River. At the San Joaquin River sites upstream of the Merced River and near Crows Landing, phosphorus concentrations increased or decreased in October in response to wetland releases to Mud Slough (increasing concentrations) and VAMP-related reservoir releases on the Merced River (decreasing concentrations).

Organic Carbon

Dissolved organic carbon (DOC) concentrations in the San Joaquin River ranged from 2.3 to 8.8 mg/L in 2000 and from 2.5 to 10.3 mg/L in 2001, with a median of 3.9 mg/L, both years. Concentrations at the tributary sites ranged from 0.7 to 17.6 mg/L, with a median concentration of 4.3 mg/L for both years. Suspended organic carbon (SOC) concentrations in the San Joaquin River ranged from 0.3 to 3.6 mg/L in 2000 and from 0.8 to 7.9 mg/L in 2001, with medians of 1.1 and 2.0 mg/L, respectively. Concentrations at the tributary sites ranged from <0.2 to >10 mg/L, with a median concentration of 1.5 mg/L for both years.

At San Joaquin River sites downstream of the Merced River, DOC concentrations usually decreased slightly from June and July to September, then increased in the fall (figs. 17 and 18). The overall trend appears to be closely related to the San Joaquin River upstream of Merced River. The increase at this site in the fall probably was related to wetland releases from the Grasslands Ecological Area to Mud Slough and Los Banos Creek (Appendix C). SOC concentrations generally decreased from June and July through the rest of the sampling period, except for some increases at the San Joaquin River sites upstream of the Merced River (site 7) and near Crows Landing (site 17) in the fall (figs. 17 and 18).

DOC concentrations were highest in the San Joaquin River sites upstream of the Merced River and generally decreased in downstream order from there. SOC concentrations were less variable than DOC, except for an unusually high value on August 9, 2001. This outlier may represent sampling variability caused by a relatively large clump of suspended organic matter being collected in the sampler by chance, resulting in a nonrepresentative sample with a value higher than ambient conditions at the time of sample collection.

The ultraviolet absorbance at 254-nm is often used to infer the qualitative differences in the composition of the organic matter in river waters. The specific ultraviolet absorbance (SUVA) is the ultraviolet absorbance at 254 nm divided by the DOC concentration. SUVA is positively correlated with the degree of aromatic carbon in the DOC (Bergamaschi and others, 2000). The median SUVA at the San Joaquin River sites was 0.027 L/mg-cm in 2000 and 0.028 L/mg-cm in 2001 (Appendix B). The median SUVA at the tributary sites was also 0.028 L/mg-cm in 2001 (Appendix C). Thus, SUVA values in the tributaries and in the San Joaquin River were essentially the same.

Chlorophyll-*a* and Pheophytin-*a*

Chlorophyll-*a* concentrations at the San Joaquin River sites ranged from 5.1 to 377 µg/L in 2000 and from 5.4 to 393 µg/L in 2001, with medians of 27.2 and 29.4 µg/L, respectively. Chlorophyll-*a* concentrations at the tributary sites ranged from 0.2 to 81.5 µg/L, with a median of 6.0 µg/L. Pheophytin-*a* concentrations at the four USGS sites on the San Joaquin River ranged from 3.7 to 46.5 µg/L in 2001, with a median of 16.4 µg/L. Pheophytin-*a* concentrations at the tributary sites sampled by USGS ranged from 0.8 to 56.8 µg/L, with a median of 6.2 µg/L.

In 2000, chlorophyll-*a* concentrations in the San Joaquin River were highest from July to mid-August, then decreased the rest of the sampling period (fig. 19). In 2001, chlorophyll-*a* concentrations increased from mid-June to early September, then decreased (fig. 20). Pheophytin-*a* concentrations in 2001 had a trend similar to that for chlorophyll-*a* (fig. 20).

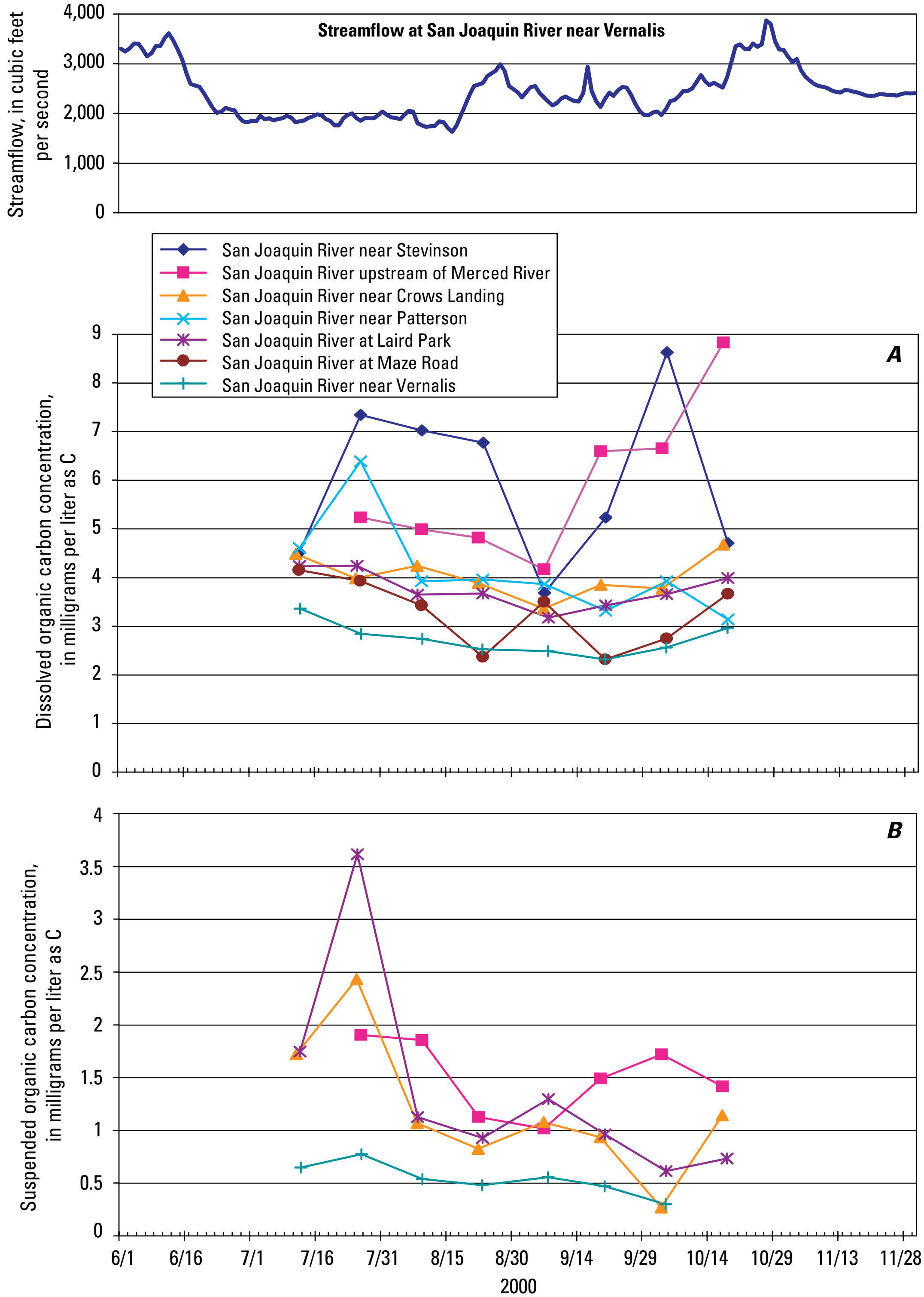

Figure 17. Concentrations of dissolved organic carbon and suspended organic carbon at San Joaquin River sites in California, from upstream to downstream for July through October 2000, with streamflow at Vernalis.

(A) Dissolved organic carbon, (B) Suspended organic carbon. C, carbon.

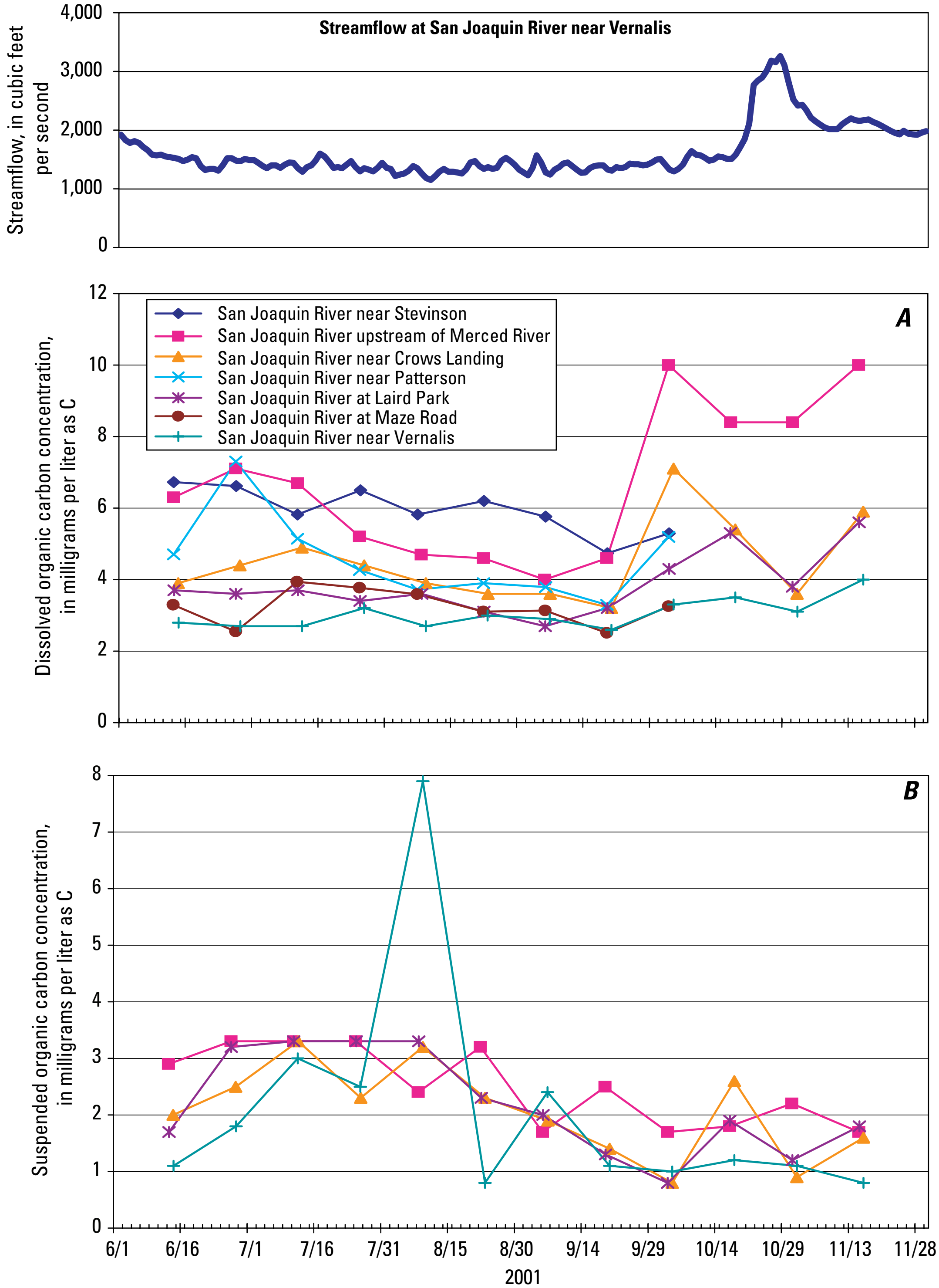

Figure 18. Concentrations of dissolved organic carbon and suspended organic carbon at San Joaquin River sites in California, from upstream to downstream for June through November 2001, with streamflow at Vernalis.

(A) Dissolved organic carbon, (B) Suspended organic carbon. C, carbon.

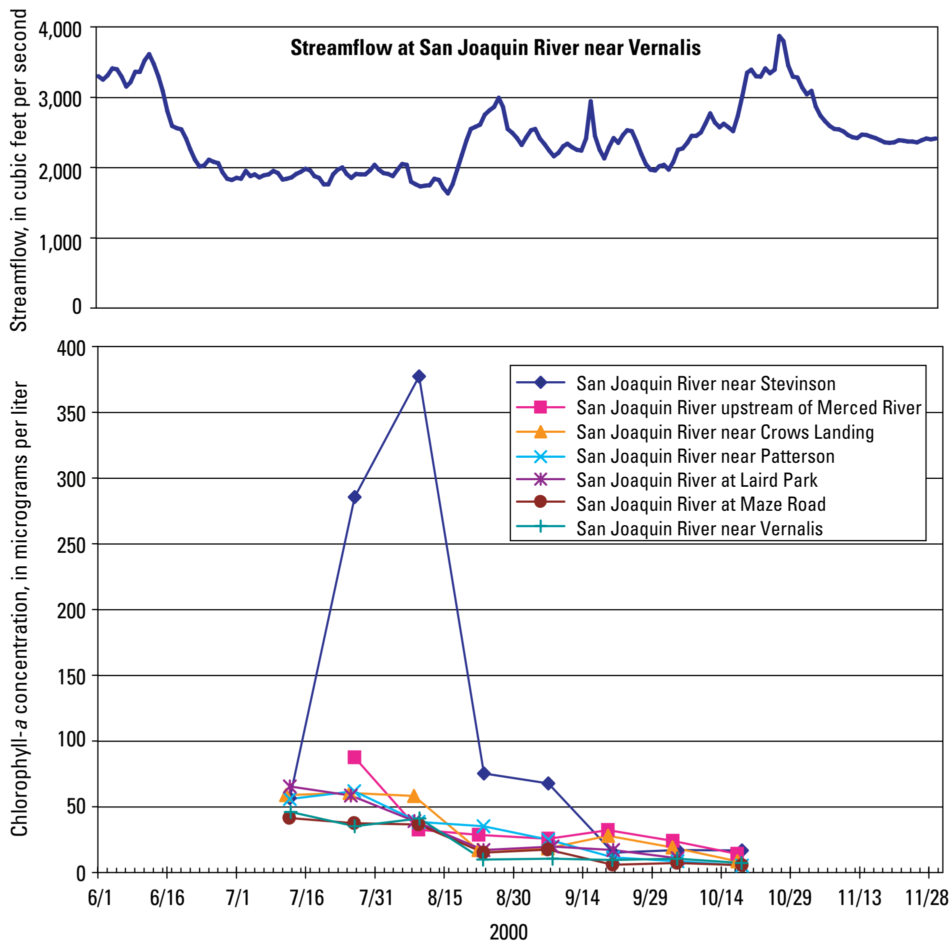

Figure 19. Concentrations of chlorophyll-*a* at San Joaquin River sites in California, from upstream to downstream for July through October 2000, with streamflow at Vernalis.

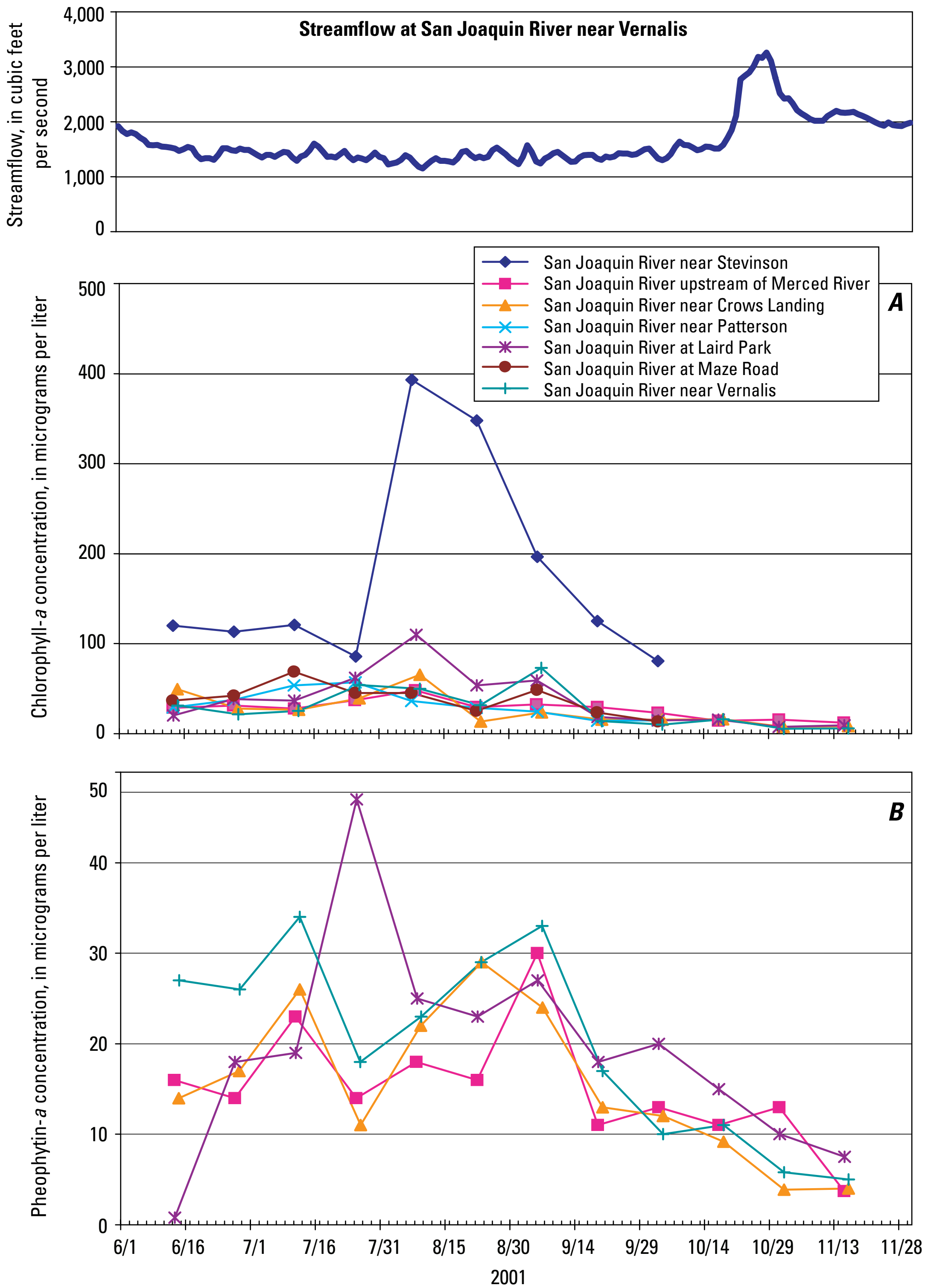

Figure 20. Concentrations of chlorophyll-*a* and pheophytin-*a* at San Joaquin River sites in California, from upstream to downstream for June through November 2001, with streamflow at Vernalis.

(A) Chlorophyll-*a*, (B) Pheophytin-*a*.

There was very little variation in chlorophyll-*a* concentrations from upstream to downstream in 2000 or 2001, despite diluting flows entering the San Joaquin River from the Merced, Tuolumne, and Stanislaus Rivers with relatively low chlorophyll-*a* concentrations (Appendix C). SJR near Stevinson had extremely high concentrations, but at very low streamflows as mentioned earlier. Pheophytin-*a* concentrations were usually higher at SJR near Vernalis and Laird Park than at upstream sites.

HISTORICAL NUTRIENT LOADS IN THE SAN JOAQUIN BASIN

Monthly Loads in the San Joaquin River near Vernalis, 1972–2001

Monthly loads of dissolved nitrate (hereinafter, nitrate), total nitrogen, and total phosphorus at SJR near Vernalis were calculated for the 30-year period in this study, 1972–2001, using version 92.11b of the load calculation program ESTIMATOR (Cohn and others, 1989). ESTIMATOR is a log-linear multiple regression model of constituent concentration against streamflow and time variables. ESTIMATOR uses standard output files from the USGS National Water Information System (NWIS) database as input data files. These data are used to develop a relation between streamflow and constituent concentration for calculating loads. The ESTIMATOR program first runs a calibration period for flows and concentrations. Only concentrations with associated streamflows (instantaneous or daily mean) are used in the calibration process. For the load-estimation period, there must be a streamflow value for each day. The ESTIMATOR program provided estimated daily, monthly, or annual loads with standard errors and standard errors of prediction. Thus, confidence intervals for the load estimates can be calculated.

In this study, the data used in ESTIMATOR are from the U.S. Environmental Protection Agency's STOrage and RETreival (STORET) and NWIS databases. The data used are described in Kratzer and Shelton (1998) for 1972–90 and in Saleh and others (2003) for 1991–2000. For 2001, only data from NWIS were used in ESTIMATOR. The calibration period and the load-estimation period were both 1972–2001. The results reported in Kratzer and Shelton (1998) for the SJR near Vernalis for 1972–90 will be slightly different than the results reported here for that period because of the different calibration period. Similarly, results reported in Saleh and others (2003) for the 1980–2000 period will be different than the results reported here for that period.

The annual variations in loads of total nitrogen and total phosphorus (fig. 21) closely follow the variations in streamflow (fig. 10), while the variations in nitrate loads are less pronounced. This is largely a function of the particulate fraction of the constituent. Total phosphorus has the highest particulate fraction (about 0.56 for 1972–2001 data), followed by total nitrogen (about 0.36 for 1972–2001 data), while the nitrate load is all in the dissolved form (by definition). Thus, because suspended sediment concentrations increase with streamflow, the ratios of wet year to dry year loads should increase with the particulate fraction of the constituent. This was the case for 1972–2001, as total phosphorus increased the most with streamflow, and nitrate the least (fig. 21). Overall, nitrate loads increased over time independent of streamflow. This increasing nitrate trend is shown as flow-adjusted concentrations in figure 22. The highly significant statistical trend ($p < 0.01$) has a slope of 0.025 mg/L per year. This is very similar to the slope for the 40-year period from 1951–90 of 0.028 mg/L per year (Kratzer and Shelton, 1998). Much of the nitrate load in the San Joaquin River originates in tile drainage from the Grasslands Drainage Project Area (fig. 1) that is only slightly sensitive to changes in streamflow in the San Joaquin River (Kratzer and Shelton, 1998). Loads and concentrations of other forms of nitrogen and total phosphorus did not increase as did nitrate, and thus, there were no statistically significant (at the 95-percent confidence level) flow-adjusted trends of total nitrogen ($p = 0.11$, slope = 0.0087 mg/L per year) and total phosphorus ($p = 0.06$, slope = – 0.0014 mg/L per year) (fig. 22).

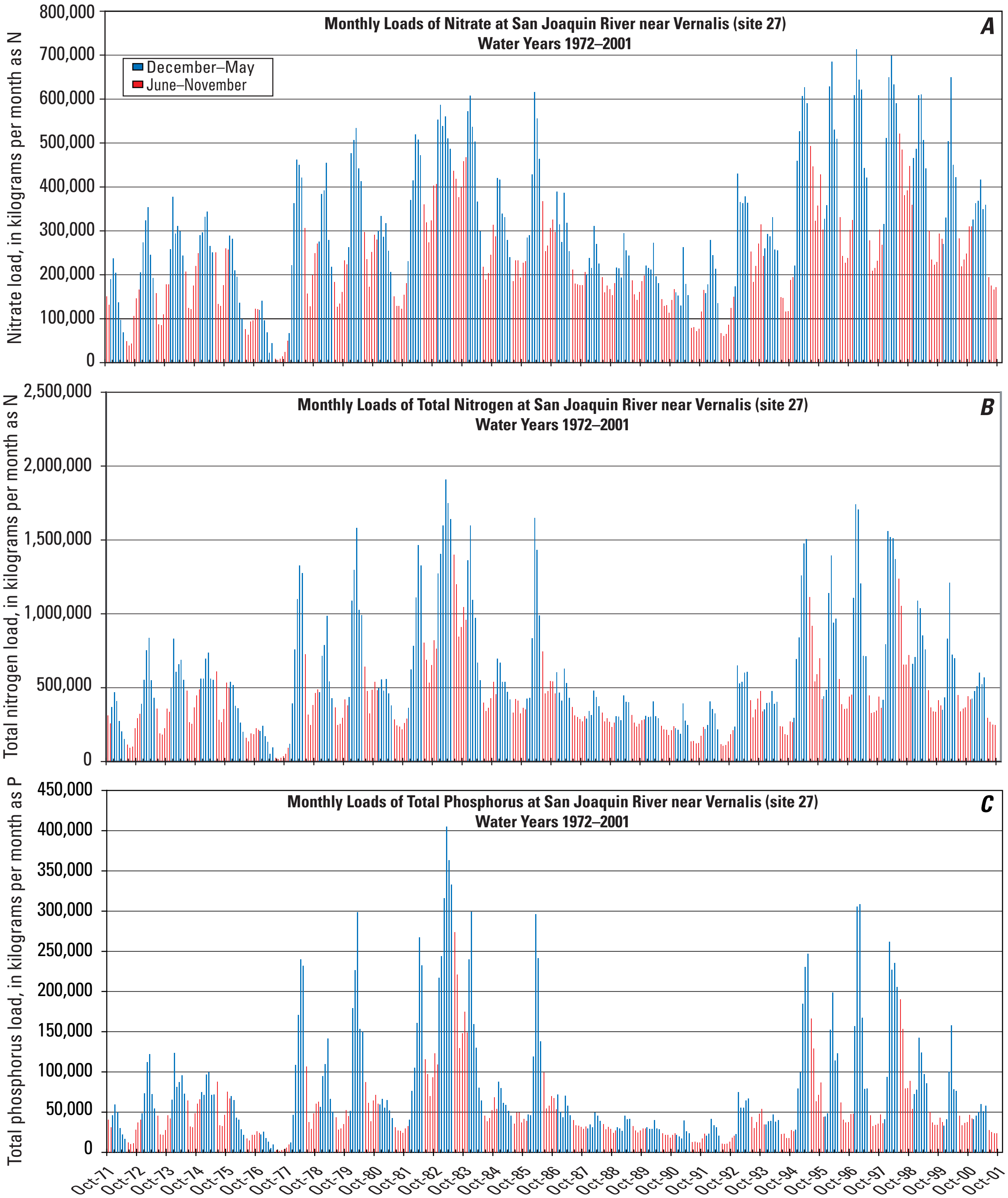

Figure 21. Monthly loads of nitrate, total nitrogen, and total phosphorus at San Joaquin River near Vernalis, California, 1972–2001 (calculated by ESTIMATOR).

(A) Nitrate, (B) Total nitrogen, (C) Total phosphorus. N, nitrogen; P, phosphorus.

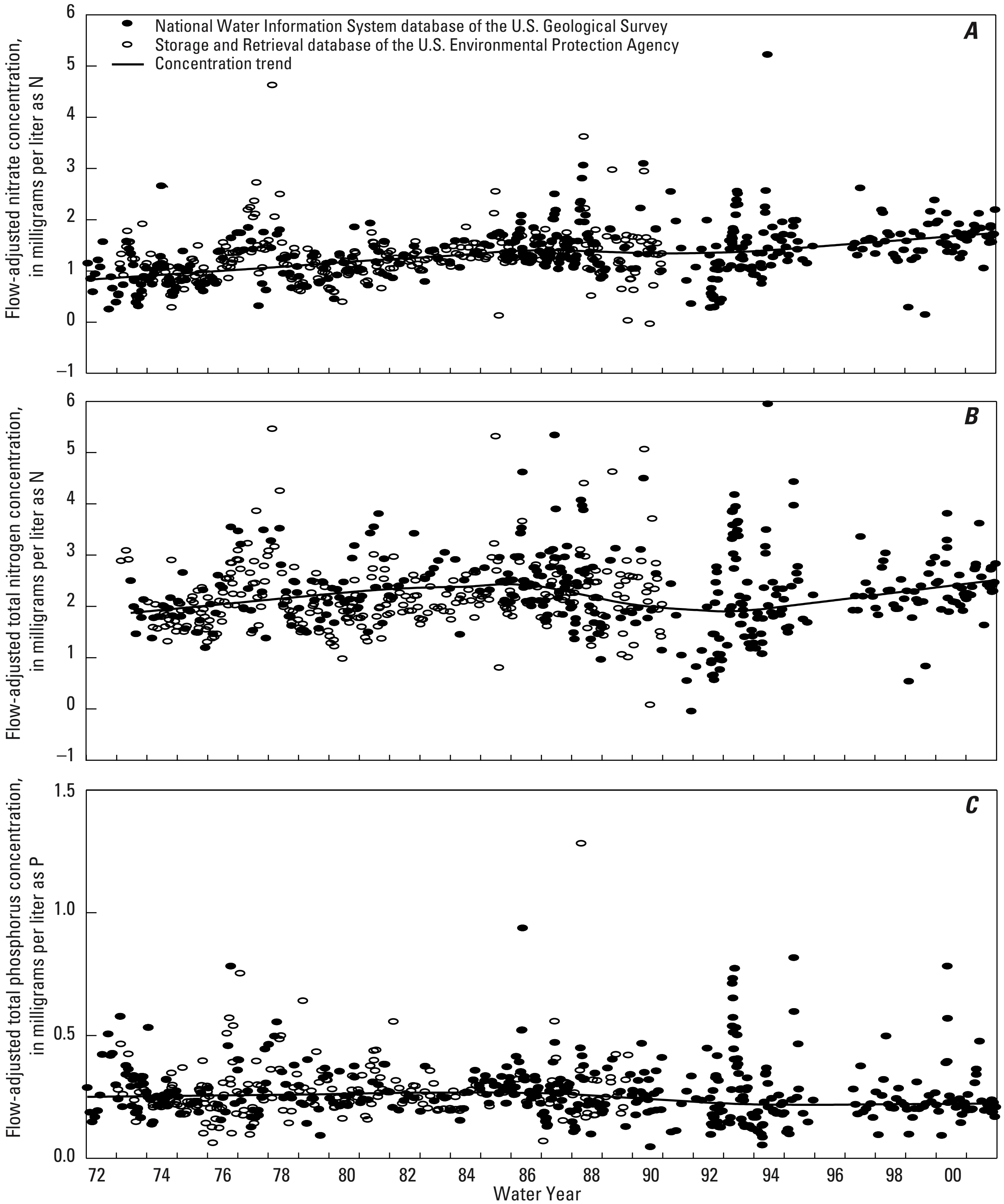

Figure 22. Flow-adjusted concentrations of nitrate, total nitrogen, and total phosphorus in the San Joaquin River near Vernalis, California, 1972–2001.

(A) Nitrate, (B) Total nitrogen, (C) Total phosphorus. N, nitrogen; P, phosphorus.

The monthly loads for nitrate, total nitrogen, and total phosphorus during the study period, 2000 and 2001, are compared with the long-term average for the previous 28 years (1972–99) in figure 23. The nitrate loads in 2000 were generally higher than the long-term average, while the 2001 loads were usually close to the average. Loads of total nitrogen in 2000 were slightly above the long-term average and 2001 loads were slightly below the average. Except for March 2000, loads of total phosphorus in 2000 and 2001 were below the long-term average. The average loads of nitrate, total nitrogen, and total phosphorus were generally lower during June through November than during the rest of the year (fig. 21).

Upstream-to-Downstream Loads in the San Joaquin River, 1986–88

The loads of nitrate, total nitrogen, and total phosphorus in the San Joaquin River were evaluated for the 1986–88 water years. These years were chosen because of the abundance of data available from a USGS monitoring program at that time. Eleven sites were monitored at least monthly during the three years. This provided enough data for the ESTIMATOR program to calculate loads for the eleven sites. The annual results of loads for the sites and summaries by five reaches of the San Joaquin River were presented in Kratzer and Shelton (1998); monthly results are presented here. Water year 1986 was classified as a wet year with an index value of 4.31 million acre-feet; water years 1987 and 1988 were both critically dry years with index values of 1.86 and 1.48 million acre-feet, respectively. The average index value for the three years, 2.55 million acre-feet, is well below the average index value for the 1972–2001 period of 3.33 million acre-feet. Thus, the 1986–88 period was relatively drier than normal overall. The annual loads of nitrate, total nitrogen, and total phosphorus in 1986 were in the highest third of loads for the 1972–2001 period; loads for 1987 were in the middle third; and loads for 1988 were in the lowest third.

Nitrate loads in the San Joaquin River for 1986–88 are shown in figures 24A–E by river reach. Loads were calculated for six mainstem sites: SJR near Stevinson (site 1; fig. 2), SJR at Fremont Ford Bridge (site 3; fig. 2), SJR near Newman (site 10; fig. 2), SJR near Patterson (site 15; fig. 2), SJR at Maze Road (site 24; fig. 2), and SJR near Vernalis (site 27; fig. 2). These mainstem sites allow us to look at loads in five reaches of the San Joaquin River and evaluate unaccounted loads. Positive unaccounted loads are inputs in the reach that are not accounted for by the site(s) that have calculated loads. As of the late 1980s, there were at least 104 agricultural discharges to the San Joaquin River in the study area (James and others, 1989). Negative unaccounted loads are outputs from the San Joaquin River in the reach. As of the late 1980s, there were at least 86 agricultural diversions from the San Joaquin River in the study area (James and others, 1989). The two largest diversions (Patterson Irrigation District and West Stanislaus Irrigation District, sites 16 and 19; fig. 2) accounted for about 40 percent of the total diversions in the study area (Kratzer and others, 1987; Quinn and Tulloch, 2002).

Salt Slough and Mud Slough accounted for most of the nitrate inputs to the San Joaquin River between Stevinson and Newman (fig. 24). The occasionally significant negative unaccounted load in February through April is probably more a function of load calculation uncertainty than diversions from the San Joaquin River; diversions are relatively low at this time of year. The mainstem San Joaquin River sites at Fremont Ford Bridge, Newman, Patterson, and Maze Road had seasonal patterns of nitrate loads with maximum during spring and minimum during fall. The unaccounted loads from Newman to Maze Road are all positive, indicating that inputs to the San Joaquin River exceeded diversions, despite the two large diversions in this reach—Patterson Irrigation District and West Stanislaus Irrigation District. The inputs from the three major east-side tributaries were generally small relative to loads in the San Joaquin River. The most significant unaccounted nitrate inputs in this reach are probably Orestimba Creek, Spanish Grant Drain, Harding Drain, Del Puerto Creek, Hospital Creek, the City of Modesto wastewater treatment plant discharge, ground-water accretions, and several smaller agricultural discharges. Harding Drain includes the discharge from the City of Turlock wastewater treatment plant. The Modesto plant only discharges surface water to the San Joaquin River during the winter months.

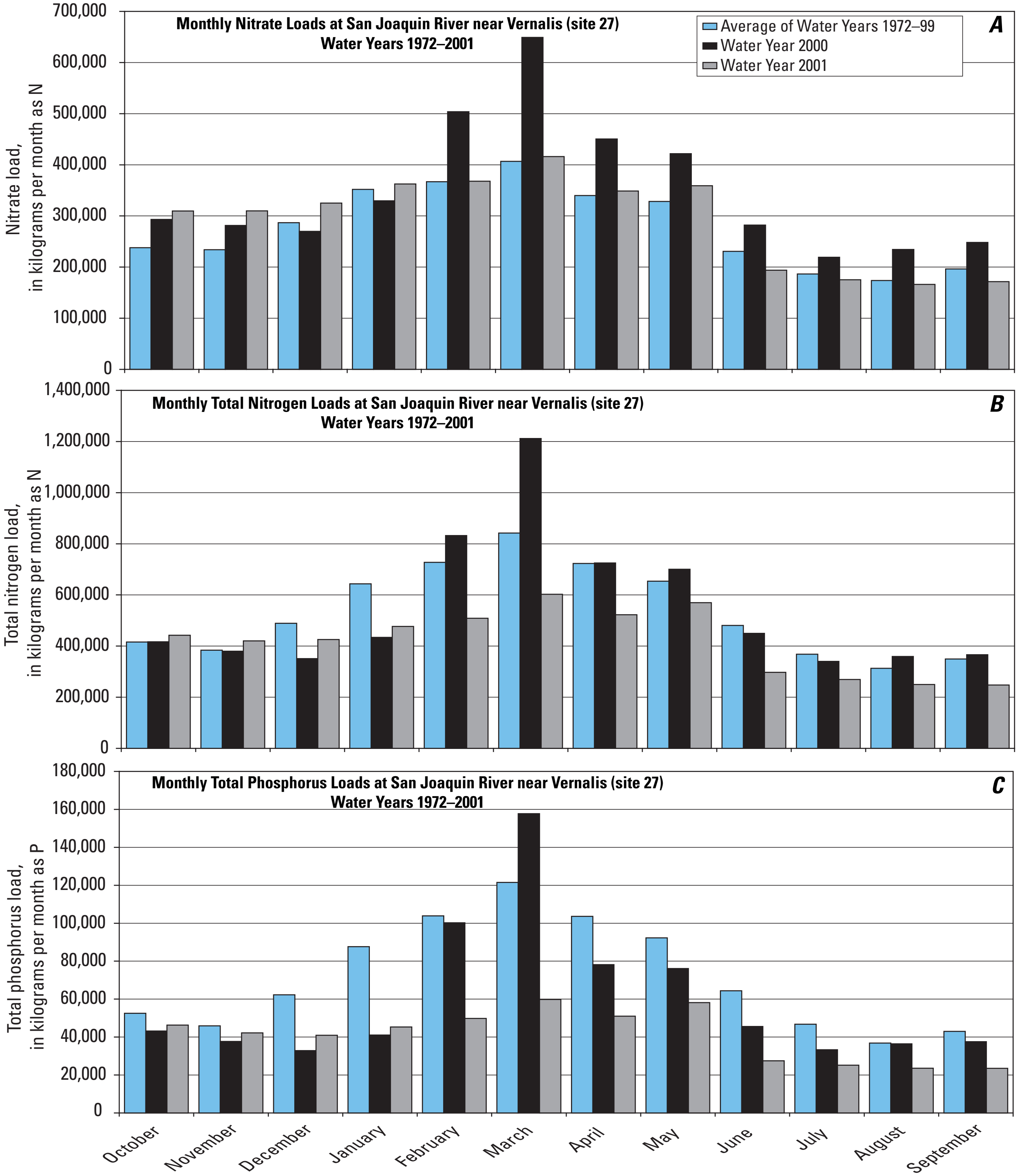

Figure 23. Monthly loads of nitrate, total nitrogen, and total phosphorus at San Joaquin River near Vernalis, California, for 1972–99 (average), 2000, and 2001.

(A) Nitrate, (B) Total nitrogen, (C) Total phosphorus. N, nitrogen; P, phosphorus.

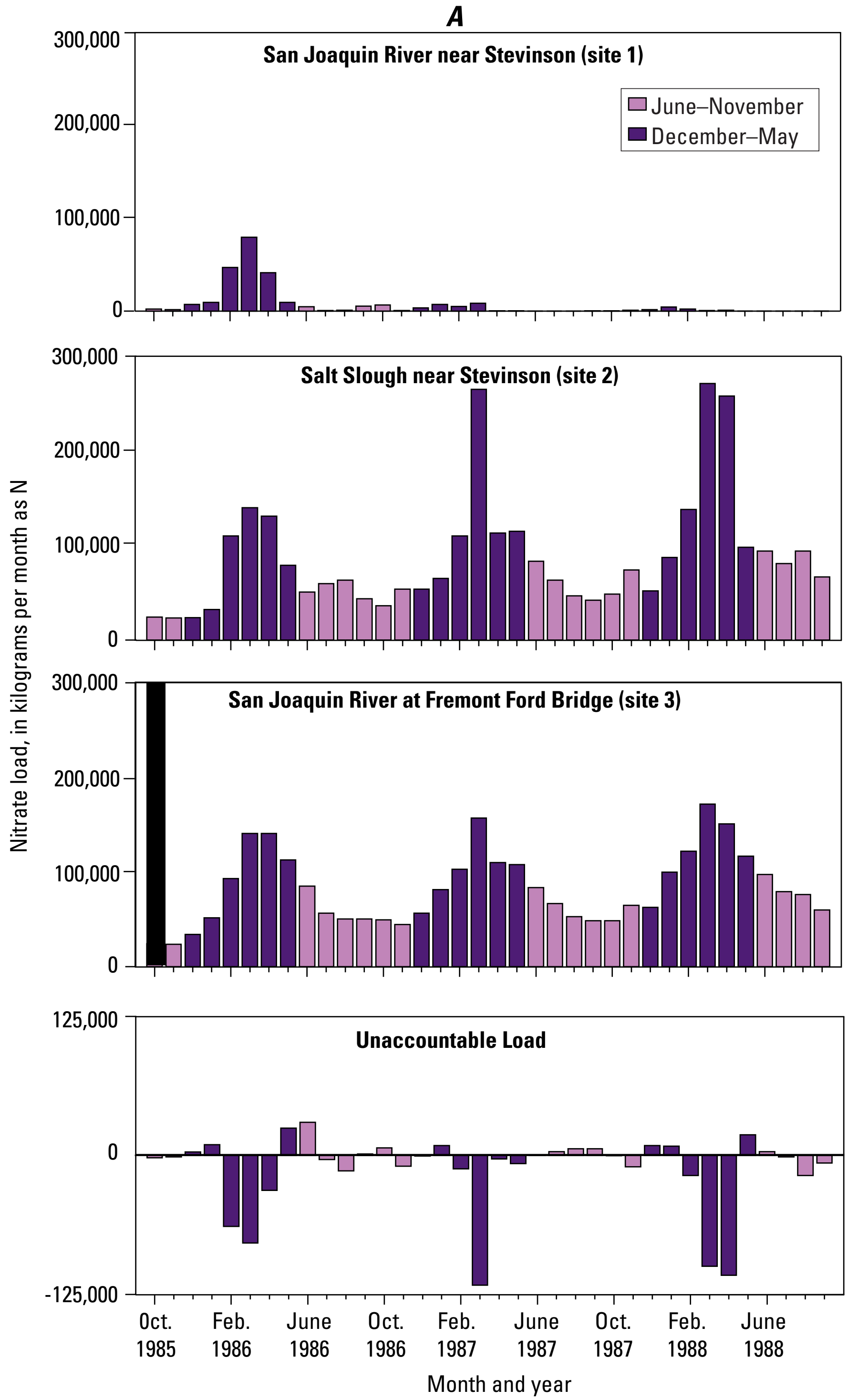

Figure 24. Monthly loads of nitrate at sites in the San Joaquin River, California, upstream to downstream for water years 1986–88.

(A) Stevinson (site 1) to Fremont Ford Bridge (site 3).

