Water-Quality Conditions, Hydrologic Budget, and Sources and Fate of Selected Trace Elements and Nutrients in Boulder Reservoir, Boulder, Colorado, 1997–98

U.S. GEOLOGICAL SURVEY

Water-Resources Investigations Report 99–4091

Prepared in cooperation with the
CITY OF BOULDER, COLORADO

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Denver, Colorado
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CONVERSION FACTORS, DEFINITIONS, AND ABBREVIATIONS

Multiply	By	To obtain
acre	0.004047	square kilometer (km^2)
acre-foot (acre-ft)	1,233	cubic meter (m^3)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
foot (ft)	0.3048	meter (m)
gallon (gal)	3.785	liter (L)
inch	2.54	centimeter (cm)
mile (mi)	1.609	kilometer (km)
square inch (in^2)	6.452	square centimeter (cm^2)
centimeter (cm)	0.3937	inch
kilogram (kg)	2.205	pound

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

$$°F=1.8\ °C+32$$

Altitude, as used in this report, refers to distance above or below sea level.

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).

ADDITIONAL ABBREVIATIONS

µg/g	micrograms per gram
µm	micrometer
mg/kg	milligrams per kilogram
mL	milliliter
mm	millimeter

Water-Quality Conditions, Hydrologic Budget, and Sources and Fate of Selected Trace Elements and Nutrients in Boulder Reservoir, Boulder, Colorado, 1997–98

By Robert A. Kimbrough

Abstract

Boulder Reservoir is located about 5 miles northeast of Boulder, Colorado. During 1997–98, a study was performed to describe the water-quality conditions of the reservoir and to determine the source and fate of selected trace elements (manganese, iron, selenium, and uranium) and nutrients (nitrogen and phosphorus) in the reservoir water column.

From April through October of each year, Boulder Reservoir receives water imported from Colorado's western slope by the Colorado-Big Thompson (CBT) Project. During a 1-year period within this study, CBT water accounted for about 82 percent of water inflow to the reservoir. The combined flow from four secondary inflows contributed about 12 percent of the inflow and precipitation about 6 percent. Releases for irrigation accounted for about 85 percent of reservoir outflow, and the remainder of outflow was attributed to evaporation and withdrawals to a drinking-water treatment plant.

During summer, Boulder Reservoir tends to stratify in response to solar heating; however, the degree of stratification is affected by the inflow and outflow of CBT water. The location of the outlet structure on the bottom of the reservoir facilitates the removal of the hypolimnion through reservoir withdrawals, which in turn breaks down stratification. Stratification was most pronounced in July 1997 following an almost 6-week period when minimal amounts of CBT water had been routed into or out of the reservoir. Throughout the winter of 1997–98, the water column stayed well mixed with regard to temperature and dissolved oxygen, primarily because of the lack of ice cover.

Manganese was detected primarily in the dissolved phase in the lower part of the water column and usually only during periods of stratification and reduced dissolved oxygen levels. In contrast, iron was consistently detected in the reservoir water column and predominantly in the particulate phase. Elevated levels of dissolved manganese (and dissolved iron) in bottom water during anoxia most likely resulted from the mobilization of reduced manganous and ferrous ions from bottom-sediment pore water and from the reduction of ferric hydroxides at the reservoir bottom. The removal of anoxic hypolimnetic water in reservoir releases could be a tool for managing manganese concentrations in Boulder Reservoir.

Oxygenated conditions that predominated in the photic zone were optimal for the mobilization of dissolved uranium and selenate, the soluble form of selenium; however, uranium concentrations generally were less than 2 micrograms per liter and selenium concentrations less than 1 microgram per liter. Uranium and selenium do not appear to be a water-quality concern for Boulder Reservoir at this time.

Total nitrogen concentrations in the reservoir ranged from 0.2 to 1.1 milligrams per liter, and total phosphorus concentrations ranged from 5 to 41 micrograms per liter. Nitrogen and phosphorus predominantly were in the organic phase, probably tied up in aquatic biomass. Dissolved

inorganic nitrogen concentrations were small and ranged from less than 0.01 to 0.19 milligram per liter. Dissolved orthophosphorus concentrations almost always were less than the detection level of 1 microgram per liter. Based on the ratio of total nitrogen to total phosphorus, phosphorus appears to be the nutrient that limits algal growth in the reservoir.

During 1 year, from July 1, 1997, through June 30, 1998, about 70 percent of the incoming manganese load to the reservoir was contained in streamflow in three natural tributaries. About 85 percent of the total inflow of iron was attributed to imported water sources (CBT water and one small irrigation ditch). During the 1-year budget period, the reservoir was a net source of manganese, iron, and uranium in reservoir outflows and was a sink for nitrogen, phosphorus, and selenium. The net loss of manganese and iron from the reservoir was facilitated by the release of anoxic hypolimnetic water that was high in manganese and iron concentration. The net gain of nitrogen and phosphorus in the reservoir most likely resulted from nitrogen- and phosphorus-rich particulate organic matter settling out of the reservoir water column.

The concentrations of trace elements in reservoir-bottom sediments were comparable to or generally smaller than background concentrations determined from reservoir and streambed sediments in the South Platte River Basin. Bed-sediment trace-element concentrations generally were higher in the deepest areas of the reservoir, where the percentage of fine-grained bed material was highest. Rates of trace element and nutrient flux from bottom-sediment pore water to the overlying water column were calculated from data collected on August 20–21, 1997, during oxic conditions at the sediment/water interface. Given the oxic conditions, flux from the sediments was estimated to contribute, on a daily basis, about 6.3 kilograms of manganese, 2.2 kilograms of iron, 9.6 kilograms of inorganic nitrogen, and 0.6 kilogram of orthophosphorus.

INTRODUCTION

Boulder Reservoir was constructed by the City of Boulder in 1955 as a municipal drinking-water supply (City of Boulder, 1996). The reservoir also is used as a source of irrigation water, for recreation (swimming, boating, and fishing), and is a major winter habitat for several birds of prey (Camp Dresser and McKee Inc., 1986). Like most western U.S. communities, Boulder depends on stored water for its drinking supply. The amount of water that is available from Boulder Reservoir is sufficient to meet all of the city's future demands (City of Boulder, 1996). The City of Boulder has an interest in preserving the water quality of Boulder Reservoir; maintaining adequate water quality can help to minimize treatment costs and can ensure that the reservoir remains a viable source of municipal, recreation, and irrigation water for years to come.

In 1997, the U.S. Geological Survey (USGS), in cooperation with the City of Boulder, began a 16-month investigation to assess the water-quality conditions of the reservoir and to determine the sources and fate of selected trace elements (manganese, iron, selenium, and uranium) and nutrients (nitrogen and phosphorus) in the reservoir. Manganese was selected for monitoring because in July 1996 elevated levels of dissolved manganese were measured in reservoir water by the City of Boulder (Amy Struthers, City of Boulder, written commun., 1996). The city suspected that low oxygen (anoxic) levels in the lower part of the reservoir had caused manganese to be released from reservoir sediments into the overlying water column. Dissolved oxygen levels may become depleted in the bottom of lakes and reservoirs as oxygen is consumed during the microbial degradation of particulate organic matter that has settled from the overlying water column (Wetzel, 1983). Iron was selected for monitoring because the biogeochemical cycling of iron in lakes and reservoirs is very similar to that of manganese (Hsiung and Tisue, 1994). Other less common trace elements are effectively transported in surface water while adsorbed to insoluble oxides of manganese and iron.

The potential for trace elements to exist in solution in Boulder Reservoir under oxic conditions was evaluated with measurements of selenium and uranium. Unlike manganese and iron, which are highly soluble under reducing conditions, selenium and uranium are soluble under oxidizing conditions. Selenium and uranium are elements contained in the marine Pierre Shale that underlies and surrounds Boulder Reservoir. Elevated levels of selenium in soil and water are toxic to fish and wildlife (Severson and others, 1991). Elevated levels of selenium in soil and water have been attributed to several marine shales of Late Cretaceous age, including the Mancos Shale, Moreno Shale, Niobrara Formation, and Pierre Shale (Butler and others, 1996; Presser and others, 1990; Wilson and others, 1990). The Pierre and other shales of Late Cretaceous age are sources of uranium in the South Platte and Arkansas River Basins in Colorado (Zielinski and others, 1995; Boberg and Runnells, 1971). Additionally, selenium and uranium were detected in ground water adjacent to Boulder Reservoir in 1996 (Bruce and O'Riley, 1997).

The inclusion of nitrogen and phosphorus in water-quality monitoring programs is essential because nitrogen and phosphorus are the major nutrients that regulate plant growth in aquatic ecosystems. Excessive nutrient concentrations in reservoirs accelerate the growth of algae and other aquatic plants, which leads to degraded aquatic habitat and higher treatment costs for drinking water. Aquatic growth resulting from nutrient enrichment may also result in conditions that are unsuitable for swimming or other forms of aquatic recreation.

Purpose and Scope

This report (1) describes the spatial and temporal distribution of selected trace-element concentrations, nutrient concentrations, and other water-quality characteristics in Boulder Reservoir, (2) summarizes the concentration of selected trace elements in reservoir bottom sediments, and (3) quantifies the sources and fate of selected trace elements and nutrients in Boulder Reservoir with the calculation of hydrologic and constituent budgets, including the constituent flux from sediment pore water. Data were collected monthly from five sites in the reservoir, five reservoir inflows, and one reservoir outflow from April 1997 to July 1998.

Acknowledgments

The author would like to thank Jim Shelley, Scot Gillespie, and Amy Struthers with the City of Boulder for their support and assistance with many aspects of the study, including field reconnaissance; stream-gage installation, maintenance, and operation; and sampling preparation, collection, and analysis. The author also thanks Dennis Miller, with the Northern Colorado Water Conservancy District, for providing information and data on reservoir operations, and USGS employees Dennis Smits and Janet Heiny for their assistance with field work.

DESCRIPTION OF THE STUDY AREA AND RESERVOIR OPERATIONS

Boulder Reservoir is situated about 5 miles northeast of Boulder, Colorado (fig. 1). The reservoir was created by the construction of earthen dams on Dry Creek and Little Dry Creek, two tributaries in the Saint Vrain Creek Basin. The bedrock underlying the reservoir is the Pierre Shale of Late Cretaceous age (Trimble, 1975). In the Dry and Little Dry Creek drainages, the Pierre Shale is overlain by Piney Creek Alluvium of Holocene age (Trimble, 1975). The Piney Creek Alluvium consists of gravel to cobble-size particles derived from crystalline rock of Precambrian age.

Although the reservoir was constructed by the City of Boulder, the reservoir is operated by the Northern Colorado Water Conservancy District (NCWCD). The NCWCD provides northeastern Colorado with irrigation and municipal water through the Colorado-Big Thompson (CBT) project. The CBT project diverts water from the Upper Colorado River Basin on the western slope of the Colorado Rocky Mountains to the South Platte River Basin on the eastern slope. Boulder Reservoir is filled primarily with CBT water that is stored in Carter Lake Reservoir, a CBT reservoir located about 20 miles north of Boulder Reservoir (fig. 1). Carter Lake Reservoir water is delivered to Boulder Reservoir in an earthen-lined canal that is open to the atmosphere. The upper one-half of the canal is named the Saint Vrain Supply Canal; the lower one-half is the Boulder Feeder Canal (fig. 1). In the spring, the Boulder Feeder Canal may receive some water from Left Hand Creek (fig. 1) through a water exchange with the Left Hand Water District (Brown and Caldwell, 1992). Most of the

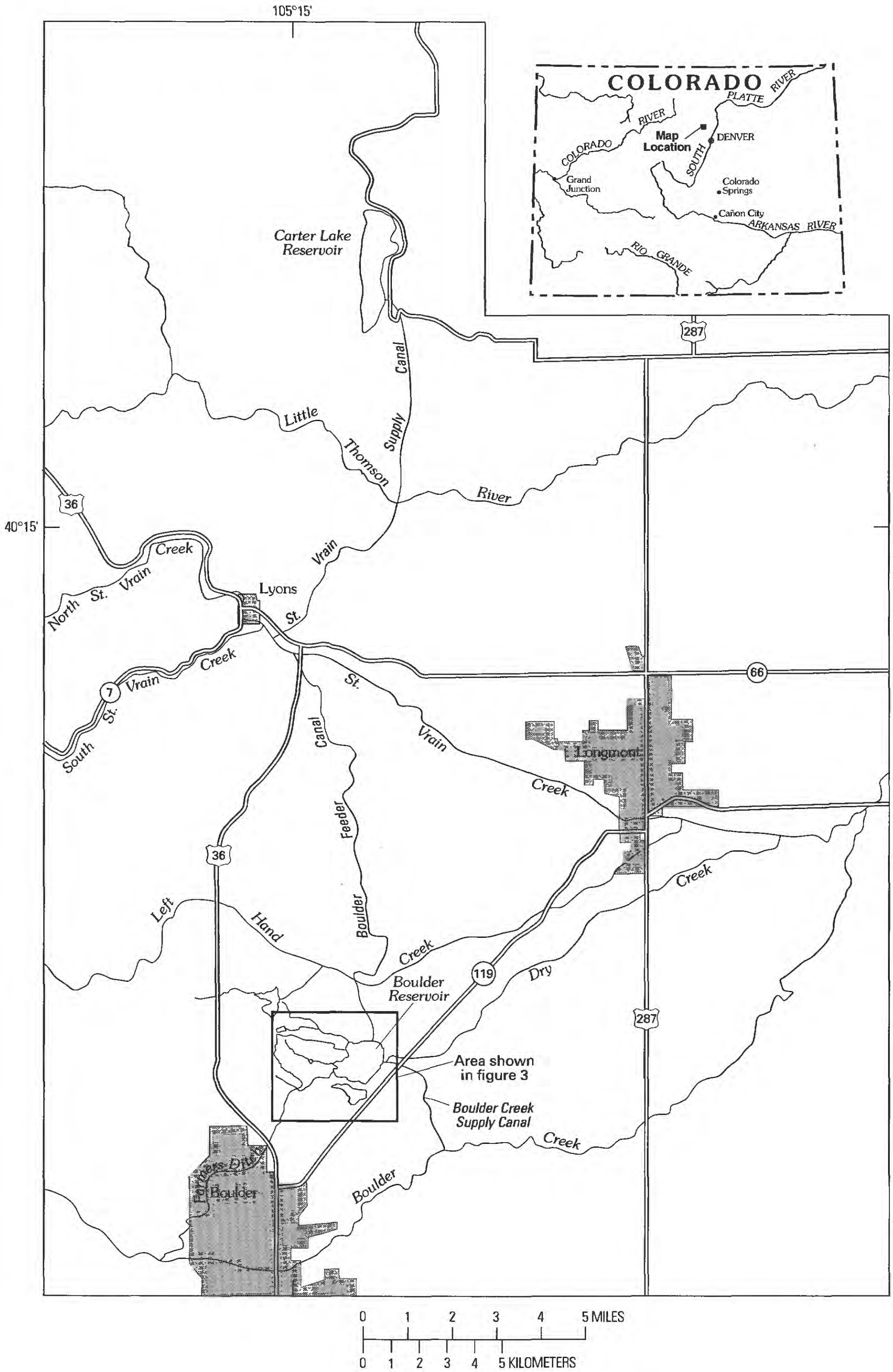

Figure 1. Map showing location of Boulder Reservoir.

water released from Boulder Reservoir is CBT water that is delivered to Boulder Creek through the Boulder Creek Supply Canal (fig. 1). Smaller amounts of water are released to several ditches for irrigation, to Dry Creek, and to a City of Boulder drinking-water treatment plant located adjacent to the eastern side of the reservoir. At maximum capacity, Boulder Reservoir contains about 13,250 acre-ft of water and the surface area is about 540 acres. The mean depth is about 24 ft, and maximum depth is about 32 ft.

During the study, the volume of water held in storage in Boulder Reservoir ranged from about 4,500 to 11,500 acre-ft (fig. 2). Storage typically is at a minimum over the winter from November through April of each year. At the beginning of this study, storage had been held at about 4,500 acre-ft during the winter of 1996–97. The winter storage in 1997–98 was somewhat higher at about 8,000 acre-ft. The reservoir receives and releases CBT water during 7 months each year from April through October (Dennis Miller, Northern Colorado Water Conservancy District, oral commun., 1997). The reservoir reached its maximum storage during the study by early June 1997 after receiving inflow for about 2 months (fig. 2). During the summer of 1997, there were two major periods of water releases from the reservoir: during the month of July and from mid-August to late September (fig. 2). During June and July 1998, reservoir outflow was about the same as reservoir inflow.

Boulder Reservoir also receives surface-water inflow from four other sources, collectively referred to herein as "the secondary inflows." Three of the secondary inflows emanate from natural drainages on the western side of the reservoir—Dry Creek, Little Dry Creek, and a small drainage referred to herein as "the unnamed drainage" (fig. 3). A 1-year record of streamflow was obtained for the secondary inflows as part of this study (fig. 4). Streamflow in Dry Creek is influenced by return flows generated by irrigation in a residential community located about 3 miles upstream from the reservoir. The residential community's treated wastewater is stored onsite and dispensed as irrigation water on a local golf course as needed (Brown and Caldwell, 1992). Wastewater treated during the nonirrigation season is stored over the winter and applied in the spring. This practice may have caused the increase in flow during spring 1998 (fig. 4). Little Dry Creek drains a small, undeveloped watershed that is predominantly rangeland and open space owned by the City and County of Boulder. Farmers Ditch is an irrigation ditch that originates at Boulder Creek and terminates in the reservoir

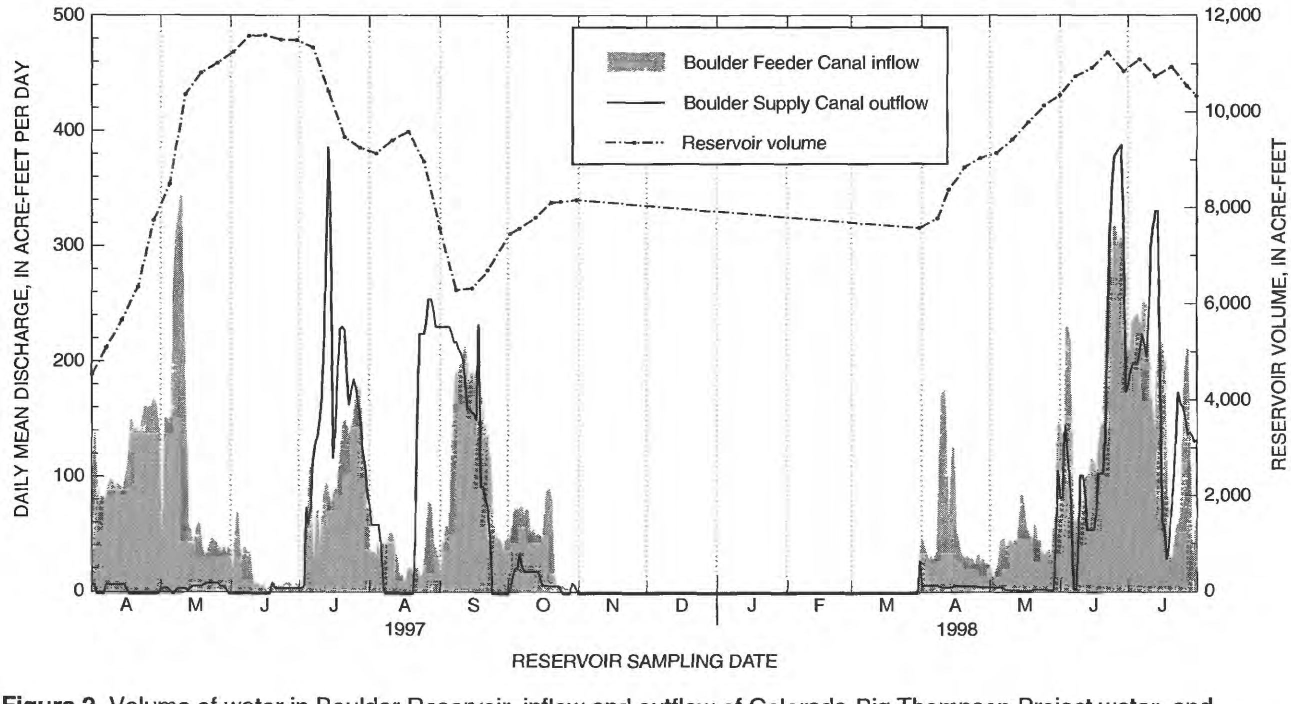

Figure 2. Volume of water in Boulder Reservoir, inflow and outflow of Colorado-Big Thompson Project water, and reservoir sampling dates, April 1997–July 1998.

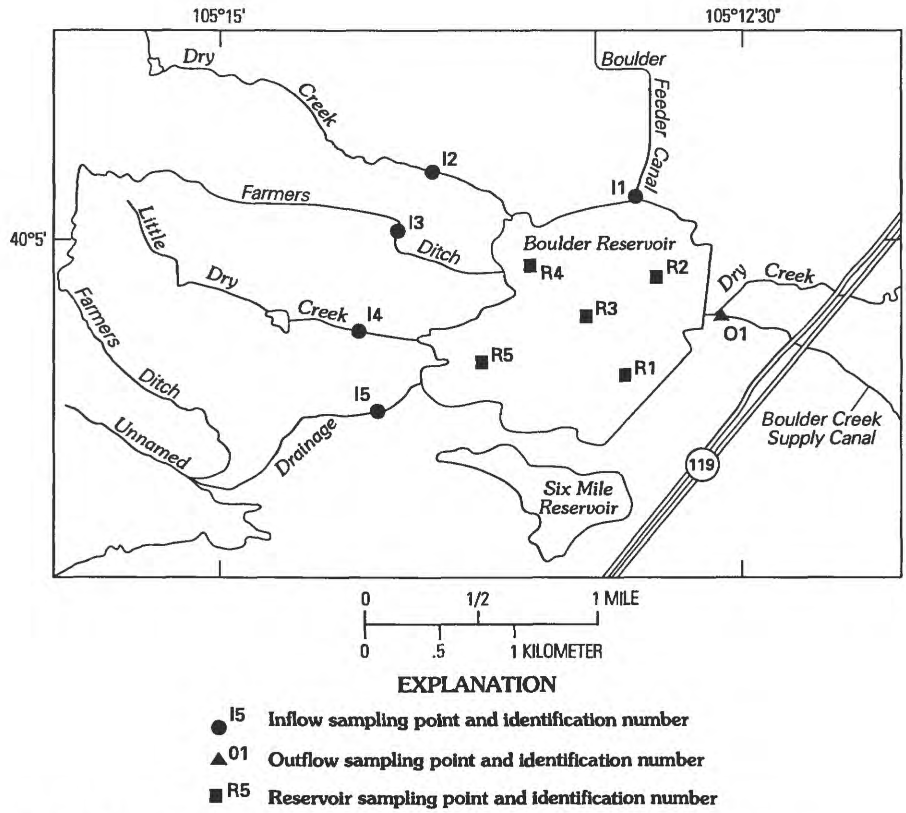

Figure 3. Location of Boulder Reservoir and surface-water sampling sites.

(figs. 1 and 3). Farmers Ditch typically flows from May through October of each year (fig. 4). Most of the water in Farmers Ditch that arrives at the reservoir is considered tail water, or supplemental ditch water. Streamflow in the unnamed drainage (fig. 4) probably is affected by upstream summer irrigation and by flow in Farmers Ditch, which transects the unnamed drainage about 1 mile upstream from the reservoir (fig. 3).