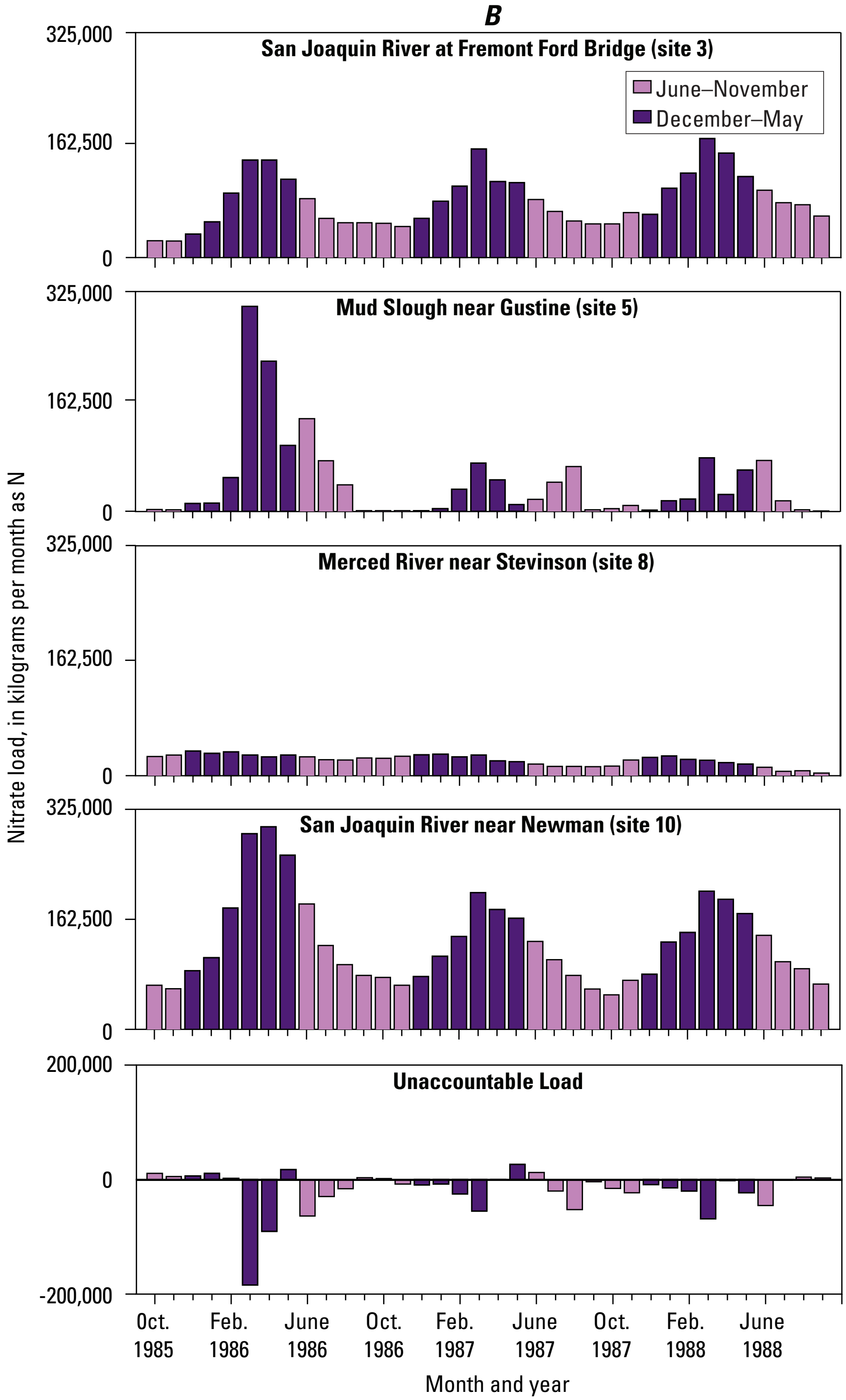

Figure 24.—*Continued.* (B) Fremont Ford Bridge (site 3) to Newman (site 10).

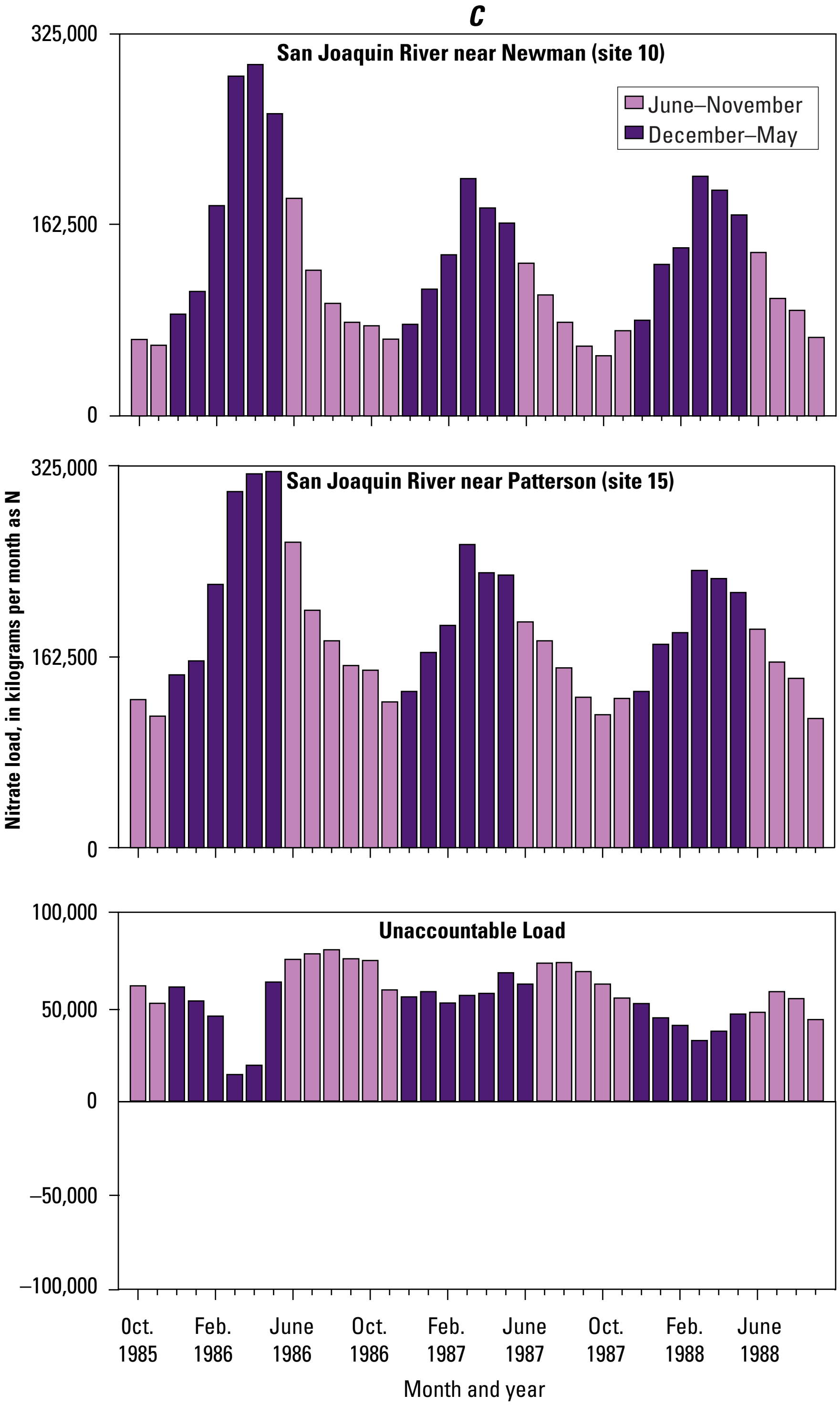

Figure 24.—*Continued.* (C) Newman (site 10) to Patterson (site 15).

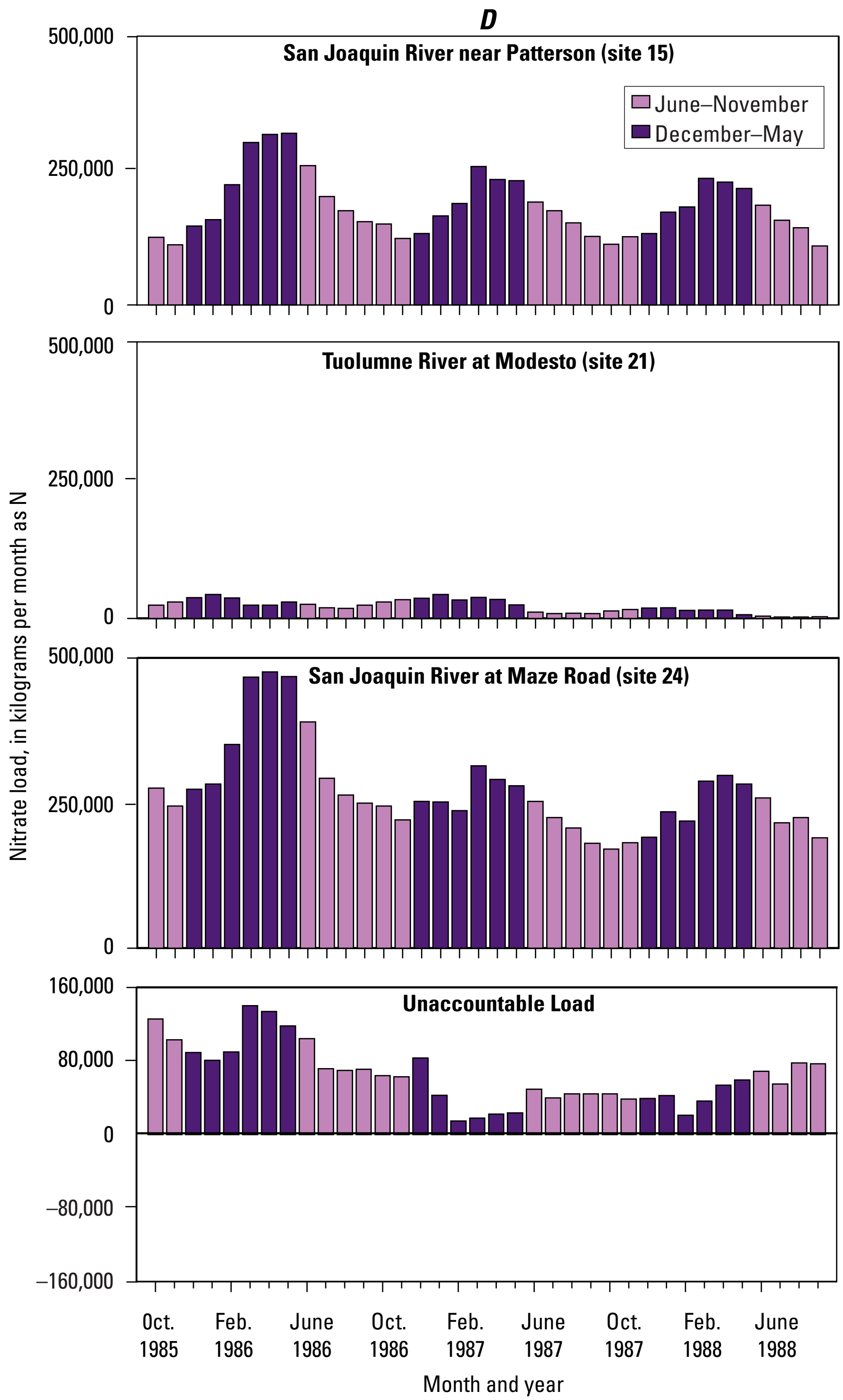

Figure 24.—*Continued.* (D) Patterson (site 15) to Maze Road (site 24).

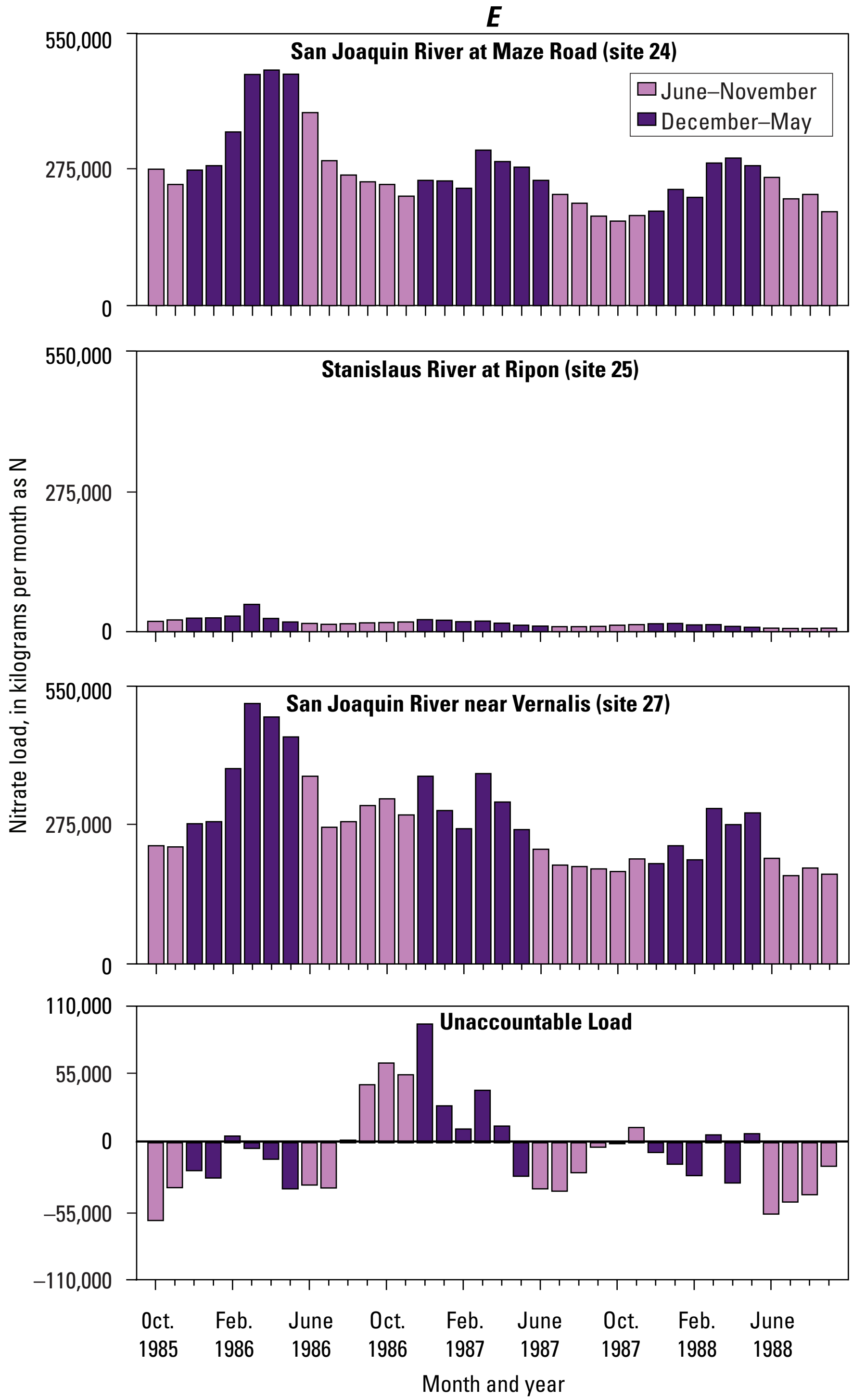

Figure 24.—*Continued.* (E) Maze Road (site 24) to Vernalis (site 27). N, nitrogen.

Loads of total nitrogen in the San Joaquin River for 1986–88 are shown in figures 25A-E by river reach. The load of nitrate in the San Joaquin River accounted for about 56 percent of the load of total nitrogen. Thus, it is not surprising that the pattern of loads of total nitrogen is similar to the pattern of loads of nitrate. However, although the loads of total nitrogen have the same seasonal pattern as nitrate, there is a greater range between the minimum and maximum loads, especially during a wet year (1986). This range is due to proportionately higher particulate nitrogen carried with higher streamflows. Thus, although the SJR near Stevinson site had a relatively small load of nitrate during the exceptionally wet spring of 1986, the load of total nitrogen was relatively large.

Loads of total phosphorus in the San Joaquin River for 1986–88 are shown in figures 26A-E by river reach. The pattern of loads of total phosphorus is similar to total nitrogen, except for the larger variation between water years and the reduced significance of Salt and Mud Sloughs. Because the total phosphorus in the San Joaquin River is about 56-percent particulate, it is very much affected by higher streamflows. This is reflected in the great difference between the loads in the wet year (1986) and the two dry years (1987–88). Also, because much of the source of nutrient load in the sloughs is tile drainage, and these tile drains have relatively low phosphorus concentrations compared with those of nitrogen, the contribution of total phosphorus from the sloughs is relatively low compared with the contributions of loads of nitrate and total nitrogen (Kratzer and Shelton, 1998).

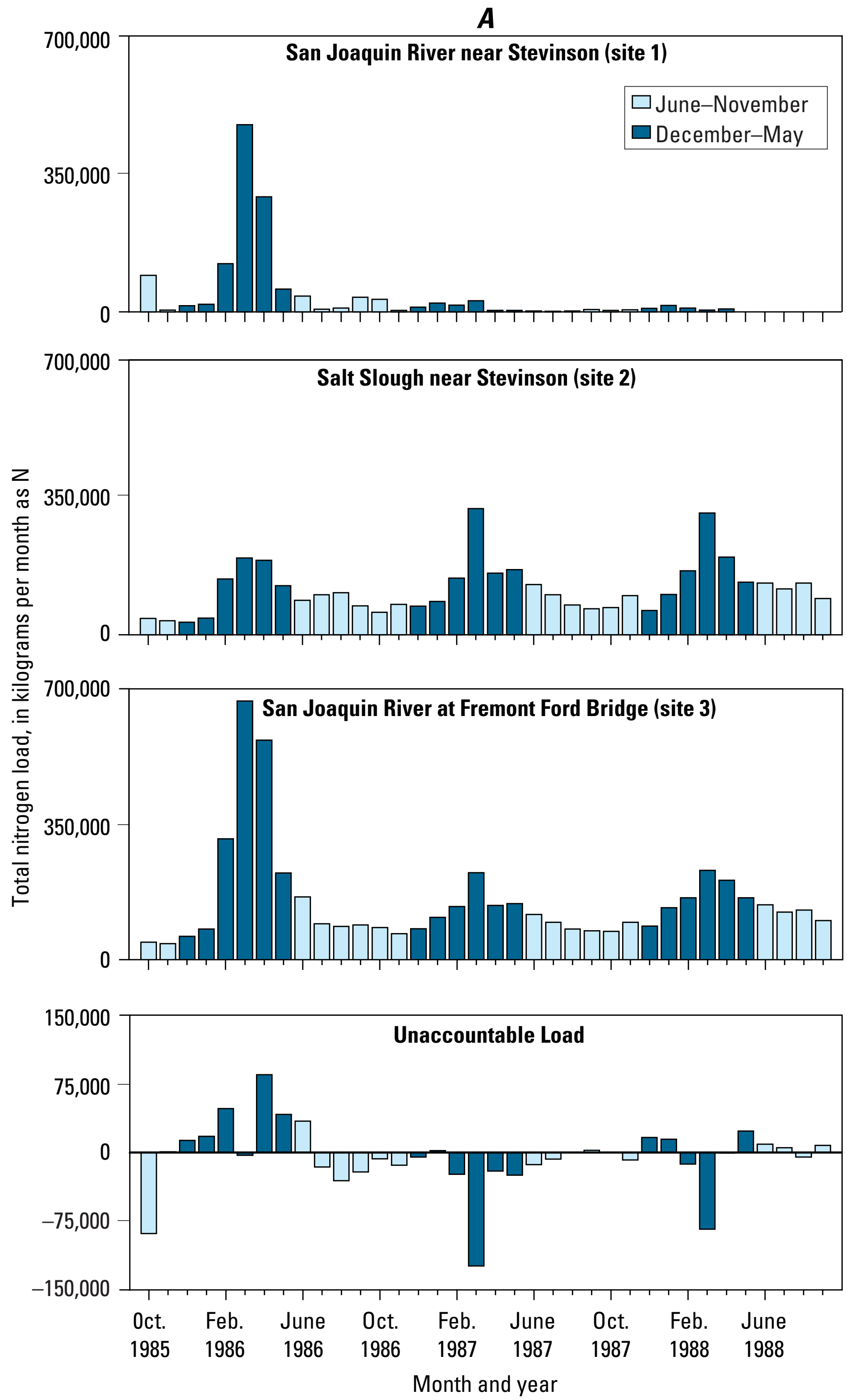

Figure 25. Monthly loads of total nitrogen at sites in the San Joaquin River, California, upstream to downstream for water years 1986–88.

(A) Stevinson (site 1) to Fremont Ford Bridge (site 3).

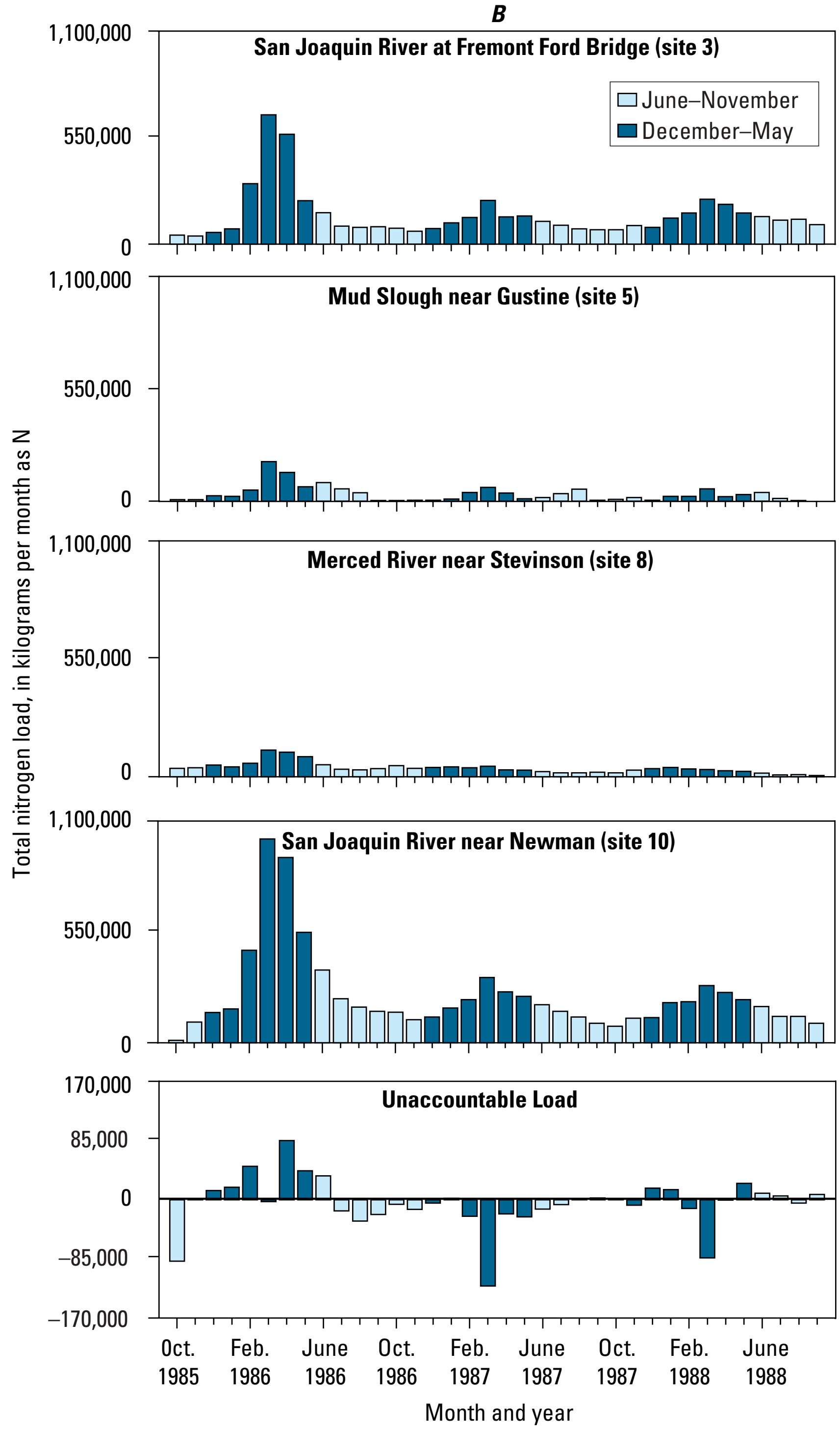

Figure 25.—*Continued.* (B) Fremont Ford Bridge (site 3) to Newman (site 10).

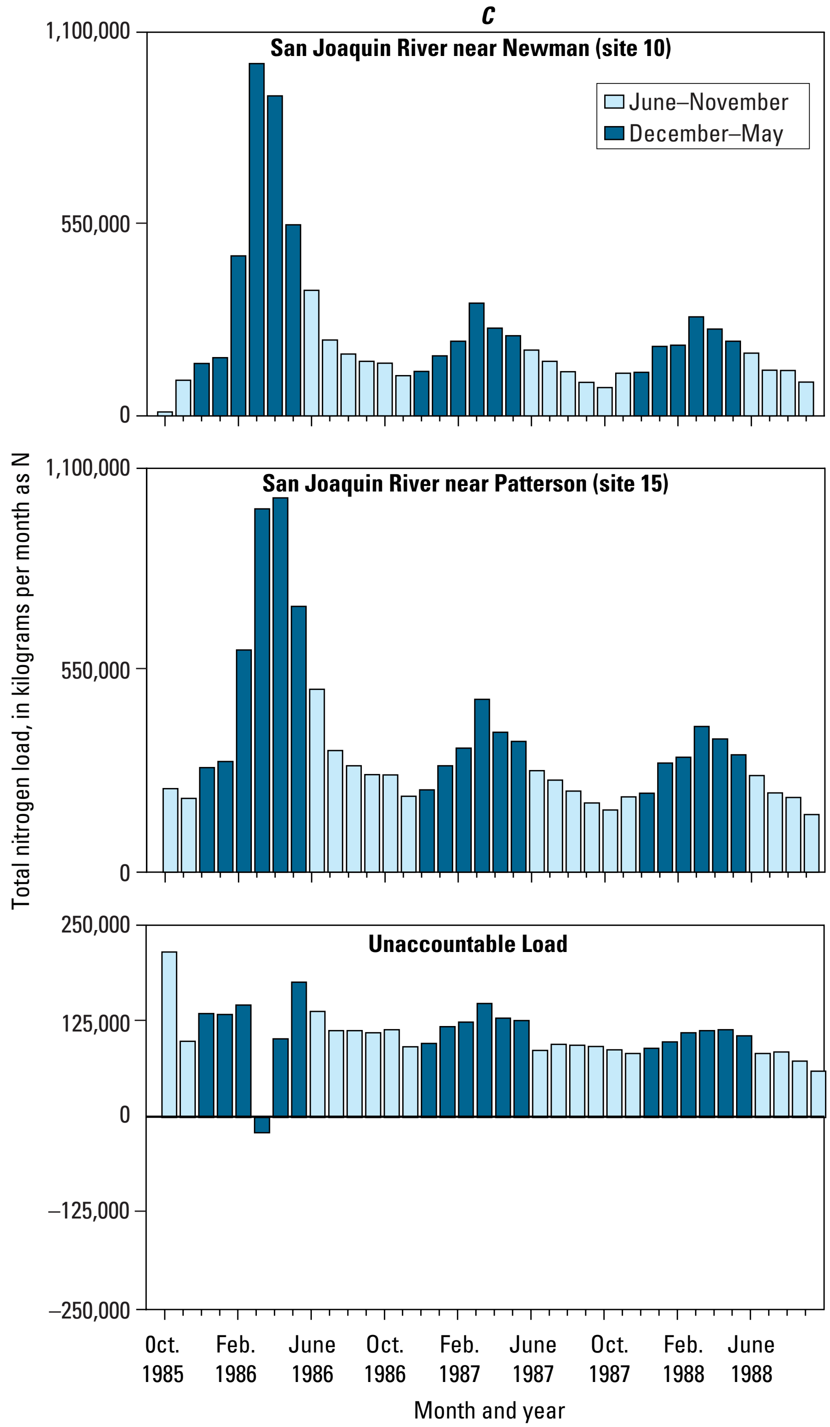

Figure 25.—*Continued.* (C) Newman (site 10) to Patterson (site 15).

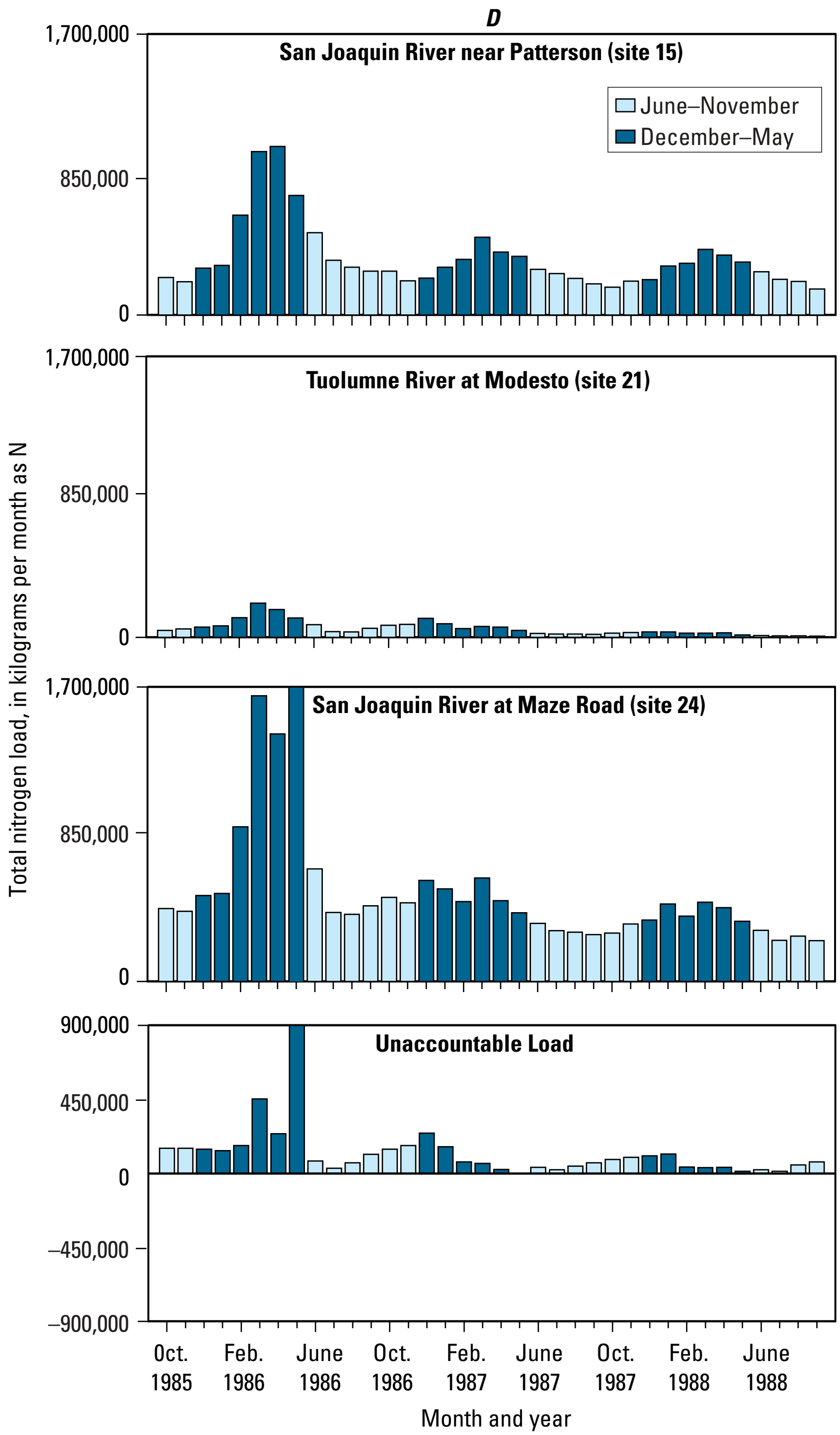

Figure 25.—*Continued.* (D) Patterson (site 15) to Maze Road (site 24).

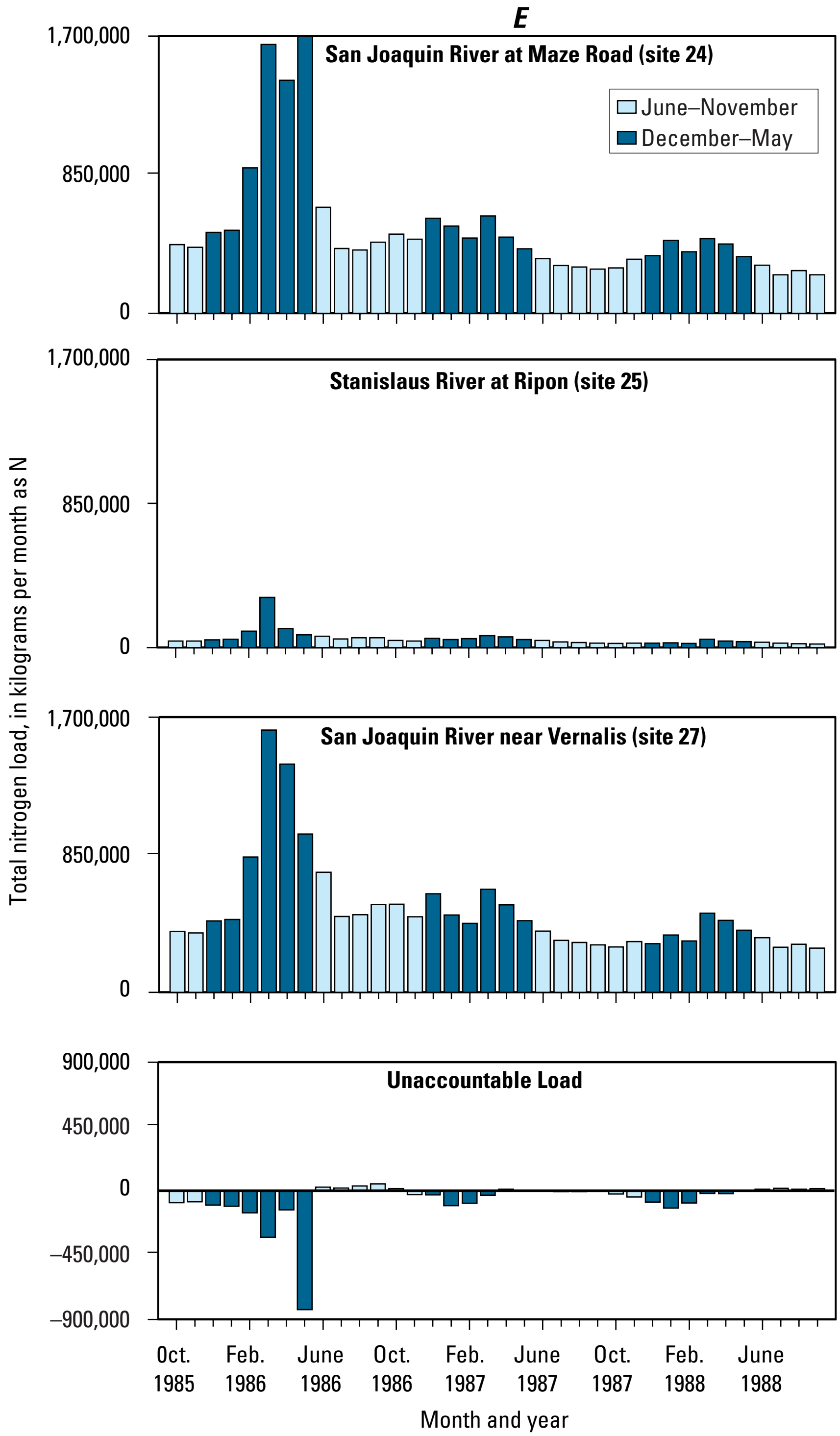

Figure 25.—*Continued.* (E) Maze Road (site 24) to Vernalis (site 27). N, nitrogen.

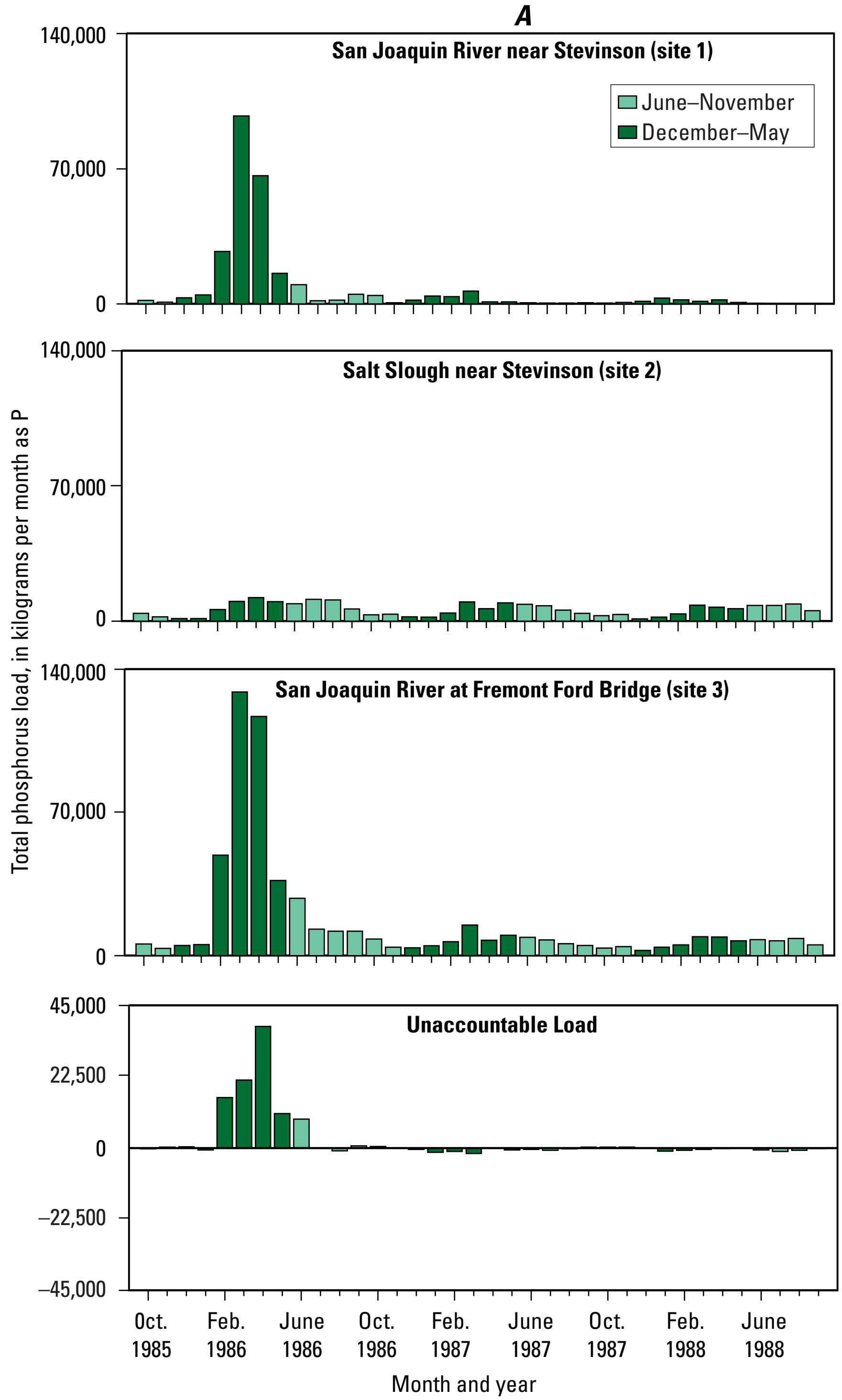

Figure 26. Monthly loads of total phosphorus at sites in the San Joaquin River, California, upstream to downstream for water years 1986–88.

(A) Stevinson (site 1) to Fremont Ford Bridge (site 3).

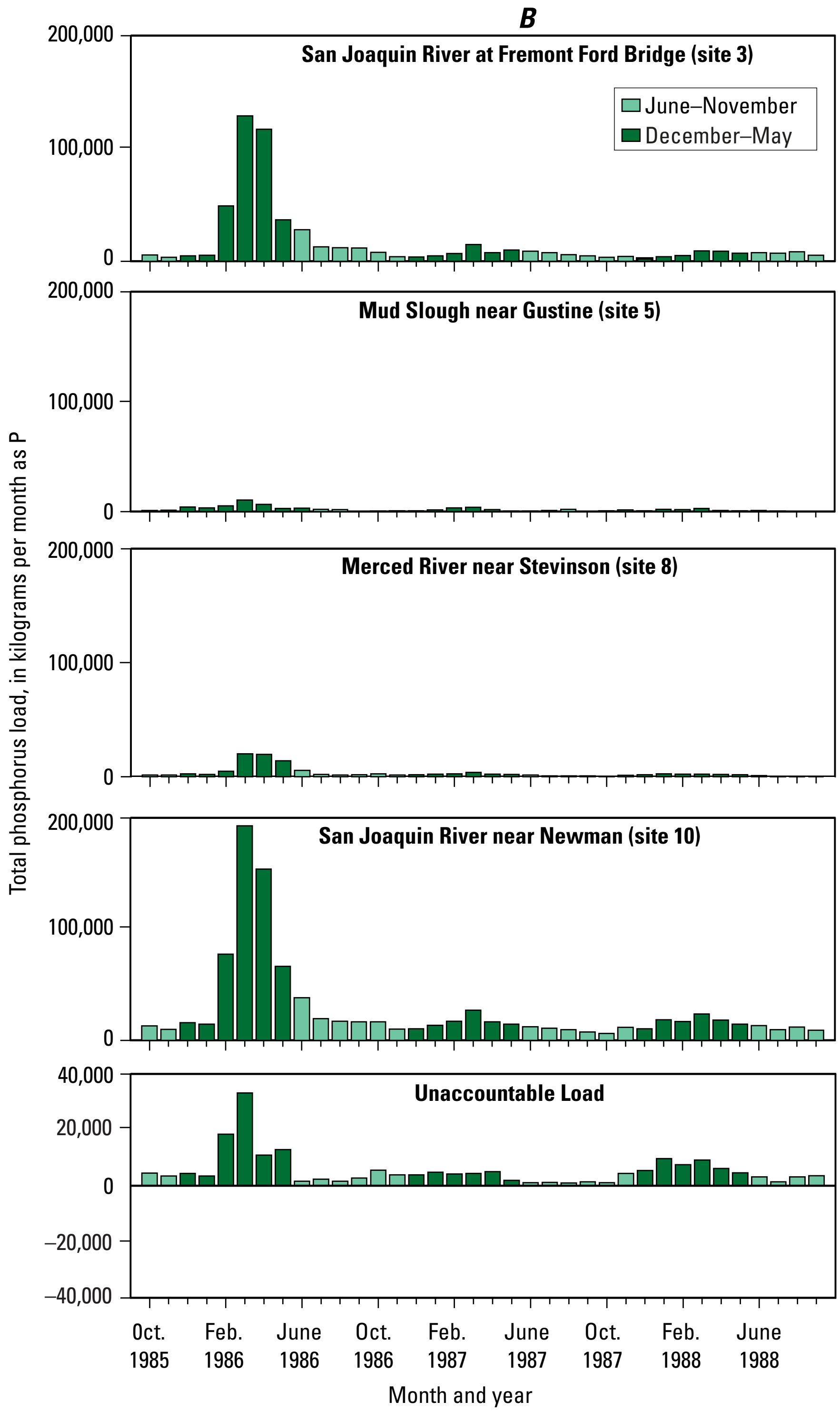

Figure 26.—*Continued.* (B) Fremont Ford Bridge (site 3) to Newman (site 10).

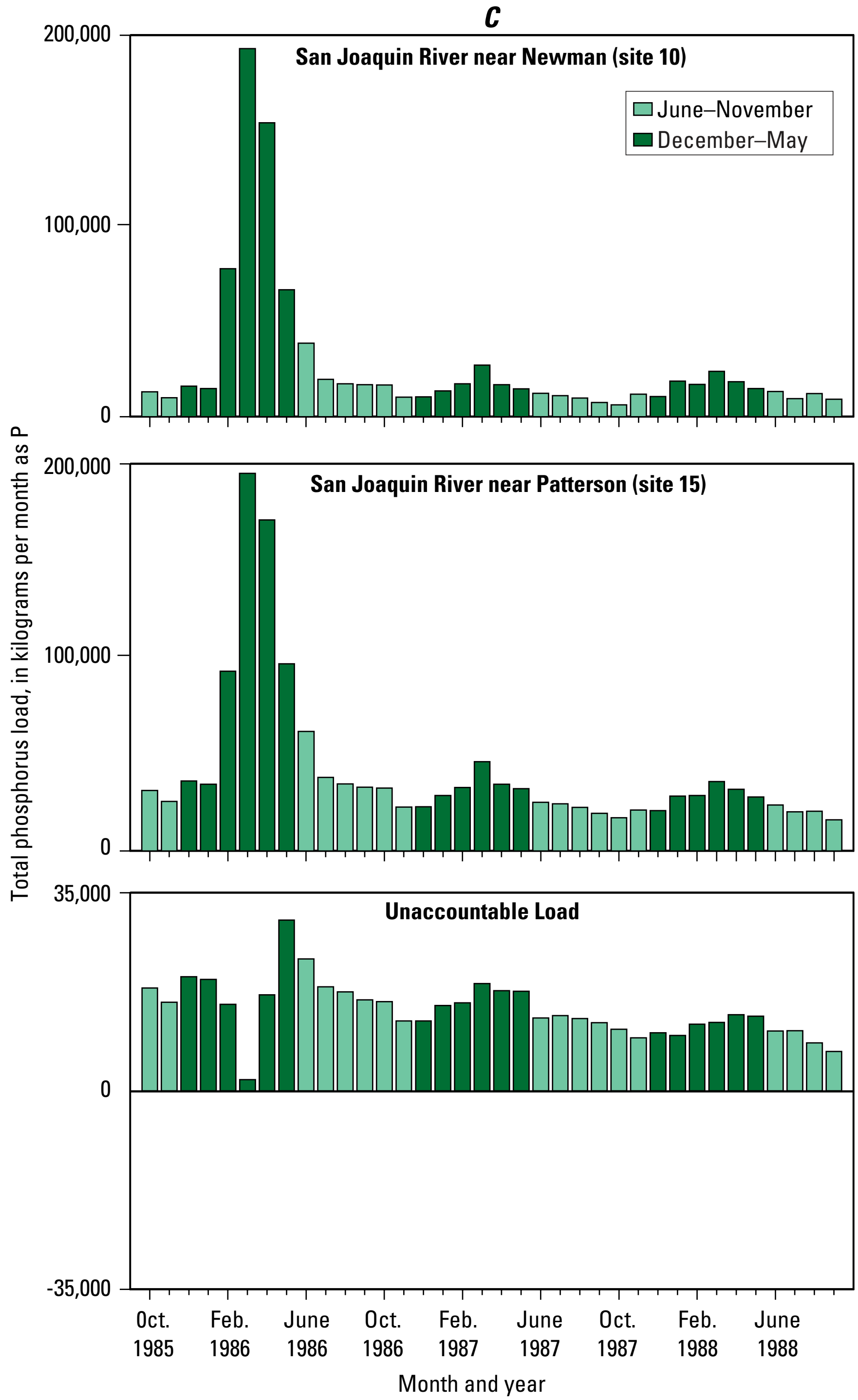

Figure 26.—*Continued.* (C) Newman (site 10) to Patterson (site 15).

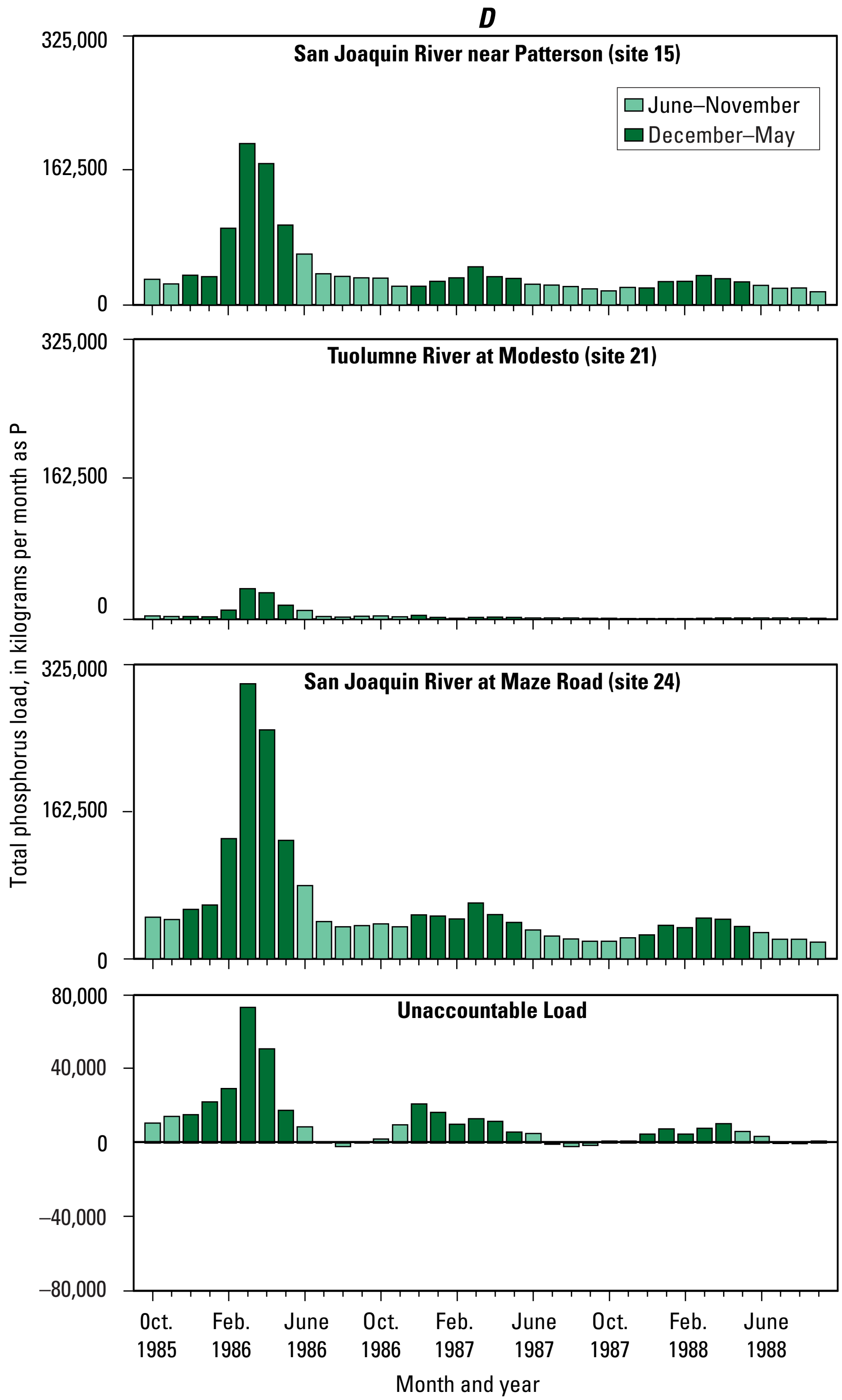

Figure 26.—*Continued.* (D) Patterson (site 15) to Maze Road (site 24).

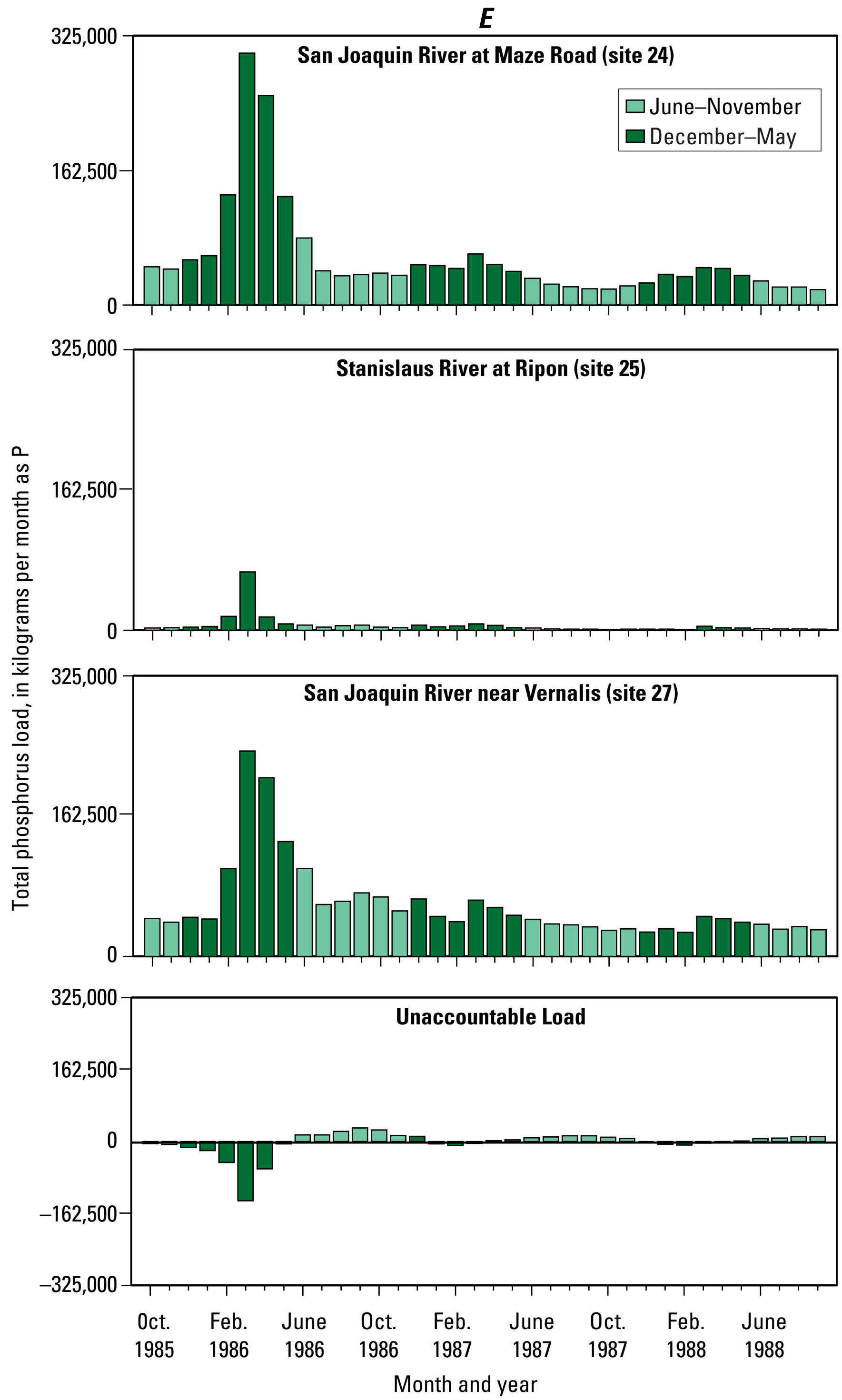

Figure 26.—*Continued.* (E) Maze Road (site 24) to Vernalis (site 27). P, phosphorus.

LOADING RATES OF NUTRIENTS, ORGANIC CARBON, AND CHLOROPHYLL-*A*

Instantaneous loading rates of nutrients, organic carbon, and chlorophyll-*a* were calculated for each sample that had a streamflow measurement. For samples having concentrations less than the laboratory reporting level, the concentration was set to half this level for the calculation of an instantaneous loading rate. Instead of using more robust methods to fit values to these samples, a simple substitution of half the reporting level produces less bias in the summary statistics for concentration at a site than the alternatives of zero or the reporting level (Helsel, 1990). It was beyond the scope of this study to evaluate the possibility of using more robust methods. The instantaneous loading rate for a sample was calculated as:

$$\text{Loading rate (kg/d)} = 2.447 \times \text{Streamflow (ft}^3\text{/s)} \times \text{Concentration (mg/L)}.$$

As with concentrations, the points representing instantaneous loading rates on figures were connected for sites to help show the trends in loading rates. This does not imply continuous trends in loading rates. Also, as for the plots of concentrations, streamflow for SJR near Vernalis is shown in each plot of loading rates to indicate streamflow variations in the entire basin. For streamflow at a given site, refer to figures 5 to 8.

Loading rates in tributaries are presented as a percent of the Vernalis loading rate. Because of the many diversions from the San Joaquin River during the irrigation season (primarily March through September), the loading rates are not simply presented as the loading rate divided by the Vernalis loading rate. To account for the removal of some of the load from the San Joaquin River before it reaches Vernalis, the following correction was applied to the loading rate in the tributary:

$$\text{Percentage of Vernalis loading rate} = 100 \times [(\text{tributary loading rate} \times \text{load factor})/\text{Vernalis loading rate}]$$

where,

load factor = (Vernalis streamflow - diversions from SJR downstream from tributary)/Vernalis streamflow.

Thus, tributaries farther upstream have a proportionately lower impact on Vernalis loads than tributaries farther downstream. The diversions are based on values used in DWR's DSM2-SJR model for river reaches in a prototypical dry water year (1985) (Quinn and Tulloch, 2002), with values for the same water year (1985) for specific diversions between reaches (Kratzer and others, 1987). The 1985 conditions are more representative of water years 2000 and 2001 than the alternatives of 1989 (critically dry) or 1986 (wet).

Nitrogen

Because nitrate is the dominant form of nitrogen in the San Joaquin River system, it explains most of the trends in nitrogen. Nitrogen loading rates at the SJR upstream of Merced River generally decreased throughout the sampling period, except for a slight increase in October (for 2000 and 2001) and November (for 2001) (figs. 27 and 28). Loading rates at SJR near Crows Landing, Patterson, and Laird Park decreased in September for both 2000 and 2001. This reduction corresponded to the end of irrigation season and reduced agricultural drainage from Mud and Salt Sloughs and other agricultural drainage inputs. The loading rates at SJR near Crows Landing and at Laird Park increased in October 2001 with the VAMP-related reservoir releases on the Merced River and wetland releases into Mud Slough. Loading rates at Maze Road and SJR near Vernalis were relatively stable throughout the sampling period of both years.

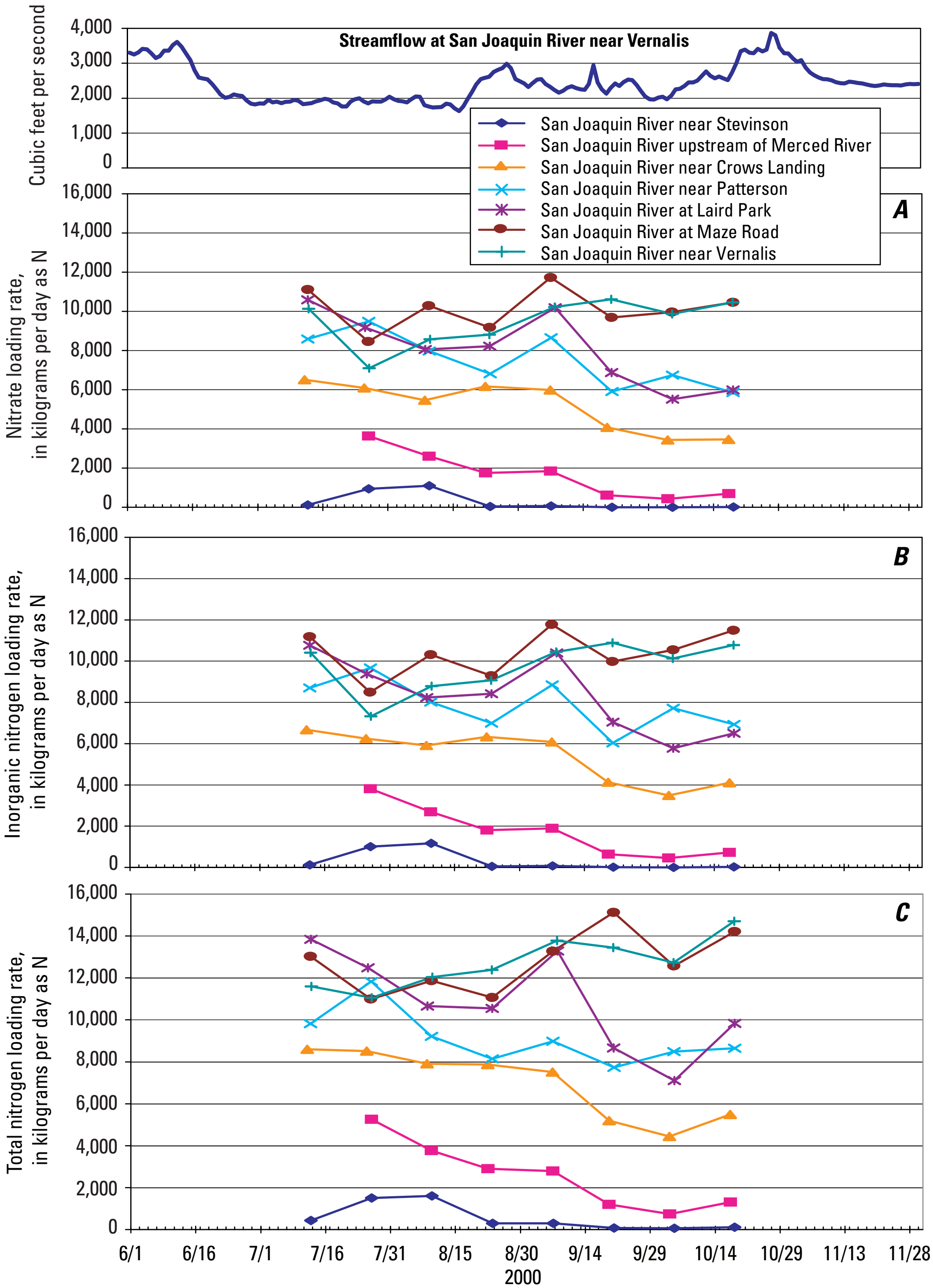

Figure 27. Instantaneous loading rates of nitrate, inorganic nitrogen, and total nitrogen at San Joaquin River sites from upstream to downstream for July through October 2000, with streamflow at Vernalis, California.

(A) Nitrate, (B) Inorganic nitrogen, and (C) Total nitrogen. N, nitrogen.

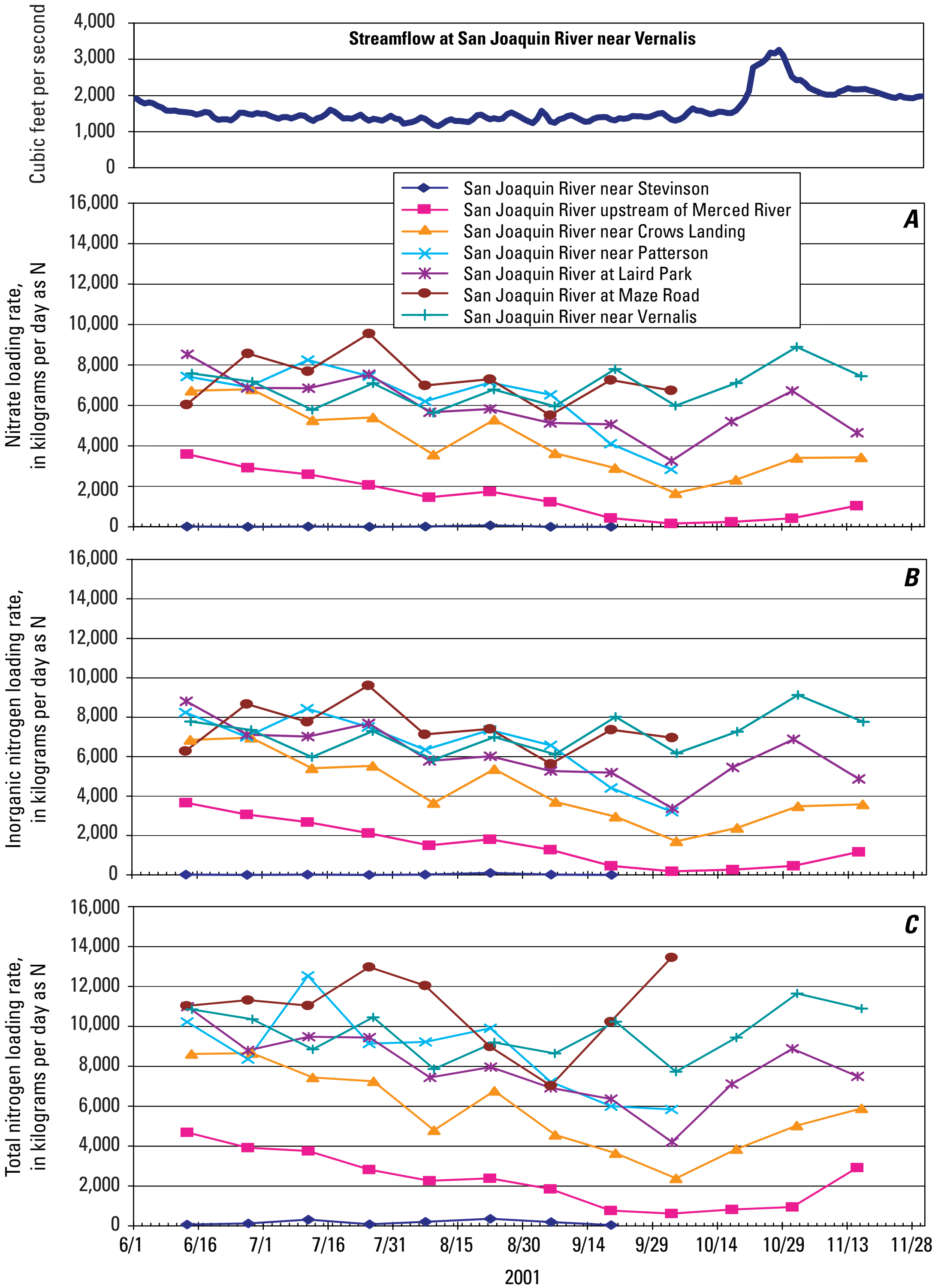

Figure 28. Instantaneous loading rates of nitrate, inorganic nitrogen, and total nitrogen at San Joaquin River sites from upstream to downstream for June through November 2001, with streamflow at Vernalis, California.

(A) Nitrate, (B) Inorganic nitrogen, and (C) Total nitrogen. N, nitrogen.

Much of the upstream-to-downstream trends in loading rates can be explained simply by the increase in streamflows from upstream to downstream (fig. 12). SJR near Stevinson had very low loading rates of nitrogen in both 2000 and 2001 sampling periods, despite some very high concentrations. The inputs from Mud and Salt Sloughs increased the loading rates from SJR near Stevinson to upstream of the Merced River. The input of the Merced River, as well as some small agricultural drains, increased loading rates at SJR near Crows Landing. Loading rates at SJR near Patterson and at Laird Park were greater than those at Crows Landing because of inputs from Harding Drain and agricultural drains. This increase was greatly affected by diversions, especially the Patterson Irrigation District diversion between Patterson and Laird Park. The trend in loading rates from Laird Park to SJR near Vernalis was very dependent upon diversions, especially the West Stanislaus Irrigation District. During that part of the sampling period that took place during the irrigation season, the diversions were often equal to or greater than discharges in this reach. Thus, sometimes the loading rate at SJR near Vernalis was actually less than that at Laird Park, despite inputs from the Tuolumne and Stanislaus Rivers. This situation changed in September when diversions were reduced, and the difference in loading rates at SJR near Vernalis versus loading rates at Laird Park reflected only the inputs between the sites.

The significance of tributary inputs as a percentage of the Vernalis loading rate is shown for 2000 and 2001 in figures 29 and 30. The most significant tributary sources of nitrogen were the Tuolumne River (13 to 23 percent of Vernalis), Harding Drain (5 to 27 percent), Mud Slough (3 to 20 percent), Salt Slough (1 to 17 percent), and the Merced River (3 to 13 percent). The Stanislaus River and Westport Drain also exceeded 10 percent of the Vernalis loading rate once each.

Phosphorus

Loading rates for orthophosphate and total phosphorus were fairly stable in 2000 and 2001 at SJR near Crows Landing and upstream until the wetlands releases into Mud Slough in October and November (figs. 31 and 32). Loading rates for orthophosphate at San Joaquin River sites downstream of Crows Landing were fairly stable in 2000 except for the rise in October. Loading rates for total phosphorus in 2000 at downstream sites were highly variable before the rise in October. Both orthophosphate and total phosphorus loading rates at downstream sites (except at Laird Park) were fairly stable in 2001 until the October and November rise.

As with nitrogen, SJR near Stevinson had very small loading rates of phosphorus. The trends in loading rates near Crows Landing are mostly explained by loading rates upstream of Merced River from Mud and Salt Sloughs. Phosphorus loading rates increased greatly from Crows Landing to Patterson with inputs from Harding Drain. Phosphorus loading rates at Laird Park were greater than near Patterson in 2000, except for orthophosphate in July and August. In 2001, phosphorus loading rates at Laird Park were less than near Patterson, except in June. These loading rates generally corresponded to the streamflows at the two sites (fig. 12). With lower streamflows in 2001, diversions from the San Joaquin River removed a greater proportion of the upstream load. Using the methodology described earlier in this section, the load factors during July through September 2000 for Laird Park were 0.76 to 0.94 compared with 0.68 to 0.89 in 2001. Loading rates for orthophosphate at SJR near Vernalis frequently were less than those at upstream sites, whereas loading rates for total phosphorus near Vernalis were almost always greater than those at upstream sites. These occurrences are partly a function of the particulate fraction of the phosphorus from the Tuolumne and Stanislaus Rivers (average 0.35) versus the particulate fraction at Laird Park (average 0.54).

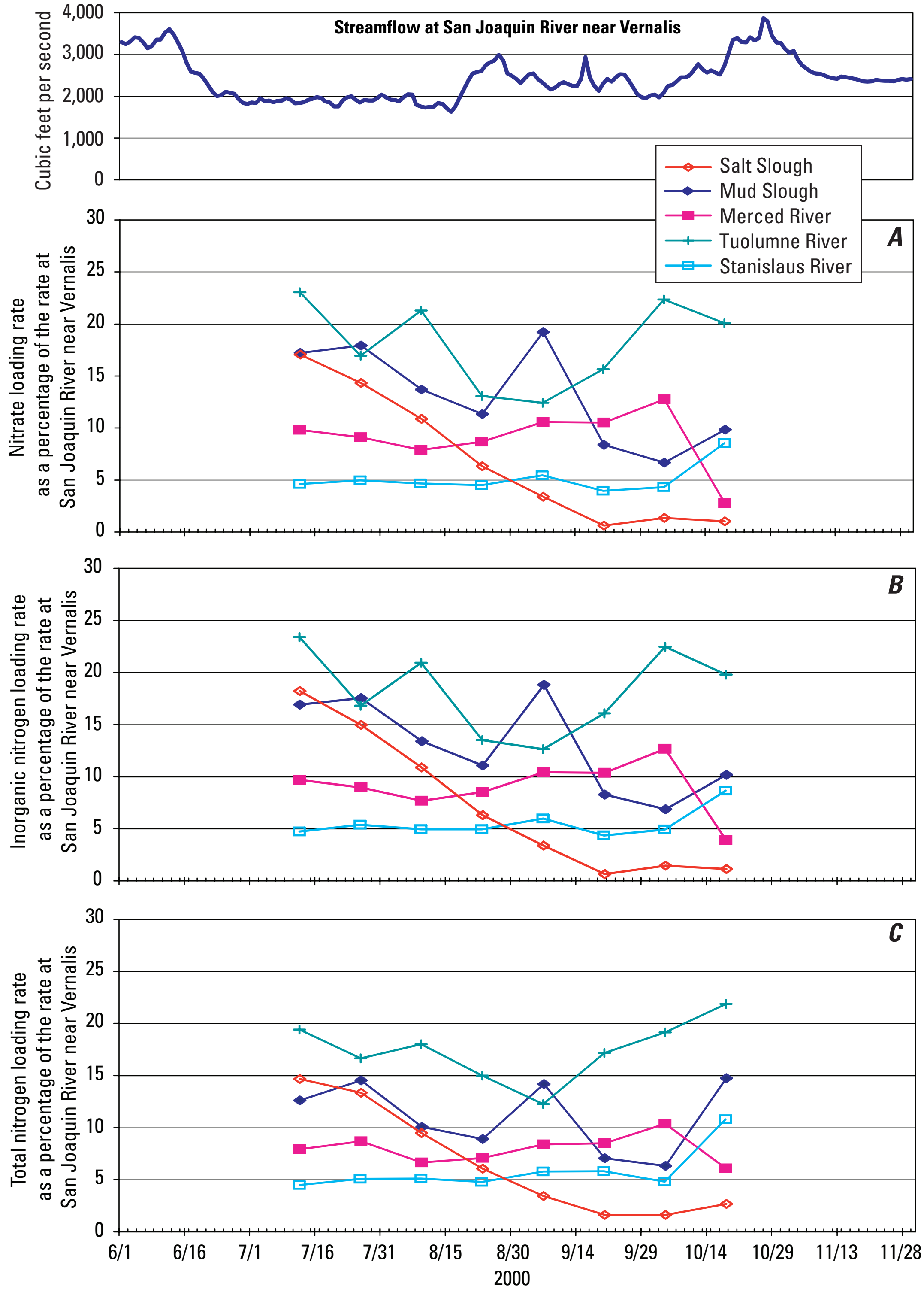

Figure 29. Instantaneous loading rates of nitrate, inorganic nitrogen, and total nitrogen in tributaries from upstream to downstream as a percentage of Vernalis loading rates for July through October 2000, with streamflow at Vernalis, California.

(A) Nitrate, (B) Inorganic nitrogen, and (C) Total nitrogen.

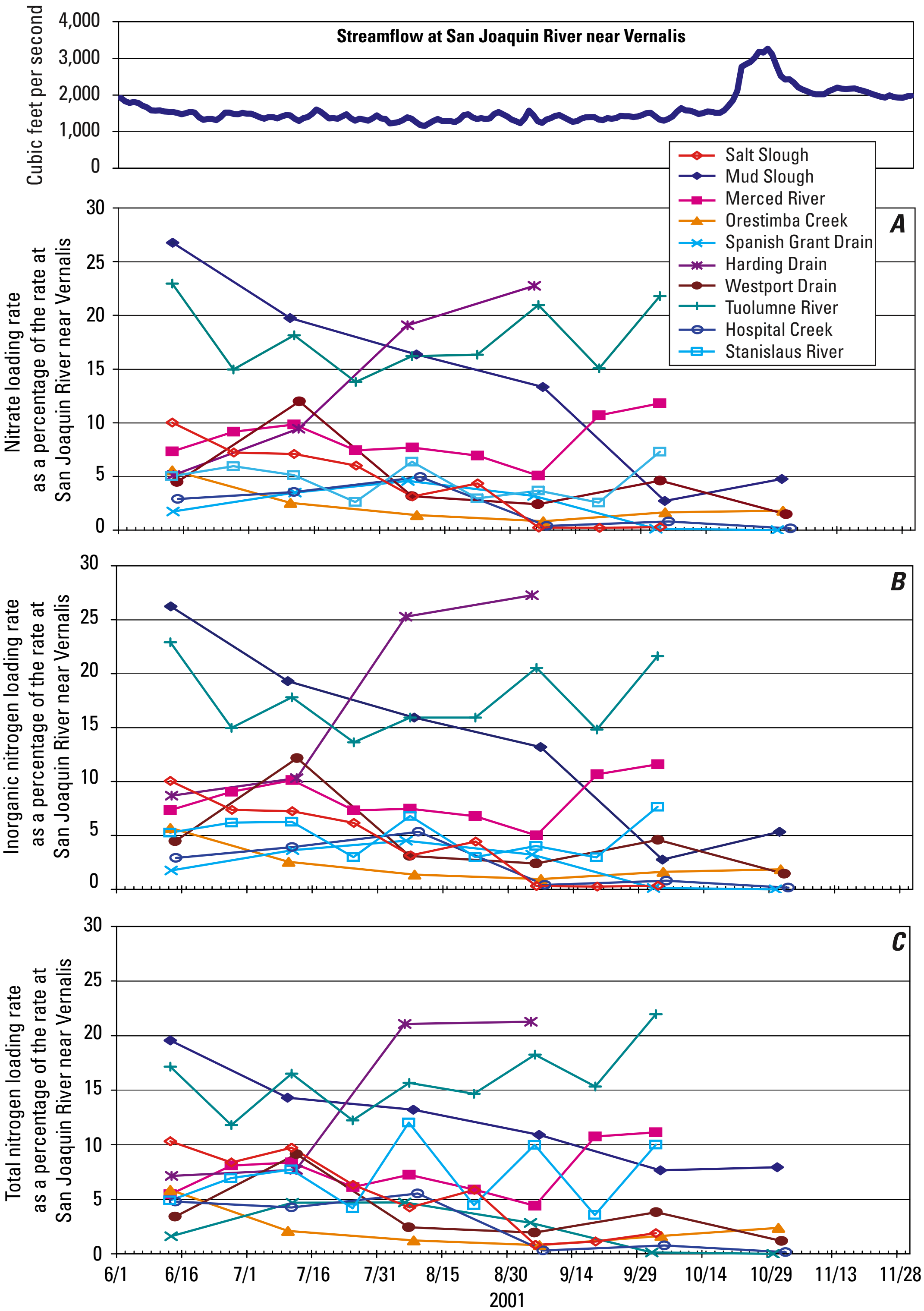

Figure 30. Instantaneous loading rates of nitrate, inorganic nitrogen, and total nitrogen in tributaries from upstream to downstream as a percentage of Vernalis loading rates for June through November 2001, with streamflow at Vernalis, California.

(A) Nitrate, (B) Inorganic nitrogen, and (C) Total nitrogen.

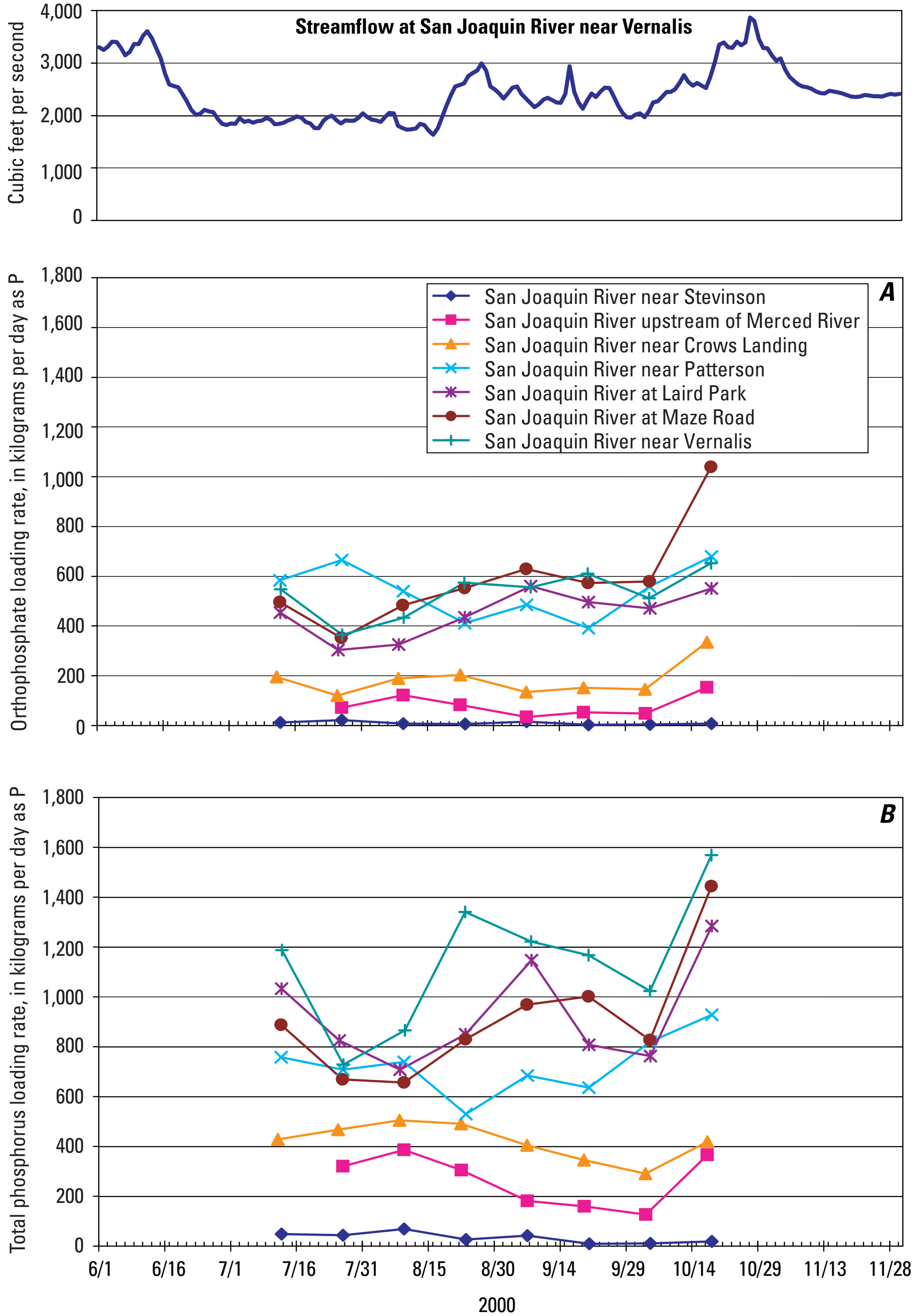

Figure 31. Instantaneous loading rates of orthophosphate and total phosphorus at San Joaquin River sites from upstream to downstream for July through October 2000, with streamflow at Vernalis, California.

(A) Orthophosphate, (B) Total phosphorus. P, phosphorus.

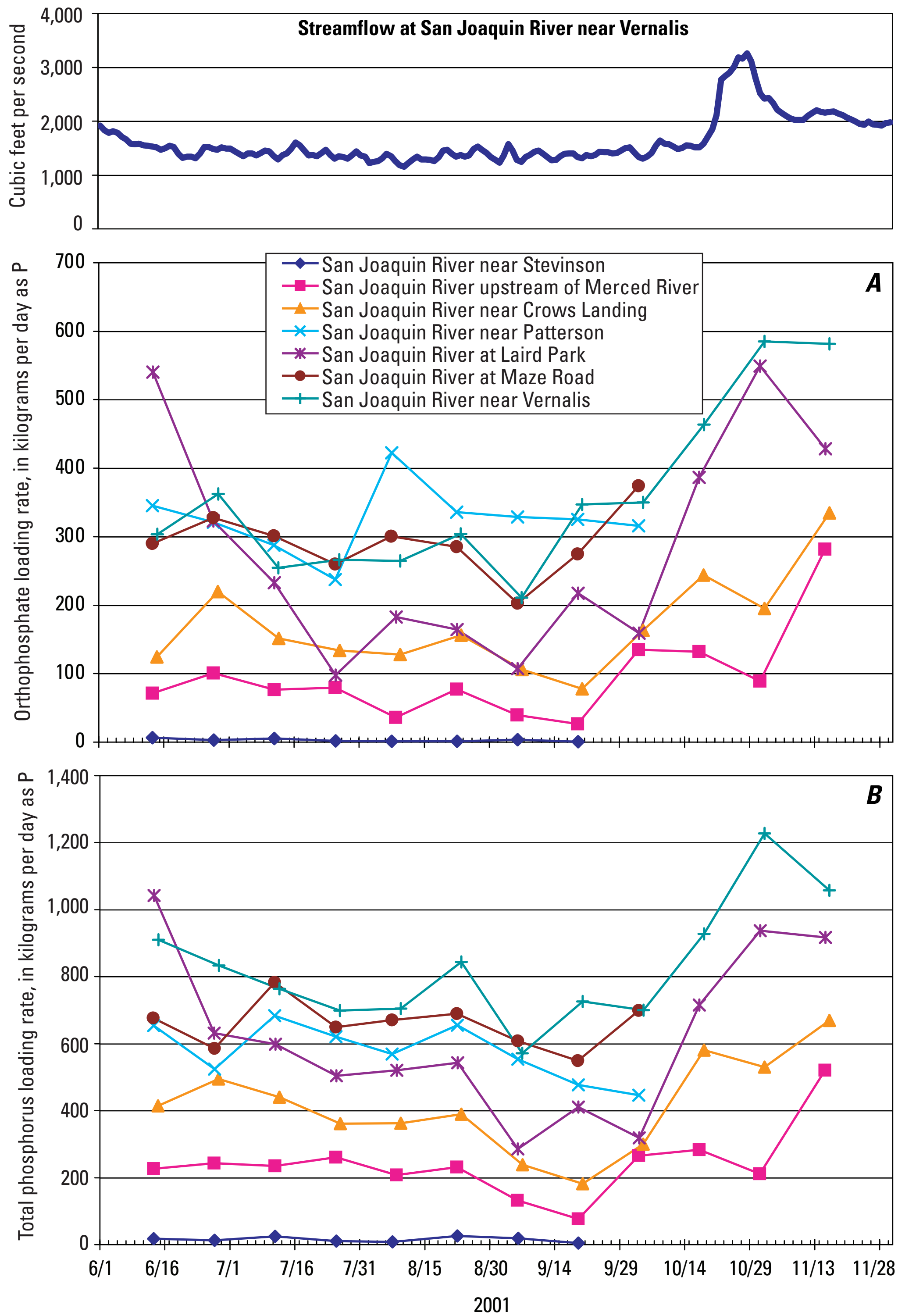

Figure 32. Instantaneous loading rates of orthophosphate and total phosphorus at San Joaquin River sites from upstream to downstream for June through November 2001, with streamflow at Vernalis, California.