METHODS OF INVESTIGATION

Several methods were used to assess water-quality conditions in Boulder Reservoir and to determine the major sources and sinks of selected trace elements and nutrients. Descriptions of the methods are discussed in this section.

Water-Quality Sampling and Analysis

Water-quality samples were collected from the reservoir water column and surface-water inflows and outflow about once per month from April 1997 through July 1998 and were analyzed for manganese, iron, selenium, uranium, nutrients (nitrogen and phosphorus), and various trace elements (listed in tables 13–27). To minimize the potential of contamination from metallic surfaces, sample-collection and sample-processing equipment made from Teflon, or high-density polyethylene plastic, was used. All sampling equipment was cleaned prior to use with a nonphosphate laboratory detergent and rinsed first with tap water, then with a 5 percent solution of hydrochloric acid, and last with deionized water. The equipment was rinsed with copious amounts of native water at the sampling sites before sample collection.

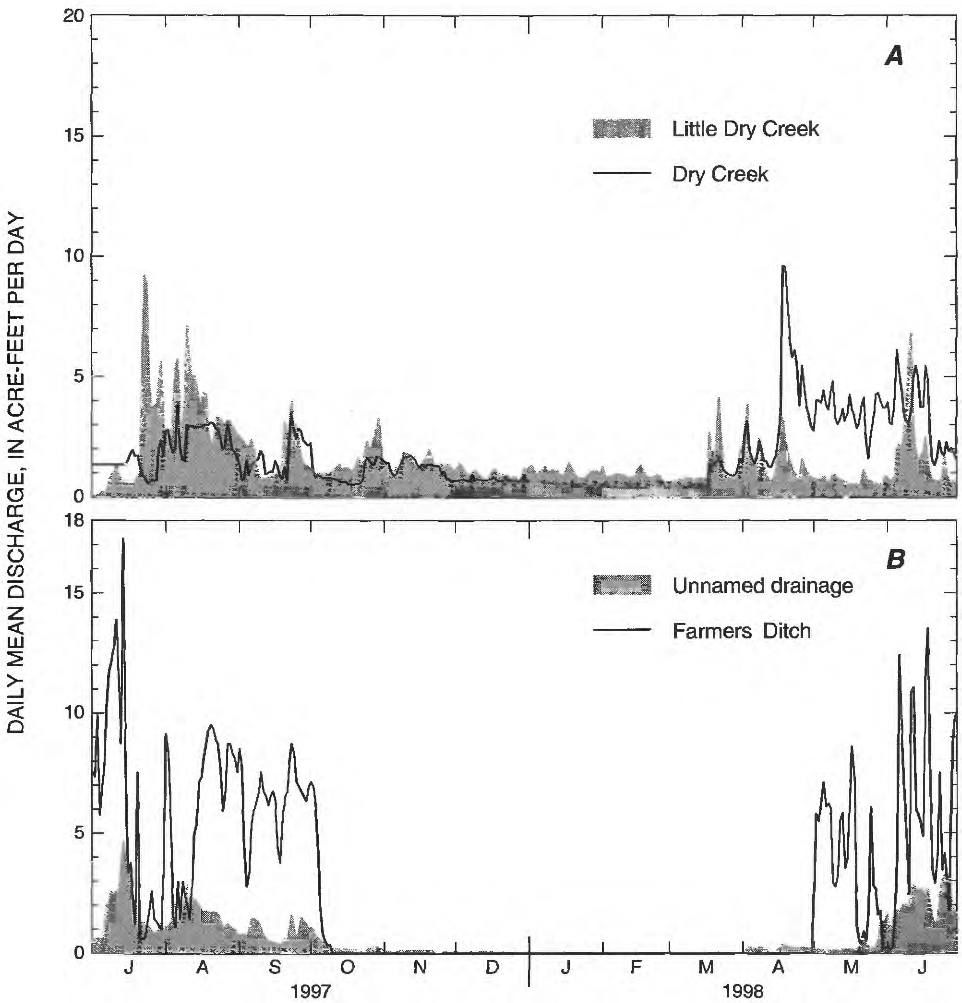

Figure 4. Daily mean discharge in (*A*) Little Dry and Dry Creeks and (*B*) the unnamed drainage and Farmers Ditch, July 1997–June 1998.

Water quality was monitored at five sites (R1–R5) in Boulder Reservoir (fig. 3). The sites were selected to provide adequate spatial coverage for determining the variability of water-quality conditions throughout the reservoir. Three of the sites (R1–R3) were located in some of the deepest areas of the reservoir, whereas two sites (R4, R5) were located in the shallow bays on the western side.

Prior to sample collection at the five sites, water transparency was measured with a Secchi disc, and depth profile measurements of water temperature, pH, dissolved oxygen, and specific conductance were obtained with a multiparameter meter. Depth profile measurements were recorded at approximately 1–ft intervals using a portable computer. Two water samples were collected at each of the three deep monitoring sites. The first sample was a depth-integrated sample collected from the photic zone (defined as twice the Secchi-disc depth), and a second sample was collected at a single depth about 3 ft above the reservoir bottom. The location of the two sampling sites on the western side of the reservoir varied slightly between sampling dates and was dependent on the volume of water in the reservoir and Secchi-disc depths. The objective for sampling these two sites was to obtain a single sample from an oxidized photic zone that extended to a depth of 3 ft above the bottom. The main intent of sampling a shallow, oxic water column was to maximize the potential for detecting trace elements such as selenium and uranium that are in solution under oxidizing conditions (selenium and uranium were sampled for at R5 but not at R4). At all reservoir sites, water samples were collected from discrete depths by using a horizontally suspended, 4-L, acrylic Van Dorn sampler. Samples of water from the photic zones were collected at the water surface and at depth intervals of about every 2 ft and were composited in a 14-L polyethylene churn splitter.

Water samples were obtained from the five reservoir inflows and one outflow to quantify sources and sinks of trace elements and nutrients in surface water (fig. 3). Concurrent with sample collection, onsite measurements were obtained for water temperature, pH, specific conductance, dissolved oxygen, and flow volume. When sufficient water was present in the streams, depth- and width-integrated water samples were collected by using the equal-width increment method (Edwards and Glysson, 1988); otherwise, grab samples were obtained in the centroid of flow.

Water samples were prepared onsite for analysis using methods described by Horowitz and others (1994) and Shelton (1994). Aliquots of unfiltered water were collected for analysis of total recoverable manganese and iron concentrations and total concentrations of selenium, ammonia plus organic nitrogen, and phosphorus. Sample water filtered through a 0.45-μm cellulose nitrate filter was used to determine constituent concentrations in the dissolved phase. Dissolved concentrations were determined for manganese, iron, selenium, uranium, ammonia as nitrogen, nitrite plus nitrate as nitrogen, and orthophosphorus. Samples for trace-element analyses were acidified to a pH of less than 2.0 using ultrapure nitric acid; samples for nutrient analyses were immediately chilled to 4°C.

Nutrient analyses were performed by the City of Boulder Drinking Water and Wastewater Laboratories using Hach method 8192, Low Range Cadmium Reduction, for nitrite plus nitrate analyses and several methods listed by Eaton and others (1995), including 4500-NH_3, the Titrimetric method for ammonia analysis; 4500-N_{org}, the Macro Kjeldahl method for determining ammonia plus organic nitrogen; and 4500-PE, the Ascorbic Acid Standard method for total phosphorus and dissolved orthophosphorus (Jim Shelley, City of Boulder, written commun., 1998). Trace-element analyses were conducted at the USGS National Water Quality Laboratory (NWQL) in Arvada, Colorado, using methods described by Fishman and Friedman (1989) and Fishman (1993). Dissolved manganese and iron were analyzed by atomic emission spectrometry, inductively coupled plasma (ICP); total recoverable manganese and iron by atomic absorption spectrometry, direct; dissolved and total selenium by atomic absorption spectrometry, hydride; and dissolved uranium by fluorimetry. About 15 percent of the total number of samples were quality-assurance/quality-control samples. These included field equipment blanks and split-replicate samples. Additionally, about 29 percent of the environmental nutrient samples were processed in duplicate and analyzed at the NWQL using colorimetric techniques described by Fishman (1993). A description of sampling sites and a summary of the primary samples collected at each site are presented in table 1. Information on additional samples collected infrequently from most sites for analysis of various other trace elements is not provided in table 1, although the results of these analyses are included in tables 13–17 and table 27 in the "Supplemental Data" section of this report.

Reservoir Bottom-Sediment and Pore-Water Sampling and Analysis

The distribution and concentration of 46 selected constituents in reservoir-bottom sediments were examined as part of this study. In March and August 1997, samples of bottom sediments were collected at each of the five monitoring sites in the reservoir. Grab samples of reservoir sediments were collected by lowering a stainless steel Eckman dredge over the side of a boat. A Teflon spoon was used to collect subsamples from the top 2–3 cm of material that was captured in the dredge. Subsamples were collected from the center of the sampler, away from the metallic sidewalls. On shore, samples were sieved in a mobile laboratory, and the <63-μm-size fraction was retained and stored at 4°C for analysis. A portion of unsieved material was collected for the determination of sediment particle-size distribution. Trace-element concentrations were determined by the USGS Chemistry Services Group in Denver, using total digestion procedures described by Arbogast (1990). Particle-size analyses were performed by the USGS sediment laboratory in Iowa City, Iowa, by using sieve and pipet analyses (sieve, 0.062 and 0.125 mm; pipet, 0.002, 0.004, and 0.016 mm) (Von Miller, U.S. Geological Survey, written commun., 1997).

The dissolved concentration of selected trace elements and nutrients in the interstitial pore water of reservoir bottom sediments was determined to evaluate the potential for dissolved constituents to move between bottom sediments and the overlying water column. On August 20–21, 1997, sediment cores were collected at sites R1 and R2 (fig. 3) using a gravity-

Table 1. Description of sampling sites and samples collected for Boulder Reservoir study, April 1997–July 1998 (Samples collected infrequently from most sites for analysis of several additional trace elements are not indicated in this table.)

[USGS, U.S. Geological Survey; Fe, iron; Mn, manganese; Se, selenium; U, uranium; P, composite sample collected from the reservoir photic zone; B, discrete sample collected 3 feet above the reservoir bottom; --, not collected]

Site number (fig. 3)	USGS site identification number	Site name	Samples collected: Fe, Mn, dissolved	Samples collected: Se, U, dissolved, Fe, Mn, Se, total recoverable	Samples collected: Nitrogen, phosphorus
		Reservoir sites			
R1	400430105130400	Boulder Reservoir near south dam	P,B	--	P,B
R2	400452105125500	Boulder Reservoir near north dam	P,B	P,B	P,B
R3	400443105131500	Boulder Reservoir near center of reservoir	P,B	--	P,B
R4	400452105132300	Boulder Reservoir near Dry Creek	P	--	P
R5	400433105133700	Boulder Reservoir near Little Dry Creek	P	P	P
		Inflow and outflow sites			
I1	400512105130200	Boulder Feeder Canal above Boulder Reservoir	Samples collected for all constituents at inflow and outflow sites		
I2	400514105135600	Dry Creek above Boulder Reservoir			
I3	400502105141400	Farmers Ditch above Boulder Reservoir			
I4	400440105142100	Little Dry Creek above Boulder Reservoir			
I5	400423105140900	Unnamed Drainage above Boulder Reservoir			
O1	400443105124100	Boulder Supply Canal below Boulder Reservoir			

driven coring device outfitted with acrylic core tubes. The cores, with a diameter of about 7 cm and ranging in length between 35 and 70 cm, were kept upright and transported to an onshore mobile laboratory for processing. Within a nitrogen gas atmosphere to prevent oxidation, the top 5 cm of each core was extruded and sectioned into 1-cm samples, and the pore water in each sample was removed by centrifuging. The pore-water samples were filtered through 0.45-μm syringe filters. Samples for trace-element analyses were acidified to a pH of less than 2.0 by using ultrapure nitric acid, whereas samples for nutrient analyses were immediately chilled to 4°C. Concentrations of selected trace elements were analyzed by ICP and nutrients by colorimetry (Fishman, 1993) at the NWQL by using low-volume techniques.