(A) Orthophosphate, (B) Total phosphorus. P, phosphorus.

The significance of tributary inputs as a percentage of the Vernalis loading rate for 2000 and 2001 is shown in figures 33 and 34. The most significant sources of phosphorus were Harding Drain (8 to 76 percent of the Vernalis loading rate), Tuolumne River (9 to 51 percent), Mud Slough (0 to 60 percent), Stanislaus River (5 to 22 percent), and Salt Slough (1 to 21 percent). Mud Slough was the main source of phosphorus in the San Joaquin River in October both years (60 and 36 percent of orthophosphate loading rate) during wetland releases. Hospital Creek, which had a high suspended sediment concentration (3,460 mg/L), contributed 14 percent of the total phosphorus loading rate in June. Orestimba Creek, Spanish Grant Drain, Westport Drain, and the Merced River were always less than 10 percent of the phosphorus loading rate to the San Joaquin River. The total percentage of the Vernalis loading rate for the sampled sites in early September was over 150 percent, half coming from Harding Drain. This points out the nonconservative nature of orthophosphate. Much of this orthophosphate is undoubtedly incorporated into phytoplankton before reaching Vernalis.

Organic Carbon

The DOC loading rates at most San Joaquin River sites were fairly stable with a slight decrease from June and July through September (figs. 35 and 36). All San Joaquin River sites except Stevinson (site 1) increased in October and November with wetland releases and VAMP-related reservoir releases. The SOC loading rates at most San Joaquin River sites fluctuated only slightly during the sampling period, except for Laird Park in 2000 and Vernalis in 2001. Two SOC concentrations were responsible for the sharp peaks in loading rates: July 25, 2000 at Laird Park and August 9, 2001 near Vernalis. SOC is one of the more variable measurements and these values could be somewhat questionable. The median variability for 10 split replicates analyzed at NWQL was 14.4 percent, with a range of 0.0 to 86.4 percent (table 3). The July 25 sample at Laird Park had a concentration of 3.6 mg/L with a split replicate concentration of 3.0 mg/L.

As for nutrients, DOC loading rates at SJR near Stevinson were very low. The sloughs had a relatively large contribution to the DOC loading rates in the San Joaquin River, especially in October and November. In 2000, the DOC loading rates at SJR near Patterson were similar to the loading rates downstream at Laird Park. In 2001, the loading rates at SJR near Patterson were considerably greater than the loading rates at Laird Park. This was similar to streamflows (fig. 12) and was also a function of greater diversion impacts in 2001 with lower streamflows. DOC loading rates at SJR near Vernalis were similar to and usually slightly greater than at the Maze Road site. SOC loading rates at SJR near Vernalis were similar to Laird Park in 2000, but were considerably greater in 2001.

The most significant tributary sources of DOC in 2000 and 2001 were Salt Slough (4 to 45 percent of the Vernalis loading rate), Mud Slough (5 to 36 percent), Tuolumne River (12 to 31 percent), and Stanislaus River (6 to 24 percent) (figs. 37 and 38). Salt Slough was an important source early in the sampling period and Mud Slough late in the period. The Merced River was 28 percent of the Vernalis DOC loading rate for the mid-October sampling during the VAMP-related reservoir releases on the Merced. The major tributaries do not have SOC data, so only minor tributary sources are shown in figure 38. Hospital Creek contributed about 13 percent of the Vernalis SOC loading rate in June when the creek had a suspended sediment concentration of 3,460 mg/L. Mud Slough contributed about 17 percent of the SOC loading rate during wetland releases in October.

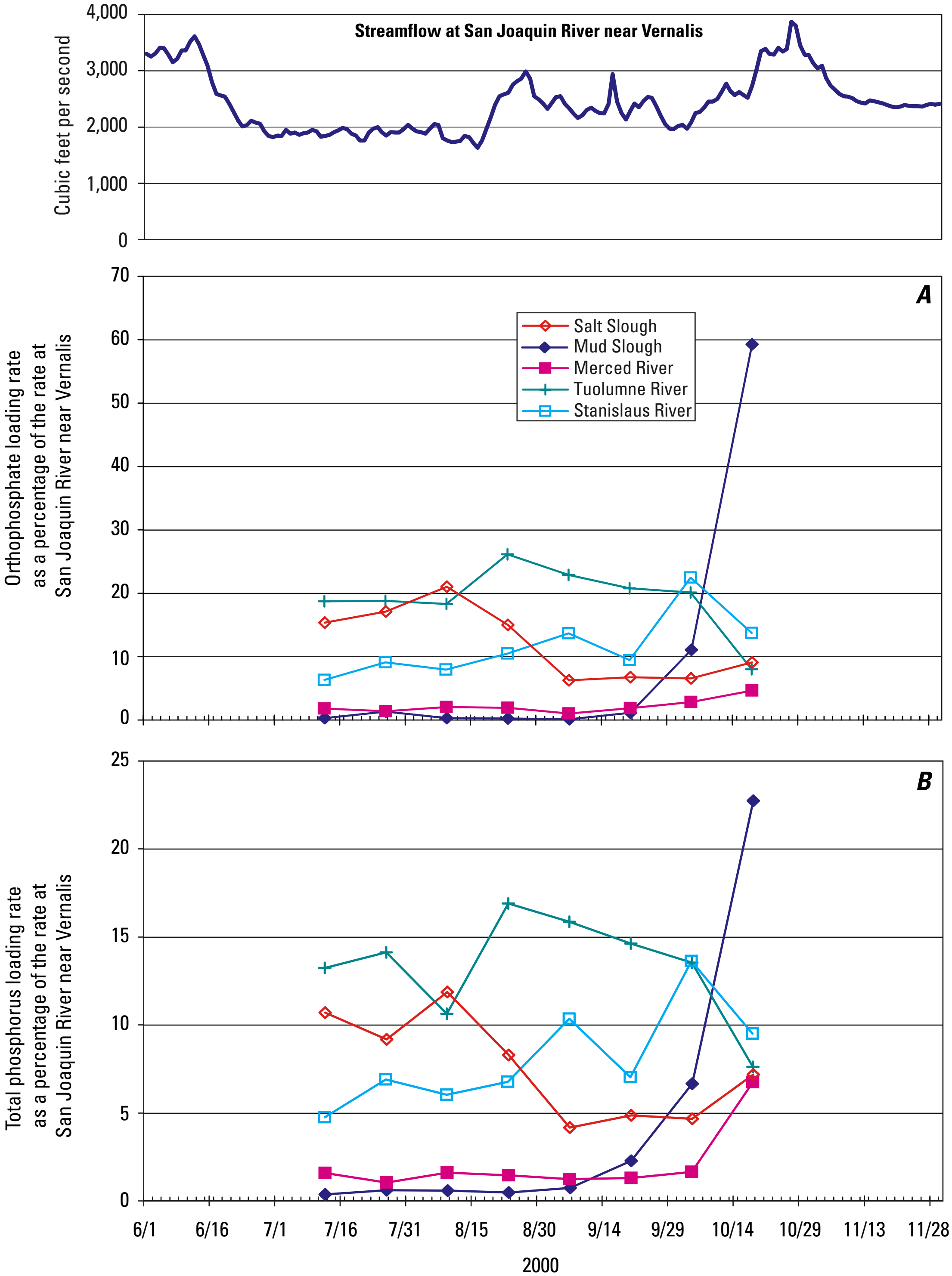

Figure 33. Instantaneous loading rates of orthophosphate and total phosphorus in tributaries from upstream to downstream as a percentage of Vernalis loading rates for July through October 2000, with streamflow at Vernalis, California.

(A) Orthophosphate, (B) Total phosphorus.

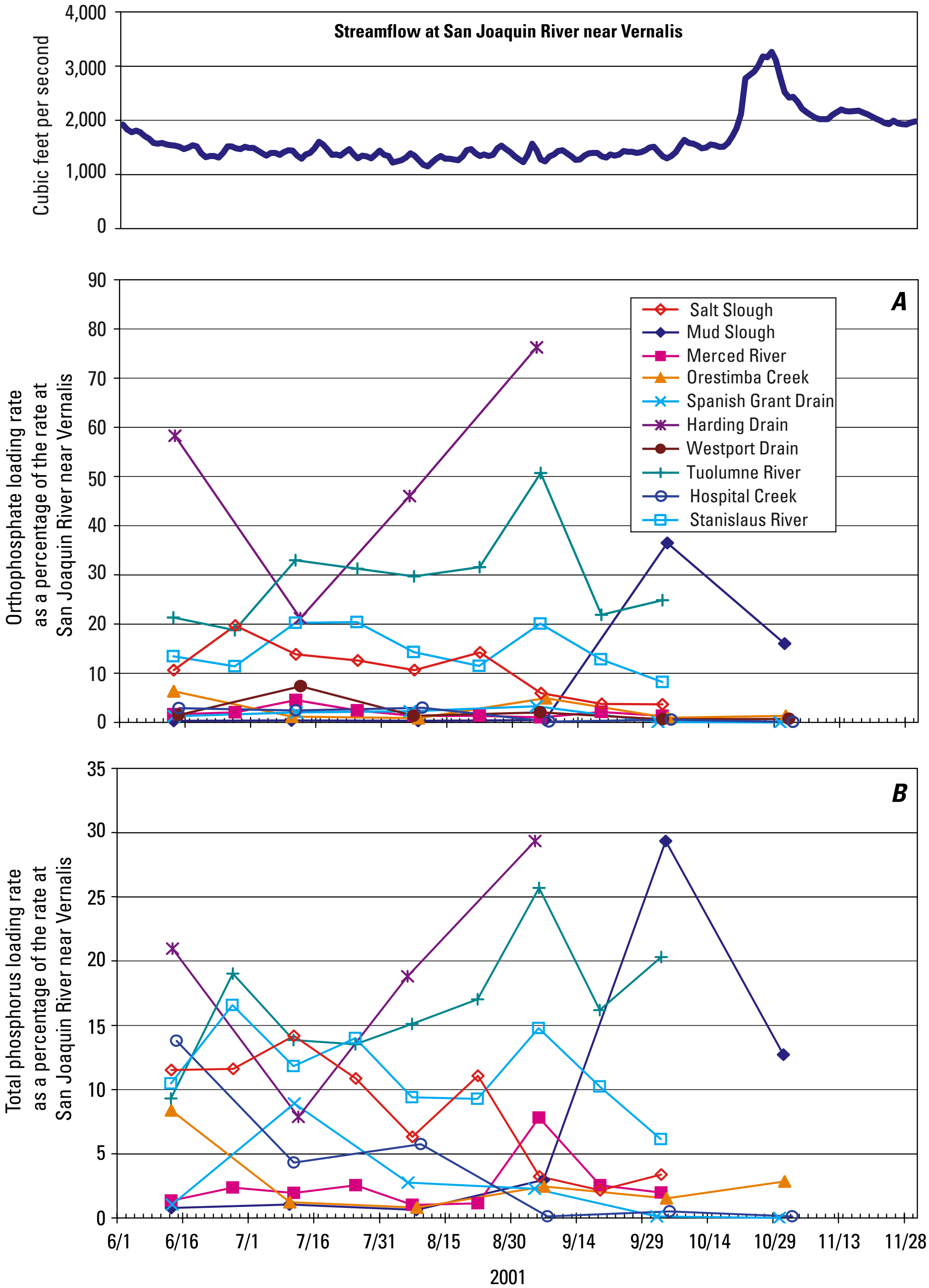

Figure 34. Instantaneous loading rates of orthophosphate and total phosphorus in tributaries from upstream to downstream as a percentage of Vernalis loading rates for June through November 2001, with streamflow at Vernalis, California.

(A) Orthophosphate, (B) Total phosphorus.

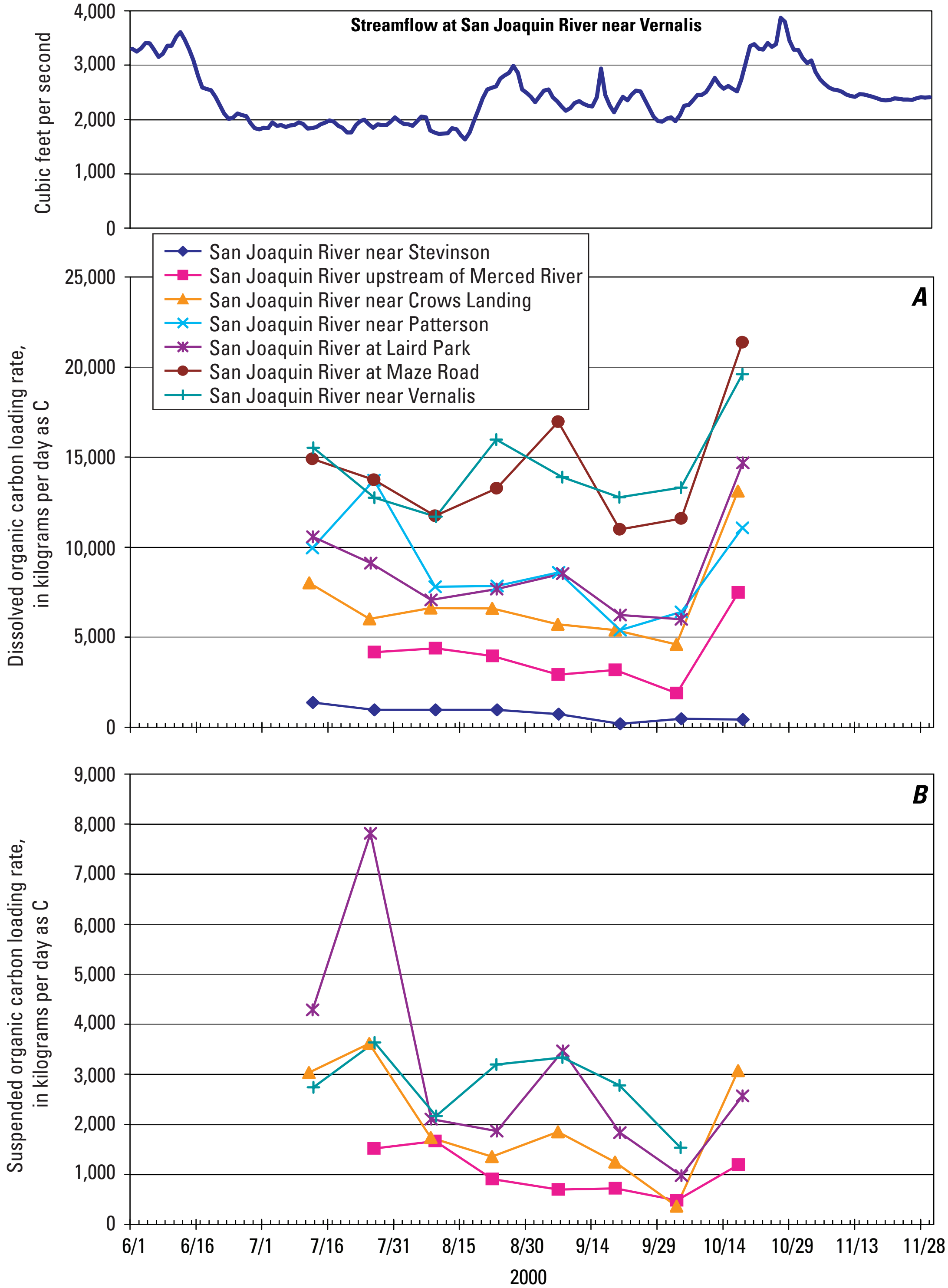

Figure 35. Instantaneous loading rates of dissolved organic carbon and suspended organic carbon at San Joaquin River sites from upstream to downstream for July through October 2000, with streamflow at Vernalis, California.

(A) Dissolved organic carbon (B) Suspended organic carbon. C, carbon.

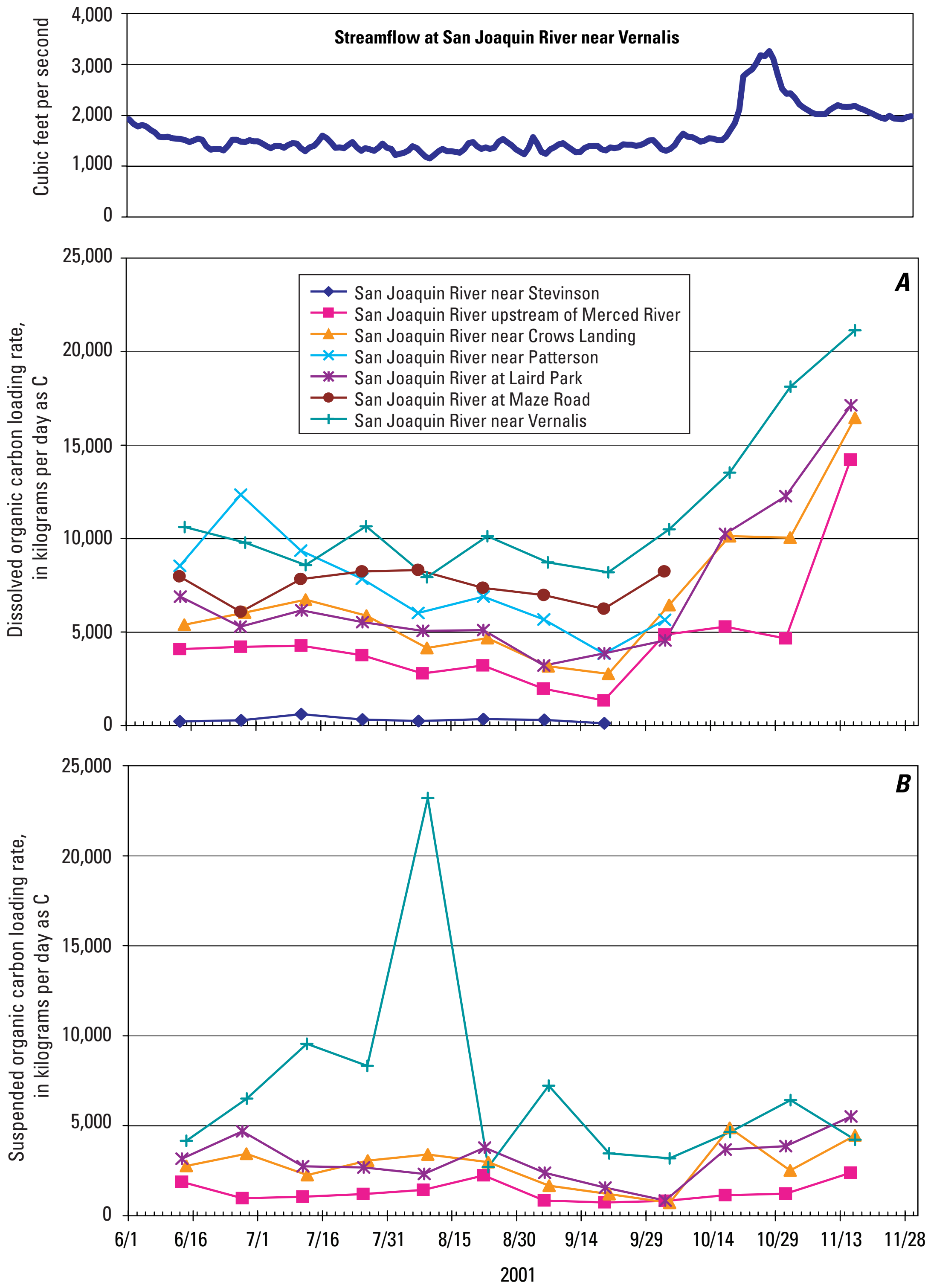

Figure 36. Instantaneous loading rates of dissolved organic carbon and suspended organic carbon at San Joaquin River sites from upstream to downstream for June through November 2001, with streamflow at Vernalis, California.

(A) Dissolved organic carbon, (B) Suspended organic carbon. C, carbon.

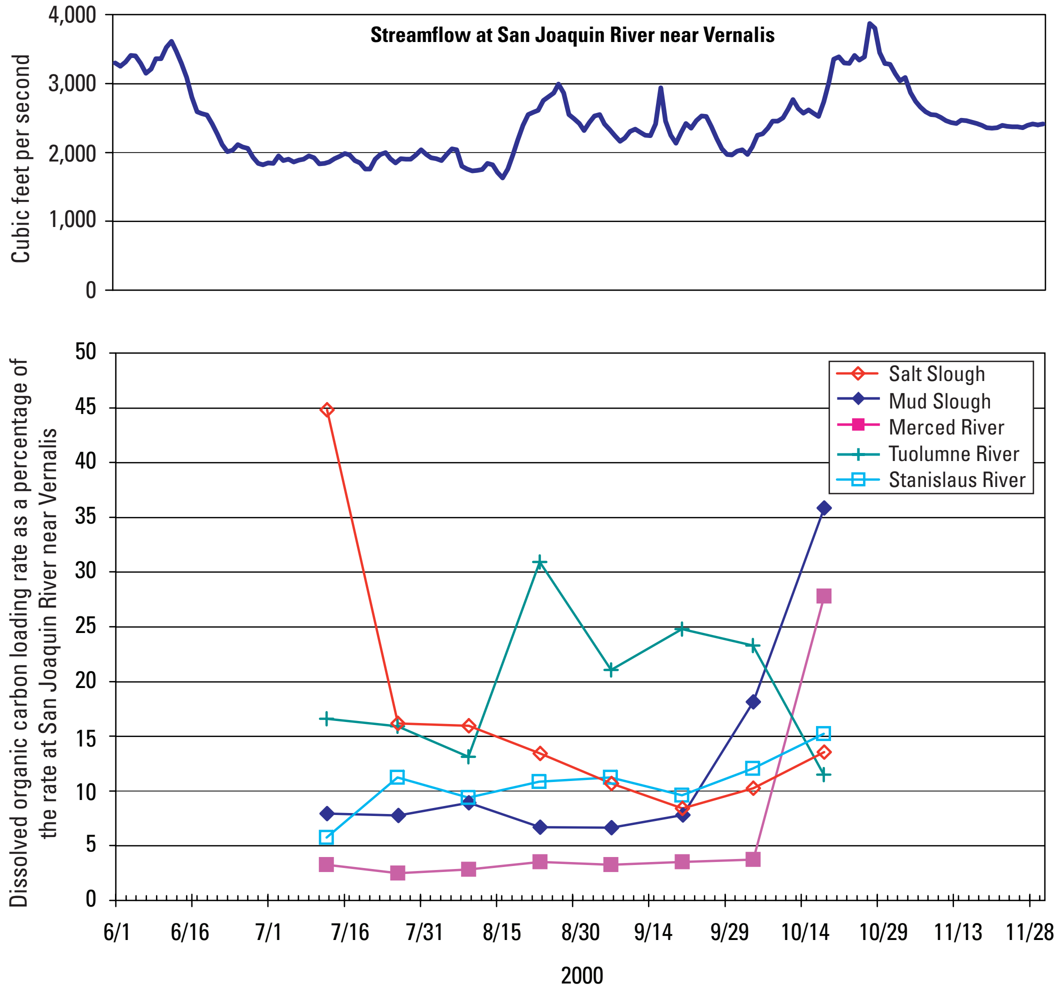

Figure 37. Instantaneous loading rates of dissolved organic carbon in tributaries from upstream to downstream as a percentage of Vernalis loading rates for July through October 2000, with streamflow at Vernalis, California.

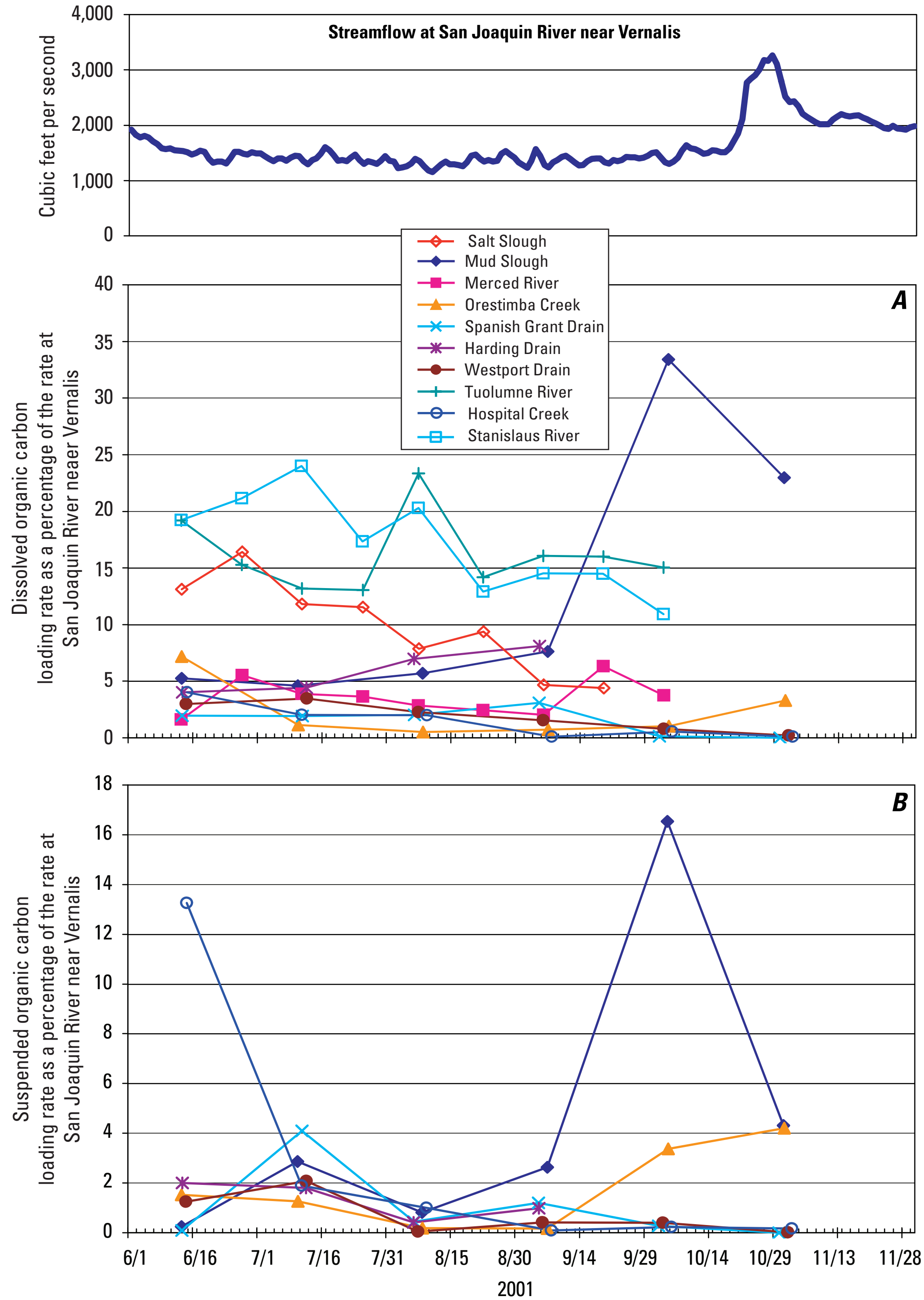

Figure 38. Instantaneous loading rates of dissolved organic carbon and suspended organic carbon in tributaries from upstream to downstream as a percentage of Vernalis loading rates for June through November 2001, with streamflow at Vernalis, California.

(A) Dissolved organic carbon, (B) Suspended organic carbon.

Chlorophyll-*a* and Pheophytin-*a*

Chlorophyll-*a* loading rates declined at all San Joaquin River sites between August 9 and August 23 in 2000, especially at SJR near Vernalis (fig. 39). Reservoir releases on the Tuolumne River that increased low chlorophyll-*a* streamflows from 500 to 2,000 ft^3/s during this period could have flushed chlorophyll-*a* from San Joaquin River sites downstream of the Tuolumne, Maze Road and SJR near Vernalis. However, loading rates also declined at San Joaquin River sites upstream of the Tuolumne River. Upstream loading rates and concentrations especially declined near Stevinson, where concentrations dropped from 377 to 76 µg/L. Concentrations near Crows Landing dropped from 58 to 17 µg/L. Loading rates and concentrations declined steadily from the beginning of the sampling at Laird Park. Chlorophyll-*a* loading rates were relatively stable after the August decline.

In 2001, there was a general increase in chlorophyll-*a* loading rates at San Joaquin River sites from June to a maximum in July through early September, then a decline in mid-September (fig. 40). This decline in chlorophyll-*a* loading rates in the San Joaquin River occurred about a month later in the year than in 2000. Between September 5 and 19 in 2001, chlorophyll-*a* concentrations at Laird Park dropped from 59 to 19 µg/L and from 73 to 14 µg/L at SJR near Vernalis. As in 2000, chlorophyll-*a* loading rates were relatively low and stable after the decline. Pheophytin-*a* loading rates in 2001 were similar to chlorophyll-*a* loading rates, except that the peaks and subsequent declines occurred about two to four weeks earlier at Laird Park and two to four weeks later near Crows Landing.

The very high concentrations of chlorophyll-*a* at SJR near Stevinson did result in significant loading rates to the San Joaquin River upstream of Merced River. Loading rates generally increased in downstream order, except that loading rates at Patterson exceeded those at Laird Park in June and July of 2001, and loading rates at Maze Road occasionally exceeded those at Vernalis. However, like SOC, the chlorophyll-*a* measurements were relatively variable. So, interpreting trends in chlorophyll-*a* concentrations or loading rates is more problematic than with nutrients or DOC. Pheophytin-*a* loading rates increased in downstream order.

The most significant tributary sources of chlorophyll-*a* in 2000 and 2001 were Mud Slough (1 to 15 percent of Vernalis), the Stanislaus River (1 to 13 percent), and the Tuolumne River (1 to 10 percent) (figs. 41 and 42). A late September sample from Mud Slough contributed about 10 percent of the pheophytin-*a* loading rate at SJR near Vernalis. Generally, compared with nutrients and DOC, tributaries were minor sources of chlorophyll-*a* and pheophytin-*a* loading rates. The chlorophyll-*a* in the San Joaquin River appeared to be produced primarily in the river.

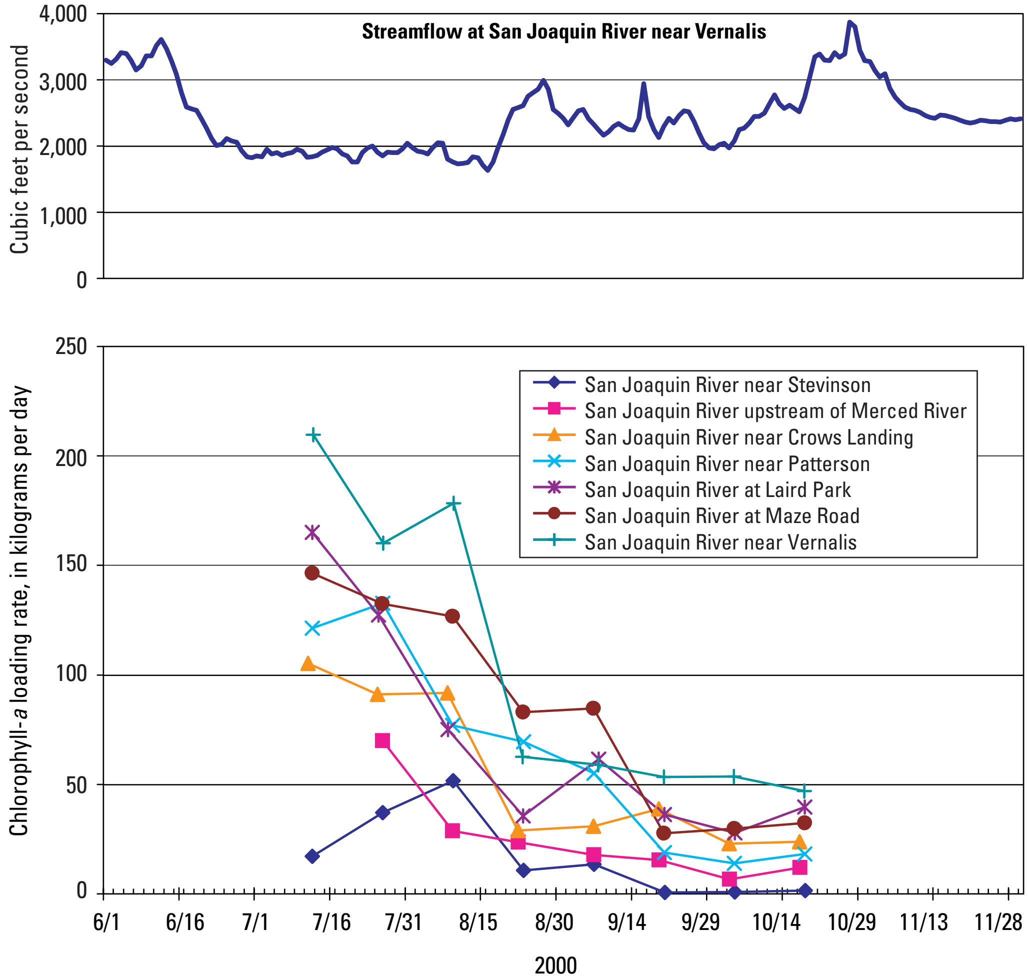

Figure 39. Instantaneous loading rates of chlorophyll-*a* at San Joaquin River sites from upstream to downstream for July through October 2000, with streamflow at Vernalis, California.

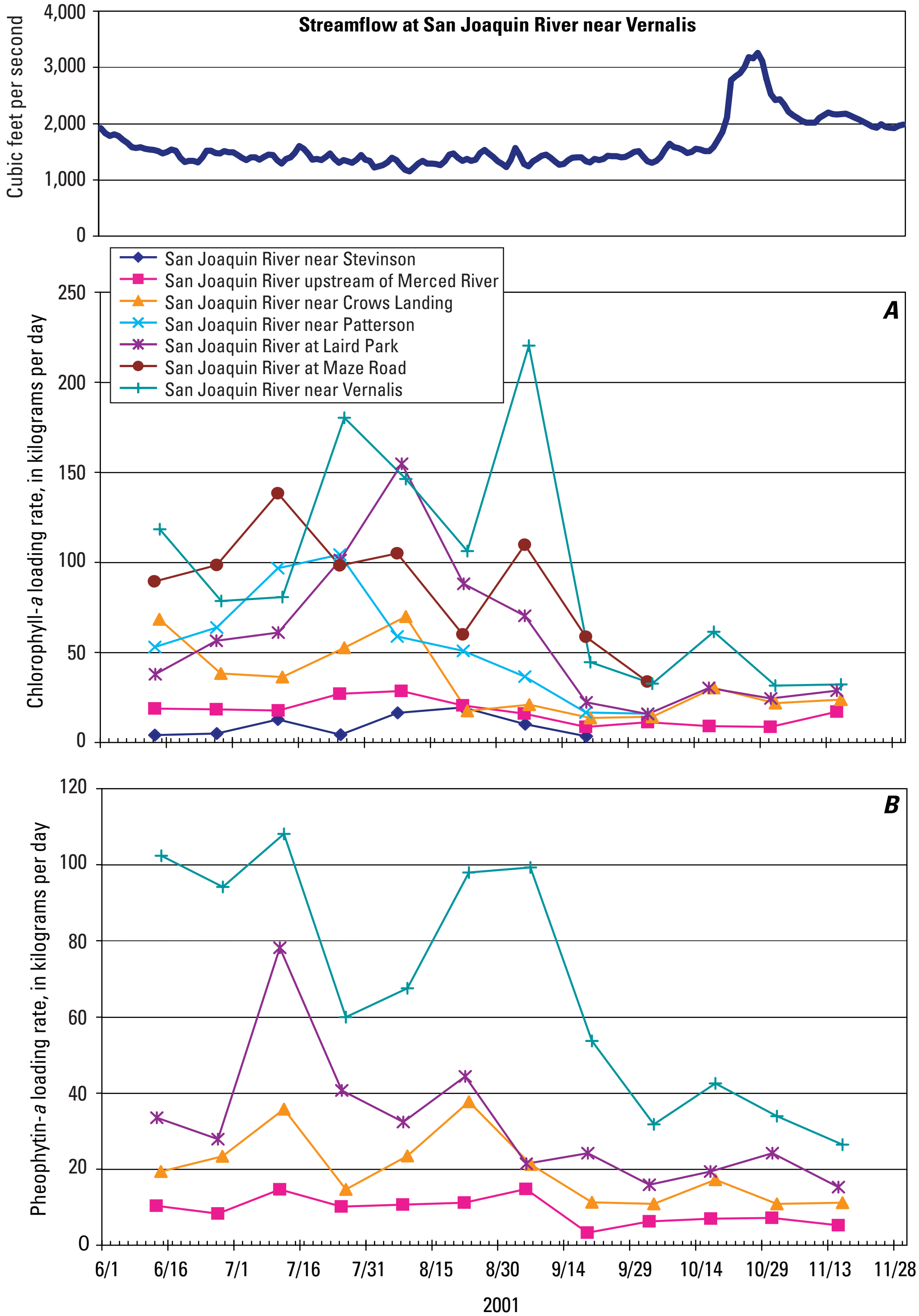

Figure 40. Instantaneous loading rates of chlorophyll-*a* and pheophytin-*a* at San Joaquin River sites, from upstream to downstream for June through November 2001, with streamflow at Vernalis, California.

(A) Chlorophyll-*a*, (B) Pheophytin-*a*.

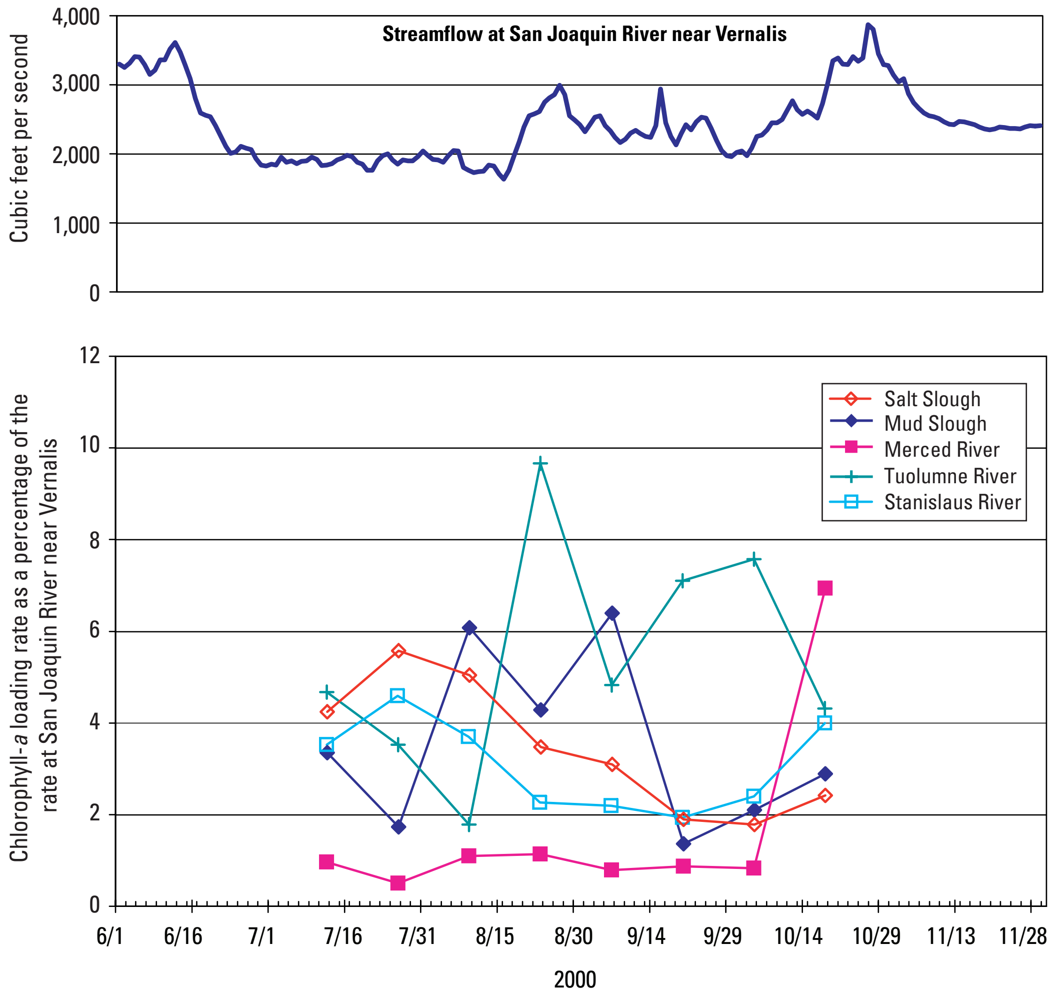

Figure 41. Instantaneous loading rates of chlorophyll-*a* in tributaries from upstream to downstream as a percentage of Vernalis loading rates for July through October 2000, with streamflow at Vernalis, California.

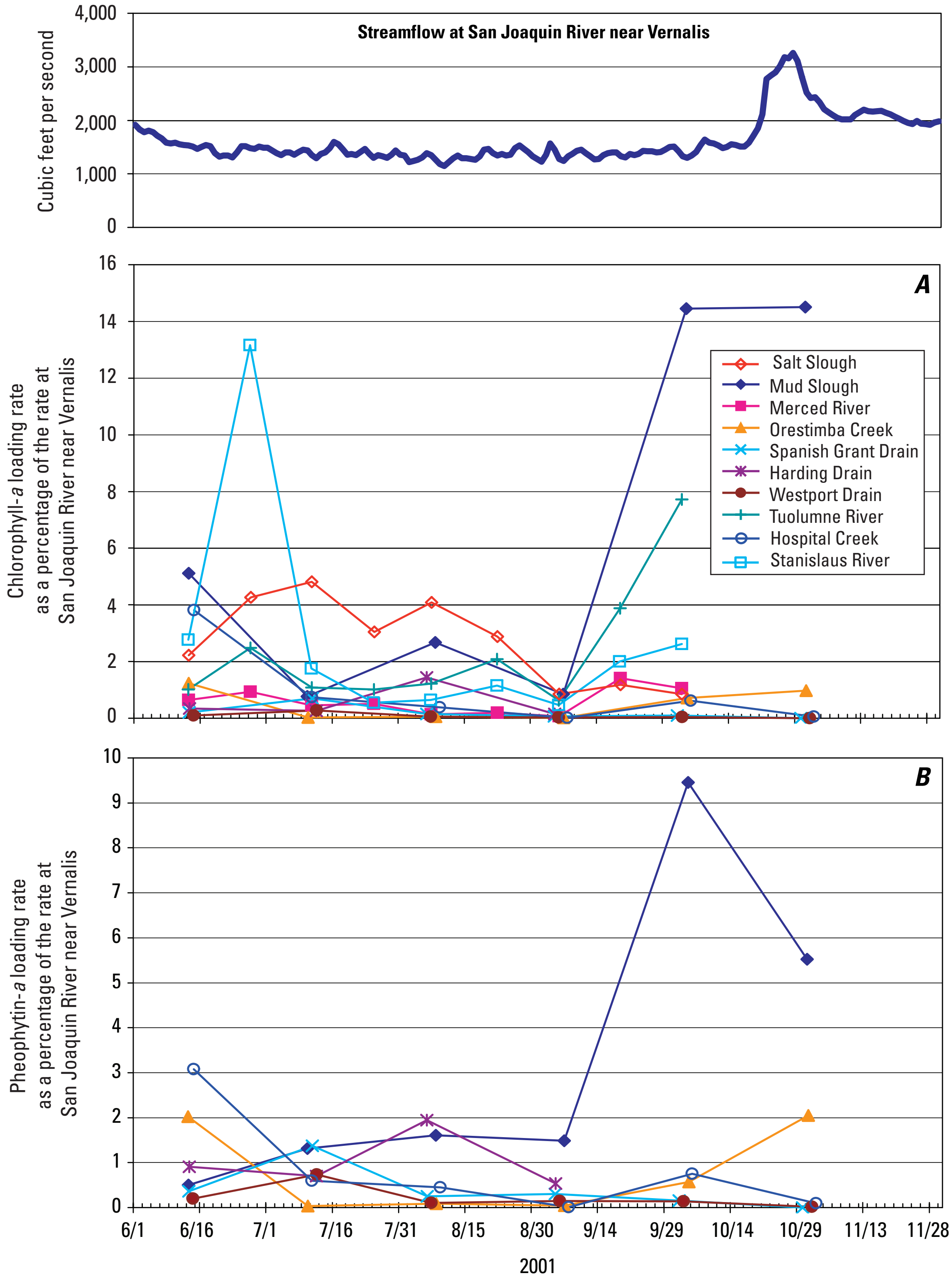

Figure 42. Instantaneous loading rates of chlorophyll-*a* and pheophytin-*a* in tributaries from upstream to downstream as a percentage of Vernalis loading rates for June through November 2001, with streamflow at Vernalis, California.

(A) Chlorophyll-*a*, (B) Pheophytin-*a*.

ISOTOPES

Different sources of nutrients often have distinctive isotope ratios. Processes such as nitrification and denitrification can alter the isotopic composition of reactants and products. The isotopic signatures of both source and cycling mechanisms are incorporated in algae and other plants. Under favorable circumstances, both the source and cycling mechanisms of nutrients can be identified with the help of isotopic analysis. In this study, elemental and isotopes of nitrogen and carbon of POM and TDN were used to address (1) the source of POM, (2) the nutrient species responsible for phytoplankton growth, and (3) the source of the nutrients in the San Joaquin River. Isotope analysis was only done on samples collected by USGS.

Sources of Particulate Organic Matter

Four broad categories of POM source materials are phytoplankton, macrophyte detritus, soil organic matter, and terrestrial plant detritus. The source materials generally have overlapping ranges of isotopic values and carbon-to-nitrogen (C:N) ratios; however, their relative importance may be evaluated by considering together isotopic, elemental, chemical, and hydrologic data. The one unique and most diagnostic measure of the four source categories is the C:N ratio of phytoplankton, which ranges between about 5 and 8. Other sources of POM have higher C:N ratios. Macrophyte detritus ranges from about 10 to 30, soil organic matter from about 8 to 15, and terrestrial plant detritus >15 (Kendall and others, 2001).

The average atomic C:N ratio of POM for the 2000 and 2001 San Joaquin River data was 6.5 and 7.5 respectively, indicating that the POM was virtually all phytoplankton (fig. 43). The C:N ratios that fell above the range of phytoplankton values were samples from October and November when VAMP-related reservoir releases and wetland releases impacted the San Joaquin River. These higher C:N ratios reflect inputs from terrestrial sources.

Figure 44 illustrates the difference in C:N ratio and $\delta^{13}C$ of POM in the San Joaquin River and the eight tributaries sampled in 2001. The generally higher C:N ratios and $\delta^{13}C$ values in the tributaries indicate a higher fraction of nonphytoplanktonic POM than in the San Joaquin River. Of the tributaries sampled, only the POM from Mud Slough matched that found in the San Joaquin River. This match suggests significant phytoplankton growth in the San Joaquin River in addition to that entering from its tributaries.

Nitrate as a Nutrient Source to Phytoplankton

Nitrate accounted for about 90 percent of the TDN in 2000 and 2001 samples. Samples collected in 2000 were analyzed only for $\delta^{15}N$ of TDN. For samples collected in 2001, a new method for concurrent analysis of $\delta^{15}N$ and $\delta^{18}O$ of nitrate at the USGS Menlo Park Stable Isotope Laboratory allowed the analysis of a subset of archived, frozen samples directly for nitrate isotopes. This allowed us to determine how well the TDN samples represent the isotopic composition of nitrate. Figure 45 shows the $\delta^{15}N$ values of nitrate and TDN over time for the 2001 San Joaquin River samples. The TDN samples were 1.9 ±1.1‰ lower than the nitrate on average. The offset was the result of organic nitrogen with lower $\delta^{15}N$ values. In general, the estimated $\delta^{15}N$ of nitrate values determined from TDN samples were a useful representation of the nitrate isotopic values.

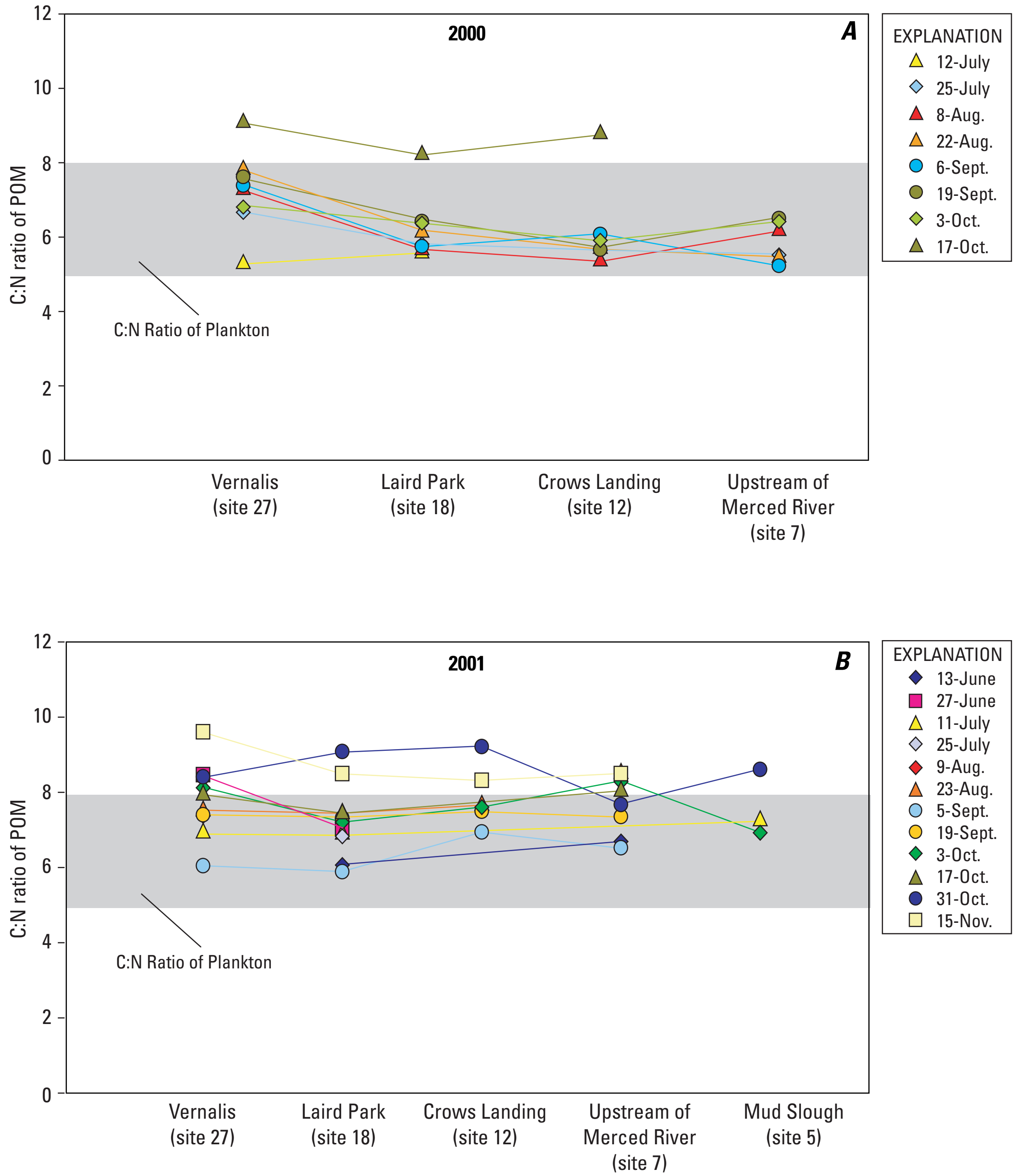

Figure 43. Atomic ratio of carbon to nitrogen (C:N) in particulate organic matter (POM) from San Joaquin River sites and Mud Slough in California.

(A) San Joaquin River sites in 2000, (B) San Joaquin River sites plus Mud Slough in 2001.

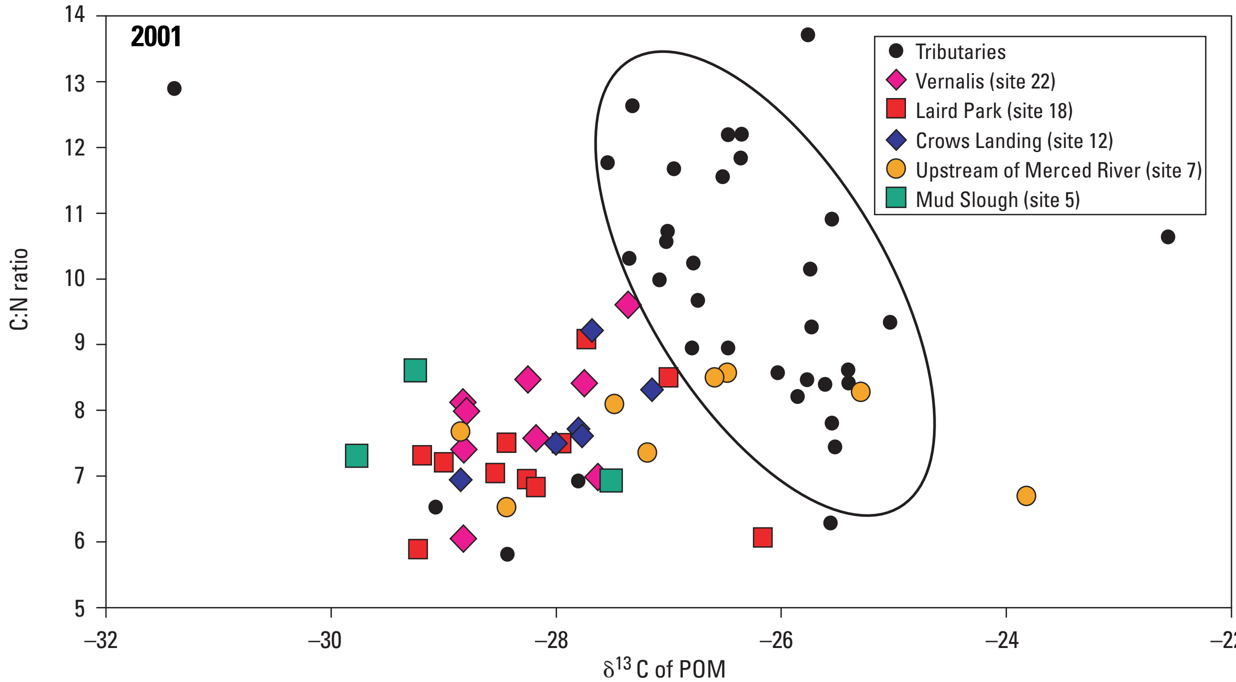

Figure 44. Atomic ratio of carbon to nitrogen (C:N) versus delta carbon-13 ($\delta^{13}C$) of particulate organic matter (POM) at San Joaquin River sites, Mud Slough, and other tributaries sampled in 2001 in California.

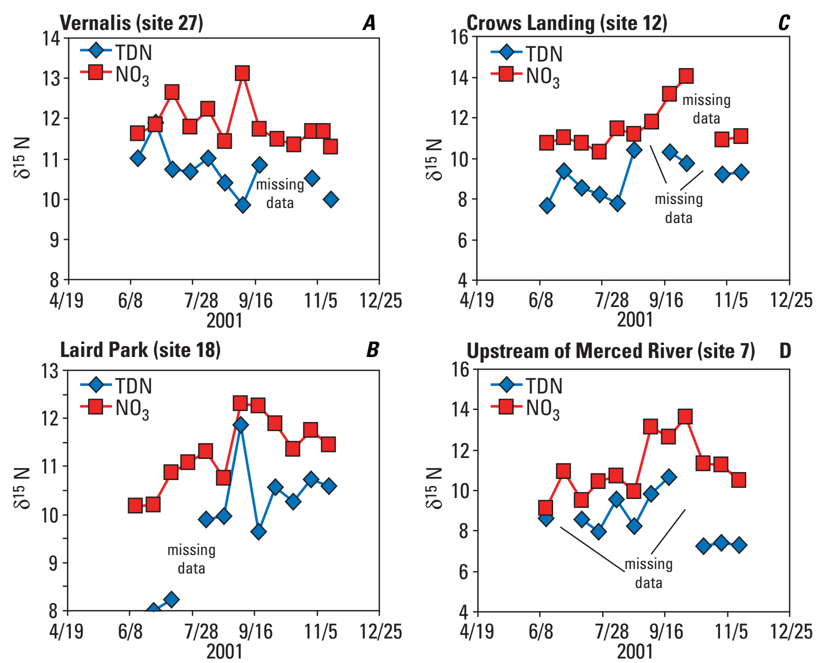

Figure 45. Delta nitrogen-15 ($\delta^{15}N$) of total dissolved nitrogen (TDN) and nitrate (NO_3) in samples from San Joaquin River, California, for 2001 (gaps indicate missing data).

(A) Vernalis, (B) Laird Park, (C) Crows Landing, and (D) Upstream of Merced River.

The $\delta^{15}N$ values of POM and TDN for the 2000 San Joaquin River samples (fig. 46) and POM and nitrate for the 2001 San Joaquin River samples (fig. 47) showed similar trends over time. When nutrients are plentiful, phytoplankton preferentially assimilate an isotopically light fraction, thus acquiring a lighter isotopic composition than their nutrient source. The data suggest that nitrate in the San Joaquin River was a significant nutrient source to the phytoplankton and, therefore, the phytoplankton either originated in the San Joaquin River or entered the river with the nitrate. Nitrate and POM data from a recent transect between Mud Slough and San Francisco Bay also strongly suggest that phytoplankton use nitrate as a significant nutrient source (Carol Kendall, U.S. Geological Survey, unpub. data from October 2002 transect, 2003).

Sources of Nitrate

Figure 48 shows the $\delta^{15}N$ and $\delta^{18}O$ values of nitrate measured in the San Joaquin River and its tributaries superimposed on the fields of common isotopic compositions from different nitrate sources (Kendall, 1998). All but a few points from the San Joaquin River fell within the range of animal waste and sewage, whereas most of the tributary values were significantly lower in a range suggesting significant amounts of soil nitrogen and (or) fertilizer. Of the tributaries, the $\delta^{15}N$ values of Mud Slough and Westport Drain fell mostly within the range of the San Joaquin River.

A possible alternative explanation for the high $\delta^{15}N$ values in the San Joaquin River is denitrification. As nitrate is microbially denitrified, the isotopic composition of nitrogen and oxygen of the residual nitrate increases in a ratio of approximately 2:1, yielding a slope of 0.5 as shown in figure 49. Denitrification occurs in anoxic environments and, therefore, it does not occur directly in the San Joaquin River. On a plot of $\delta^{15}N$ versus $\delta^{18}O$ of nitrate showing San Joaquin River samples plus Mud Slough, the data suggest denitrification for a few samples at Mud Slough and the SJR upstream of Merced River (fig. 49).

Some of the same samples with the highest $\delta^{15}N$ values had the lowest nitrate concentrations, also consistent with a limited amount of denitrification. The high $\delta^{15}N$ values and relatively high nitrate concentrations (Appendix C) at Westport Drain and Mud Slough, in contrast with the lower $\delta^{15}N$ values at other tributaries, suggest source rather than denitrification as the primary cause of the high $\delta^{15}N$ values in those tributaries and in the San Joaquin River (fig. 50). The nitrate isotopic data suggest that (1) animal waste and (or) sewage represented a significant source of nitrate in the San Joaquin River at the time of sampling, (2) the measured tributaries did not completely account for the nitrate in the San Joaquin River, and (3) that nitrate sources were locally variable in isotopic composition.

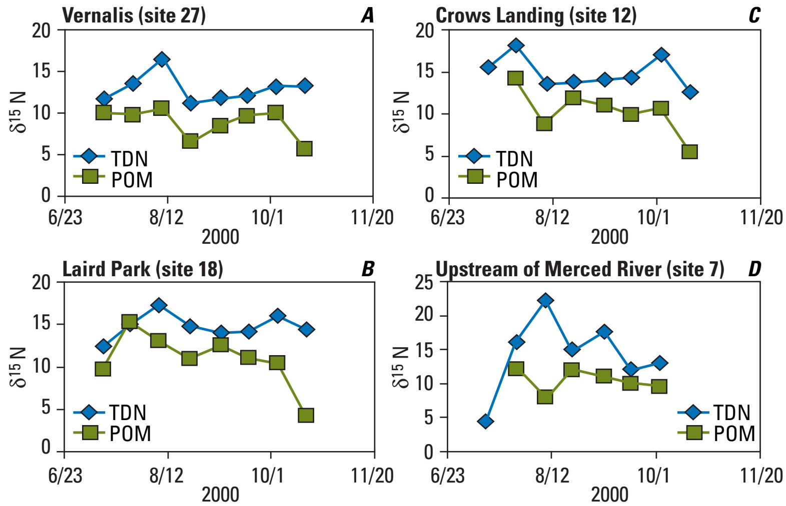

Figure 46. Delta nitrogen-15 ($\delta^{15}N$) of total dissolved nitrogen (TDN) and particulate organic matter (POM) in samples from San Joaquin River, California, for 2000.

(A) Vernalis, (B) Laird Park, (C) Crows Landing, and (D) Upstream of Merced River.

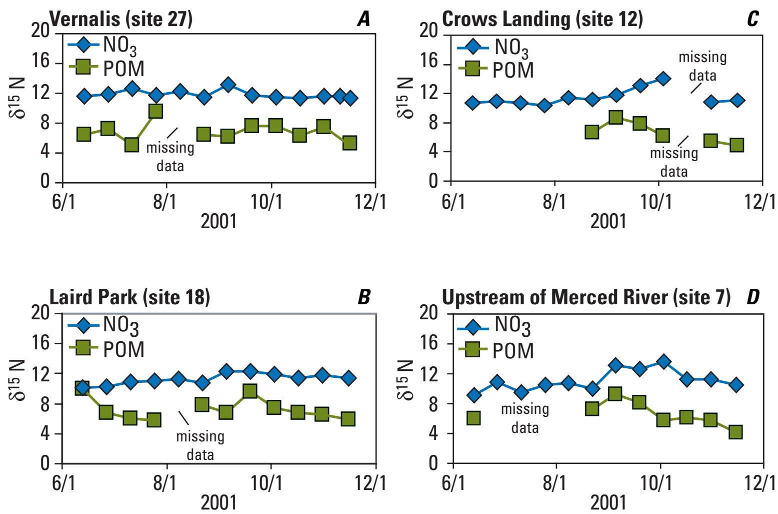

Figure 47. Delta nitrogen-15 ($\delta^{15}N$) of nitrate (NO_3) and particulate organic matter (POM) in samples from San Joaquin River, California, for 2001 (gaps indicate missing data).

(A) Vernalis, (B) Laird Park, (C) Crows Landing, and (D) Upstream of Merced River.

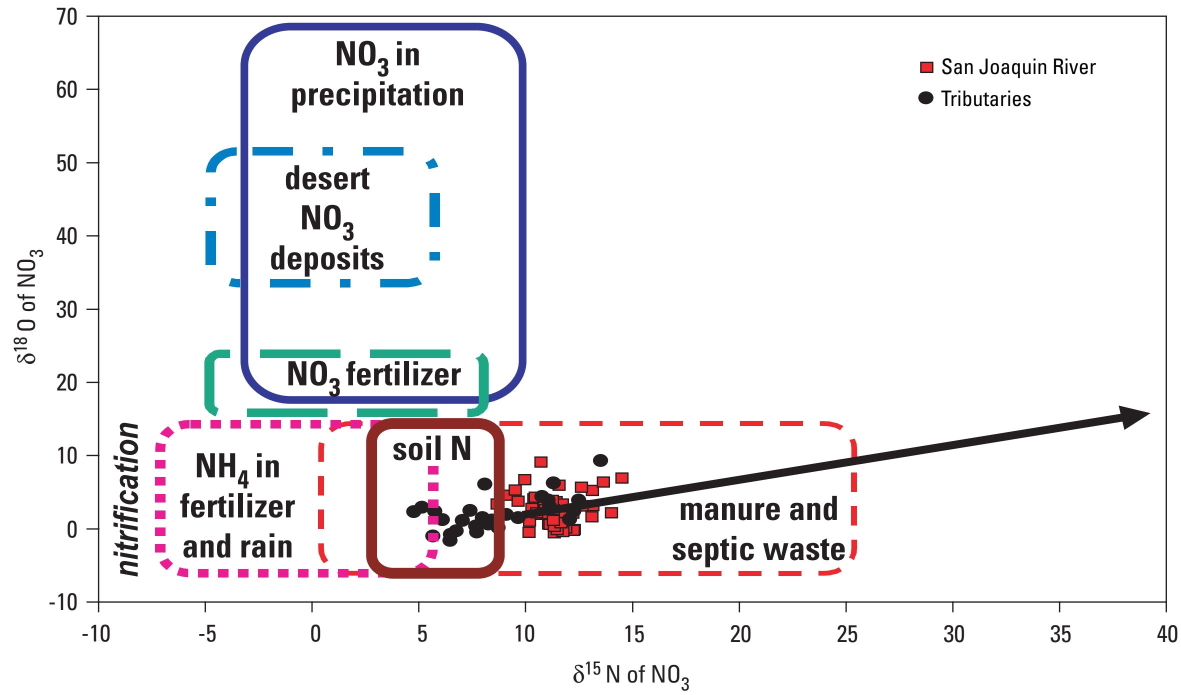

Figure 48. Delta nitrogen-15 ($\delta^{15}N$) versus delta oxygen-18 ($\delta^{18}O$) of nitrate (NO_3) for San Joaquin River, California, and tributary samples for 2001 superimposed on fields of common isotopic compositions from different nitrate sources.

(From Kendall, 1998).

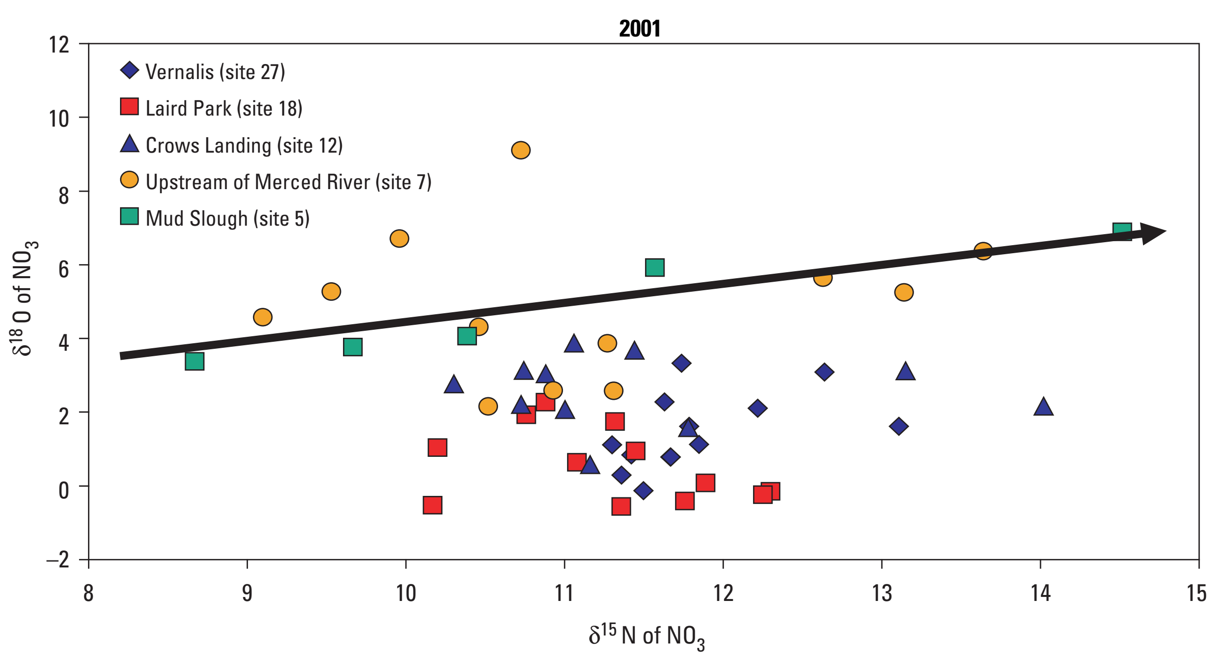

Figure 49. Delta nitrogen-15 ($\delta^{15}N$) versus delta oxygen-18 ($\delta^{18}O$) of nitrate (NO_3) for San Joaquin River, California, and tributary samples for 2001 with possible denitrification trend line.

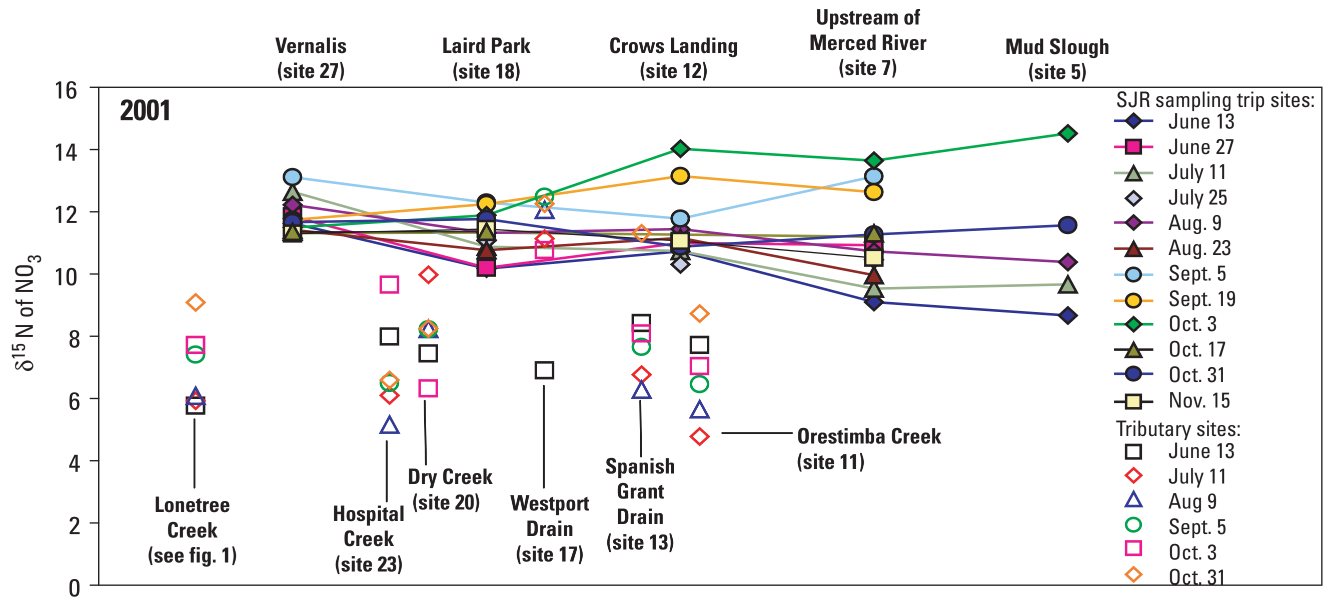

Figure 50. Delta nitrogen-15 ($\delta^{15}N$) of nitrate (NO3) for San Joaquin River, California, and tributary samples for 2001.

SJR, San Joaquin River.

SUMMARY AND CONCLUSIONS

Samples were collected and analyzed by USGS in July through October 2000 at four San Joaquin River sites and in June through November 2001 at the same four sites plus eight tributary sites. The data for these sites are supplemented in this report with data from samples collected and analyzed by UCD from three San Joaquin River sites and eight tributary sites as part of a separate study. Streamflows in the San Joaquin River were slightly above the long-term average in 2000 and slightly below average in 2001. There were several differences in the methods used by USGS and UCD for sample collection and laboratory analyses. As a result of quality control data comparing the different methods, we do not report the UCD pheophytin-*a* data and do not consider the USGS VSS and the UCD POM data to be comparable.

The median concentrations at San Joaquin River sites in 2000 and 2001 were 2.67 and 2.60 mg/L for nitrate, 0.12 mg/L for orthophosphate, 3.9 mg/L for DOC, and 27.2 and 29.4 µg/L for chlorophyll-*a*. The median concentrations of all tributary samples in 2000 and 2001 were 2.66 mg/L for nitrate, 0.08 mg/L for orthophosphate, 4.3 mg/L for DOC, and 6.0 µg/L for chlorophyll-*a*.

Nitrate loads near Vernalis in 2000 were above the long-term average, whereas loads in 2001 were about average. Total nitrogen loads in 2000 were slightly above average, whereas loads in 2001 were slightly below average. Total phosphorus loads in 2000 and 2001 were well below the long-term average. These loads correspond with the flow-adjusted concentration trends for these constituents—nitrate has significantly increased since 1972 ($p < 0.01$), whereas total nitrogen and total phosphorus have not ($p > 0.05$).

Loading rates of nutrients and organic carbon increased in the San Joaquin River in October and November with the release of wetland drainage into Mud Slough and the increased reservoir releases on the Merced River as part of the Vernalis Adaptive Management Plan (VAMP). Chlorophyll-*a* loading rates and concentrations declined in the San Joaquin River during August in 2000 and September in 2001. Irrigation diversions from the San Joaquin River in June through August have a significant impact on the pattern of upstream to downstream loading rates, especially in the reach from Crows Landing to Maze Road.

The most significant tributary sources of nitrogen and phosphorus to the San Joaquin River were the Tuolumne River, Harding Drain, and Mud Slough. These tributaries individually accounted for as much as 20 to 27 percent of the nitrogen loading rate at SJR near Vernalis, and as much as 51 to 76 percent of the phosphorus loading rate near Vernalis during a sampling period. The most significant sources of DOC were Salt Slough, Mud Slough, and the Tuolumne and Stanislaus Rivers. These tributaries accounted for as much as 24 to 45 percent of the DOC loading rate at SJR near Vernalis. During the VAMP-related reservoir releases in October 2000, the Merced River accounted for 28 percent of the DOC loading rate at SJR near Vernalis. Mud Slough was the only tributary to account for as much as 15 percent of the chlorophyll-*a* loading rate near Vernalis; this occurred in September and October 2001. Generally, compared with nutrients and DOC, tributaries were minor sources of chlorophyll-*a* loading rate, suggesting that most of the chlorophyll-*a* is produced in the San Joaquin River instead of entering from the tributaries.

On the basis of carbon-to-nitrogen ratios and the $\delta^{13}C$ of POM in the San Joaquin River and tributaries, the POM in the San Joaquin River was primarily comprised of phytoplankton. Of the tributaries sampled, only the POM in Mud Slough had a signature consistent with the San Joaquin River. This is consistent with the above conclusion that Mud Slough was the largest tributary source of chlorophyll-*a*. On the basis of the $\delta^{15}N$ values of POM, TDN, and nitrate, the nitrate in the San Joaquin River appears to be a significant nutrient source to the phytoplankton. The range of $\delta^{15}N$ and $\delta^{18}O$ values of nitrate in the San Joaquin River and tributaries suggest that animal waste or sewage was a significant source of nitrate in the San Joaquin River at the time of sampling. This signature was higher in east-side tributaries than in west-side tributaries. The west-side sources were more suggestive of a soil nitrogen or fertilizer source. Denitrification may have been a reason for some high $\delta^{15}N$ samples in Mud Slough and the SJR upstream of Merced River.

REFERENCES CITED

Bergamaschi, B.A., Fram, M.S., Fujii, R., Aiken, G.R., Kendall, C., and Silva, S.R., 2000, Trihalomethanes formed from natural organic matter isolates: using isotopic and compositional data to help understand sources, in Barrett, S.E., Krasner, S.W., and Amy, G.L., eds., Natural organic matter and disinfection by-products, characterization and control in drinking water: American Chemical Society Symposium Series 761, p. 206-222.

Britton, L.J., and Greeson, P.E., eds., 1987, Methods for collection and analysis of aquatic biological and microbiological samples: U.S. Geological Survey Techniques of Water-Resources Investigations, book 5, chap. A4, p. 227.

California Department of Water Resources, 1987, California Central Valley unimpaired flow data (2d ed.): California Department of Water Resources, Division of Planning, 38 p.

California Department of Water Resources, Division of Flood Management, Chronological reconstructed Sacramento and San Joaquin Valley water year hydrologic classification indices: accessed February 20, 2003, at URL http://cdec.water.ca.gov/cgi-progs/iodir/WSIHIST

California Regional Water Quality Control Board, Central Valley Region, 1998, The water quality control plan (basin plan) for the California Regional Water Quality Control Board, Central Valley Region (Sacramento River Basin and San Joaquin River Basin), (4th ed.).

California State Water Resources Control Board, 1998, 1998 California 303(d) list and TMDL priority schedule: Sacramento, Calif. (approved by U.S. Environmental Protection Agency on May 12, 1999).

Carlson, R.M., 1978, Automated separation and conductimetric determination of ammonia and dissolved carbon dioxide: Analytical Chemistry, v. 50, p. 1528-1531.

———, 1986, Continuous flow reduction of nitrate to ammonia with granular zinc: Analytical Chemistry, v. 58, p. 1590-1591.

Casciotti, K.L., Sigman, D.M., Hastings, M.G., Bohlke, J.K., and Hilkert, A., 2002, Measurement of the oxygen isotopic composition of nitrate in seawater and freshwater using the denitrifier method: Analytical Chemistry, v. 74, p. 4905-4912.

Cohn, T.A., DeLong, L.L., Gilroy, E.J., Hirsch, R.M., and Wells, D.K., 1989, Estimating constituent loads: Water Resources Research, v. 25, no. 5, p. 937-942.

Eaton, A.D., Clesceri, L.S., Greenberg, A.E., 1995, Standard methods for the examination of water and wastewater: Baltimore, Md., United Book Press, Inc., p. 5-60.

Fishman, M.J., and Friedman, L.C., eds., 1989, Methods for determination of inorganic substances in water and fluvial sediments: U.S. Geological Survey Techniques of Water-Resources Investigations, book 5, chap. A1, 545 p.

Guy, H.P., 1973, Laboratory theory and methods for sediment analysis: U.S. Geological Survey Techniques of Water-Resources Investigation, book 5, chap. C1, p. 17.

Helsel, D.R., 1990, Less than obvious-statistical treatment of data below the detection limit: Environmental Science and Technology, v. 24, no. 12, p. 1766-1774.

James, E.W., Westcot, D.W., and Gonzalez, J.L., 1989, Water diversion and discharge points along the San Joaquin River, Mendota Pool Dam to Mossdale Bridge: California Regional Water Quality Control Board, Central Valley Region, v. 1 (main report), 41 p. and v. 2-A (appendix A), 198 p.

Kendall, Carol, 1998, Tracing nitrogen sources and cycling in catchments, in Kendall, Carol and McDonnell, J.J., eds., Isotope tracers in catchment hydrology: Elsevier Science, p. 519-576.

Kendall, Carol, Silva, S.R., and Kelly, V.J., 2001, Carbon and nitrogen isotopic compositions of particulate organic matter in four large river systems across the United States: Hydrological Processes, v. 15, p. 1301-1346.

Kratzer, C.R., and Biagtan, R.N., 1997, Determination of travel times in the lower San Joaquin River Basin, California, from dye-tracer studies during 1994-1995: U.S. Geological Survey Water-Resources Investigations Report 97-4018, 20 p.

Kratzer, C.R., Pickett, P.J., Rashmawi, E.A., Cross, C.L., and Bergeron, K.D., 1987, An input-output model of the San Joaquin River from the Lander Avenue bridge to the Airport Way bridge, Appendix C of San Joaquin River Basin Technical Committee Report: Regulation of agricultural drainage to the San Joaquin River: California State Water Resources Control Board Order no. WQ 85-1, 173 p.

Kratzer, C.R., and Shelton, J.L., 1998, Water quality assessment of the San Joaquin-Tulare Basins, California: Analysis of available data on nutrients and suspended sediment in surface water, 1972-1990: U.S. Geological Survey Professional Paper 1587, 92 p.

Lee, G.F., and Jones-Lee, Anne, 2003, Synthesis and discussion of findings on the causes and factors influencing low DO in the San Joaquin River Deep Water Ship Channel, CA: including 2002 data: Report submitted to SJR DO TMDL [San Joaquin River dissolved oxygen total maximum daily load] Steering Committee/Technical Advisory Committee and CALFED Bay-Delta Program (updated February 26, 2003), variously paged.

Quinn, N.W.T., McGahan, Joseph, and Delamore, Michael, 1998, Innovative strategies reduce selenium in Grasslands drainage: California Agriculture, v. 52, no. 5, p. 12-17.

Quinn, N.W.T., and Tulloch, A., 2002, San Joaquin River diversion data assimilation, drainage estimation and installation of diversion monitoring stations: CALFED Project no. ERP-01-N61-02, 55 p.

Radtke, D.B., Horowitz, A.J., Gibs, Jacob, and Wilde, F.D., 1999, Raw Samples in Wilde, F.D., Radtke, D.B., Gibs, Jacob, and Iwatsubo, R.T., eds., National field manual for the collection of water quality data: processing of water samples: U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap A5, p. 23-35.

Saleh, D.K., Domagalski, J.L., Kratzer, C.R., and Knifong, D.L., 2003, Organic carbon trends, loads, and yields to the Sacramento-San Joaquin Delta, California, water years 1980 to 2000: U.S. Geological Survey Water-Resources Investigations Report 03-4070, 77 p. Also available at http://water.usgs.gov/pubs/wri/wrir034070

San Joaquin River Group Authority, 2002, 2001 annual technical report on implementation and monitoring of the San Joaquin River Agreement and the Vernalis Adaptive Management Plan: Prepared for the California State Water Resources Control Board in compliance with D-1641, June 2002, variously paged.

Sigman, D. M., Casciotti, K.L., Andreani, M., Barford, C., Galanter, M., and Bohlke, J.K., 2001, A bacterial method for the nitrogen isotopic analysis of nitrate in seawater and freshwater: Analytical Chemistry, v. 73, p. 4145-4153.

U.S. Environmental Protection Agency, 1997, Method 445.0, In vitro determination of chlorophyll a and pheophytin a in marine and freshwater algae by fluorescence [USEPA report], revised September 1997: accessed March 7, 2003, at URL http://www.epa.gov/nerlcwww/m445_0.pdf

U.S. Geological Survey, 1999, National Water Quality Laboratory technical memorandum 99.05, effective January 1999: accessed March 13, 2003, at URL http://nwql.usgs.gov/Public/tech_memos/nwql.99-05.html

U.S. Geological Survey, , 2000, Frequently asked questions, organic analysis and schedules, revised August 2000: accessed March 13, 2003, at URL http://wwwnwql.cr.usgs.gov/USGS/faqOrganic.html

Webb, W.E., Radtke, D.B., and Iwatsubo, R.T., 1999, Surface-water sampling: collection methods at flowing-water and still-water sites in Wilde, F.D., Radtke, D.B., Gibs, Jacob, and Iwatsubo, R.T., eds., National field manual for the collection of water-quality data; collection of water samples: U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap A4, p. 23-59.

Wershaw, R.L., Fishman, M.J., Grabbe, R.R., and Lowe, L.E., eds., 1987, Methods for the determination of organic substances in water and fluvial sediments: U.S. Geological Survey Techniques of Water-Resources Investigations, book 5, chap. A3, 80 p.

Wilde, F.D., Schertz, T.L., and Radtke, D.B., 1998, Quality-control samples in Wilde, F.D., Radtke, D.B., Gibs, Jacob, and Iwatsubo, R.T., eds., National field manual for the collection of water quality data; collection of water samples: U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A4, p. 91-103.

Yu, Z., Northup, R.R., Dahlgren, R.A., 1994, Determination of dissolved organic nitrogen using persulfate oxidation and conductimetric quantification of nitrate-nitrogen: Communications in Soil Science and Plant Analysis, v. 25, p. 3161-3169.