Computation of the Hydrologic Budget

A hydrologic budget was computed to quantify the input and output of water in Boulder Reservoir. Ultimately, results of the hydrologic budget were used to compute constituent loads in reservoir inflows and outflows. Although water-quality data were collected throughout the 16-month study, continuous records of surface-water flow from all sources were collected only for 12 months. Therefore, an annual hydrologic budget for the reservoir was computed for the period of July 1, 1997, through June 30, 1998.

The mass balance equation for determining the hydrologic budget for Boulder Reservoir can be stated as "inflow minus outflow equals the change in reservoir storage," and is written as follows:

$$P + SI + GI - E - SO - GO - MSO = \Delta S \qquad (1)$$

where

- P is direct precipitation on the reservoir,
- SI is surface-water inflow to the reservoir,
- GI is ground-water inflow to the reservoir,
- E is evaporation from the reservoir water surface,
- SO is surface-water outflow from the reservoir,
- GO is ground-water outflow from the reservoir,
- MSO is municipal surface-water withdrawals from the reservoir, and
- ΔS is the change in reservoir storage or the change in water volume for the period of interest.

Measurements of ground-water movement were outside the scope of this study; therefore, the water balance equation is rearranged so that net ground-water flux is computed as the residual, R:

$$P + SI - E - SO - MSO - \Delta S = R \qquad (2)$$

Each term in the hydrologic budget has an associated error that is dependent on the method of its measurement or calculation. As a result, a certain amount of error is inherent in the calculated value of ground-water flux (residual). To evaluate the validity of calculated ground-water flux, the error associated with the hydrologic budget was computed using methods described in detail by Winter (1981), Brown (1987), and Lee and Swancar (1997). Briefly, the percentage error in measuring individual terms in the budget was used to define the total standard error or confidence limits around each measured term with the following equation (Woods, 1997):

$$Eq = \sqrt{(P)^2 (Q)^2} \qquad (3)$$

where

- Eq is the total standard error associated with the budget term,
- P is the percent error in measuring the budget term (expressed as a decimal), and
- Q is the quantity of water associated with the budget term.

Percent errors in measuring each budget term, derived from Winter (1981) and Woods (1997), were 7.5 percent for surface-water inflows, outflows, and change in reservoir storage; 15 percent for precipitation; and 25 percent for evaporation.

Using the computed errors for each budget term, the overall standard error for the hydrologic budget was computed with the following equation (Brown, 1987):

$$OEQ = \sqrt{(Eq_1)^2 + (Eq_2)^2 + \ldots (Eq_n)^2} \qquad (4)$$

where

- OEQ is the overall standard error of the hydrologic budget, and
- Eq is the total standard error associated with each budget term.

The overall error is a reasonable estimate of the typical magnitude of the resulting error in estimating ground-water flux as the residual of the hydrologic budget (Winter, 1981).

Several methods were used to quantify hydrologic budget terms. Precipitation for the period of study was determined from the National Weather Service precipitation gage located in downtown Boulder. Precipitation, in inches, was multiplied by the surface area of the reservoir to determine the amount of precipitation falling on the reservoir. Evaporation was computed using data from the National Weather Service Class A evaporation pan located in Fort Collins, Colorado, about 40 miles north of the reservoir. A pan coefficient of 0.74 (Farnsworth and others, 1982) was used to convert monthly pan evaporation to evaporation from the reservoir water surface.

Surface-water flow into and out of Boulder Reservoir were obtained from two sources. Records of flow for the Boulder Feeder Canal and Boulder Creek Supply Canal, which transport CBT water into and out of Boulder Reservoir, were obtained from the NCWCD. The NCWCD measures inflow in the Boulder Feeder Canal at a continuous recording streamflow-gaging station located at the reservoir (site I1, fig. 3). Streamflow at the outfall is determined by rated staff gages located in the outflow canal (site O1, fig. 3) and at the diversion for Dry Creek. Diversion points for several other irrigation ditches that are supplied with water from the reservoir are located farther downstream from site O1 and are not shown on any figures in this report. Streamflow measurements obtained by the USGS during monthly visits to the reservoir indicated that NCWCD records were reliable.

Streamflow for the secondary inflows to the reservoir (sites I2–I5, fig. 3) were computed using Parshall flumes that were installed by the City of Boulder in June and July 1997 specifically for this study. The flumes, ranging in size from 9 inches to 2 ft, were equipped with continuous recorders set to a 15-minute recording interval. Mean daily streamflows, computed with a computerized spreadsheet by the City of Boulder, were reviewed monthly by USGS personnel. The USGS also obtained streamflow measurements monthly at the secondary inflows to verify flows computed from the Parshall flumes.

The change in reservoir storage was computed from a record of daily reservoir stage and a stage-volume rating table for the reservoir, both of which were obtained from the NCWCD. The record of municipal water withdrawals to the City of Boulder's drinking-water treatment plant located at the reservoir were obtained from the plant operators.

Computation of Constituent Budgets

Constituent budgets (mass-balance computations) were calculated to determine the major sources and fate of selected trace elements and nutrients in Boulder Reservoir and to quantify the amount of constituents entering and leaving the reservoir in surface-water inflows and the outflow. The constituent budgets were computed for the same time period as the water budget: July 1, 1997, through June 30, 1998.

Mass-balance computations use calculations of loads. Load is the mass of a constituent transported in the quantity of water associated with a budget term. Loads, in kilograms, are the product of constituent concentration, in micrograms per liter, the quantity of water associated with the budget term, in acre-feet, and a conversion factor of 1.23349×10^{-3}. The mass-balance equation for determining constituent budgets for Boulder Reservoir is similar to the equation for the hydrologic budget, but the evaporation term has been eliminated and two terms have been added to account for processes within the reservoir that affect constituent masses—primarily, internal loading from bottom sediments (source) and sedimentation (sink). The constituent mass-balance equation for Boulder Reservoir is expressed as

$$P_L + SI_L + GI_L + RI_L - SO_L - GO_L - RO_L - MSO_L = \Delta S_L \qquad (5)$$

where

P_L is the constituent load in direct precipitation on the reservoir,

SI_L is the constituent load in surface-water inflow,

GI_L is the constituent load in ground-water inflow,

RI_L is the constituent load from internal reservoir sources (sediments),

SO_L is the constituent load in surface-water outflow,

GO_L is the constituent load in ground-water outflow,

RO_L is the constituent load removed by internal reservoir processes (sedimentation),

MSO_L is the constituent load in municipal surface-water withdrawals, and

ΔS_L is the change in the mass of a constituent held in storage in the reservoir water column.

The equation is rearranged to solve for the residual, R_L, which is the net constituent flux from ground water and internal recycling:

$$P_L + SI_L - SO_L - MSO_L - \Delta S_L = R_L \qquad (6)$$

As with the hydrologic budget, each term in the constituent budget has an error associated with the method of measurement or calculation, and so a certain amount of error exists in the calculated value of the residual. Errors in the constituent budget arise from the measurement of streamflow, the determination of concentrations, and from the calculation of loads. Errors associated with concentrations (and resultant loads) are primarily affected by sampling frequency. For calculating loads in this report, concentrations determined from monthly sampling were assumed to be representative of the actual concentrations between sampling dates. A degree of uncertainty is inherent in the computed loads because the actual variability of constituent concentrations during the month was unknown. More frequent sampling over varying streamflow regimes (for example, storm-runoff events) could result in more accurate load computations. The equation used to calculate the standard error for each constituent budget term (Brown, 1987) accounts for some of the error associated with using monthly concentrations (denoted by the term Ec):

$$El = \sqrt{[(Ec)^2 (Q)^2 (K)^2] + [(Eq)^2 (C)^2 (K)^2]} \qquad (7)$$

where

El is the total standard error associated with the constituent budget term, in kilograms,

Ec is the standard error associated with the mean constituent concentration, C, in micrograms per liter,

Q is the quantity of water associated with the budget term, in acre-feet, Eq is the standard error associated with the quantity of water, Q, in acre-feet (from equation 3),

C is the mean constituent concentration for the budget period, in micrograms per liter, and

K is a conversion factor equal to 1.23349×10^{-3}.

The standard error associated with the constituent concentration (Ec), is calculated in the same manner as Eq. The percent errors associated with concentrations, derived from Brown (1987) and Woods (1997), were 15 percent for surface-water inflows, outflows, and change in reservoir storage and 30 percent for precipitation.

The overall standard error for the constituent budget is similar to equation 4:

$$OEL = \sqrt{(El_1)^2 + (El_2)^2 + \ldots (El_n)^2} \qquad (8)$$

where

OEL is the overall standard error of the constituent budget, and

El_n is the total standard error associated with each constituent budget term.

Several methods were used to quantify constituent budget terms. Constituent input from direct precipitation on the reservoir was calculated with data collected at the National Atmospheric Deposition Program (NADP) Sugarloaf Station, located about 15 miles southwest of the reservoir at an altitude of about 8,280 ft (about 3,100 ft above the reservoir). Monthly mean constituent concentrations in precipitation were multiplied by the volume of daily precipitation falling on the reservoir to compute daily constituent loads from precipitation. Concentration data from the NADP site were available only for nitrogen and phosphorus (metal concentrations in wet or dry atmospheric deposition were not available).

Constituent loads in surface-water inflows and outflows were calculated with records of daily streamflow and monthly concentration data using the time-interval method described by Scheider and others (1979) and Mueller and Ruddy (1993). Briefly, the daily inflow and outflow streamflow records were divided into several time intervals, and the constituent load for each interval was computed. Time-interval divisions were made at the midpoint between sampling dates, and the constituent load for each interval was computed by multiplying the volume of streamflow for each interval by the corresponding constituent concentration. Constituent loads for each interval were then summed to determine the total constituent load. Concentration data for the inflows and Boulder Creek Supply Canal outflow were obtained monthly at the inflow/outflow monitoring sites. Concentrations below detection limits were assigned a value of zero, so the computed load for a nondetected constituent for the corresponding time period also was calculated as zero. For some constituents, detection limits for the dissolved phase were lower than the detection limits for total concentrations. Reported dissolved concentrations were used in load calculations if the total concentration was indicated as less than detection. Concentration data for determining loads diverted to the drinking-water treatment plant were determined from data for bottom water at sites R1 and R2 in the reservoir, as the treatment plant intake is located near the bottom of the reservoir. The change in constituent mass held in storage in the reservoir water column was defined as the difference in constituent mass held in storage on July 1, 1997, and on June 30, 1998. The constituent mass in the water column was a weighted average concentration determined from data collected at the reservoir monitoring sites. Direct determination of net constituent flux from ground water and internal reservoir loading or sedimentation was outside the scope of this study and is, therefore, calculated as the residual of the constituent budget.

WATER-QUALITY CONDITIONS IN BOULDER RESERVOIR

Selected data from reservoir sampling are discussed in this section. A complete tabulation of onsite measurements, USGS metals data, City of Boulder nutrient data, trace elements in bed-sediment data, and pore-water data are listed in tables 8–27 in the "Supplemental Data" section of this report.

Water Temperature and Dissolved Oxygen

The seasonal variation of water temperature and dissolved oxygen in Boulder Reservoir followed a pattern that has been observed in many Temperate-Zone lakes, where water temperature and dissolved oxygen generally are uniform with depth during fall through spring and decrease with depth during the summer when thermal stratification (the formation of three distinct temperature zones) occurs in response to solar heating and variations in water density. Unlike natural lakes in the Temperate Zones, the duration and degree of thermal stratification and the formation of the epilimnion (upper zone), metalimnion (transition zone), and hypolimnion (lower zone) in Boulder Reservoir was erratic throughout the summer months.

The instability of thermal stratification during summer months is most likely the result of reservoir operations, or the routing of CBT water through the reservoir. The routing of CBT water into or out of the reservoir may displace or remove the hypolimnion in Boulder Reservoir, and either process may lead to a breakdown of stratification. The displacement of water in the hypolimnion may occur when colder, denser water flows into the reservoir through the Boulder Feeder Canal. The water in the canal is withdrawn off the bottom of Carter Lake Reservoir (maximum depth greater than 100 ft), and as a result, summer water temperatures in the canal during the study (about 8° to 18°C) were cooler than summer water temperatures in Boulder Reservoir (about 15° to 22°C). The removal of the hypolimnion in Boulder Reservoir may result from large amounts of water being released from the reservoir through the outlet structure near the bottom of the north dam, in one of the deepest parts of the reservoir.

The processes described above provide an explanation for the temperature and dissolved oxygen profiles that were obtained during the study (fig. 5). In April 1997, the reservoir was well circulated, and water temperature and dissolved oxygen were uniform throughout the water column. The reservoir began to stratify in May, and by early July 1997, the reservoir had a clearly defined epilimnion extending from the surface to a depth of about 15 ft, a metalimnion from about 15 to 21 ft, and a hypolimnion that was anoxic from a depth of about 22 ft to the bottom of the reservoir (28 ft). The stratified conditions in July, which were the most developed stratified conditions observed during the study, followed an almost 6-week period when minimal amounts of CBT water had been routed into or out of the reservoir (fig. 2).

During July 1997, water withdrawals exceeded water inflows, and reservoir storage decreased from about 11,500 to 9,000 acre-ft. The result was an increase in the depth of the epilimnion at sites R1– R3 (by early August), a partial removal of the hypolimnion at site R1 (near the south dam), and a large reduction in the size of the hypolimnion at site R2 (located midway between the Boulder Feeder Canal inflow and reservoir outflow) (fig. 5). The variability in stratification between sites R1 and R2 is an example of the short-circuiting effect caused by routing water through the reservoir. Because of the location of the CBT inlet and outlet structures, hypolimnetic water in the northern part of the reservoir was removed in reservoir withdrawals prior to the removal of hypolimnetic water in the southern part.

By mid-August 1997, the reservoir had obtained equilibrium after removal of the hypolimnion, and water temperature and dissolved oxygen again were relatively uniform throughout the water column (fig. 5). Thermal stratification had begun to form again by early September. An anoxic hypolimnion existed at the southern site (R1), but large withdrawals from the reservoir had prevented the formation of an anoxic hypolimnion at the northern site (R2). In fact, increases in dissolved oxygen were measured in the bottom 1 ft of site R2, probably because the multiparameter probe had been lowered into an underflow of dense, oxygenated water being drawn straight from the inflow towards the outflow. Thermal stratification began to break down by October 1997, probably as the result of air cooling, and by November, the reservoir had turned over and become isothermal. From November 1997 through April 1998, the water column stayed well mixed with regard to temperature and dissolved oxygen, primarily because of the lack of ice cover. The reservoir stratified to a small degree after April 1998, but relatively large inflows and outflow in June and early July 1998 prevented a well-defined, anoxic hypolimnion from forming by July 7, the date of the last profile taken (fig. 5).

pH

In Boulder Reservoir, pH, a measure of the hydrogen-ion activity, ranged from 7.0 to 8.3 (fig. 6*A* and tables 8–12) and no values were outside the range of 6.5 to 9.0, the water-quality standard for Boulder

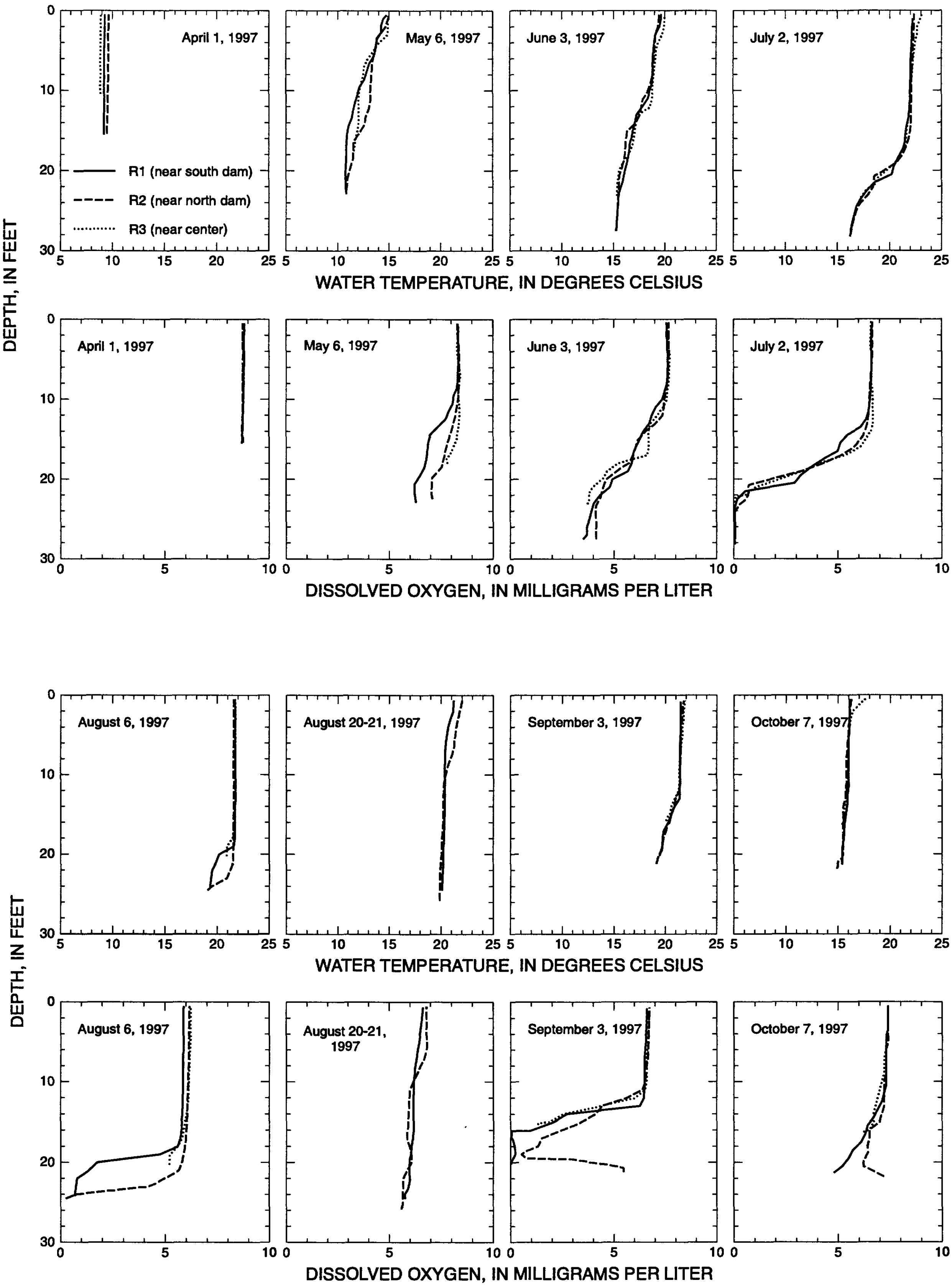

Figure 5. Profiles of water temperature and dissolved oxygen at sites R1–R3 in Boulder Reservoir, April 1997–July 1998.

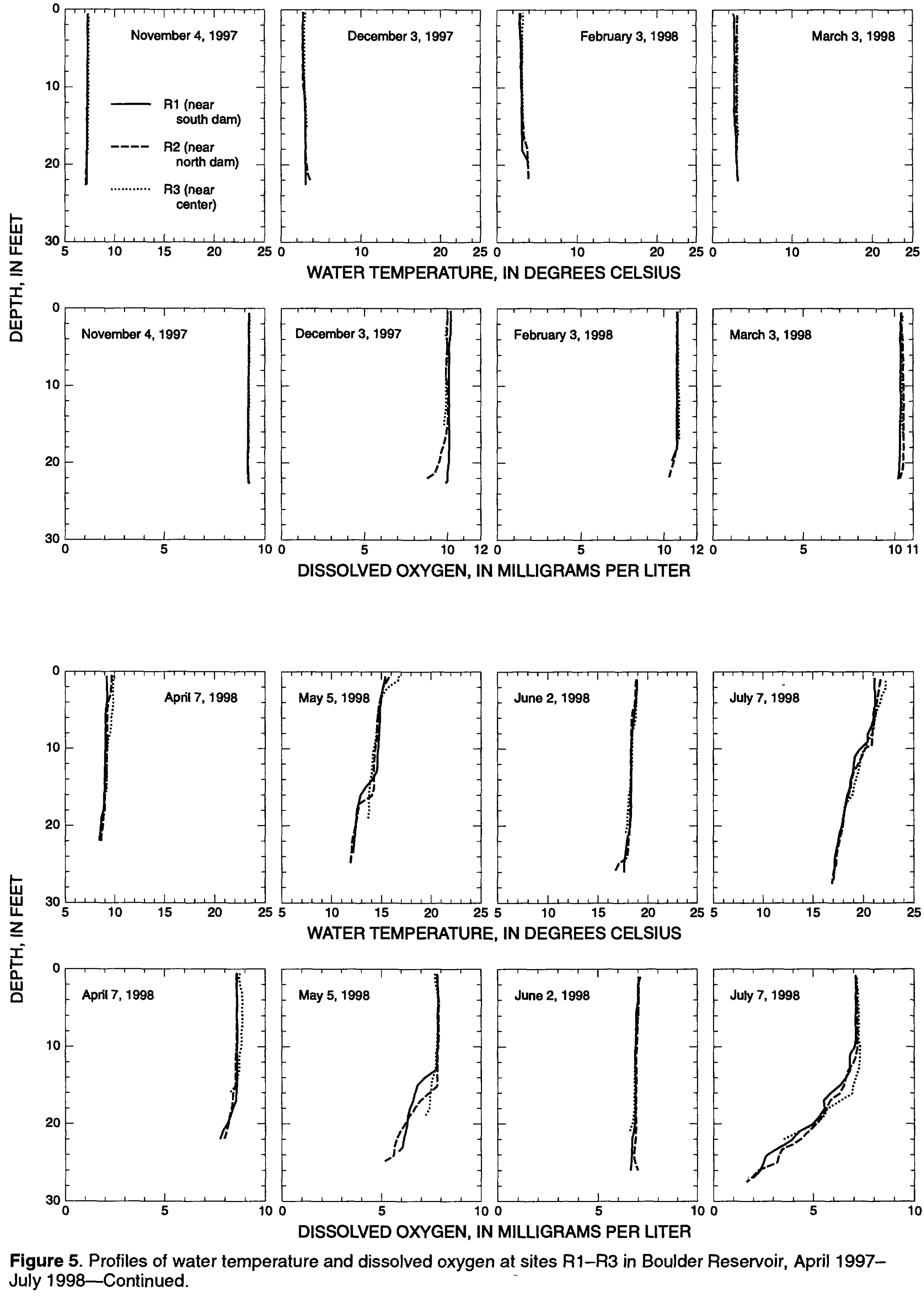

Figure 5. Profiles of water temperature and dissolved oxygen at sites R1–R3 in Boulder Reservoir, April 1997–July 1998—Continued.