APPENDIXES

Appendix A. Results of quality control samples for split replicates, sequential replicates, and field blanks in the San Joaquin River Basin, California, in 2000 and 2001

[Site names are slightly abbreviated from full versions listed in table 1. RPD, relative percent difference; N, nitrogen; P, phosphorus; C, carbon; SJR, San Joaquin River; E, estimated value; EWI, equal width increment; USGS, U.S. Geological Survey; NWQL, National Water Quality Laboratory; UCDBL, University of California at Davis Biogeochemistry Laboratory; VSS, volatile suspended solids (NWQL analytical method); POM, particulate organic matter (UCDBL analytical method). mg/L, milligram per liter; nm, nanometer; cm-1, per centimeter; µg/L, microgram per liter; mm, millimeter. <, less than; >, greater than; NA, not applicable; nc, sample not collected or not analyzed; —, no data]

Site number	Site name	Date	Time	Ammonia, dissolved (mg/L as N)	RPD	Ammonia and organic nitrogen, dissolved (mg/L as N)	RPD	Ammonia and organic nitrogen, total (mg/L as N)	RPD	Nitrite, dissolved (mg/L as N)	RPD	Nitrate, dissolved (mg/L as N)	RPD	Nitrite and nitrate, dissolved (mg/L as N)	RPD
	Split replicates														
5	Mud Slough near Gustine	10/31/01	10:00	0.14	11.8	1.1	0.0	1.4	0.0	0.037	27.7	1.22	0.0	1.26	0.8
		10/31/01	10:01	0.12		1.1		1.4		0.028		1.22		1.25	
7	SJR upstream of Merced	6/13/01	9:40	< 0.04	NA	0.69	13.5	1.6	6.5	0.079	1.3	5.55	2.0	5.63	2.0
	River	6/13/01	9:41	< 0.04		0.79		1.5		0.080		5.44		5.52	
11	Orestimba Creek near Crows	10/4/01	15:00	E 0.02	40.0	0.45	14.3	0.91	3.2	0.028	3.6	3.41	0.6	3.44	0.9
	Landing	10/4/01	15:01	E 0.03		0.39		0.94		0.027		3.39		3.41	
12	SJR near Crows Landing	9/19/00	11:00	<0.02	NA	0.37	8.6	0.79	2.5	0.024	0.0	2.95	0.0	2.97	0.0
		9/19/00	11:01	<0.02		0.40		0.81		0.024		2.95		2.97	
12	SJR near Crows Landing	9/20/01	10:30	< 0.04	NA	0.30	0.0	0.81	10.5	0.030	0.0	3.36	3.2	3.39	3.2
		9/20/01	10:31	< 0.04		0.30		0.90		0.030		3.47		3.50	
13	Spanish Grant Drain	7/11/01	12:30	0.31	0.0	0.87	2.3	5.4	3.8	0.095	2.1	5.15	0.0	5.25	0.0
		7/11/01	12:31	0.31		0.89		5.2		0.097		5.15		5.25	
17	Westport Drain near Modesto	8/7/01	10:30	0.05	0.0	0.31	3.2	0.43	4.6	0.051	1.9	5.90	4.5	5.95	4.5
		8/7/01	10:31	0.05		0.32		0.45		0.052		5.64		5.69	
18	SJR at Laird Park	7/25/00	18:00	<0.02	NA	0.43	13.0	1.4	6.9	0.077	0.0	4.23	0.2	4.30	0.1
		7/25/00	18:01	<0.02		0.49		1.5		0.077		4.22		4.30	
18	SJR at Laird Park	8/8/01	13:30	E 0.02	40.0	0.38	0.0	1.2	0.0	0.073	0.0	4.02	1.0	4.09	0.7
		8/8/01	13:31	E 0.03		0.38		1.2		0.073		3.98		4.06	
20	Dry Creek at Gallo Bridge	9/5/01	13:00	< 0.04	NA	0.49	6.3	0.61	10.3	0.008	13.3	0.34	2.9	0.35	0.0
		9/5/01	13:01	< 0.04		0.46		0.55		0.007		0.35		0.35	
27	SJR near Vernalis	7/26/01	10:30	< 0.04	NA	0.22	0.0	0.97	8.6	0.041	2.5	2.13	0.0	2.17	0.0
		7/26/01	10:31	< 0.04		0.22		0.89		0.040		2.13		2.17	
27	SJR near Vernalis	10/4/01	11:00	< 0.04	NA	0.28	10.2	0.51	2.0	0.038	2.6	1.88	0.5	1.92	0.5
		10/4/01	11:01	< 0.04		0.31		0.50		0.039		1.89		1.93	

Appendix A. Results of quality control samples for split replicates, sequential replicates, and field blanks in the San Joaquin River Basin, California, in 2000 and 2001—*Continued.*

Site number	Total nitrogen (mg/L as N)	RPD	Orthophosphate, dissolved (mg/L as P)	RPD	Total phosphorus (mg/L as P)	RPD	Organic carbon, dissolved (mg/L as C)	RPD	Organic carbon, suspended (mg/L as C)	RPD	Ultraviolet absorbance at 254 nm (cm^{-1})	RPD	Volatile suspended solids (mg/L)	RPD	Chlorophyll-*a* (µg/L)	RPD	Pheophytin-*a* (µg/L)	RPD	Suspended sediment (mg/L)	RPD	Suspended sediment size fraction < 0.062 mm (percent)	RPD
Split replicates																						
5	2.7	3.8	0.27	0.0	0.45	0.0	11.7	0.9	0.8	0.0	0.341	2.6	8	0.0	13.2	12.9	5.4	35.1	29	NA	82	NA
	2.6		0.27		0.45		11.6		0.8		0.350		8		11.6		7.7		nc		nc	
7	7.2	2.8	0.10	0.0	0.35	0.0	6.3	3.2	2.9	9.8	—	NA	9	0.0	28.9	63.2	16.1	55.0	124	NA	94	NA
	7.0		0.10		0.35		6.1		3.2		—		9		55.6		28.3		nc		nc	
11	4.3	2.3	0.11	0.0	0.37	2.7	3.7	0.0	3.7	5.3	0.095	0.0	17	5.7	8.1	5.1	6.3	15.4	239	NA	97	NA
	4.4		0.11		0.38		3.7		3.9		0.095		18		7.7		5.4		nc		nc	
12	3.8	0.0	0.11	0.0	0.25	0.0	3.9	5.3	0.9	11.8	0.101	0.0	<10	NA	30.8	NA	nc	NA	nc	NA	nc	NA
	3.8		0.11		0.25		3.7		0.8		0.101		<10		nc		nc		nc		nc	
12	4.2	4.7	0.09	0.0	0.21	4.7	3.2	3.1	1.4	15.4	0.102	0.0	6	0.0	15.8	10.7	12.8	21.0	47	NA	47	NA
	4.4		0.09		0.22		3.3		1.2		0.102		6		14.2		15.8		nc		nc	
13	11	9.5	0.13	0.0	1.74	3.5	4.2	NA	>10.0	NA	nc	NA	134	4.6	14.4	42.0	37.8	0.8	1920	NA	98	NA
	10		0.13		1.68		nc		nc		nc		128		9.4		38.1		nc		nc	
17	6.4	4.8	0.12	8.0	0.17	0.0	6.0	92.7	0.3	28.6	0.069	17.3	1	0.0	2.5	77.8	2.3	78.8	10	NA	93	NA
	6.1		0.13		0.17		2.2		0.4		0.058		1		1.1		1.0		nc		nc	
18	5.8	0.0	0.14	7.4	0.38	2.7	4.2	2.4	3.6	18.2	0.116	0.2	14	15.4	64.4	25.6	nc	NA	nc	NA	nc	NA
	5.8		0.13		0.37		4.3		3.0		0.115		12		49.8		nc		nc		nc	
18	5.3	0.0	0.13	0.0	0.37	5.3	3.6	2.8	>3.3	NA	0.102	0.0	16	13.3	110	28.1	23.4	16.2	86	NA	89	NA
	5.3		0.13		0.39		3.5		2.2		0.102		14		82.9		19.9		nc		nc	
20	0.96	5.4	0.47	0.0	0.56	1.8	7.0	0.0	0.7	13.3	0.240	16.1	4	28.6	1.2	16.1	3.3	39.6	23	NA	88	NA
	0.91		0.47		0.55		7.0		0.8		0.282		3		1.4		4.9		nc		nc	
27	3.1	0.0	0.08	0.0	0.21	0.0	3.2	9.8	2.5	86.4	0.082	0.0	7	0.0	54.2	5.0	17.6	16.7	63	NA	96	NA
	3.1		0.08		0.21		2.9		6.3		0.082		7		57.0		20.8		nc		nc	
27	2.4	0.0	0.11	0.0	0.22	0.0	3.3	3.1	1.0	26.1	0.083	0.0	4	22.2	10.3	10.1	10.3	17.7	46	NA	83	NA
	2.4		0.11		0.22		3.2		1.3		0.083		5		11.4		12.3		nc		nc	

Appendix A. Results of quality control samples for split replicates, sequential replicates, and field blanks in the San Joaquin River Basin, California, in 2000 and 2001—*Continued.*

Site number	Site name	Date	Time	Ammonia, dissolved (mg/L as N)	RPD	Ammonia and organic nitrogen, dissolved (mg/L as N)	RPD	Ammonia and organic nitrogen, total (mg/L as N)	RPD	Nitrite, dissolved (mg/L as N)	RPD	Nitrate, dissolved (mg/L as N)	RPD	Nitrite and nitrate, dissolved (mg/L as N)	RPD	Total nitrogen (mg/L as N)	RPD
Sequential replicates—sampling methods comparison																	
7	USGS EWI	8/9/00	12:00	< 0.02	NA	0.47	0.0	1.2	22.2	0.083	1.2	2.97	0.7	3.05	0.7	4.3	6.7
7	USGS grab	8/9/00	12:01	< 0.02		0.47		1.5		0.084		2.95		3.03		4.6	
7	USGS EWI	10/3/00	12:30	0.04	22.2	0.62	0.0	1.1	10.5	0.041	2.5	1.52	0.7	1.56	0.6	2.6	3.9
7	USGS grab	10/3/00	12:31	0.05		0.62		0.99		0.040		1.51		1.55		2.5	
12	USGS EWI	7/25/00	12:00	< 0.02	NA	0.44	4.4	1.5	6.9	0.077	0.0	4.04	0.5	4.12	0.2	5.7	1.8
12	USGS grab	7/25/00	12:01	< 0.02		0.46		1.4		0.077		4.06		4.13		5.6	
12	USGS EWI	8/22/00	10:30	0.04	40.0	0.49	2.1	0.96	13.6	0.045	0.0	3.65	1.4	3.69	1.1	4.7	0.0
12	USGS grab	8/22/00	10:31	0.06		0.48		1.1		0.045		3.60		3.65		4.7	
18	USGS EWI	7/12/00	13:30	< 0.02	NA	0.47	4.4	1.2	8.7	0.059	8.1	4.19	0.7	4.25	0.7	5.5	1.8
18	USGS grab	7/12/00	13:31	< 0.02		0.45		1.1		0.064		4.22		4.28		5.4	
18	USGS EWI	9/7/00	12:20	< 0.02	NA	0.33	3.1	1.1	17.8	0.063	4.9	3.82	0.5	3.88	0.5	5.0	4.1
18	USGS grab	9/7/00	12:21	< 0.02		0.32		0.92		0.060		3.84		3.90		4.8	
27	USGS EWI	9/20/00	10:30	< 0.02	NA	0.21	6.9	0.48	3.1	0.025	4.1	1.91	NA	1.94	1.0	2.4	NA
27	USGS grab	9/20/00	10:31	< 0.02		0.23		0.50		0.024		—		1.92		—	
27	USGS EWI	10/4/00	10:00	< 0.02	NA	0.20	22.2	0.52	3.9	0.030	3.3	1.93	0.5	1.96	0.5	2.5	0.0
27	USGS grab	10/4/00	10:01	< 0.02		0.25		0.50		0.031		1.94		1.97		2.5	

Appendix A. Results of quality control samples for split replicates, sequential replicates, and field blanks in the San Joaquin River Basin, California, in 2000 and 2001—*Continued.*

Site number	Orthophosphate, dissolved (mg/L as P)	RPD	Total phosphorus (mg/L as P)	RPD	Organic carbon, dissolved (mg/L as C)	RPD	Organic carbon, suspended (mg/L as C)	RPD	Ultraviolet absorbance at 254 nm (cm^{-1})	RPD	Volatile suspended solids (mg/L)	RPD	Chlorophyll-*a* (µg/L)	RPD	Pheophytin-*a* (µg/L)	RPD	Suspended sediment (mg/L)	RPD	Suspended sediment size fraction < 0.062 mm (percent)	RPD
Sequential replicates—sampling methods comparison																				
7	0.14	0.0	0.44	2.3	5.0	2.0	1.9	23.5	0.135	0.0	12	8.7	E 35.9	193	—	NA	—	NA	—	NA
7	0.14		0.45		5.1		1.5		0.135		11		E 0.7		—		—		—	
7	0.17	0.0	0.45	4.6	6.7	4.6	1.7	0.0	0.182	6.2	—	NA	26.3	110	—	NA	96	NA	—	NA
7	0.17		0.43		6.4		1.7		0.171		10		7.6		—		—		—	
12	0.08	0.0	0.31	10.2	4.0	0.0	2.4	82.4	0.117	0.9	<10	NA	66.3	13.1	—	NA	55	NA	—	NA
12	0.08		0.28		4.0		1.0		0.118		<10		75.6		—		—		—	
12	0.12	8.0	0.28	3.5	3.9	0.0	0.8	11.8	—	NA	<10	NA	18.8	9.6	—	NA	—	NA	—	NA
12	0.13		0.29		3.9		0.9		—		—		20.7		—		—		—	
18	0.18	0.0	0.41	2.5	4.2	2.4	1.7	45.5	0.103	1.0	13	7.4	71.8	8.3	—	NA	185	NA	—	NA
18	0.18		0.40		4.3		2.7		0.104		14		78.0		—		—		—	
18	0.20	5.1	0.42	4.9	3.2	3.1	1.3	16.7	0.084	2.4	<10	NA	25.3	2.3	—	NA	—	NA	—	NA
18	0.19		0.40		3.3		1.1		0.086		—		25.9		—		—		—	
27	0.11	0.0	0.21	4.9	2.3	NA	0.5	NA	0.068	NA	<10	NA	10.5	27.9	—	NA	58	NA	—	NA
27	0.11		0.20		—		—		—		<10		13.9		—		—		—	
27	0.10	0.0	0.20	4.9	2.6	3.9	0.3	28.6	0.078	13.7	<10	NA	11.5	10.7	—	NA	43	NA	—	NA
27	0.10		0.21		2.5		0.4		0.068		<10		12.8		—		—		—	

Appendix A. Results of quality control samples for split replicates, sequential replicates, and field blanks in the San Joaquin River Basin, California, in 2000 and 2001—*Continued.*

Site number	Laboratory	Date	Time	Ammonia, dissolved (mg/L as N)	RPD	Ammonia and organic nitrogen, dissolved (mg/L as N)	RPD	Ammonia and organic nitrogen, total (mg/L as N)	RPD	Nitrite, dissolved (mg/L as N)	RPD	Nitrate, dissolved (mg/L as N)	RPD	Nitrite and nitrate, dissolved (mg/L as N)	RPD	Total nitrogen (mg/L as N)	RPD
Sequential replicates—laboratory performance comparison																	
7	NWQL	8/9/00	12:01	< 0.02	NA	0.47	NA	1.5	NA	0.084	NA	2.95	10.6	3.03	NA	4.6	15.5
7	UCDBL	8/9/00	12:02	0.01		—		—		—		3.28		—		3.94	
12	NWQL	7/25/00	12:01	< 0.02	NA	0.46	NA	1.4	NA	0.077	NA	4.06	10.3	4.13	NA	5.6	0.7
12	UCDBL	7/25/00	12:02	0.10		—		—		—		4.50		—		5.64	
12	NWQL	8/22/00	10:31	0.06	50.0	0.48	NA	1.1	NA	0.045	NA	3.60	5.4	3.65	NA	4.7	2.6
12	UCDBL	8/22/00	10:32	0.10		—		—		—		3.80		—		4.58	
18	NWQL	7/12/00	13:31	< 0.02	NA	0.45	NA	1.1	NA	0.064	NA	4.22	1.7	4.28	NA	5.4	1.3
18	UCDBL	7/12/00	13:32	0.08		—		—		—		4.29		—		5.33	

Appendix A. Results of quality control samples for split replicates, sequential replicates, and field blanks in the San Joaquin River Basin, California, in 2000 and 2001—*Continued.*

Site number	Orthophosphate, dissolved (mg/L as P)	RPD	Total phosphorus (mg/L as P)	RPD	Organic carbon, dissolved (mg/L as C)	RPD	Organic carbon, suspended (mg/L as C)	RPD	Ultraviolet absorbance at 254 nm (cm^{-1})	RPD	VSS/POM (mg/L)	RPD	Chlorophyll-*a* (μg/L)	RPD	Pheophytin-*a* (μg/L)	RPD	Suspended sediment (mg/L)	RPD	Suspended sediment size fraction <0.062 mm (percent)	RPD
Sequential replicates—laboratory performance comparison																				
7	0.14	8.6	0.45	54.6	5.1	4.0	1.5	NA	0.135	NA	11	53.3	E 0.7	190	—	NA	—	NA	—	NA
7	0.155		0.257		4.9		—		—		19		29.1		10.3		114		—	
12	0.08	6.8	0.28	50.1	4.0	29.9	1.0	NA	0.118	NA	<10	NA	75.6	37.2	—	NA	—	NA	—	NA
12	0.086		0.168		5.4		—		—		15		51.9		5.4		48		—	
12	0.12	3.7	0.29	31.3	3.9	47.6	0.9	NA	—	NA	—	NA	20.7	12.7	—	NA	—	NA	—	NA
12	0.125		0.212		2.4		—		—		13		23.5		4.6		71		—	
18	0.18	6.5	0.41	47.6	4.2	77.4	2.7	NA	0.104	NA	14	30.3	78.0	59.1	—	NA	—	NA	—	NA
18	0.169		0.252		9.5		—		—		19		42.4		10.8		164		—	

Appendix A. Results of quality control samples for split replicates, sequential replicates, and field blanks in the San Joaquin River Basin, California, in 2000 and 2001—*Continued.*

Site number	Date	Time	Ammonia, dissolved (mg/L as N)	Ammonia and organic nitrogen, dissolved (mg/L as N)	Ammonia and organic nitrogen, total (mg/L as N)	Nitrite, dissolved (mg/L as N)	Nitrite and nitrate, dissolved (mg/L as N)
				Field Blanks			
7	7/25/01	10:58	< 0.04	< 0.10	E 0.04	< 0.006	E 0.03
7	8/22/01	10:58	< 0.04	< 0.10	< 0.08	< 0.006	< 0.05
11	9/6/01	14:08	< 0.04	< 0.10	< 0.08	< 0.006	E 0.03
12	10/18/01	10:28	< 0.04	< 0.10	< 0.10	< 0.006	< 0.05
13	9/4/01	11:18	< 0.04	< 0.10	< 0.08	< 0.006	< 0.05
17	10/3/01	11:38	< 0.04	< 0.10	< 0.10	< 0.008	E 0.02
18	8/23/00	11:38	< 0.02	< 0.10	< 0.10	< 0.01	< 0.05
18	9/19/01	11:38	< 0.04	< 0.10	E 0.04	< 0.006	E 0.02
27	8/9/00	16:08	< 0.02	< 0.10	< 0.10	< 0.01	< 0.05

Appendix A. Results of quality control samples for split replicates, sequential replicates, and field blanks in the San Joaquin River Basin, California, in 2000 and 2001—*Continued.*

Site number	Date	Time	Orthophosphate, dissolved (mg/L as P)	Total phosphorus (mg/L as P)	Organic carbon, dissolved (mg/L as C)	Ultraviolet absorbance at 254 nm (cm^{-1})	Volatile suspended solids (mg/L)	Chlorophyll-*a* (µg/L)	Pheophytin-*a* (µg/L)
					Field Blanks				
7	7/25/01	10:58	< 0.02	< 0.004	0.5	< 0.004	< 4	< 0.1	< 0.1
7	8/22/01	10:58	< 0.02	< 0.004	E 0.2	< 0.004	4	—	—
11	9/6/01	14:08	< 0.02	< 0.004	0.5	< 0.004	< 4	—	—
12	10/18/01	10:28	< 0.02	< 0.004	E 0.2	< 0.004	4	< 0.1	0.1
13	9/4/01	11:18	< 0.02	< 0.004	E 0.2	< 0.004	4	—	—
17	10/3/01	11:38	< 0.02	< 0.004	E 0.2	—	< 4	< 0.1	0.1
18	8/23/00	11:38	< 0.01	< 0.008	< 0.3	—	< 10	—	—
18	9/19/01	11:38	< 0.02	< 0.004	< 0.3	< 0.004	< 4	< 0.1	0.1
27	8/9/00	16:08	< 0.01	< 0.008	0.4	—	< 10	< 0.1	—

Appendix B. All data (University of California at Davis and U.S. Geological Survey) for 2000 and 2001 for nutrients, organic carbon, and chlorophyll for San Joaquin River sites in California

[SUVA, specific ultraviolet absorbance; SJR, San Joaquin River; UCD, University of California at Davis; USGS, U.S. Geological Survey; E, estimated. ft^3/s, cubic foot per second; µS/cm, microsiemens per centimeter; mg/L, milligram per liter; in., inch; nm, nanometer; cm^{-1}, per centimeter; L/mg-cm, liter per milligram-centimeter; µg/L, microgram per liter; mm, millimeter; <, less than; >, greater than; —, no data reported]

Site number	Site name	Date	Time	Laboratory	Stream flow (ft^3/s)	Water temperature (°C)	pH	Specific conductance (µS/cm at 25°C)	Dissolved oxygen (mg/L)	Alkalinity (mg/L $CaCO_3$)	Secchi disk depth (in.)	Ammonia, dissolved (mg/L as N)	Nitrate, dissolved (mg/L as N)	Inorganic nitrogen, dissolved (mg/L as N)	Organic nitrogen, dissolved (mg/L as N)
1	SJR near Stevinson	07/12/00	13:40	UCD	E 124	27.8	8.9	413	—	—	—	0.05	0.37	0.42	0.09
1	SJR near Stevinson	07/26/00	14:15	UCD	E 53	27.2	9.1	1060	—	—	—	0.50	7.29	7.78	1.51
1	SJR near Stevinson	08/09/00	12:46	UCD	E 56	26.9	7.9	1110	—	—	—	0.45	8.06	8.51	1.33
1	SJR near Stevinson	08/23/00	13:42	UCD	E 58	26.0	9.1	1030	—	—	—	0.04	0.32	0.35	0.98
1	SJR near Stevinson	09/06/00	14:15	UCD	E 81	22.7	8.5	384	—	—	—	0.02	0.34	0.36	0.34
1	SJR near Stevinson	09/20/00	15:10	UCD	E 16	29.0	8.7	1140	—	—	—	0.13	0.16	0.29	0.83
1	SJR near Stevinson	10/04/00	13:31	UCD	E 22	22.9	8.4	1480	—	—	—	0.07	0.01	0.09	0.44
1	SJR near Stevinson	10/18/00	13:01	UCD	E 38	20.3	8.4	745	—	—	—	< 0.01	0.21	0.22	0.51
1	SJR near Stevinson	06/13/01	09:50	UCD	E 14	22.5	7.5	1450	—	—	—	0.04	0.45	0.49	1.27
1	SJR near Stevinson	06/27/01	12:10	UCD	E 18	23.9	8.4	1640	—	—	—	0.02	0.13	0.15	1.52
1	SJR near Stevinson	07/11/01	09:45	UCD	E 43	25.8	8.5	1820	—	—	—	0.05	0.08	0.13	1.08
1	SJR near Stevinson	07/25/01	14:40	UCD	E 21	31.0	8.2	1410	—	—	—	0.02	0.02	0.05	0.55
1	SJR near Stevinson	08/07/01	13:20	UCD	E 17	29.4	9.3	1440	—	—	—	0.04	0.24	0.28	1.96
1	SJR near Stevinson	08/22/01	13:01	UCD	E 23	26.1	9.3	1370	—	—	—	0.53	1.15	1.68	1.49
1	SJR near Stevinson	09/05/01	13:21	UCD	E 24	26.8	8.6	1410	—	—	—	0.38	0.03	0.40	0.97
1	SJR near Stevinson	09/19/01	11:15	UCD	E 11	23.7	8.1	1530	—	—	—	0.06	0.02	0.08	0.88
1	SJR near Stevinson	10/03/01	10:40	UCD	E 31	23.5	8.2	1670	—	—	—	0.03	0.02	0.04	1.00
7	SJR upstream of Merced	07/26/00	14:00	USGS	E 327	28.0	8.3	1660	10.6	130	E 8	< 0.02	4.54	4.75	0.65
7	SJR upstream of Merced	08/09/00	12:00	USGS	E 358	26.5	8.5	1350	8.2	140	7	< 0.02	2.97	3.06	0.46
7	SJR upstream of Merced	08/22/00	12:20	USGS	E 336	24.5	8.3	1340	8.2	140	8	< 0.02	2.13	2.19	0.48
7	SJR upstream of Merced	09/06/00	12:40	USGS	E 284	21.0	8.6	1620	10.2	170	11	< 0.02	2.66	2.71	0.40
7	SJR upstream of Merced	09/19/00	12:30	USGS	E 197	25.0	8.2	1340	8.7	150	11	< 0.02	1.28	1.32	0.43
7	SJR upstream of Merced	10/03/00	12:30	USGS	E 115	22.0	8.0	1440	8.6	170	13	0.04	1.52	1.60	0.58
7	SJR upstream of Merced	10/17/00	12:30	USGS	E 347	19.0	7.9	1180	6.9	170	11	E 0.02	0.80	0.85	0.64
7	SJR upstream of Merced	06/13/01	09:40	USGS	E 265	21.0	8.2	2390	8.1	180	—	< 0.04	5.55	5.65	0.67
7	SJR upstream of Merced	06/27/01	10:00	USGS	E 242	23.0	8.0	1740	6.7	150	6	0.17	4.93	5.18	0.64
7	SJR upstream of Merced	07/11/01	10:20	USGS	E 260	24.5	8.2	1860	8.1	150	5	< 0.04	4.08	4.21	0.59
7	SJR upstream of Merced	07/25/01	10:50	USGS	E 296	25.5	8.2	1680	7.9	—	7	< 0.04	2.85	2.92	0.39
7	SJR upstream of Merced	08/08/01	10:10	USGS	E 243	27.0	8.3	1840	7.4	140	—	E 0.03	2.46	2.52	0.41
7	SJR upstream of Merced	08/22/01	10:50	USGS	E 286	24.0	8.2	1630	7.5	140	12	< 0.04	2.50	2.58	0.44
7	SJR upstream of Merced	09/05/01	09:30	USGS	E 201	23.0	8.2	2270	8.2	190	17	< 0.04	2.50	2.58	0.54
7	SJR upstream of Merced	09/19/01	09:30	USGS	E 120	21.5	7.9	2260	8.7	180	11	< 0.04	1.49	1.54	0.50
7	SJR upstream of Merced	10/03/01	10:00	USGS	E 197	22.5	7.8	1700	5.5	190	5	< 0.04	0.34	0.38	0.82
7	SJR upstream of Merced	10/17/01	09:30	USGS	E 257	19.0	8.0	1350	6.0	180	8	E 0.02	0.39	0.42	0.67
7	SJR upstream of Merced	10/31/01	08:40	USGS	E 227	15.5	8.0	[1]1950	7.0	210	11	E 0.03	0.76	0.82	0.67
7	SJR upstream of Merced	11/15/01	09:20	USGS	E 575	15.5	8.2	1380	6.6	180	—	0.06	0.74	0.83	0.72
12	SJR near Crows Landing	07/11/00	18:00	USGS	737	27.0	8.5	1080	11.0	140	—	< 0.02	3.66	3.73	0.40
12	SJR near Crows Landing	07/25/00	12:00	USGS	612	25.0	8.4	1260	8.6	140	11	< 0.02	4.04	4.13	0.43
12	SJR near Crows Landing	08/08/00	11:00	USGS	644	24.0	8.0	1040	7.5	130	10	0.21	3.47	3.75	0.48
12	SJR near Crows Landing	08/22/00	10:30	USGS	713	23.5	8.1	1020	7.1	130	10	0.04	3.65	3.73	0.45

Appendix B. All data (University of California at Davis and U.S. Geological Survey) for 2000 and 2001 for nutrients, organic carbon, and chlorophyll for San Joaquin River sites in California—*Continued*

Site number	Site name	Date	Total nitrogen, dissolved (mg/L as N)	Total nitrogen (mg/L as N)	Orthophosphate, dissolved (mg/L as P)	Total phosphorus (mg/L as P)	Organic carbon, dissolved (mg/L as C)	Organic carbon, suspended (mg/L as C)	Ultraviolet absorbance at 254 nm (cm^{-1})	SUVA (L/mg-cm)	Volatile suspended solids (mg/L)	Particulate organic matter (mg/L)	Chlorophyll-*a* (μg/L)	Pheophytin-*a* (μg/L)	Suspended sediment (mg/L)	Suspended sediment, size fraction < 0.062 mm (percent)
1	SJR near Stevinson	07/12/00	0.51	1.41	0.04	0.16	4.5	—	—	—	—	24	56.6	—	58	—
1	SJR near Stevinson	07/26/00	9.29	11.6	0.17	0.34	7.4	—	—	—	—	42	286	—	37	—
1	SJR near Stevinson	08/09/00	9.83	11.7	0.06	0.50	7.0	—	—	—	—	50	377	—	54	—
1	SJR near Stevinson	08/23/00	1.33	2.11	0.04	0.19	6.8	—	—	—	—	21	75.5	—	25	—
1	SJR near Stevinson	09/06/00	0.70	1.52	0.08	0.21	3.7	—	—	—	—	12	67.8	—	35	—
1	SJR near Stevinson	09/20/00	1.12	1.74	0.09	0.23	5.2	—	—	—	—	12	15.1	—	17	—
1	SJR near Stevinson	10/04/00	0.52	1.04	0.10	0.21	8.6	—	—	—	—	19	17.1	—	24	—
1	SJR near Stevinson	10/18/00	0.73	1.25	0.09	0.20	4.7	—	—	—	—	15	16.7	—	30	—
1	SJR near Stevinson	06/13/01	1.76	1.92	0.19	0.50	6.7	—	—	—	—	18	120	—	46	—
1	SJR near Stevinson	06/27/01	1.66	2.86	0.07	0.29	6.6	—	—	—	—	18	113	—	34	—
1	SJR near Stevinson	07/11/01	1.22	2.96	0.05	0.23	5.8	—	—	—	—	27	121	—	64	—
1	SJR near Stevinson	07/25/01	0.60	1.61	0.03	0.21	6.5	—	—	—	—	29	85.7	—	33	—
1	SJR near Stevinson	08/07/01	2.24	4.78	0.03	0.20	5.8	—	—	—	—	61	393	—	69	—
1	SJR near Stevinson	08/22/01	3.17	6.35	0.02	0.47	6.2	—	—	—	—	39	348	—	44	—
1	SJR near Stevinson	09/05/01	1.37	3.77	0.07	0.37	5.8	—	—	—	—	45	197	—	49	—
1	SJR near Stevinson	09/19/01	0.96	1.57	0.03	0.19	4.7	—	—	—	—	13	125	—	25	—
1	SJR near Stevinson	10/03/01	1.04	2.76	0.06	0.18	5.3	—	—	—	—	18	80.6	—	22	—
7	SJR upstream of Merced	07/26/00	5.40	6.54	0.09	0.40	5.2	1.9	0.149	0.029	14	—	95.9	—	—	—
7	SJR upstream of Merced	08/09/00	3.52	4.25	0.14	0.44	5.0	1.9	0.135	0.027	12	—	E 35.9	—	—	—
7	SJR upstream of Merced	08/22/00	2.67	3.48	0.10	0.37	4.8	1.1	—	—	14	—	31.4	—	—	—
7	SJR upstream of Merced	09/06/00	3.11	4.00	0.05	0.26	4.2	1.0	0.114	0.027	<10	—	28.1	—	—	—
7	SJR upstream of Merced	09/19/00	1.75	2.51	0.11	0.33	6.6	1.5	0.135	0.020	12	—	35.2	—	—	—
7	SJR upstream of Merced	10/03/00	2.18	2.66	0.17	0.45	6.7	1.7	0.182	0.027	—	—	26.3	—	96	90
7	SJR upstream of Merced	10/17/00	1.49	1.55	—	0.43	8.8	1.4	0.240	0.027	<10	—	15.5	—	74	86
7	SJR upstream of Merced	06/13/01	6.32	7.23	0.10	0.35	6.3	2.9	—	—	9	—	28.9	16.1	124	94
7	SJR upstream of Merced	06/27/01	5.82	6.61	0.17	0.41	7.1	>3.3	0.169	0.024	16	—	31.2	14.4	163	84
7	SJR upstream of Merced	07/11/01	4.80	5.89	0.12	0.37	—	—	—	0.025	20	—	27.8	22.9	138	86
7	SJR upstream of Merced	07/25/01	3.31	3.90	0.10	0.36	5.2	>3.3	0.149	0.029	19	—	37.4	13.6	158	85
7	SJR upstream of Merced	08/08/01	2.93	3.79	0.06	0.34	4.7	2.4	0.141	0.030	15	—	48.2	18.2	114	89
7	SJR upstream of Merced	08/22/01	3.02	3.41	0.11	0.33	4.6	3.2	0.133	0.029	18	—	29.4	15.6	143	85
7	SJR upstream of Merced	09/05/01	3.12	3.76	0.08	0.27	4.0	1.7	0.161	0.040	10	—	32.4	30.4	44	86
7	SJR upstream of Merced	09/19/01	2.04	2.62	0.09	0.26	4.6	2.4	0.160	0.035	8	—	29.4	10.8	58	94
7	SJR upstream of Merced	10/03/01	1.20	1.29	0.28	0.55	10.3	1.7	E 0.298	0.030	11	—	23.4	13.3	103	77
7	SJR upstream of Merced	10/17/01	1.09	1.31	0.21	0.45	8.4	1.8	0.239	0.028	14	—	14.4	11.3	90	89
7	SJR upstream of Merced	10/31/01	1.49	1.71	0.16	0.38	8.4	2.2	0.235	0.028	10	—	15.5	12.9	57	94
7	SJR upstream of Merced	11/15/01	1.55	2.07	0.20	0.37	10.1	1.7	E 0.266	0.027	8	—	12.2	3.7	120	82
12	SJR near Crows Landing	07/11/00	4.13	4.82	0.11	0.24	4.5	1.7	0.117	0.026	10	—	64.7	—	71	94
12	SJR near Crows Landing	07/25/00	4.56	5.62	0.08	0.31	4.0	2.4	0.117	0.029	<10	—	66.3	—	55	86
12	SJR near Crows Landing	08/08/00	4.23	5.04	0.12	0.32	4.2	1.1	0.115	0.027	<10	—	E 63.8	—	—	—
12	SJR near Crows Landing	08/22/00	4.18	4.65	0.12	0.28	3.9	0.8	—	—	—	—	18.8	—	—	—

Appendix B. All data (University of California at Davis and U.S. Geological Survey) for 2000 and 2001 for nutrients, organic carbon, and chlorophyll for San Joaquin River sites in California—*Continued*

Site number	Site name	Date	Time	Laboratory	Stream flow (ft^3/s)	Water temperature (°C)	pH	Specific conductance (μS/cm at 25°C)	Dissolved oxygen (mg/L)	Alkalinity (mg/L $CaCO_3$)	Secchi disk depth (in.)	Ammonia, dissolved (mg/L as N)	Nitrate, dissolved (mg/L as N)	Inorganic nitrogen, dissolved (mg/L as N)	Organic nitrogen, dissolved (mg/L as N)
12	SJR near Crows Landing	09/06/00	10:30	USGS	708	20.5	8.2	960	8.1	130	10	< 0.02	3.56	3.60	0.31
12	SJR near Crows Landing	09/19/00	11:00	USGS	569	23.5	8.0	910	7.2	140	12	< 0.02	2.95	2.98	0.36
12	SJR near Crows Landing	10/03/00	11:00	USGS	464	21.5	7.7	990	7.7	130	10	< 0.02	2.85	2.88	0.35
12	SJR near Crows Landing	10/17/00	11:20	USGS	1190	18.0	7.8	585	7.8	91	—	0.21	1.24	1.46	0.50
12	SJR near Crows Landing	06/14/01	10:00	USGS	565	22.0	8.2	1330	8.2	130	—	< 0.04	4.86	4.95	0.41
12	SJR near Crows Landing	06/28/01	09:50	USGS	562	23.0	8.1	1240	7.4	150	—	0.06	4.93	5.06	0.56
12	SJR near Crows Landing	07/12/01	10:30	USGS	562	24.0	8.5	1320	7.4	150	9	< 0.04	3.83	3.93	0.41
12	SJR near Crows Landing	07/26/01	11:30	USGS	546	24.5	8.3	1330	7.4	—	8	< 0.04	4.05	4.14	0.38
12	SJR near Crows Landing	08/09/01	10:30	USGS	435	26.5	8.3	1420	8.0	160	—	E 0.02	3.35	3.43	0.41
12	SJR near Crows Landing	08/23/01	11:00	USGS	531	23.0	8.2	1150	7.8	130	10	< 0.04	4.07	4.13	0.34
12	SJR near Crows Landing	09/06/01	13:00	USGS	361	22.5	8.2	1540	8.9	170	15	< 0.04	4.11	4.19	0.41
12	SJR near Crows Landing	09/20/01	10:30	USGS	354	22.5	8.2	1070	7.5	120	13	< 0.04	3.36	3.41	0.28
12	SJR near Crows Landing	10/04/01	10:30	USGS	371	21.5	7.8	[1]1350	6.4	170	14	< 0.04	1.83	1.88	0.56
12	SJR near Crows Landing	10/18/01	10:20	USGS	773	19.0	8.0	846	7.0	120	22	< 0.04	1.24	1.27	0.37
12	SJR near Crows Landing	11/01/01	10:00	USGS	1190	16.0	7.9	[1]620	8.8	76	14	< 0.04	1.22	1.25	0.24
12	SJR near Crows Landing	11/16/01	09:20	USGS	1190	15.0	7.8	[1]840	7.9	120	10	0.04	1.23	1.28	0.49
15	SJR near Patterson	07/12/00	12:50	UCD	E 884	25.2	8.1	923	—	—	—	0.05	3.97	4.02	0.30
15	SJR near Patterson	07/26/00	13:10	UCD	E 876	25.1	8.1	1160	—	—	—	0.08	4.43	4.51	0.53
15	SJR near Patterson	08/09/00	11:45	UCD	E 817	24.2	7.8	869	—	—	—	0.02	3.99	4.01	0.29
15	SJR near Patterson	08/23/00	12:40	UCD	E 802	24.4	8.1	946	—	—	—	0.10	3.47	3.56	0.42
15	SJR near Patterson	09/06/00	13:10	UCD	E 902	21.4	8.2	835	—	—	—	0.08	3.92	4.01	0.02
15	SJR near Patterson	09/20/00	14:20	UCD	E 667	25.9	8.0	911	—	—	—	0.08	3.62	3.70	0.70
15	SJR near Patterson	10/04/00	12:20	UCD	E 671	21.1	8.1	851	—	—	—	0.58	4.11	4.70	0.41
15	SJR near Patterson	10/18/00	11:57	UCD	E1460	18.2	8.1	471	—	—	—	0.30	1.64	1.94	0.44
15	SJR near Patterson	06/13/01	08:50	UCD	E 743	21.6	7.9	1280	—	—	—	0.44	4.09	4.53	0.69
15	SJR near Patterson	06/27/01	10:55	UCD	E 691	23.1	8.0	1230	—	—	—	0.05	4.08	4.14	0.35
15	SJR near Patterson	07/11/01	08:45	UCD	E 735	23.1	8.0	1120	—	—	—	0.11	4.58	4.69	1.68
15	SJR near Patterson	07/25/01	11:40	UCD	E 747	25.9	8.1	1210	—	—	—	0.03	4.07	4.10	0.66
15	SJR near Patterson	08/07/01	11:43	UCD	E 664	27.1	8.2	1200	—	—	—	0.09	3.82	3.91	1.30
15	SJR near Patterson	08/22/01	11:31	UCD	E 723	23.6	8.0	1080	—	—	—	0.11	4.03	4.15	0.95
15	SJR near Patterson	09/05/01	12:03	UCD	E 611	24.5	8.2	1100	—	—	—	0.02	4.37	4.40	0.27
15	SJR near Patterson	09/19/01	10:00	UCD	E 475	21.7	8.3	1160	—	—	—	0.27	3.53	3.79	1.36
15	SJR near Patterson	10/03/01	09:55	UCD	E 445	22.1	7.9	1310	—	—	—	0.34	2.60	2.94	1.57
18	SJR at Laird Park	07/12/00	13:30	USGS	E1030	25.5	8.2	1080	10.1	140	E 12	< 0.02	4.19	4.26	0.46
18	SJR at Laird Park	07/25/00	18:00	USGS	E 890	28.0	8.8	1220	16.4	300	E 11	< 0.02	4.23	4.31	0.42
18	SJR at Laird Park	08/08/00	13:00	USGS	782	24.5	8.4	1160	11.0	150	12	< 0.02	4.21	4.29	0.39
18	SJR at Laird Park	08/23/00	11:30	USGS	847	23.0	8.1	959	8.1	140	13	< 0.02	3.97	4.05	0.40
18	SJR at Laird Park	09/07/00	12:20	USGS	1090	22.5	8.1	1060	10.3	150	11	< 0.02	3.82	3.89	0.32
18	SJR at Laird Park	09/20/00	13:30	USGS	750	24.5	8.0	974	8.1	150	12	< 0.02	3.75	3.83	0.34
18	SJR at Laird Park	10/04/00	13:00	USGS	663	21.0	8.0	1090	8.6	170	5	0.06	3.40	3.56	0.37
18	SJR at Laird Park	10/18/00	12:30	USGS	1500	18.5	7.8	547	7.5	91	—	0.10	1.63	1.77	0.37
18	SJR at Laird Park	06/13/01	11:30	USGS	761	21.5	8.3	1410	9.1	160	—	E 0.03	4.58	4.73	0.47