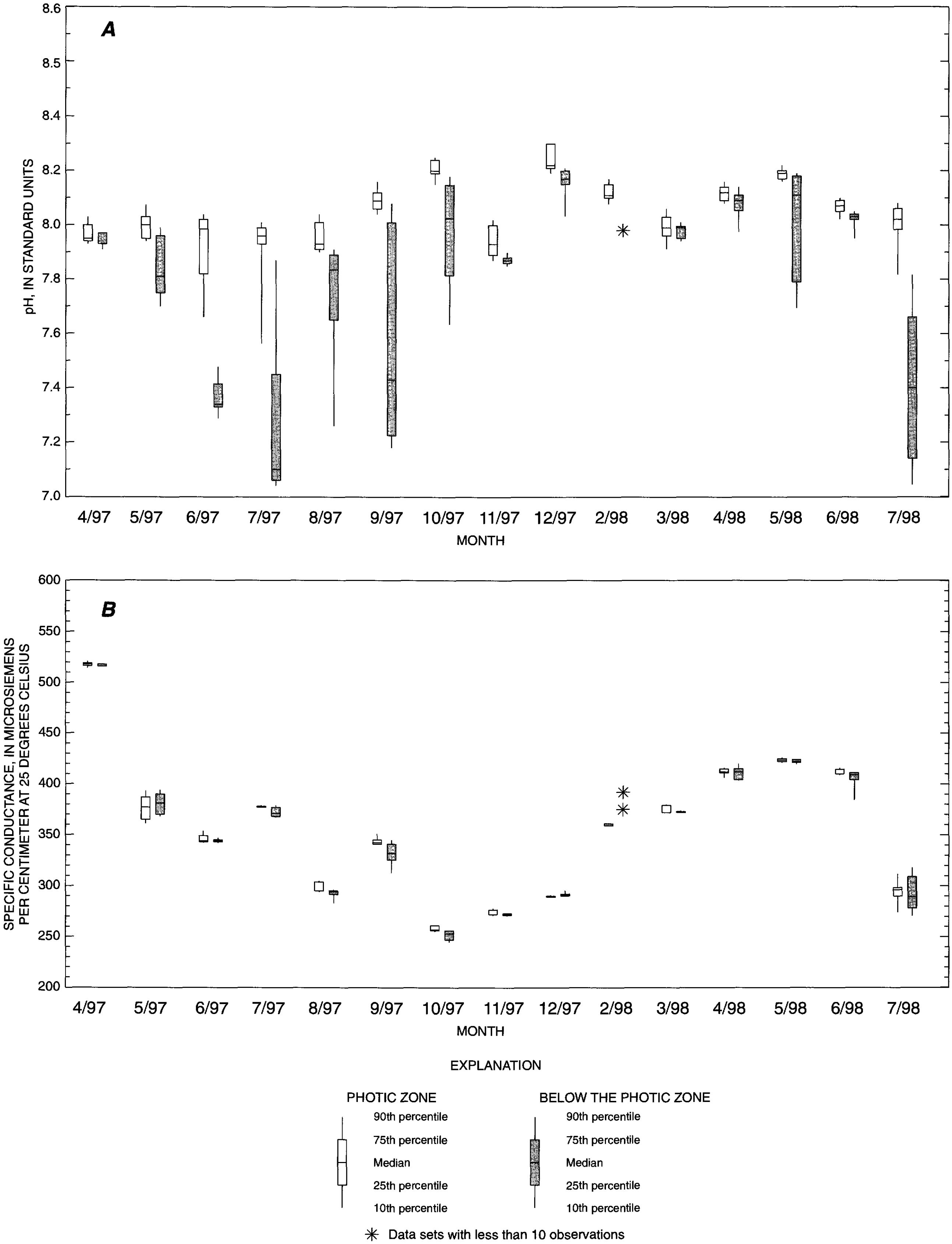

Figure 6. Distribution of (*A*) pH and (*B*) specific conductance obtained with the multiparameter meter in Boulder Reservoir, April 1997–July 1998.

Reservoir set by the Colorado Department of Public Health and Environment (CDPHE) (1996). Little variation in pH was measured with depth during isothermal conditions from fall through spring. However, during periods of thermal stratification (summer), pH was higher in the upper part of the reservoir (photic zone) than in the lower part (below the photic zone) (fig. 6*A*). Although not shown in figure 6*A*, pH steadily decreased with depth during periods of thermal stratification, and the lowest values were recorded in the lower hypolimnion (tables 8–12). The pH of reservoir water is altered primarily by the distribution of carbon dioxide in the water column. The utilization of carbon dioxide during photosynthesis in excess of respiration increases pH in the photic zone, whereas the release of carbon dioxide during respiration and decomposition of organic matter decreases pH in the hypolimnion (Wetzel, 1983).

Specific Conductance

Specific conductance increases in proportion to the quantity of ions in solution; therefore, specific conductance can be used as an indication of the dissolved-solids concentration in Boulder Reservoir. For most waters, the conversion factor between specific conductance and dissolved-solids concentration varies between 0.55 and 0.75 (Hem, 1989).

Specific conductance varied little with depth in Boulder Reservoir (fig. 6*B*). Temporal variations in specific conductance primarily were influenced by the amount of water in storage and by the inflow of water from the Boulder Feeder Canal. The highest specific conductance values were recorded in April 1997 after the reservoir had remained at a relatively low level (4,500 acre-ft) throughout the previous winter and in the absence of inflow from the Boulder Feeder Canal. From April to October 1997, the decrease in specific conductance coincided with the inflow of more dilute CBT water (table 20). During this period, slight increases in specific conductance were measured between some of the sampling dates when relatively small amounts of CBT water were delivered to the reservoir. Specific conductance increased during the winter of 1997–98 as the reservoir remained at a constant volume of about 8,000 acre-ft, and no CBT water was routed through the reservoir (fig. 2). During the summer of 1998, the decrease in specific conductance from May to July again coincided with the delivery of CBT water.

Manganese

Total recoverable concentrations of manganese in Boulder Reservoir ranged from less than detection (10 µg/L) to 730 µg/L (table 2), and no concentrations exceeded the 1,000-µg/L aquatic-life standard set by the CDPHE (1996). Ninety percent of total recoverable manganese concentrations were less than 66 µg/L (table 2). Higher concentrations of total recoverable manganese resulted primarily from increases in the dissolved phase; therefore, the following discussion focuses on the spatial and temporal distribution of dissolved manganese.

Concentrations of dissolved manganese in Boulder Reservoir ranged from less than 4 to 930 µg/L (table 2). At least 90 percent of the detections were less than the 50-µg/L drinking-water-supply standard set by the CDPHE (1996). Dissolved manganese detections primarily were limited to samples collected from near the bottom of the reservoir at sites R1–R3 during periods of reduced dissolved oxygen in the summer (fig. 7). Detections of manganese in the photic zone at all five reservoir sites were few (fig. 7 or tables 13–17). During summer, small concentrations of manganese detected in the photic zone coincided with larger concentrations detected near the bottom (fig. 7).

A plot of dissolved manganese concentrations in bottom-water samples from sites R1–R3 and corresponding dissolved oxygen levels at the same sampling depths indicate that manganese concentrations generally increased with decreasing dissolved oxygen (fig. 8). Manganese concentrations in bottom-water samples peaked in July 1997 (fig. 7) when the hypolimnion was completely anoxic at sites R1–R3 (fig. 5). Manganese concentrations near the bottom of the reservoir were lower or not detectable when the water column was oxygenated throughout the reservoir profile. Oxic conditions near the bottom of the reservoir and smaller manganese concentrations were promoted by (1) the displacement or removal of an anoxic hypolimnion by reservoir operations, and (2) by the circulation of the water column beginning with fall turnover and continuing through spring. The removal of the anoxic hypolimnion in reservoir

Table 2. Summary statistics for selected trace elements in Boulder Reservoir (Samples collected approximately monthly from April to November 1997, and March to July 1998.)

[Concentrations are in micrograms per liter; <, less than; --, not computed or no standard]

Constituent	Total number of analyses	Total number of detections	Minimum concentration	Concentration at indicated percentile					Maximum concentration	Standard[1]
				10	25	50	75	90		
Iron, dissolved	96	11	<10	<10	<10	<10	<10	15	130	300
Iron, total recoverable	36	36	90	137	172	285	488	583	660	1,000
Manganese, dissolved	104	30	<4	<4	<4	<4	4.8	42	930	50
Manganese, total recoverable	36	27	<10	<10	<10	20	20	66	730	1,000
Selenium, dissolved	49	0	--	--	--	--	--	--	--	--
Selenium, total recoverable	36	1	<1	--	--	--	--	--	1.0	10
Uranium, dissolved	52	50	<1.0	1.1	1.2	1.6	2.1	3.0	3.0	20[2]

[1]Unless noted otherwise, values are chronic aquatic-life or drinking-water supply standards for Boulder Reservoir (Colorado Department of Public Health and Environment, 1996).

[2]Proposed Maximum Contaminant Level (MCL) for finished drinking water (U.S. Environmental Protection Agency, 1996).

releases during July and September 1997 led to decreased manganese concentrations in August and October 1997 (fig. 7). Beginning with fall turnover in 1997 and continuing through April 1998, the water column stayed well mixed with regard to dissolved oxygen. Consequently, manganese concentrations near the bottom of the reservoir were below detectable levels in November 1997 and March and April 1998 (fig. 7).

Elevated concentrations of dissolved manganese in anoxic hypolimnetic water most likely resulted from the mobilization of manganese from pore water

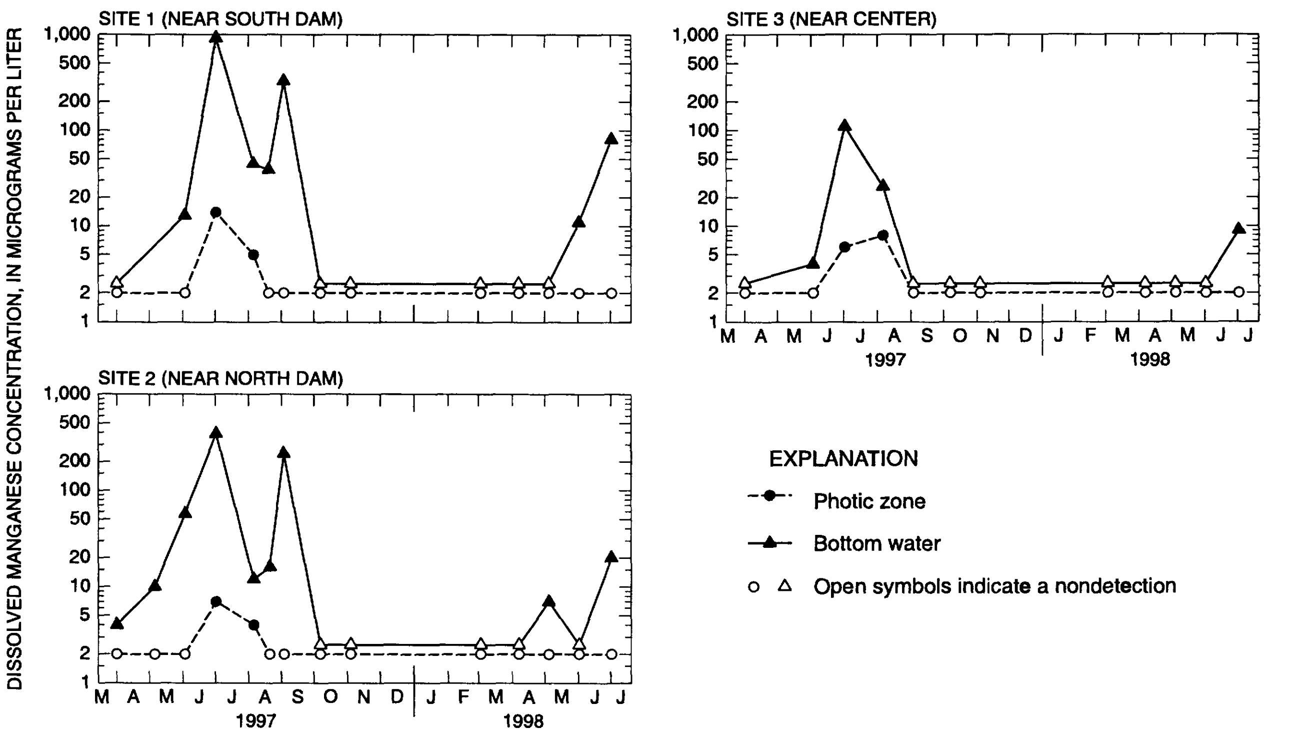

Figure 7. Concentrations of dissolved manganese at sites R1–R3 in Boulder Reservoir, April 1997–July 1998.