Appendix B. All data (University of California at Davis and U.S. Geological Survey) for 2000 and 2001 for nutrients, organic carbon, and chlorophyll for San Joaquin River sites in California—*Continued*

Site number	Site name	Date	Total nitrogen, dissolved (mg/L as N)	Total nitrogen (mg/L as N)	Orthophosphate, dissolved (mg/L as P)	Total phosphorus (mg/L as P)	Organic carbon, dissolved (mg/L as C)	Organic carbon, suspended (mg/L as C)	Ultraviolet absorbance at 254 nm (cm^{-1})	SUVA (L/mg-cm)	Volatile suspended solids (mg/L)	Particulate organic matter (mg/L)	Chlorophyll-*a* (µg/L)	Pheophytin-*a* (µg/L)	Suspended sediment (mg/L)	Suspended sediment, size fraction < 0.062 mm (percent)
12	SJR near Crows Landing	09/06/00	3.91	4.46	0.08	0.24	3.4	1.1	0.093	0.027	<10	—	20.1	—	—	—
12	SJR near Crows Landing	09/19/00	3.34	3.76	0.11	0.25	3.9	0.9	0.101	0.026	<10	—	30.8	—	—	—
12	SJR near Crows Landing	10/03/00	3.23	3.67	0.12	0.24	3.8	0.3	0.104	0.028	<10	—	20.8	—	52	86
12	SJR near Crows Landing	10/17/00	1.96	1.96	0.12	0.15	4.7	1.1	0.126	0.027	—	—	9.3	—	90	86
12	SJR near Crows Landing	06/14/01	5.36	6.23	0.09	0.30	3.9	2.0	0.111	0.028	6	—	49.5	14.0	72	91
12	SJR near Crows Landing	06/28/01	5.62	6.30	0.16	0.35	4.4	2.5	0.135	0.031	12	—	27.8	16.7	53	91
12	SJR near Crows Landing	07/12/01	4.34	5.41	0.11	0.32	4.9	>3.3	0.128	0.026	19	—	26.5	25.9	111	91
12	SJR near Crows Landing	07/26/01	4.52	5.42	0.10	0.27	4.4	2.3	0.121	0.028	13	—	39.4	11.2	107	87
12	SJR near Crows Landing	08/09/01	3.84	4.51	0.12	0.34	3.9	3.2	0.115	0.029	10	—	65.7	21.7	81	90
12	SJR near Crows Landing	08/23/01	4.47	5.21	0.12	0.29	3.6	2.3	0.104	0.029	12	—	13.5	29.0	96	91
12	SJR near Crows Landing	09/06/01	4.60	5.17	0.12	0.27	3.6	1.9	0.113	0.031	6	—	23.7	24.1	51	82
12	SJR near Crows Landing	09/20/01	3.69	4.20	0.09	0.21	3.2	1.4	0.102	0.032	6	—	15.8	12.8	47	47
12	SJR near Crows Landing	10/04/01	2.44	2.63	0.18	0.33	7.1	0.8	0.185	0.026	7	—	15.7	12.1	54	93
12	SJR near Crows Landing	10/18/01	1.64	2.05	0.13	0.31	5.4	2.6	0.150	0.028	11	—	16.2	9.2	108	90
12	SJR near Crows Landing	11/01/01	1.49	1.80	0.07	0.19	3.6	0.9	0.108	0.030	4	—	7.8	3.9	53	81
12	SJR near Crows Landing	11/16/01	1.77	2.11	0.12	0.24	5.9	1.6	0.167	0.028	6	—	8.5	4.0	69	91
15	SJR near Patterson	07/12/00	4.32	4.54	0.27	0.35	4.6	—	—	—	—	17	56.1	—	58	—
15	SJR near Patterson	07/26/00	5.05	5.52	0.31	0.33	6.4	—	—	—	—	19	61.9	—	58	—
15	SJR near Patterson	08/09/00	4.30	4.61	0.27	0.37	3.9	—	—	—	—	16	38.5	—	85	—
15	SJR near Patterson	08/23/00	3.98	4.15	0.21	0.27	4.0	—	—	—	—	13	35.4	—	48	—
15	SJR near Patterson	09/06/00	4.03	4.07	0.22	0.31	3.9	—	—	—	—	9.0	25.0	—	58	—
15	SJR near Patterson	09/20/00	4.41	4.74	0.24	0.39	3.3	—	—	—	—	8.8	11.6	—	33	—
15	SJR near Patterson	10/04/00	5.10	5.17	0.34	0.50	3.9	—	—	—	—	8.8	8.5	—	32	—
15	SJR near Patterson	10/18/00	2.38	2.42	0.19	0.26	3.1	—	—	—	—	12	5.1	—	68	—
15	SJR near Patterson	06/13/01	5.22	5.62	0.19	0.36	4.7	—	—	—	—	17	29.2	—	75	—
15	SJR near Patterson	06/27/01	4.49	4.94	0.19	0.31	7.3	—	—	—	—	16	37.8	—	71	—
15	SJR near Patterson	07/11/01	6.37	6.97	0.16	0.38	5.2	—	—	—	—	15	53.8	—	70	—
15	SJR near Patterson	07/25/01	4.77	5.00	0.13	0.34	4.3	—	—	—	—	18	57.1	—	68	—
15	SJR near Patterson	08/07/01	5.21	5.67	0.26	0.35	3.7	—	—	—	—	19	36.2	—	62	—
15	SJR near Patterson	08/22/01	5.10	5.60	0.19	0.37	3.9	—	—	—	—	14	28.8	—	65	—
15	SJR near Patterson	09/05/01	4.67	4.83	0.22	0.37	3.8	—	—	—	—	9.3	24.5	—	38	—
15	SJR near Patterson	09/19/01	5.15	5.16	0.28	0.41	3.3	—	—	—	—	8.2	14.3	—	39	—
15	SJR near Patterson	10/03/01	4.51	5.36	0.29	0.41	5.2	—	—	—	—	7.4	14.8	—	29	—
18	SJR at Laird Park	07/12/00	4.72	5.45	0.18	0.41	4.2	1.7	0.103	0.025	13	—	71.8	—	185	93
18	SJR at Laird Park	07/25/00	4.73	5.70	0.14	0.38	4.2	3.6	0.116	0.028	14	—	64.4	—	85	81
18	SJR at Laird Park	08/08/00	4.68	5.58	0.17	0.37	3.6	1.1	0.099	0.028	12	—	E 43.0	—	76	82
18	SJR at Laird Park	08/23/00	4.45	5.04	0.21	0.41	3.7	0.9	—	—	<10	—	18.9	—	—	—
18	SJR at Laird Park	09/07/00	4.21	4.98	0.20	0.42	3.2	1.3	0.084	0.026	<10	—	25.3	—	—	—
18	SJR at Laird Park	09/20/00	4.17	4.72	0.27	0.44	3.4	1.0	0.092	0.027	<10	—	21.7	—	—	—
18	SJR at Laird Park	10/04/00	3.93	4.38	0.29	0.47	3.7	0.6	0.102	0.028	<10	—	18.9	—	57	85
18	SJR at Laird Park	10/18/00	2.14	2.67	0.15	0.35	4.0	0.7	0.110	0.028	<10	—	11.8	—	122	74
18	SJR at Laird Park	06/13/01	5.20	5.90	0.29	0.56	3.7	1.7	—	—	8	—	20.3	17.6	108	85

Appendix B. All data (University of California at Davis and U.S. Geological Survey) for 2000 and 2001 for nutrients, organic carbon, and chlorophyll for San Joaquin River sites in California—*Continued*

Site number	Site name	Date	Time	Laboratory	Stream flow (ft^3/s)	Water temperature (°C)	pH	Specific conductance (µS/cm at 25°C)	Dissolved oxygen (mg/L)	Alkalinity (mg/L $CaCO_3$)	Secchi disk depth (in.)	Ammonia, dissolved (mg/L as N)	Nitrate, dissolved (mg/L as N)	Inorganic nitrogen, dissolved (mg/L as N)	Organic nitrogen, dissolved (mg/L as N)
18	SJR at Laird Park	06/27/01	09:50	USGS	600	22.5	7.9	1270	7.6	160	11	0.05	4.67	4.84	0.36
18	SJR at Laird Park	07/11/01	11:50	USGS	680	24.0	8.4	1110	11.1	140	14	< 0.04	4.12	4.22	0.35
18	SJR at Laird Park	07/25/01	13:00	USGS	665	26.0	8.5	1220	10.7	—	19	< 0.04	4.63	4.72	0.32
18	SJR at Laird Park	08/08/01	13:30	USGS	575	26.5	8.4	1360	13.6	180	14	E 0.02	4.02	4.11	0.36
18	SJR at Laird Park	08/22/01	13:30	USGS	672	24.0	8.3	1240	7.8	150	12	< 0.04	3.55	3.66	0.32
18	SJR at Laird Park	09/05/01	11:30	USGS	487	23.0	8.5	1300	11.3	160	35	< 0.04	4.32	4.42	0.35
18	SJR at Laird Park	09/19/01	11:30	USGS	E 494	—	7.9	1180	—	170	13	< 0.04	4.19	4.29	0.36
18	SJR at Laird Park	10/03/01	11:40	USGS	E 434	22.0	7.9	1260	8.0	170	16	< 0.04	3.07	3.17	0.43
18	SJR at Laird Park	10/17/01	08:40	USGS	790	18.5	7.8	1080	7.6	160	15	0.07	2.70	2.82	0.50
18	SJR at Laird Park	10/31/01	09:30	USGS	1320	16.5	7.8	[1]687	8.3	86	23	< 0.04	2.08	2.13	0.24
18	SJR at Laird Park	11/15/01	11:00	USGS	E 1250	16.0	8.1	877	8.0	120	18	< 0.04	1.52	1.57	0.49
24	SJR at Maze Road	07/12/00	12:13	UCD	E 1450	24.7	8.0	712	—	—	—	0.02	3.13	3.15	0.18
24	SJR at Maze Road	07/26/00	11:30	UCD	E 1440	23.7	8.1	615	—	—	—	0.01	2.40	2.41	0.48
24	SJR at Maze Road	08/09/00	10:47	UCD	E 1410	23.5	8.1	700	—	—	—	< 0.01	2.98	2.99	0.14
24	SJR at Maze Road	08/23/00	11:35	UCD	E 2260	22.0	8.0	426	—	—	—	0.01	1.66	1.68	0.10
24	SJR at Maze Road	09/06/00	11:30	UCD	E 1980	19.7	8.2	539	—	—	—	0.01	2.42	2.43	0.06
24	SJR at Maze Road	09/20/00	12:00	UCD	E 1950	23.7	7.9	464	—	—	—	0.06	2.03	2.09	0.47
24	SJR at Maze Road	10/04/00	11:40	UCD	E 1690	20.0	8.2	555	—	—	—	0.14	2.41	2.55	0.30
24	SJR at Maze Road	10/18/00	11:15	UCD	E 2360	18.3	8.2	489	—	—	—	0.19	1.81	1.99	0.43
24	SJR at Maze Road	06/13/01	08:00	UCD	E 988	21.4	8.0	1020	—	—	—	0.10	2.50	2.60	0.78
24	SJR at Maze Road	06/27/01	10:20	UCD	E 957	22.4	8.0	931	—	—	—	0.04	3.66	3.70	0.27
24	SJR at Maze Road	07/11/01	07:45	UCD	E 820	23.9	8.2	942	—	—	—	0.04	3.83	3.87	1.17
24	SJR at Maze Road	07/25/01	11:37	UCD	E 885	24.9	8.0	915	—	—	—	0.03	4.41	4.44	0.56
24	SJR at Maze Road	08/07/01	11:00	UCD	E 945	26.7	8.3	815	—	—	—	0.06	3.02	3.08	1.69
24	SJR at Maze Road	08/22/01	10:58	UCD	E 972	23.2	8.1	819	—	—	—	0.05	3.07	3.11	0.35
24	SJR at Maze Road	09/05/01	11:26	UCD	E 920	24.1	8.6	945	—	—	—	0.05	2.45	2.50	0.38
24	SJR at Maze Road	09/19/01	09:10	UCD	E 1020	21.7	8.1	817	—	—	—	0.04	2.91	2.95	0.85
24	SJR at Maze Road	10/03/01	09:20	UCD	E 1020	22.0	7.9	880	—	—	—	0.09	2.70	2.79	2.41
27	SJR near Vernalis	07/12/00	17:30	USGS	1870	26.0	8.6	600	11.7	93	—	< 0.02	2.22	2.26	0.27
27	SJR near Vernalis	07/26/00	15:30	USGS	1860	25.5	9.0	550	12.9	79	10	< 0.02	1.56	1.60	0.22
27	SJR near Vernalis	08/09/00	16:00	USGS	1770	26.0	8.6	615	12.8	88	19	< 0.02	1.98	2.02	0.27
27	SJR near Vernalis	08/23/00	09:30	USGS	2610	22.0	8.0	430	8.3	66	17	< 0.02	1.38	1.41	0.19
27	SJR near Vernalis	09/07/00	10:30	USGS	2270	20.0	8.0	504	8.5	72	17	< 0.02	1.84	1.87	0.19
27	SJR near Vernalis	09/20/00	10:30	USGS	2270	23.0	7.6	459	7.7	86	12	< 0.02	1.91	1.95	0.20
27	SJR near Vernalis	10/04/00	10:00	USGS	2090	19.5	8.0	510	8.3	94	10	< 0.02	1.93	1.97	0.19
27	SJR near Vernalis	10/18/00	10:00	USGS	2690	18.0	7.8	490	8.1	86	—	E 0.03	1.60	1.65	0.25
27	SJR near Vernalis	06/14/01	12:00	USGS	1550	22.5	8.6	752	10.2	100	—	< 0.04	2.00	2.05	0.20
27	SJR near Vernalis	06/28/01	11:50	USGS	1480	22.5	8.4	659	9.4	95	13	< 0.04	1.97	2.03	0.21
27	SJR near Vernalis	07/12/01	10:00	USGS	1300	22.5	8.9	661	11.3	100	15	< 0.04	1.82	1.88	0.18
27	SJR near Vernalis	07/26/01	10:30	USGS	1360	25.5	8.7	719	11.8	—	—	< 0.04	2.12	2.19	0.20
27	SJR near Vernalis	08/09/01	11:00	USGS	1200	26.0	8.5	744	10.2	170	5	E 0.03	1.92	1.99	0.24
27	SJR near Vernalis	08/23/01	10:30	USGS	1380	23.0	8.3	732	9.5	100	—	< 0.04	2.01	2.07	0.22

Appendix B. All data (University of California at Davis and U.S. Geological Survey) for 2000 and 2001 for nutrients, organic carbon, and chlorophyll for San Joaquin River sites in California—*Continued*

Site number	Site name	Date	Total nitrogen, dissolved (mg/L as N)	Total nitrogen (mg/L as N)	Orthophosphate, dissolved (mg/L as P)	Total phosphorus (mg/L as P)	Organic carbon, dissolved (mg/L as C)	Organic carbon, suspended (mg/L as C)	Ultraviolet absorbance at 254 nm (cm^{-1})	SUVA (L/mg-cm)	Volatile suspended solids (mg/L)	Particulate organic matter (mg/L)	Chlorophyll-*a* (μg/L)	Pheophytin-*a* (μg/L)	Suspended sediment (mg/L)	Suspended sediment, size fraction < 0.062 mm (percent)
18	SJR at Laird Park	06/27/01	5.20	5.99	0.22	0.43	3.6	3.2	0.107	0.030	11	—	38.5	18.7	116	86
18	SJR at Laird Park	07/11/01	4.57	5.70	0.14	0.36	3.7	> 3.3	0.106	0.029	20	—	36.7	46.5	115	88
18	SJR at Laird Park	07/25/01	5.04	5.80	0.06	0.31	3.4	> 3.3	0.104	0.031	13	—	62.3	25.4	109	86
18	SJR at Laird Park	08/08/01	4.47	5.29	0.13	0.37	3.6	> 3.3	0.102	0.028	16	—	110	23.4	86	89
18	SJR at Laird Park	08/22/01	3.98	4.84	0.10	0.33	3.1	2.3	0.091	0.029	14	—	53.6	27.3	111	82
18	SJR at Laird Park	09/05/01	4.77	5.80	0.09	0.24	2.7	2.0	0.095	0.035	10	—	59.1	18.2	38	69
18	SJR at Laird Park	09/19/01	4.65	5.26	0.18	0.34	3.2	1.3	0.090	0.028	6	—	18.5	20.3	59	83
18	SJR at Laird Park	10/03/01	3.60	3.96	0.14	0.30	4.3	0.8	0.115	0.027	5	—	14.8	15.2	60	79
18	SJR at Laird Park	10/17/01	3.32	3.68	0.20	0.37	5.3	1.9	0.145	0.027	94	—	15.7	10.3	—	—
18	SJR at Laird Park	10/31/01	2.37	2.75	0.17	0.29	3.8	1.2	0.094	0.025	18	—	7.6	7.5	62	82
18	SJR at Laird Park	11/15/01	2.06	2.45	0.14	0.29	5.6	1.8	0.150	0.027	10	—	9.4	5.0	71	85
24	SJR at Maze Road	07/12/00	3.34	3.67	0.14	0.25	4.2	—	—	—	—	18	41.3	—	98	—
24	SJR at Maze Road	07/26/00	2.89	3.12	0.10	0.19	3.9	—	—	—	—	14	37.6	—	50	—
24	SJR at Maze Road	08/09/00	3.13	3.44	0.14	0.19	3.4	—	—	—	—	11	36.7	—	46	—
24	SJR at Maze Road	08/23/00	1.78	2.00	0.10	0.15	2.4	—	—	—	—	11	15.0	—	64	—
24	SJR at Maze Road	09/06/00	2.49	2.74	0.13	0.20	3.5	—	—	—	—	8.0	17.5	—	56	—
24	SJR at Maze Road	09/20/00	2.56	3.17	0.12	0.21	2.3	—	—	—	—	7.2	5.8	—	44	—
24	SJR at Maze Road	10/04/00	2.84	3.04	0.14	0.20	2.8	—	—	—	—	7.8	7.2	—	36	—
24	SJR at Maze Road	10/18/00	2.42	2.46	0.18	0.25	3.7	—	—	—	—	12	5.6	—	74	—
24	SJR at Maze Road	06/13/01	3.38	4.56	0.12	0.28	3.3	—	—	—	—	15	37.0	—	63	—
24	SJR at Maze Road	06/27/01	3.97	4.83	0.14	0.25	2.6	—	—	—	—	18	42.1	—	98	—
24	SJR at Maze Road	07/11/01	5.04	5.50	0.15	0.39	3.9	—	—	—	—	20	68.9	—	110	—
24	SJR at Maze Road	07/25/01	5.00	5.99	0.12	0.30	3.8	—	—	—	—	22	45.4	—	96	—
24	SJR at Maze Road	08/07/01	4.77	5.21	0.13	0.29	3.6	—	—	—	—	21	45.4	—	80	—
24	SJR at Maze Road	08/22/01	3.46	3.78	0.12	0.29	3.1	—	—	—	—	15	25.2	—	75	—
24	SJR at Maze Road	09/05/01	2.88	3.12	0.09	0.27	3.1	—	—	—	—	12	48.7	—	41	—
24	SJR at Maze Road	09/19/01	3.81	4.10	0.11	0.22	2.5	—	—	—	—	8.0	23.5	—	46	—
24	SJR at Maze Road	10/03/01	5.20	5.39	0.15	0.28	3.3	—	—	—	—	6.7	13.5	—	32	—
27	SJR near Vernalis	07/12/00	2.53	3.01	0.12	0.26	3.4	0.6	0.084	0.025	<10	—	50.3	—	63	89
27	SJR near Vernalis	07/26/00	1.82	2.42	0.08	0.16	2.8	0.8	0.084	0.029	<10	—	38.6	—	36	84
27	SJR near Vernalis	08/09/00	2.29	2.78	0.10	0.20	2.7	0.5	0.068	0.025	<10	—	E 45.2	—	23	81
27	SJR near Vernalis	08/23/00	1.60	1.94	0.09	0.21	2.5	0.5	—	—	<10	—	10.8	—	84	80
27	SJR near Vernalis	09/07/00	2.06	2.48	0.10	0.22	2.5	0.6	0.070	0.028	<10	—	—	—	37	80
27	SJR near Vernalis	09/20/00	2.15	2.42	0.11	0.21	2.3	0.5	0.068	0.030	<10	—	10.5	—	58	90
27	SJR near Vernalis	10/04/00	2.16	2.48	0.10	0.20	2.6	0.3	0.078	0.030	<10	—	11.5	—	43	78
27	SJR near Vernalis	10/18/00	1.90	2.24	0.10	0.24	3.0	—	0.089	0.030	<10	—	7.9	—	72	88
27	SJR near Vernalis	06/14/01	2.25	2.86	0.08	0.24	2.8	1.1	0.071	0.025	5	—	31.2	27.0	49	89
27	SJR near Vernalis	06/28/01	2.24	2.86	0.10	0.23	2.7	1.8	0.080	0.030	7	—	21.7	26.1	63	87
27	SJR near Vernalis	07/12/01	2.06	2.78	0.08	0.24	2.7	3.0	0.078	0.029	12	—	25.4	33.8	58	89
27	SJR near Vernalis	07/26/01	2.39	3.14	0.08	0.21	3.2	2.5	0.082	0.026	7	—	54.2	17.6	63	93
27	SJR near Vernalis	08/09/01	2.23	2.68	0.09	0.24	2.7	7.9	0.080	0.030	7	—	49.8	23.0	54	88
27	SJR near Vernalis	08/23/01	2.29	2.72	0.09	0.25	3.0	0.8	0.073	0.024	11	—	31.5	28.9	167	41

Appendix B. All data (University of California at Davis and U.S. Geological Survey) for 2000 and 2001 for nutrients, organic carbon, and chlorophyll for San Joaquin River sites in California—*Continued*

Site number	Site name	Date	Laboratory	Stream flow (ft^3/s)	Water temperature (°C)	pH	Specific conductance (μS/cm at 25°C)	Dissolved oxygen (mg/L)	Alkalinity (mg/L $CaCO_3$)	Secchi disk depth (in.)	Ammonia, dissolved (mg/L as N)	Nitrate, dissolved (mg/L as N)	Inorganic nitrogen, dissolved (mg/L as N)	Organic nitrogen, dissolved (mg/L as N)
27	SJR near Vernalis	09/06/01	USGS	1230	22.0	8.4	790	9.3	120	27	< 0.04	1.98	2.03	0.26
27	SJR near Vernalis	09/20/01	USGS	1290	21.0	8.2	584	—	98	17	< 0.04	2.47	2.52	0.20
27	SJR near Vernalis	10/04/01	USGS	1300	21.5	7.7	[1]702	8.2	110	—	< 0.04	1.88	1.94	0.26
27	SJR near Vernalis	10/18/01	USGS	1580	19.0	8.0	690	8.1	120	22	< 0.04	1.84	1.88	0.25
27	SJR near Vernalis	11/01/01	USGS	2390	16.5	7.9	[1]507	8.6	78	20	< 0.04	1.52	1.56	0.20
27	SJR near Vernalis	11/16/01	USGS	2170	15.0	7.7	668	8.4	97	—	0.04	1.41	1.46	0.30

[1]Laboratory value.

Appendix B. All data (University of California at Davis and U.S. Geological Survey) for 2000 and 2001 for nutrients, organic carbon, and chlorophyll for San Joaquin River sites in California—*Continued*

Site number	Site name	Date	Total nitrogen, dissolved (mg/L as N)	Total nitrogen (mg/L as N)	Orthophosphate, dissolved (mg/L as P)	Total phosphorus (mg/L as P)	Organic carbon, dissolved (mg/L as C)	Organic carbon, suspended (mg/L as C)	Ultraviolet absorbance at 254 nm (cm^{-1})	SUVA (L/mg-cm)	Volatile suspended solids (mg/L)	Particulate organic matter (mg/L)	Chlorophyll-*a* (µg/L)	Pheophytin-*a* (µg/L)	Suspended sediment (mg/L)	Suspended sediment, size fraction < 0.062 mm (percent)
27	SJR near Vernalis	09/06/01	2.29	2.87	0.07	0.19	2.9	2.4	0.076	0.026	7	—	73.2	32.9	29	83
27	SJR near Vernalis	09/20/01	2.72	3.24	0.11	0.23	2.6	1.1	0.080	0.031	6	—	14.1	17.4	50	73
27	SJR near Vernalis	10/04/01	2.20	2.43	0.11	0.22	3.3	1.0	0.083	0.025	4	—	10.3	10.3	46	83
27	SJR near Vernalis	10/18/01	2.13	2.44	0.12	0.23	3.5	1.2	0.091	0.026	7	—	15.9	11.1	57	82
27	SJR near Vernalis	11/01/01	1.76	1.99	0.10	0.21	3.1	1.1	0.077	0.025	6	—	5.4	5.8	56	80
27	SJR near Vernalis	11/16/01	1.76	2.06	0.11	0.20	4.0	0.8	0.111	0.028	6	—	6.1	5.0	58	87

Appendix C. All data (University of California at Davis and U.S. Geological Survey) for 2000 and 2001 for nutrients, organic carbon, and chlorophyll for tributary sites

[SUVA, specific ultraviolet absorbance; UCD, University of California at Davis; USGS, U.S. Geological Survey; E, estimated; Rd., road; Cr., creek; S.P., State Park. ft^3/s, cubic foot per second; µS/cm, microsiemens per centimeter; mg/L, milligram per liter; in., inch; nm, nanometer; cm-1, per centimeter; L/mg-cm, liter per milligram-centimeter; µg/L, microgram per liter; mm, millimeter; <, less than; >, greater than; —, no data reported]

Site number	Site name	Date	Time	Laboratory	Stream flow (ft^3/s)	Water Temperature (°C)	pH	Specific conductance (µS/cm at 25°C)	Dissolved Oxygen (mg/L)	Alkalinity (mg/L $CaCO_3$)	Secchi disk depth (in.)	Ammonia, dissolved (mg/L as N)	Nitrate, dissolved (mg/L as N)	Inorganic nitrogen, dissolved (mg/L as N)	Organic nitrogen, dissolved (mg/L as N)
2	Salt Slough near Stevinson	07/12/00	13:50	UCD	225	26.1	7.6	905	—	—	—	0.34	3.67	4.02	0.33
2	Salt Slough near Stevinson	07/26/00	14:30	UCD	171	26.2	8.0	969	—	—	—	0.29	4.06	4.34	0.80
2	Salt Slough near Stevinson	08/09/00	12:58	UCD	205	25.5	7.7	775	—	—	—	0.06	2.27	2.33	0.27
2	Salt Slough near Stevinson	08/23/00	13:55	UCD	164	24.9	8.0	901	—	—	—	0.04	1.66	1.70	0.24
2	Salt Slough near Stevinson	09/06/00	14:30	UCD	101	22.4	8.3	1070	—	—	—	0.03	1.13	1.16	0.26
2	Salt Slough near Stevinson	09/20/00	15:25	UCD	85	28.1	8.2	2190	—	—	—	0.02	0.25	0.27	0.38
2	Salt Slough near Stevinson	10/04/00	13:46	UCD	85	21.4	8.1	1180	—	—	—	0.05	0.50	0.55	0.13
2	Salt Slough near Stevinson	10/18/00	13:14	UCD	116	19.7	8.3	1260	—	—	—	0.04	0.28	0.32	0.46
2	Salt Slough near Stevinson	06/13/01	10:00	UCD	135	20.5	7.8	1230	—	—	—	0.10	3.61	3.71	0.89
2	Salt Slough near Stevinson	06/27/01	12:30	UCD	205	23.0	7.9	927	—	—	—	0.09	1.77	1.85	0.98
2	Salt Slough near Stevinson	07/11/01	10:00	UCD	196	23.3	7.8	917	—	—	—	0.10	2.18	2.28	1.33
2	Salt Slough near Stevinson	07/25/01	13:36	UCD	187	29.1	8.1	1020	—	—	—	0.10	1.92	2.01	0.41
2	Salt Slough near Stevinson	08/07/01	13:40	UCD	153	29.7	7.9	1040	—	—	—	0.03	1.15	1.18	0.60
2	Salt Slough near Stevinson	08/22/01	13:19	UCD	195	23.4	7.9	956	—	—	—	0.06	1.26	1.32	0.90
2	Salt Slough near Stevinson	09/05/01	13:45	UCD	51	26.2	8.4	1570	—	—	—	0.05	0.17	0.22	0.35
2	Salt Slough near Stevinson	09/19/01	11:30	UCD	53	22.7	8.0	1580	—	—	—	0.04	0.14	0.18	0.78
2	Salt Slough near Stevinson	10/03/01	10:45	UCD	45	21.3	7.9	1730	—	—	—	0.05	0.19	0.24	0.64
4	San Luis Drain, Site B	07/12/00	14:20	UCD	E 67	27.2	8.4	3400	—	—	—	0.12	12.5	12.6	0.06
4	San Luis Drain, Site B	07/26/00	15:00	UCD	E 57	27.9	8.5	3700	—	—	—	0.07	15.4	15.5	3.08
4	San Luis Drain, Site B	08/09/00	13:26	UCD	E 55	27.4	8.3	3450	—	—	—	0.01	10.8	10.8	0.11
4	San Luis Drain, Site B	08/23/00	14:20	UCD	E 57	26.4	8.5	3020	—	—	—	0.02	8.59	8.60	0.80
4	San Luis Drain, Site B	09/06/00	15:00	UCD	E 47	22.4	8.5	3510	—	—	—	0.05	13.6	13.7	0.31
4	San Luis Drain, Site B	09/20/00	15:55	UCD	E 21	30.1	8.6	4520	—	—	—	0.04	13.5	13.5	1.65
4	San Luis Drain, Site B	10/04/00	14:20	UCD	21	23.6	8.4	4190	—	—	—	0.36	10.6	11.0	0.29
4	San Luis Drain, Site B	10/18/00	13:45	UCD	19	21.0	8.3	3440	—	—	—	0.20	12.5	12.7	1.42
4	San Luis Drain, Site B	06/13/01	10:25	UCD	61	21.1	8.0	4180	—	—	—	0.12	19.5	19.6	0.05
4	San Luis Drain, Site B	06/27/01	13:20	UCD	50	24.4	8.3	3650	—	—	—	0.04	11.9	11.9	0.09
4	San Luis Drain, Site B	07/11/01	10:40	UCD	59	25.1	8.2	3580	—	—	—	0.03	13.4	13.4	0.58
4	San Luis Drain, Site B	07/25/01	13:41	UCD	56	26.2	8.1	4230	—	—	—	0.17	15.5	15.6	2.29
4	San Luis Drain, Site B	08/07/01	14:10	UCD	61	29.3	8.6	3510	—	—	—	0.03	9.90	9.93	0.67
4	San Luis Drain, Site B	08/22/01	13:34	UCD	53	25.2	8.5	3380	—	—	—	0.24	10.5	10.7	0.79
4	San Luis Drain, Site B	09/05/01	14:15	UCD	33	27.9	8.4	3410	—	—	—	0.14	8.57	8.71	1.80
4	San Luis Drain, Site B	09/19/01	12:20	UCD	17	24.4	8.4	4400	—	—	—	0.06	9.46	9.52	3.41
4	San Luis Drain, Site B	10/03/01	10:55	UCD	9	23.7	8.1	3880	—	—	—	0.09	4.27	4.36	1.30
5	Mud Slough near Gustine	07/12/00	14:25	UCD	74	26.8	8.4	3220	—	—	—	0.07	11.1	11.2	0.32
5	Mud Slough near Gustine	07/26/00	15:10	UCD	63	27.2	8.5	3590	—	—	—	0.04	13.6	13.6	2.02
5	Mud Slough near Gustine	08/09/00	13:38	UCD	64	26.3	8.3	3110	—	—	—	0.02	9.10	9.12	0.22
5	Mud Slough near Gustine	08/23/00	14:40	UCD	60	25.8	8.5	2860	—	—	—	0.01	8.03	8.04	0.70
5	Mud Slough near Gustine	09/06/00	15:10	UCD	56	22.4	8.5	3120	—	—	—	0.04	11.6	11.6	0.24
5	Mud Slough near Gustine	09/20/00	15:59	UCD	53	28.5	7.9	2200	—	—	—	0.08	5.32	5.40	0.31

Appendix C. All data (University of California at Davis and U.S. Geological Survey) for 2000 and 2001 for nutrients, organic carbon, and chlorophyll for tributary sites—*Continued*

Site number	Site name	Date	Total nitrogen, dissolved (mg/L as N)	Total nitrogen (mg/L as N)	Orthophosphate, dissolved (mg/L as P)	Total phosphorus (mg/L as P)	Organic carbon, dissolved (mg/L as C)	Organic carbon, suspended (mg/L as C)	Ultraviolet absorbance at 254 nm (cm^{-1})	SUVA (L/mg-cm)	Volatile suspended solids (mg/L)	Particulate organic matter (mg/L)	Chlorophyll-*a* (µg/L)	Pheophytin-*a* (µg/L)	Suspended sediment (mg/L)	Suspended sediment, size fraction < 0.062 mm (percent)
2	Salt Slough near Stevinson	07/12/00	4.35	4.52	0.13	0.28	13.5	—	—	—	—	25	14.2	—	152	—
2	Salt Slough near Stevinson	07/26/00	5.14	5.40	0.19	0.31	6.4	—	—	—	—	28	24.6	—	146	—
2	Salt Slough near Stevinson	08/09/00	2.60	2.84	0.18	0.30	4.7	—	—	—	—	30	16.4	—	169	—
2	Salt Slough near Stevinson	08/23/00	1.94	2.28	0.16	0.26	4.9	—	—	—	—	28	14.2	—	165	—
2	Salt Slough near Stevinson	09/06/00	1.42	1.64	0.08	0.17	5.0	—	—	—	—	10	16.1	—	70	—
2	Salt Slough near Stevinson	09/20/00	0.65	0.93	0.11	0.23	4.7	—	—	—	—	10	11.9	—	43	—
2	Salt Slough near Stevinson	10/04/00	0.68	0.85	0.10	0.21	5.3	—	—	—	—	18	10.2	—	85	—
2	Salt Slough near Stevinson	10/18/00	0.78	1.03	0.10	0.23	5.1	—	—	—	—	23	10.2	—	135	—
2	Salt Slough near Stevinson	06/13/01	4.60	5.31	0.15	0.50	6.6	—	—	—	—	30	12.5	—	148	—
2	Salt Slough near Stevinson	06/27/01	2.83	2.93	0.19	0.34	5.6	—	—	—	—	25	16.3	—	181	—
2	Salt Slough near Stevinson	07/11/01	3.61	4.28	0.17	0.52	5.1	—	—	—	—	33	23.0	—	215	—
2	Salt Slough near Stevinson	07/25/01	2.43	2.88	0.16	0.42	5.1	—	—	—	—	28	15.1	—	152	—
2	Salt Slough near Stevinson	08/07/01	1.78	2.24	0.16	0.28	4.0	—	—	—	—	23	23.5	—	93	—
2	Salt Slough near Stevinson	08/22/01	2.22	2.42	0.16	0.38	3.8	—	—	—	—	22	13.0	—	115	—
2	Salt Slough near Stevinson	09/05/01	0.57	0.82	0.17	0.27	4.6	—	—	—	—	9.3	9.4	—	30	—
2	Salt Slough near Stevinson	09/19/01	0.96	1.09	0.10	0.18	4.2	—	—	—	—	11	12.5	—	74	—
2	Salt Slough near Stevinson	10/03/01	0.89	1.90	0.10	0.28	5.3	—	—	—	—	13	9.3	—	56	—
4	San Luis Drain, Site B	07/12/00	12.7	13.0	0.01	0.02	7.0	—	—	—	—	16	31.0	—	40	—
4	San Luis Drain, Site B	07/26/00	18.6	19.1	0.02	0.02	8.2	—	—	—	—	15	20.8	—	31	—
4	San Luis Drain, Site B	08/09/00	10.9	11.4	0.01	0.03	6.6	—	—	—	—	18	53.9	—	33	—
4	San Luis Drain, Site B	08/23/00	9.40	9.60	< 0.01	0.04	6.7	—	—	—	—	17	30.9	—	26	—
4	San Luis Drain, Site B	09/06/00	14.0	14.2	< 0.01	0.03	5.9	—	—	—	—	19	75.5	—	50	—
4	San Luis Drain, Site B	09/20/00	15.2	16.2	0.01	0.02	5.1	—	—	—	—	13	12.4	—	34	—
4	San Luis Drain, Site B	10/04/00	11.2	11.4	< 0.01	0.03	5.7	—	—	—	—	22	20.7	—	42	—
4	San Luis Drain, Site B	10/18/00	14.1	14.7	0.01	0.02	6.0	—	—	—	—	12	14.0	—	26	—
4	San Luis Drain, Site B	06/13/01	19.7	22.9	0.01	0.07	5.6	—	—	—	—	20	62.2	—	47	—
4	San Luis Drain, Site B	06/27/01	12.0	12.6	< 0.01	0.12	6.4	—	—	—	—	12	55.1	—	58	—
4	San Luis Drain, Site B	07/11/01	14.0	14.9	0.01	0.02	8.1	—	—	—	—	15	24.5	—	39	—
4	San Luis Drain, Site B	07/25/01	17.9	19.5	< 0.01	0.08	5.3	—	—	—	—	18	47.9	—	37	—
4	San Luis Drain, Site B	08/07/01	10.6	11.5	0.01	0.03	5.3	—	—	—	—	19	57.1	—	30	—
4	San Luis Drain, Site B	08/22/01	11.5	11.6	0.01	0.03	4.7	—	—	—	—	14	32.8	—	21	—
4	San Luis Drain, Site B	09/05/01	10.5	11.4	0.01	0.03	5.4	—	—	—	—	12	16.8	—	20	—
4	San Luis Drain, Site B	09/19/01	12.9	13.6	< 0.01	0.06	4.7	—	—	—	—	10	10.8	—	16	—
4	San Luis Drain, Site B	10/03/01	5.66	5.79	0.01	0.02	5.2	—	—	—	—	13	17.8	—	25	—
5	Mud Slough near Gustine	07/12/00	11.5	11.6	0.01	0.03	7.1	—	—	—	—	18	33.7	—	57	—
5	Mud Slough near Gustine	07/26/00	15.6	15.7	0.04	0.06	8.2	—	—	—	—	17	20.4	—	52	—
5	Mud Slough near Gustine	08/09/00	9.34	9.56	0.01	0.05	8.3	—	—	—	—	23	62.9	—	61	—
5	Mud Slough near Gustine	08/23/00	8.74	9.00	0.01	0.04	6.6	—	—	—	—	20	47.3	—	44	—
5	Mud Slough near Gustine	09/06/00	11.8	12.2	<0.01	0.05	5.6	—	—	—	—	13	60.1	—	45	—
5	Mud Slough near Gustine	09/20/00	5.71	6.43	0.03	0.17	6.9	—	—	—	—	13	13.6	—	35	—

Appendix C. All data (University of California at Davis and U.S. Geological Survey) for 2000 and 2001 for nutrients, organic carbon, and chlorophyll for tributary sites—*Continued*