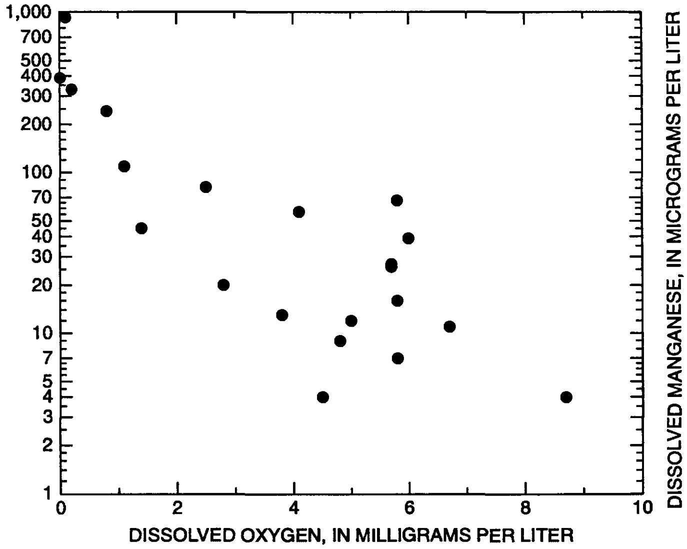

Figure 8. Relation between dissolved manganese and dissolved oxygen concentrations in bottom-water samples collected at sites R1–R3, Boulder Reservoir, April 1997–July 1998 (concentrations reported as less than [<] in tables 13–15 are not plotted).

in reservoir bottom sediments. The release of manganese (or iron) from sediment pore water to anoxic hypolimnetic water is a well-documented process (Kuhn and others, 1994; Klapper, 1991; Wetzel, 1983). The diffusion of manganese (or iron) from pore water to the overlying water column is regulated by the reduction-oxidation, or redox potential, at the sediment/water interface. Redox conditions at the sediment/water interface are regulated by dissolved oxygen levels which in turn are mediated by microbial degradation of particulate organic matter that has settled from the overlying epilimnion. As dissolved oxygen approaches zero from microbial degradation, redox potential decreases markedly, and reduced manganous and ferrous ions diffuse readily from the pore water to the overlying anoxic water column (Wetzel, 1983). Manganese mobilizes at a slightly higher redox potential than iron and diffuses first out of the pore water (Hsiung and Tisue, 1994). Once mobilized into the water column, much of the iron may be rendered insoluble, either by formation of ferrous sulfide under anoxic conditions or by the precipitation of ferric hydroxides in the presence of even small amounts of oxygen (Kuhn and others, 1994).

The formation of an anoxic hypolimnion, the primary condition leading to increased manganese levels in Boulder Reservoir, is highly influenced by the routing of CBT water through the reservoir; thus, reservoir operations could be a viable mechanism for managing manganese levels in Boulder Reservoir. The delivery of CBT water during summer has the ability to impede the stratification process, thus promoting oxic conditions in the reservoir bottom. It also has been shown that once stratification has formed, the anoxic hypolimnion is effectively removed by reservoir withdrawals.

Iron

In contrast to manganese, iron was consistently detected in Boulder Reservoir and predominantly in the particulate phase. Iron was detected in all of the whole-water samples, and total recoverable concentrations ranged from 90 to 660 µg/L (table 2). Dissolved iron was detected in only about 10 percent of samples, and no concentrations exceeded the 300-µg/L drinking-water-supply standard set by the CDPHE (1996). Occurrences of dissolved iron were almost exclusively limited to bottom-water samples during periods of anoxia. As with manganese, the occurrence and distribution of iron in Boulder Reservoir are regulated to a large extent by variations in the concentration of dissolved oxygen. In oxygenated waters with near-neutral pH, ferric (oxidized) iron is the predominant form of iron (Stumm and Morgan, 1981). Ferric iron generally precipitates from solution rapidly, primarily as ferric hydroxide. In anoxic waters, ferrous (reduced) iron is the predominant form of iron and can remain in solution as a free ion or as an ion pair.

At the beginning of the study (April 1997), when the reservoir was well mixed with regard to temperature and oxygen, total recoverable iron concentrations generally were equivalent throughout the water column, as indicated by data collected from the photic zone (sites R2, photic and R5) and from near the bottom of the reservoir (site R2, bottom) (fig. 9). From April to early July, during the formation of stratification, iron concentrations decreased in the photic zone and increased in bottom water. The variability in iron concentration throughout the water column most likely resulted from particulate iron complexes settling out of the photic zone and accumulating in the hypolimnion; however, the release of ferrous iron from sediments and the subsequent precipitation of ferric hydroxide is probably an additional source.

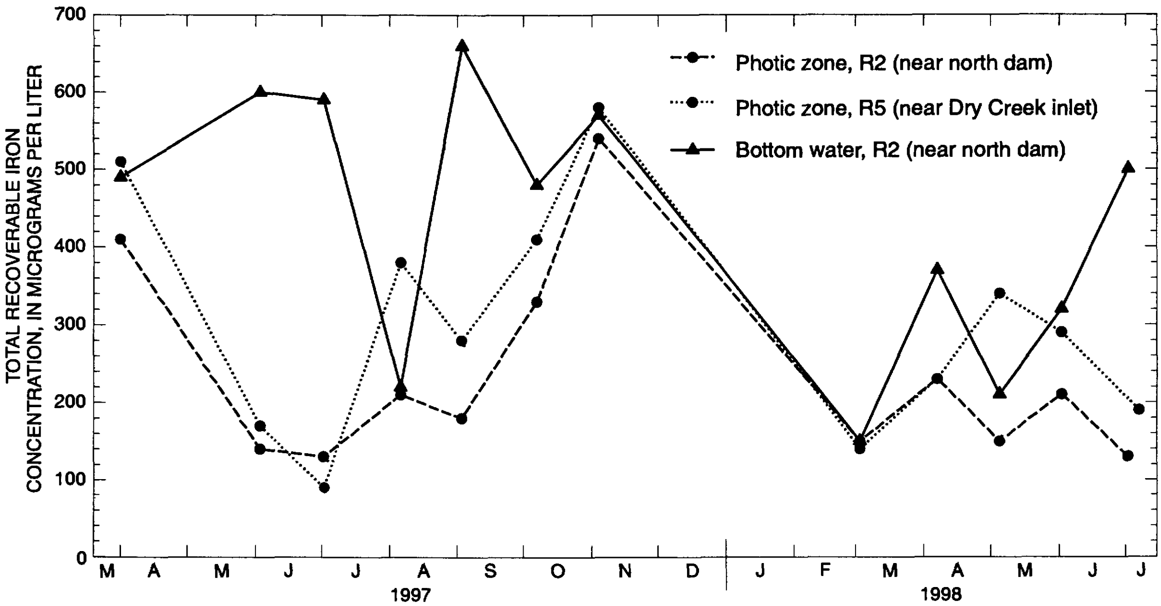

Figure 9. Concentrations of total recoverable iron at sites R2 and R5, Boulder Reservoir, April 1997–July 1998.

By early August 1997, iron concentrations near the reservoir bottom had decreased substantially after the removal of hypolimnetic water by reservoir withdrawals (fig. 9). By early September, iron concentrations again were much larger in the hypolimnion than in the photic zone. In addition to the process discussed above, increased hypolimnetic iron concentrations in September 1997 also may have been caused by the resuspension of iron-laden bottom sediments by the current of underflowing Boulder Feeder Canal water (depicted in the dissolved oxygen profile for September 1997, fig. 5).

The distribution of iron concentrations for the remainder of the study may be explained by the same process already discussed; the removal of hypolimnetic water in September may have again decreased iron concentration in bottom water (October 1997); recirculation during fall turnover recirculated particulate iron from the hypolimnion, resulting in equivalent concentrations throughout the water column (November 1997); and subsequent resettling of the particulate iron over the winter rendered uniformly low concentrations in March 1998 (fig. 9). In 1998, iron concentrations again began to increase in the bottom water with the formation of stratification.

Selenium and Uranium

Selenium was detected only once in the reservoir throughout the study, and even then only at the detection level of 1 µg/L (table 2). Uranium was consistently detected in the reservoir with a median concentration of about 1.5 µg/L (table 2). Maximum uranium concentrations of 3.0 µg/L were well below the proposed drinking-water standard of 20 µg/L (U.S. Environmental Protection Agency, 1996). Samples for selenium and uranium analysis were collected from shallow and from deep areas in the reservoir. The oxygenated conditions in the photic zone of site R2 and in the shallow areas of site R5 were optimal for mobilization of dissolved uranium and selenate, the soluble form of selenium. Nonetheless, selenium and uranium concentrations did not appear to be affected by variations in water temperature, pH, and dissolved oxygen and at this time do not appear to be a water-quality concern in Boulder Reservoir.

Nitrogen and Phosphorus

Total nitrogen concentrations in Boulder Reservoir, calculated as the sum of ammonia plus total organic nitrogen and dissolved nitrite plus nitrate nitrogen, ranged between 0.2 and 1.1 mg/L (fig. 10). Nitrogen in Boulder Reservoir predominantly was in the organic phase, either as dissolved or suspended organic nitrogen. Most organic nitrogen in lakes and reservoirs typically is tied up in living or dead biomass (Horne and Goldman, 1994). Dissolved inorganic nitrogen (the sum of ammonia, nitrite, and nitrate), the