Site number	Site name	Date	Time	Laboratory	Stream flow (ft^3/s)	Water Temperature (°C)	pH	Specific conductance (µS/cm at 25°C)	Dissolved Oxygen (mg/L)	Alkalinity (mg/L $CaCO_3$)	Secchi disk depth (in.)	Ammonia, dissolved (mg/L as N)	Nitrate, dissolved (mg/L as N)	Inorganic nitrogen, dissolved (mg/L as N)	Organic nitrogen, dissolved (mg/L as N)
5	Mud Slough near Gustine	10/04/00	14:27	UCD	87	22.8	7.8	1550	—	—	—	0.13	2.40	2.53	0.20
5	Mud Slough near Gustine	10/18/00	13:53	UCD	197	20.5	8.2	1107	—	—	—	0.10	1.56	1.66	1.35
5	Mud Slough near Gustine	06/13/01	10:35	UCD	68	21.1	8.1	4110	—	—	—	0.06	19.7	19.8	0.84
5	Mud Slough near Gustine	06/27/01	12:50	UCD	63	23.3	8.4	4110	—	—	—	0.04	17.1	17.1	1.67
5	Mud Slough near Gustine	07/10/01	09:50	USGS	79	27.0	8.1	3730	8.8	—	18	< 0.04	11.3	11.4	0.61
5	Mud Slough near Gustine	07/25/01	14:05	UCD	64	29.1	8.2	4120	—	—	—	0.14	14.7	14.9	2.03
5	Mud Slough near Gustine	08/08/01	10:20	USGS	67	—	8.6	3170	—	120	17	E 0.02	10.2	10.3	0.60
5	Mud Slough near Gustine	08/22/01	13:41	UCD	60	25.2	8.5	3260	—	—	—	0.05	9.11	9.17	0.57
5	Mud Slough near Gustine	09/06/01	12:00	USGS	50	24.0	8.5	2010	8.5	140	17	< 0.04	7.53	7.65	0.84
5	Mud Slough near Gustine	09/19/01	12:05	UCD	46	24.1	8.4	2500	—	—	—	0.05	3.64	3.69	1.71
5	Mud Slough near Gustine	10/04/01	11:30	USGS	105	23.0	7.6	[1]1590	8.2	200	19	< 0.04	0.65	0.68	1.18
5	Mud Slough near Gustine	10/31/01	10:00	USGS	133	18.0	8.0	[1]1900	5.9	210	23	0.14	1.22	1.40	0.96
6	Los Banos Creek at Hwy 140	07/12/00	14:50	UCD	2	32.9	8.1	1090	—	—	—	0.03	0.04	0.07	0.69
6	Los Banos Creek at Hwy 140	07/26/00	15:24	UCD	6	30.2	8.4	885	—	—	—	<0.01	0.02	0.02	1.19
6	Los Banos Creek at Hwy 140	08/09/00	13:50	UCD	3	29.1	7.9	1360	—	—	—	<0.01	0.43	0.43	0.81
6	Los Banos Creek at Hwy 140	08/23/00	14:48	UCD	3	30.3	8.4	1320	—	—	—	0.32	1.67	1.99	0.44
6	Los Banos Creek at Hwy 140	09/06/00	15:24	UCD	12	24.6	8.2	1150	—	—	—	0.11	0.52	0.63	0.98
6	Los Banos Creek at Hwy 140	09/20/00	16:20	UCD	6	27.8	7.5	553	—	—	—	0.02	0.74	0.76	0.39
6	Los Banos Creek at Hwy 140	10/04/00	14:40	UCD	27	23.1	7.4	576	—	—	—	0.01	0.02	0.03	0.61
6	Los Banos Creek at Hwy 140	10/18/00	14:07	UCD	38	22.0	8.2	631	—	—	—	0.08	0.13	0.20	0.90
6	Los Banos Creek at Hwy 140	06/13/01	10:50	UCD	7	20.7	7.7	1191	—	—	—	0.12	2.77	2.89	1.79
6	Los Banos Creek at Hwy 140	06/27/01	13:30	UCD	4	23.9	7.9	982	—	—	—	0.01	1.20	1.21	1.81
6	Los Banos Creek at Hwy 140	07/11/01	11:15	UCD	6	24.6	7.7	1330	—	—	—	0.05	0.08	0.14	1.92
6	Los Banos Creek at Hwy 140	07/25/01	13:15	UCD	13	27.5	8.1	1640	—	—	—	0.30	0.46	0.75	1.67
6	Los Banos Creek at Hwy 140	08/07/01	14:45	UCD	5	34.2	8.7	1420	—	—	—	0.03	0.22	0.25	0.93
6	Los Banos Creek at Hwy 140	08/22/01	13:57	UCD	14	28.1	8.2	1390	—	—	—	0.20	1.37	1.57	1.15
6	Los Banos Creek at Hwy 140	09/05/01	14:27	UCD	8	28.1	8.2	1040	—	—	—	0.28	1.02	1.30	0.85
6	Los Banos Creek at Hwy 140	09/19/01	12:45	UCD	3	24.6	8.5	1190	—	—	—	0.06	0.09	0.15	1.34
6	Los Banos Creek at Hwy 140	10/03/01	11:15	UCD	45	23.5	7.5	836	—	—	—	0.01	0.44	0.45	4.84
9	Merced River at River Rd.	07/12/00	13:20	UCD	E 182	25.8	7.9	259	—	—	—	0.03	2.97	3.00	0.07
9	Merced River at River Rd.	07/26/00	14:10	UCD	E 137	27.4	8.0	293	—	—	—	0.03	3.67	3.70	0.33
9	Merced River at River Rd.	08/09/00	12:22	UCD	E 140	24.8	7.7	245	—	—	—	<0.01	2.77	2.77	0.19
9	Merced River at River Rd.	08/23/00	13:18	UCD	E 153	25.3	8.0	234	—	—	—	0.03	2.78	2.81	0.15
9	Merced River at River Rd.	09/06/00	14:10	UCD	E 153	22.4	8.0	198	—	—	—	0.03	2.73	2.76	0.08
9	Merced River at River Rd.	09/20/00	14:50	UCD	E 156	27.2	7.9	236	—	—	—	0.03	2.66	2.70	0.06
9	Merced River at River Rd.	10/04/00	13:10	UCD	E 139	19.8	8.0	286	—	—	—	0.07	3.36	3.43	0.19
9	Merced River at River Rd.	10/18/00	12:36	UCD	E 797	16.7	7.7	41	—	—	—	0.06	0.13	0.19	0.08
9	Merced River at River Rd.	06/13/01	09:30	UCD	E 158	21.4	8.0	249	—	—	—	0.06	2.27	2.33	0.03
9	Merced River at River Rd.	06/27/01	11:30	UCD	E 158	22.9	7.6	276	—	—	—	0.03	2.68	2.71	0.42
9	Merced River at River Rd.	07/11/01	09:15	UCD	E 125	23.0	8.2	274	—	—	—	0.23	3.43	3.65	0.41
9	Merced River at River Rd.	07/25/01	12:57	UCD	E 122	25.8	8.1	334	—	—	—	0.04	3.25	3.29	0.45
9	Merced River at River Rd.	08/07/01	12:05	UCD	E 85	27.8	7.9	322	—	—	—	0.04	3.66	3.69	0.41
9	Merced River at River Rd.	08/22/01	12:05	UCD	E 98	23.7	8.1	334	—	—	—	0.03	3.45	3.48	0.17

Appendix C. All data (University of California at Davis and U.S. Geological Survey) for 2000 and 2001 for nutrients, organic carbon, and chlorophyll for tributary sites—*Continued*

Site number	Site name	Date	Total nitrogen, dissolved (mg/L as N)	Total nitrogen (mg/L as N)	Orthophosphate, dissolved (mg/L as P)	Total phosphorus (mg/L as P)	Organic carbon, dissolved (mg/L as C)	Organic carbon, suspended (mg/L as C)	Ultraviolet absorbance at 254 nm (cm^{-1})	SUVA (L/mg-cm)	Volatile suspended solids (mg/L)	Particulate organic matter (mg/L)	Chlorophyll-*a* (µg/L)	Pheophytin-*a* (µg/L)	Suspended sediment (mg/L)	Suspended sediment, size fraction < 0.062 mm (percent)
5	Mud Slough near Gustine	10/04/00	2.73	3.27	0.16	0.29	9.2	—	—	—	—	16	11.8	—	52	—
5	Mud Slough near Gustine	10/18/00	3.01	3.35	0.38	0.43	8.0	—	—	—	—	10	7.2	—	30	—
5	Mud Slough near Gustine	06/13/01	20.6	20.7	0.01	0.07	5.4	—	—	—	—	21	58.8	—	50	—
5	Mud Slough near Gustine	06/27/01	18.8	19.0	< 0.01	0.12	6.7	—	—	—	—	8.3	55.4	—	34	—
5	Mud Slough near Gustine	07/10/01	12.0	12.5	< 0.02	0.08	3.9	2.7	0.138	0.035	9	—	6.1	14	36	83
5	Mud Slough near Gustine	07/25/01	16.9	17.4	< 0.01	0.02	5.5	—	—	—	—	20	55.4	—	40	—
5	Mud Slough near Gustine	08/08/01	10.9	11.5	< 0.02	0.05	5.0	2.1	0.127	0.025	9	—	43.3	12	25	25
5	Mud Slough near Gustine	08/22/01	9.73	10.8	<0.01	0.06	5.1	—	—	—	—	16	31.3	—	34	—
5	Mud Slough near Gustine	09/06/01	8.49	8.93	E 0.09	0.16	6.3	1.8	0.186	0.030	8	—	17.9	14	22	94
5	Mud Slough near Gustine	09/19/01	5.40	5.89	0.06	0.19	6.9	—	—	—	—	8.0	13.7	—	24	—
5	Mud Slough near Gustine	10/04/01	1.86	2.36	0.51	0.82	14.0	2.1	0.424	0.030	6	—	18.9	12	24	46
5	Mud Slough near Gustine	10/31/01	2.36	2.66	0.27	0.45	12.0	0.8	0.341	0.028	8	—	13.2	5.4	29	82
6	Los Banos Creek at Hwy 140	07/12/00	0.76	1.09	0.12	0.27	7.9	—	—	—	—	14	66.7	—	49	—
6	Los Banos Creek at Hwy 140	07/26/00	1.21	1.80	0.35	0.49	16.1	—	—	—	—	33	50.1	—	132	—
6	Los Banos Creek at Hwy 140	08/09/00	1.24	1.60	0.25	0.30	9.6	—	—	—	—	16	13.9	—	53	—
6	Los Banos Creek at Hwy 140	08/23/00	2.43	3.04	0.30	0.38	10.6	—	—	—	—	27	19.6	—	161	—
6	Los Banos Creek at Hwy 140	09/06/00	1.61	1.84	0.19	0.27	13.3	—	—	—	—	12	15.1	—	71	—
6	Los Banos Creek at Hwy 140	09/20/00	1.15	1.88	0.27	0.77	10.9	—	—	—	—	11	9.7	—	20	—
6	Los Banos Creek at Hwy 140	10/04/00	0.63	1.15	0.41	0.91	15.1	—	—	—	—	13	11.0	—	17	—
6	Los Banos Creek at Hwy 140	10/18/00	1.10	1.16	0.32	0.52	17.6	—	—	—	—	6.7	3.2	—	24	—
6	Los Banos Creek at Hwy 140	06/13/01	4.68	5.40	0.16	0.57	12.3	—	—	—	—	29	66.1	—	135	—
6	Los Banos Creek at Hwy 140	06/27/01	3.02	3.57	0.05	0.31	7.5	—	—	—	—	20	41.0	—	110	—
6	Los Banos Creek at Hwy 140	07/11/01	2.06	3.28	0.30	0.64	11.1	—	—	—	—	29	65.5	—	91	—
6	Los Banos Creek at Hwy 140	07/25/01	2.43	3.36	0.04	0.08	14.4	—	—	—	—	27	33.7	—	64	—
6	Los Banos Creek at Hwy 140	08/07/01	1.18	2.73	0.19	0.37	12.9	—	—	—	—	32	47.5	—	82	—
6	Los Banos Creek at Hwy 140	08/22/01	2.72	3.62	0.08	0.36	8.1	—	—	—	—	23	33.1	—	98	—
6	Los Banos Creek at Hwy 140	09/05/01	2.15	3.16	0.10	0.35	5.6	—	—	—	—	20	17.3	—	123	—
6	Los Banos Creek at Hwy 140	09/19/01	1.49	2.08	0.51	0.63	8.8	—	—	—	—	4.6	9.1	—	11	—
6	Los Banos Creek at Hwy 140	10/03/01	5.29	6.54	0.36	0.62	8.3	—	—	—	—	8.0	15.4	—	16	—
9	Merced River at River Rd.	07/12/00	3.08	3.14	0.04	0.07	2.0	—	—	—	—	2.2	1.0	—	5	—
9	Merced River at River Rd.	07/26/00	4.03	4.57	0.04	0.06	2.0	—	—	—	—	2.3	0.7	—	4	—
9	Merced River at River Rd.	08/09/00	2.96	3.06	0.05	0.08	2.0	—	—	—	—	2.5	1.4	—	4	—
9	Merced River at River Rd.	08/23/00	2.96	2.98	0.04	0.06	2.3	—	—	—	—	2.4	1.3	—	5	—
9	Merced River at River Rd.	09/06/00	2.84	2.84	0.02	0.04	1.7	—	—	—	—	1.0	0.7	—	6	—
9	Merced River at River Rd.	09/20/00	2.75	2.82	0.03	0.05	1.8	—	—	—	—	1.1	0.8	—	5	—
9	Merced River at River Rd.	10/04/00	3.62	3.58	0.05	0.06	2.0	—	—	—	—	2.1	0.8	—	2	—
9	Merced River at River Rd.	10/18/00	0.27	0.37	0.01	0.04	2.6	—	—	—	—	3.2	1.1	—	14	—
9	Merced River at River Rd.	06/13/01	2.36	2.41	0.02	0.05	0.7	—	—	—	—	2.4	3.1	—	7	—
9	Merced River at River Rd.	06/27/01	3.13	3.42	0.03	0.08	2.2	—	—	—	—	2.1	3.0	—	9	—
9	Merced River at River Rd.	07/11/01	4.06	4.46	0.07	0.09	2.0	—	—	—	—	3.3	2.2	—	18	—
9	Merced River at River Rd.	07/25/01	3.74	3.94	0.04	0.11	2.4	—	—	—	—	4.8	5.6	—	12	—
9	Merced River at River Rd.	08/07/01	4.10	4.82	0.03	0.06	1.9	—	—	—	—	2.6	1.7	—	5	—
9	Merced River at River Rd.	08/22/01	3.65	3.97	0.03	0.07	1.8	—	—	—	—	2.2	1.5	—	8	—

Appendix C. All data (University of California at Davis and U.S. Geological Survey) for 2000 and 2001 for nutrients, organic carbon, and chlorophyll for tributary sites—*Continued*

Site number	Site name	Date	Time	Laboratory	Stream flow (ft^3/s)	Water Temperature (°C)	pH	Specific conductance (μS/cm at 25°C)	Dissolved Oxygen (mg/L)	Alkalinity (mg/L $CaCO_3$)	Secchi disk depth (in.)	Ammonia, dissolved (mg/L as N)	Nitrate, dissolved (mg/L as N)	Inorganic nitrogen, dissolved (mg/L as N)	Organic nitrogen, dissolved (mg/L as N)
9	Merced River at River Rd.	09/05/01	12:33	UCD	E 49	24.7	7.9	330	—	—	—	0.04	2.92	2.95	0.42
9	Merced River at River Rd.	09/19/01	10:45	UCD	E 175	22.3	8.0	215	—	—	—	0.05	2.25	2.31	0.55
9	Merced River at River Rd.	10/03/01	10:20	UCD	E 96	21.0	7.9	344	—	—	—	0.04	3.05	3.09	0.62
11	Orestimba Creek at River Rd.	07/12/00	13:10	UCD	11	23.2	8.1	643	—	—	—	0.02	4.52	4.54	0.19
11	Orestimba Creek at River Rd.	07/26/00	13:40	UCD	13	23.4	8.2	661	—	—	—	0.15	6.27	6.42	0.40
11	Orestimba Creek at River Rd.	08/09/00	12:07	UCD	27	22.5	7.9	498	—	—	—	<0.01	2.44	2.44	0.13
11	Orestimba Creek at River Rd.	08/23/00	13:01	UCD	11	22.4	8.2	635	—	—	—	0.03	4.03	4.06	0.42
11	Orestimba Creek at River Rd.	09/06/00	13:40	UCD	23	19.6	8.3	446	—	—	—	0.08	2.03	2.11	0.07
11	Orestimba Creek at River Rd.	09/20/00	14:35	UCD	28	25.9	8.1	436	—	—	—	0.08	1.64	1.72	0.70
11	Orestimba Creek at River Rd.	10/04/00	12:49	UCD	11	18.1	8.1	450	—	—	—	0.06	0.90	0.96	0.06
11	Orestimba Creek at River Rd.	10/18/00	12:08	UCD	81	18.3	8.2	438	—	—	—	0.05	0.54	0.59	0.33
11	Orestimba Creek at River Rd.	06/13/01	10:00	USGS	100	20.5	8.2	667	8.3	120	4	0.10	2.66	2.79	0.30
11	Orestimba Creek at River Rd.	06/27/01	11:15	UCD	17	21.9	8.1	738	—	—	—	0.05	5.36	5.41	0.24
11	Orestimba Creek at River Rd.	07/10/01	12:40	USGS	19	—	7.9	860	6.4	—	4	0.06	5.56	5.82	0.50
11	Orestimba Creek at River Rd.	07/25/01	12:36	UCD	9.7	26.3	8.3	811	—	—	—	0.09	5.99	6.08	0.70
11	Orestimba Creek at River Rd.	08/08/01	12:40	USGS	12	—	8.3	[1]800	—	130	—	E0.02	4.61	4.66	0.26
11	Orestimba Creek at River Rd.	08/22/01	11:54	UCD	10	20.6	8.1	846	—	—	—	0.10	3.84	3.94	0.68
11	Orestimba Creek at River Rd.	09/05/01	12:18	UCD	7.3	22.5	8.1	925	—	—	—	0.12	5.05	5.16	0.82
11	Orestimba Creek at River Rd.	09/19/01	10:25	UCD	1.4	19.3	8.1	1210	—	—	—	0.05	7.06	7.11	2.04
11	Orestimba Creek at River Rd.	10/04/01	15:00	USGS	11	20.5	7.9	[1]968	5.2	140	—	E0.02	3.41	3.46	0.43
11	Orestimba Creek at River Rd.	10/31/01	15:40	USGS	78	17.0	8.2	[1]743	9.0	98	12	E0.02	0.84	0.87	0.22
13	Spanish Grant Drain	06/13/01	13:00	USGS	13	23.0	7.9	1280	6.9	190	4	0.08	6.35	6.54	0.72
13	Spanish Grant Drain	07/11/01	12:30	USGS	28	—	7.8	971	7.2	120	3	0.31	5.15	5.56	0.56
13	Spanish Grant Drain	08/06/01	12:30	USGS	29	24.0	8.2	927	7.4	170	5	0.08	6.11	6.27	0.54
13	Spanish Grant Drain	09/04/01	11:10	USGS	17	27.5	8.0	892	—	130	9	E0.08	E5.45	E 5.41	E 0.82
13	Spanish Grant Drain	10/02/01	10:20	USGS	2.0	21.0	7.9	[1]815	7.6	120	7	0.04	1.61	1.69	0.27
13	Spanish Grant Drain	10/30/01	09:50	USGS	<0.01	17.0	7.7	[1]778	4.0	120	—	E0.04	1.00	1.07	0.38
14	Harding Drain at Carpenter Rd.	06/13/01	16:00	USGS	57	22.0	7.8	454	7.9	100	>32	2.43	4.18	7.26	0.67
14	Harding Drain at Carpenter Rd.	07/12/01	10:10	USGS	85	22.0	8.0	458	8.2	—	>29	0.33	4.47	5.04	0.35
14	Harding Drain at Carpenter Rd.	08/06/01	10:30	USGS	106	21.5	[1]7.8	[1]558	6.2	140	>36	1.86	6.81	9.35	0.84
14	Harding Drain at Carpenter Rd.	09/04/01	13:10	USGS	82	24.0	8.1	467	—	150	>32	E1.02	E7.68	E9.43	E0.78
14	Harding Drain at Carpenter Rd.	10/02/01	12:30	USGS	—	22.5	7.8	438	7.4	140	>60	1.05	6.82	8.63	0.65
14	Harding Drain at Carpenter Rd.	10/30/01	12:00	USGS	—	19.0	8.0	875	6.0	220	—	2.10	11.6	15.4	0.90
17	Westport Drain near Modesto	06/14/01	12:30	USGS	36	23.5	8.2	1230	9.1	86	>23	E0.04	5.21	E 5.32	0.21
17	Westport Drain near Modesto	07/12/01	13:00	USGS	76	24.0	8.0	307	8.4	—	—	0.22	5.59	5.87	0.29
17	Westport Drain near Modesto	08/07/01	10:30	USGS	18	23.0	8.0	320	8.8	94	>24	0.05	5.90	6.00	0.26
17	Westport Drain near Modesto	09/05/01	10:20	USGS	20	21.5	8.2	309	8.1	120	—	E0.04	3.29	3.38	0.25
17	Westport Drain near Modesto	10/03/01	11:30	USGS	13	22.5	8.0	679	7.1	200	>13	0.11	8.77	8.99	0.42
17	Westport Drain near Modesto	11/01/01	11:00	USGS	2.9	15.0	8.3	[1]957	9.8	300	>8	0.04	18.5	18.7	0.66
20	Dry Creek at Gallo Bridge	06/15/01	10:00	USGS	93	20.0	7.7	104	7.7	58	10	< 0.04	0.40	0.46	0.67
20	Dry Creek at Gallo Bridge	07/13/01	09:20	USGS	70	25.0	7.5	113	7.8	35	19	< 0.04	0.63	0.69	0.53
20	Dry Creek at Gallo Bridge	08/07/01	14:40	USGS	92	25.5	7.4	759	7.2	44	—	E0.04	0.32	0.37	0.57
20	Dry Creek at Gallo Bridge	09/05/01	13:00	USGS	99	23.0	8.1	84	7.7	38	—	< 0.04	0.34	0.37	0.47

Appendix C. All data (University of California at Davis and U.S. Geological Survey) for 2000 and 2001 for nutrients, organic carbon, and chlorophyll for tributary sites—*Continued*

Site number	Site name	Date	Total nitrogen, dissolved (mg/L as N)	Total nitrogen (mg/L as N)	Orthophosphate, dissolved (mg/L as P)	Total phosphorus (mg/L as P)	Organic carbon, dissolved (mg/L as C)	Organic carbon, suspended (mg/L as C)	Ultraviolet absorbance at 254 nm (cm^{-1})	SUVA (L/mg-cm)	Volatile suspended solids (mg/L)	Particulate organic matter (mg/L)	Chlorophyll-*a* (µg/L)	Pheophytin-*a* (µg/L)	Suspended sediment (mg/L)	Suspended sediment, size fraction < 0.062 mm (percent)
9	Merced River at River Rd.	09/05/01	3.37	3.66	0.02	0.43	1.7	—	—	—	—	1.5	1.6	—	6	—
9	Merced River at River Rd.	09/19/01	2.86	2.97	0.02	0.05	1.4	—	—	—	—	2.1	1.7	—	8	—
9	Merced River at River Rd.	10/03/01	3.71	3.72	0.02	0.06	1.7	—	—	—	—	1.4	1.5	—	3	—
11	Orestimba Creek at River Rd.	07/12/00	4.74	4.99	0.13	0.17	3.7	—	—	—	—	27	2.0	—	170	—
11	Orestimba Creek at River Rd.	07/26/00	6.82	6.95	0.12	0.17	3.2	—	—	—	—	29	4.0	—	214	—
11	Orestimba Creek at River Rd.	08/09/00	2.57	2.74	0.08	0.14	2.5	—	—	—	—	37	6.0	—	306	—
11	Orestimba Creek at River Rd.	08/23/00	4.48	4.71	0.10	0.14	3.9	—	—	—	—	22	2.9	—	144	—
11	Orestimba Creek at River Rd.	09/06/00	2.17	2.25	0.08	0.16	2.7	—	—	—	—	12	6.6	—	122	—
11	Orestimba Creek at River Rd.	09/06/00	5.85	6.25	—	—	—	—	—	—	—	—	—	—	—	—
11	Orestimba Creek at River Rd.	09/20/00	2.42	2.61	0.06	0.19	2.5	—	—	—	—	14	5.8	—	118	—
11	Orestimba Creek at River Rd.	10/04/00	1.02	1.14	0.07	0.11	2.8	—	—	—	—	11	2.1	—	51	—
11	Orestimba Creek at River Rd.	10/18/00	0.92	1.03	0.05	0.10	3.2	—	—	—	—	17	5.6	—	164	—
11	Orestimba Creek at River Rd.	06/13/01	3.09	3.99	0.12	0.48	4.8	0.4	0.392	0.082	21	—	9.2	13	521	96
11	Orestimba Creek at River Rd.	06/27/01	5.65	5.72	0.12	0.15	3.5	—	—	—	—	41	18.9	—	328	—
11	Orestimba Creek at River Rd.	07/10/01	6.32	7.06	0.11	0.36	3.7	4.6	0.104	0.028	23	—	0.8	1.5	273	96
11	Orestimba Creek at River Rd.	07/25/01	6.78	7.06	0.10	0.58	2.7	—	—	—	—	31	1.1	—	198	—
11	Orestimba Creek at River Rd.	08/08/01	4.92	5.57	0.13	0.33	2.4	2.5	0.070	0.029	24	—	5.2	3.4	272	99
11	Orestimba Creek at River Rd.	08/22/01	4.62	5.21	0.06	0.31	3.4	—	—	—	—	24	2.4	—	165	—
11	Orestimba Creek at River Rd.	09/05/01	5.98	6.35	0.07	0.28	3.1	—	—	—	—	13	3.1	—	114	—
11	Orestimba Creek at River Rd.	09/19/01	9.15	9.81	0.05	0.17	3.7	—	—	—	—	4.3	2.3	—	27	—
11	Orestimba Creek at River Rd.	10/04/01	3.89	4.35	0.11	0.37	3.7	3.7	0.095	0.026	17	—	8.1	6.3	239	97
11	Orestimba Creek at River Rd.	10/31/01	1.09	1.43	0.04	0.18	3.1	1.4	0.087	0.028	6	—	1.6	3.6	125	95
13	Spanish Grant Drain	06/13/01	7.26	8.37	0.18	0.46	9.9	0.2	0.470	0.047	13	—	11.8	18	245	93
13	Spanish Grant Drain	07/11/01	6.12	10.6	0.13	1.74	4.2	>10	—	—	134	—	14.4	38	1920	98
13	Spanish Grant Drain	08/06/01	6.81	8.79	0.14	0.46	3.8	2.5	0.111	0.029	26	—	5.4	4.0	464	91
13	Spanish Grant Drain	09/04/01	E6.23	E6.73	E0.18	0.36	7.4	2.4	0.176	0.024	16	—	4.5	8.3	177	88
13	Spanish Grant Drain	10/02/01	1.96	2.25	0.03	0.18	3.1	1.8	0.094	0.030	8	—	6.4	10	109	94
13	Spanish Grant Drain	10/30/01	1.45	1.97	0.07	0.18	5.1	1.6	0.124	0.024	10	—	6.7	4.6	36	98
14	Harding Drain at Carpenter Rd.	06/13/01	7.93	8.33	1.90	2.05	4.6	0.9	0.098	0.021	E2	—	4.4	10	12	73
14	Harding Drain at Carpenter Rd.	07/12/01	5.39	5.56	0.44	0.49	3.1	1.4	0.074	0.024	6	—	1.7	6.2	25	69
14	Harding Drain at Carpenter Rd.	08/06/01	10.2	10.5	0.77	0.84	3.5	0.6	0.079	0.023	6	—	13.3	8.3	37	37
14	Harding Drain at Carpenter Rd.	09/04/01	E10.2	E10.4	E0.91	0.94	4.0	0.4	0.093	0.023	4	—	1.9	3.0	10	82
14	Harding Drain at Carpenter Rd.	10/02/01	9.28	9.38	0.62	0.71	3.4	0.5	0.078	0.023	E3	—	6.3	5.5	14	76
14	Harding Drain at Carpenter Rd.	10/30/01	16.3	16.6	2.27	2.58	5.2	0.5	0.101	0.019	4	—	4.5	4.5	15	81
17	Westport Drain near Modesto	06/14/01	5.53	5.67	0.07	0.13	4.9	0.8	0.076	0.016	E2	—	1.7	3.1	21	63
17	Westport Drain near Modesto	07/12/01	6.16	6.51	0.14	0.20	2.4	1.6	0.064	0.027	8	—	1.8	6.4	44	89
17	Westport Drain near Modesto	08/07/01	6.26	6.38	0.12	0.17	6.0	0.3	0.069	0.012	E1	—	2.5	2.3	10	93
17	Westport Drain near Modesto	09/05/01	3.63	3.86	0.10	0.16	3.1	0.7	0.052	0.017	4	—	1.4	3.4	26	83
17	Westport Drain near Modesto	10/03/01	9.41	9.39	0.06	0.10	2.6	0.4	E0.057	0.022	E<1	—	0.5	1.4	11	50
17	Westport Drain near Modesto	11/01/01	19.4	19.5	0.60	0.59	5.2	<0.2	0.144	0.028	E2	—	0.2	0.8	—	—
20	Dry Creek at Gallo Bridge	06/15/01	1.13	1.54	0.50	0.71	8.7	2.4	0.276	0.032	6	—	3.7	7.3	59	64
20	Dry Creek at Gallo Bridge	07/13/01	1.22	1.42	0.58	0.66	7.9	1.5	0.285	0.036	8	—	1.7	3.9	33	70
20	Dry Creek at Gallo Bridge	08/07/01	0.94	1.09	0.53	0.66	7.5	0.6	0.340	0.045	E3	—	2.0	3.9	27	68
20	Dry Creek at Gallo Bridge	09/05/01	0.84	0.96	0.46	0.56	7.0	0.7	0.240	0.034	4	—	1.2	3.3	23	88

Appendix C. All data (University of California at Davis and U.S. Geological Survey) for 2000 and 2001 for nutrients, organic carbon, and chlorophyll for tributary sites—*Continued*

Site number	Site name	Date	Time	Laboratory	Stream flow (ft^3/s)	Water Temperature (°C)	pH	Specific conductance (µS/cm at 25°C)	Dissolved Oxygen (mg/L)	Alkalinity (mg/L $CaCO_3$)	Secchi disk depth (in.)	Ammonia, dissolved (mg/L as N)	Nitrate, dissolved (mg/L as N)	Inorganic nitrogen, dissolved (mg/L as N)	Organic nitrogen, dissolved (mg/L as N)
20	Dry Creek at Gallo Bridge	10/03/0	14:20	USGS	90	21.0	7.3	88	6.8	34	>22	< 0.04	0.25	0.28	0.48
20	Dry Creek at Gallo Bridge	11/01/0	15:30	USGS	7.4	16.0	7.6	[1] 104	10.6	36	>13	< 0.04	0.28	0.30	0.20
22	Tuolumne River at Shiloh Rd.	07/12/0	12:20	UCD	E 620	24.3	7.7	165	—	—	—	0.06	1.55	1.62	0.07
22	Tuolumne River at Shiloh Rd.	07/26/0	12:20	UCD	E 732	22.7	7.8	116	—	—	—	0.02	0.98	1.00	0.22
22	Tuolumne River at Shiloh Rd.	08/09/0	11:11	UCD	E 497	27.9	7.7	198	—	—	—	0.02	1.75	1.76	0.10
22	Tuolumne River at Shiloh Rd.	08/23/0	12:10	UCD	E1633	20.3	7.6	65	—	—	—	0.02	0.33	0.35	0.07
22	Tuolumne River at Shiloh Rd.	09/06/0	12:20	UCD	E 851	20.2	7.9	128	—	—	—	0.02	0.55	0.57	0.04
22	Tuolumne River at Shiloh Rd.	09/20/0	12:20	UCD	E1129	22.9	7.6	100	—	—	—	0.03	0.52	0.55	0.09
22	Tuolumne River at Shiloh Rd.	10/04/0	11:47	UCD	E 974	19.1	7.7	121	—	—	—	0.03	0.84	0.87	0.06
22	Tuolumne River at Shiloh Rd.	10/18/0	11:27	UCD	E 551	17.1	8.1	171	—	—	—	0.02	1.34	1.35	0.24
22	Tuolumne River at Shiloh Rd.	06/13/0	08:20	UCD	E 234	21.0	8.1	314	—	—	—	0.08	3.50	3.58	0.11
22	Tuolumne River at Shiloh Rd.	06/27/0	10:40	UCD	E 213	22.4	7.6	295	—	—	—	0.06	2.37	2.43	0.05
22	Tuolumne River at Shiloh Rd.	07/11/0	08:15	UCD	E 182	22.9	8.2	298	—	—	—	0.04	2.88	2.92	0.47
22	Tuolumne River at Shiloh Rd.	07/25/0	12:05	UCD	E 277	26.0	8.2	251	—	—	—	0.03	1.76	1.79	0.35
22	Tuolumne River at Shiloh Rd.	08/07/0	11:20	UCD	E 277	27.7	7.8	227	—	—	—	0.03	1.63	1.66	0.46
22	Tuolumne River at Shiloh Rd.	08/22/0	11:15	UCD	E 296	23.1	8.0	226	—	—	—	< 0.01	1.85	1.86	0.35
22	Tuolumne River at Shiloh Rd.	09/05/0	11:41	UCD	E 286	23.7	7.8	236	—	—	—	0.01	1.87	1.88	0.44
22	Tuolumne River at Shiloh Rd.	09/19/0	09:30	UCD	E 296	21.1	8.1	234	—	—	—	0.02	1.70	1.72	0.44
22	Tuolumne River at Shiloh Rd.	10/03/0	09:35	UCD	E 324	20.8	7.9	236	—	—	—	0.04	1.65	1.69	0.40
23	Hospital Cr. below Ingram Cr.	06/14/0	15:30	USGS	26	29.0	8.3	—	6.8	140	1	< 0.04	4.00	4.10	0.37
23	Hospital Cr. below Ingram Cr.	07/11/0	09:40	USGS	18	21.0	8.0	1070	7.3	—	2	0.61	5.67	6.51	1.79
23	Hospital Cr. below Ingram Cr.	08/09/0	10:30	USGS	23	22.5	[1]8.0	[1]1120	8.4	140	1	0.46	5.98	6.71	0.54
23	Hospital Cr. below Ingram Cr.	09/07/0	10:30	USGS	0.86	19.0	8.1	1870	7.6	210	5	0.18	11.8	12.4	0.64
23	Hospital Cr. below Ingram Cr.	10/05/0	10:00	USGS	4.9	19.0	8.1	[1]1350	8.9	180	>7	< 0.04	4.05	4.18	0.44
23	Hospital Cr. below Ingram Cr.	11/02/0	09:30	USGS	1.7	14.0	8.0	[1]937	9.6	110	>5	< 0.04	3.33	3.37	0.45
26	Stanislaus River at Caswell	07/12/0	11:40	UCD	E 400	22.1	7.6	97	—	—	—	0.02	0.42	0.45	0.08
26	Stanislaus River at Caswell	07/26/0	11:00	UCD	E 462	22.1	7.8	93	—	—	—	0.05	0.42	0.47	0.06
26	Stanislaus River at Caswell	08/09/0	10:20	UCD	E 391	21.5	7.5	89	—	—	—	0.04	0.44	0.48	0.10
26	Stanislaus River at Caswell	08/23/0	10:35	UCD	E 391	21.0	7.8	94	—	—	—	0.05	0.42	0.48	0.05
26	Stanislaus River at Caswell	09/06/0	11:00	UCD	E 391	17.1	7.8	94	—	—	—	0.07	0.51	0.57	0.04
26	Stanislaus River at Caswell	09/20/0	11:30	UCD	E 380	21.1	7.7	110	—	—	—	0.05	0.38	0.43	0.22
26	Stanislaus River at Caswell	10/04/0	11:04	UCD	E 384	18.1	7.8	99	—	—	—	0.07	0.41	0.48	0.12
26	Stanislaus River at Caswell	10/18/0	10:35	UCD	E 597	16.2	8.0	104	—	—	—	0.02	0.52	0.54	0.17
26	Stanislaus River at Caswell	06/13/0	07:35	UCD	E 564	19.1	7.8	75	—	—	—	0.03	0.28	0.30	0.04
26	Stanislaus River at Caswell	06/27/0	09:30	UCD	E 571	19.4	7.5	72	—	—	—	0.03	0.31	0.33	0.02
26	Stanislaus River at Caswell	07/11/0	07:00	UCD	E 536	20.4	7.8	74	—	—	—	0.06	0.23	0.29	0.07
26	Stanislaus River at Caswell	07/25/0	10:53	UCD	E 452	22.2	7.9	84	—	—	—	0.03	0.17	0.20	0.18
26	Stanislaus River at Caswell	08/07/0	10:32	UCD	E 393	22.8	7.6	85	—	—	—	0.04	0.38	0.42	0.23
26	Stanislaus River at Caswell	08/22/0	10:22	UCD	E 362	19.8	7.8	83	—	—	—	0.01	0.23	0.24	0.16
26	Stanislaus River at Caswell	09/05/0	10:45	UCD	E 348	20.7	7.6	85	—	—	—	0.03	0.26	0.29	0.45
26	Stanislaus River at Caswell	09/19/0	08:20	UCD	E 306	19.6	7.7	93	—	—	—	0.05	0.27	0.32	0.14
26	Stanislaus River at Caswell	10/03/0	08:50	UCD	E 293	22.8	7.8	112	—	—	—	0.05	0.61	0.66	0.22

[1]Laboratory value.

Appendix C. All data (University of California at Davis and U.S. Geological Survey) for 2000 and 2001 for nutrients, organic carbon, and chlorophyll for tributary sites—*Continued*

Site number	Site name	Date	Total nitrogen, dissolved (mg/L as N)	Total nitrogen (mg/L as N)	Orthophosphate, dissolved (mg/L as P)	Total phosphorus (mg/L as P)	Organic carbon, dissolved (mg/L as C)	Organic carbon, suspended (mg/L as C)	Ultraviolet absorbance at 254 nm (cm^{-1})	SUVA (L/mg-cm)	Volatile suspended solids (mg/L)	Particulate organic matter (mg/L)	Chlorophyll-*a* (μg/L)	Pheophytin-*a* (μg/L)	Suspended sediment (mg/L)	Suspended sediment, size fraction < 0.062 mm (percent)
20	Dry Creek at Gallo Bridge	10/03/01	0.76	0.80	0.33	0.42	6.7	0.4	E.252	0.038	E 1	—	1.4	2.7	9	74
20	Dry Creek at Gallo Bridge	11/01/01	0.50	0.62	0.18	0.21	3.8	—	0.130	0.034	E 3	—	0.4	0.8	—	—
22	Tuolumne River at Shiloh Rd.	07/12/00	1.69	1.71	0.08	0.12	2.3	—	—	—	—	3.6	1.1	—	15	—
22	Tuolumne River at Shiloh Rd.	07/26/00	1.22	1.27	0.07	0.11	1.9	—	—	—	—	3.0	0.7	—	9	—
22	Tuolumne River at Shiloh Rd.	08/09/00	1.87	1.94	0.10	0.12	2.2	—	—	—	—	2.3	0.5	—	5	—
22	Tuolumne River at Shiloh Rd.	08/23/00	0.42	0.49	0.04	0.06	1.6	—	—	—	—	2.9	0.9	—	9	—
22	Tuolumne River at Shiloh Rd.	09/06/00	0.62	0.71	0.07	0.10	1.9	—	—	—	—	1.9	0.8	—	9	—
22	Tuolumne River at Shiloh Rd.	09/20/00	0.64	0.75	0.05	0.07	1.7	—	—	—	—	3.0	0.8	—	15	—
22	Tuolumne River at Shiloh Rd.	10/04/00	0.93	0.94	0.05	0.07	1.8	—	—	—	—	3.0	1.0	—	11	—
22	Tuolumne River at Shiloh Rd.	10/18/00	1.59	1.91	0.04	0.07	1.6	—	—	—	—	3.6	1.0	—	15	—
22	Tuolumne River at Shiloh Rd.	06/13/01	3.69	3.74	0.13	0.17	4.1	—	—	—	—	3.1	2.4	—	10	—
22	Tuolumne River at Shiloh Rd.	06/27/01	2.48	2.70	0.15	0.35	3.3	—	—	—	—	3.6	4.3	—	14	—
22	Tuolumne River at Shiloh Rd.	07/11/01	3.39	4.00	0.23	0.29	3.1	—	—	—	—	2.4	2.4	—	8	—
22	Tuolumne River at Shiloh Rd.	07/25/01	2.13	2.30	0.15	0.17	2.5	—	—	—	—	3.9	3.3	—	11	—
22	Tuolumne River at Shiloh Rd.	08/07/01	2.12	2.20	0.14	0.19	3.3	—	—	—	—	3.1	3.2	—	8	—
22	Tuolumne River at Shiloh Rd.	08/22/01	2.21	2.25	0.16	0.24	2.4	—	—	—	—	4.6	3.7	—	20	—
22	Tuolumne River at Shiloh Rd.	09/05/01	2.32	2.36	0.16	0.22	2.1	—	—	—	—	2.2	2.1	—	9	—
22	Tuolumne River at Shiloh Rd.	09/19/01	2.16	2.27	0.11	0.17	1.9	—	—	—	—	2.7	2.5	—	12	—
22	Tuolumne River at Shiloh Rd.	10/03/01	2.09	2.15	0.11	0.18	2.0	—	—	—	—	3.2	3.2	—	12	—
23	Hospital Cr. below Ingram Cr.	06/14/01	4.47	9.38	0.16	2.27	7.7	>10	0.119	0.015	126	—	81.5	57	3460	95
23	Hospital Cr. below Ingram Cr.	07/11/01	8.30	10.4	0.17	0.91	4.8	>5.0	0.098	0.020	66	—	16.7	18	1160	94
23	Hospital Cr. below Ingram Cr.	08/09/01	7.25	9.35	0.17	0.87	3.4	>5.0	0.102	0.030	46	—	12.1	6.5	998	94
23	Hospital Cr. below Ingram Cr.	09/07/01	13.0	13.3	0.19	0.32	4.3	3.5	0.105	0.024	9	—	10.0	6.2	134	97
23	Hospital Cr. below Ingram Cr.	10/05/01	4.62	5.01	0.15	0.29	4.7	0.6	0.107	0.023	7	—	16.9	20	77	75
23	Hospital Cr. below Ingram Cr.	11/02/01	3.82	4.45	0.15	0.38	5.0	2.6	0.146	0.029	15	—	4.2	7.6	286	86
26	Stanislaus River at Caswell S.P.	07/12/00	0.53	0.54	0.04	0.06	1.1	—	—	—	—	2.7	1.1	—	8	—
26	Stanislaus River at Caswell S.P.	07/26/00	0.53	0.57	0.05	0.08	1.9	—	—	—	—	3.2	1.4	—	10	—
26	Stanislaus River at Caswell S.P.	08/09/00	0.57	0.63	0.05	0.08	1.8	—	—	—	—	3.6	1.2	—	11	—
26	Stanislaus River at Caswell S.P.	08/23/00	0.53	0.59	0.06	0.09	2.1	—	—	—	—	3.3	0.8	—	10	—
26	Stanislaus River at Caswell S.P.	09/06/00	0.62	0.71	0.08	0.13	2.1	—	—	—	—	1.8	0.7	—	8	—
26	Stanislaus River at Caswell S.P.	09/20/00	0.65	0.73	0.06	0.09	1.9	—	—	—	—	1.9	0.7	—	8	—
26	Stanislaus River at Caswell S.P.	10/04/00	0.59	0.60	0.14	0.18	2.3	—	—	—	—	2.4	0.8	—	5	—
26	Stanislaus River at Caswell S.P.	10/18/00	0.71	0.86	0.06	0.08	1.9	—	—	—	—	2.2	0.9	—	4	—
26	Stanislaus River at Caswell S.P.	06/13/01	0.35	0.39	0.03	0.07	1.5	—	—	—	—	3.4	2.4	—	13	—
26	Stanislaus River at Caswell S.P.	06/27/01	0.35	0.52	0.03	0.10	1.5	—	—	—	—	8.1	7.5	—	40	—
26	Stanislaus River at Caswell S.P.	07/11/01	0.37	0.53	0.04	0.07	1.6	—	—	—	—	3.3	1.1	—	11	—
26	Stanislaus River at Caswell S.P.	07/25/01	0.38	0.40	0.05	0.09	1.7	—	—	—	—	3.5	0.9	—	8	—
26	Stanislaus River at Caswell S.P.	08/07/01	0.65	1.00	0.04	0.07	1.7	—	—	—	—	2.5	1.0	—	5	—
26	Stanislaus River at Caswell S.P.	08/22/01	0.40	0.47	0.04	0.09	1.5	—	—	—	—	2.9	1.4	—	8	—
26	Stanislaus River at Caswell S.P.	09/05/01	0.74	1.02	0.05	0.10	1.5	—	—	—	—	1.5	1.2	—	6	—
26	Stanislaus River at Caswell S.P.	09/19/01	0.46	0.49	0.06	0.10	1.6	—	—	—	—	1.3	1.2	—	8	—
26	Stanislaus River at Caswell S.P.	10/03/01	0.88	1.08	0.04	0.06	1.6	—	—	—	—	1.4	1.2	—	6	—