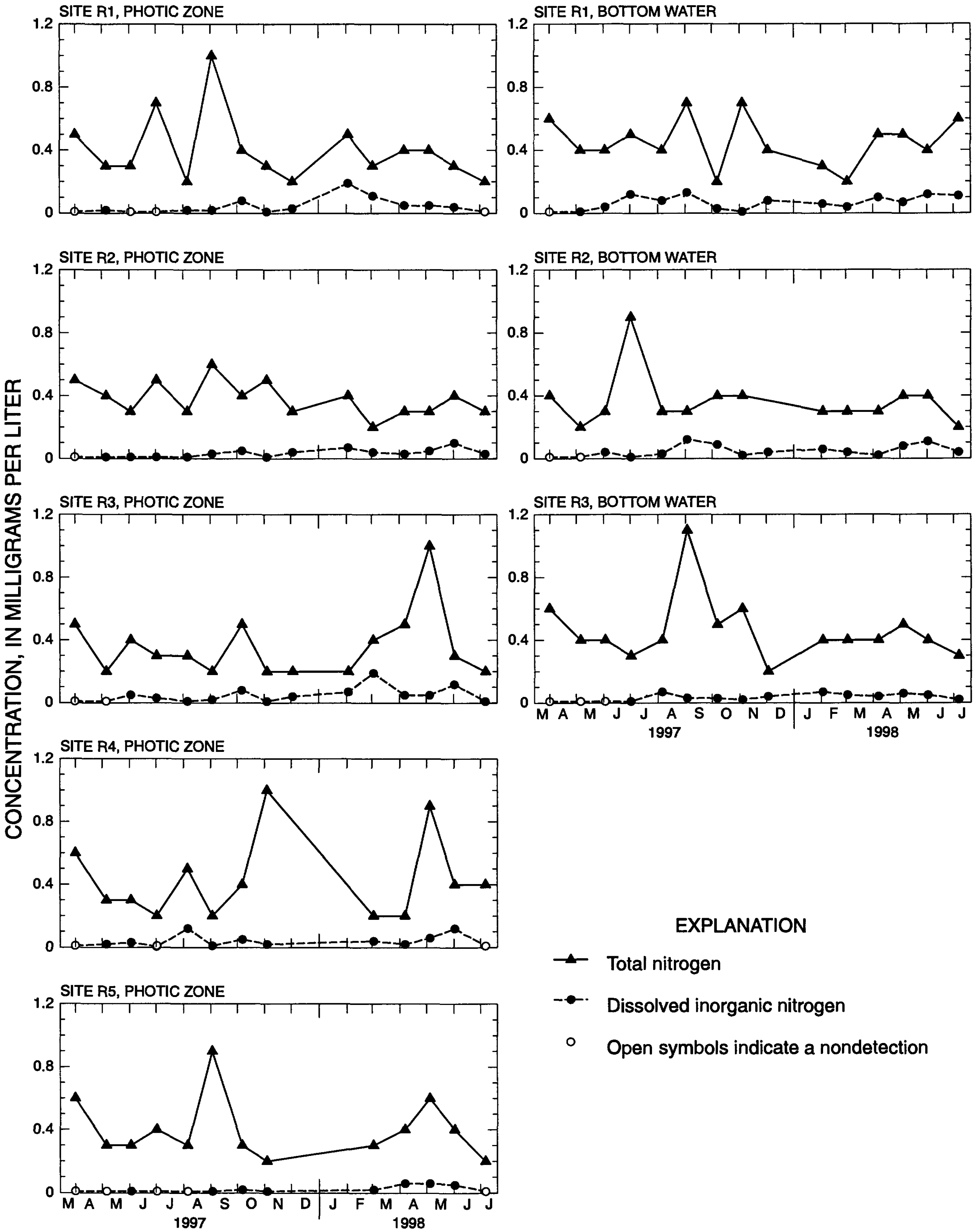

Figure 10. Concentrations of total nitrogen and dissolved inorganic nitrogen in Boulder Reservoir, April 1997–July 1998.

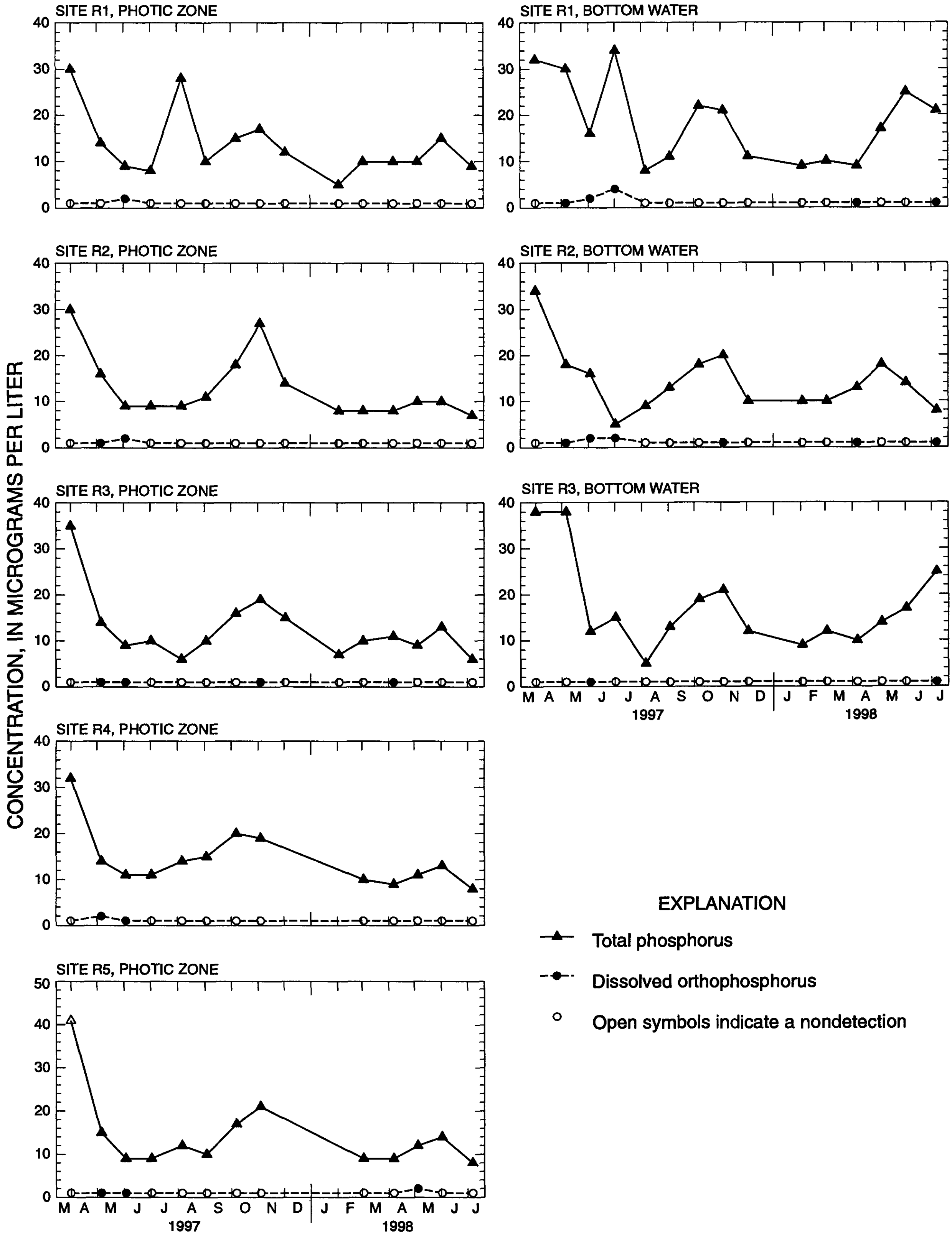

Figure 11. Concentrations of total phosphorus and dissolved orthophosphorus in Boulder Reservoir, April 1997–July 1998.

phase of nitrogen most readily available for uptake by aquatic biota, was small and ranged from less than 0.01 to 0.19 mg/L (fig. 10 and table 18).

Total phosphorus concentrations in Boulder Reservoir ranged from 5 to 41 µg/L (fig. 11). Even more so than nitrogen, phosphorus in Boulder Reservoir was almost exclusively in the dissolved or suspended organic phase and most likely was contained in living or dead biomass. Dissolved inorganic orthophosphorus, the only form of phosphorus available for use by phytoplankton, typically was present at concentrations less than the detection limit of 1 µg/L (fig. 11 and table 18). In the absence of dissolved orthophosphorus in the water column, phosphorus taken up by algae is effectively recycled and made available to phytoplankton by way of excretion from fish, zooplankton, and bacterial activity (Horne and Goldman, 1994). An additional source of phosphorus for algal growth is the release of orthophosphorus from anoxic sediments to the overlying water column, but the consistently low concentrations of orthophosphorus in bottom-water samples (fig. 11) indicate that this is a minor process in Boulder Reservoir. An exception might be in July 1997, when the highest orthophosphorus concentration of the study (4 µg/L) was measured in anoxic hypolimnetic water at site R1.

The concept that photosynthesis continues until the least abundant major nutrient becomes depleted in the water column is the basis of the limiting nutrient theory. Although several micronutrients may limit plant growth, it is widely accepted that nitrogen or phosphorus are the nutrients that most frequently limit algal production in lakes and reservoirs (Klapper, 1991; Wetzel, 1983). The nitrogen to phosphorus ratio of plants is roughly 7N:1P by weight (Klapper, 1991). Thus, if N:P by weight is less than 7, nitrogen may be the nutrient that most likely limits algal growth. Conversely, a ratio greater than 7 would indicate that phosphorus is limiting. Typically, N:P ratios are calculated using the biologically available forms of these two nutrients. Where orthophosphorus concentrations are very low or undetectable, the ratio may be approximated by substituting in total phosphorus and total nitrogen (Horne and Goldman, 1994). In this study, dissolved orthophosphorus was predominantly below detectable levels, so total concentrations of nitrogen and phosphorus were used to calculate the N:P values. The results indicate that phosphorus is most likely the limiting nutrient in Boulder Reservoir. Values of the 112 N:P ratios calculated ranged from 7 to 180. More than 90 percent of the ratios were greater than 14, 50 percent were greater than 29, and 10 percent were greater than 62.

TRACE-ELEMENT CONCENTRATIONS IN RESERVOIR-BOTTOM SEDIMENTS

Although the concentrations of 46 constituents in reservoir-bottom sediments were quantified, the following discussion is limited to 13 selected trace elements of most interest. Data for the remaining constituents are included in the "Supplemental Data" section of this report (table 19).

Analytical results indicate that mean concentrations for most of the 13 selected trace elements are slightly to moderately enriched compared to samples from unaffected fine-grained sediments collected from several environments throughout the United States (Horowitz and others, 1996) (table 3). However, when compared to background levels that have been determined for reservoir and streambed sediments in the South Platte River Basin (Heiny and Tate, 1997), most mean concentrations are below local background levels (table 3). The mean concentration of elements that are slightly enriched relative to local background levels (1.1 to 1.3 times) are aluminum, arsenic, chromium, and mercury (table 3). The mean concentrations of the primary metals for this study (iron, manganese, selenium, uranium) are all less than background levels for the South Platte River Basin. Additionally, the mean concentrations of metals commonly associated with mining-affected areas (most of the metals in table 3) predominantly are low relative to local and nationwide background levels.

Currently, no Federal or State guidelines exist for concentrations of trace elements in bed sediment, but Canadian guidelines have been established by the Ontario Ministry of Environment for trace elements considered to be most toxic to aquatic life (Persaud and others, 1993). Comparison of trace-element concentrations in bottom sediment from Boulder Reservoir to the Canadian Guideline (table 3) reveals that mean concentrations for seven elements are above the Lowest Effect Level (LEL) (arsenic, chromium, copper, iron, lead, manganese, and zinc). The LEL indicates that the sediment is marginally contaminated, and most sediment-dwelling organisms are unaffected by the elevated concentrations (Persaud

Table 3. Statistical summary of selected trace elements in surficial bottom sediments of Boulder Reservoir, March and August 1997 (Statistics computed on 10 samples.)

[Concentrations are in micrograms per gram unless noted as percent; %, percent; PSQG, Provincial Sediment Quality Guideline; --, no data; <, less than]

Element	Minimum	Maximum	Mean	Background concentration for South Platte River Basin[1]	Nationwide background concentration[2]	PSQG Lowest Effect Level[3]	PSQG Severe Effect Level[4]
Aluminum (%)	6.7	8.8	7.8	7.2	5.5	--	--
Arsenic	6.8	13	9.2	7.8	7	6	33
Cadmium	0.30	0.80	0.59	3.3	--	0.6	9.5
Chromium	67	85	76	60	51	26	110
Copper	18	59	40	104	20	16	110
Iron (%)	2.9	4	3.5	4.9	2.8	2.1	4.4
Lead	24	40	33	100	23	31	250
Manganese	360	930	600	1,260	600	460	1,100
Mercury	<0.02	0.05	0.04	0.03	0.05	0.2	2
Selenium	1.0	2.1	1.5	2.9	--	--	--
Silver	0.20	0.30	0.22	1.2	--	--	--
Uranium	4.8	5.6	5.2	9	--	--	--
Zinc	110	150	130	450	88	120	820

[1]Determined from reservoir and streambed sediments in the South Platte River Basin (from Heiny and Tate, 1997).
[2]Nationwide averages for fine-grained bed sediments from around the United States (from Horowitz and others, 1996).
[3]Marginally contaminated sediments, guidelines developed by the Ontario Ministry of the Environment (Persaud and others, 1993).
[4]Highly contaminated sediments, guidelines set by the Ontario Ministry of the Environment (Persaud and others, 1993).

and others, 1993). None of the trace-element concentrations exceed the Severe Effect Level (SEL).

The concentration of trace elements in bottom sediments varied spatially throughout the reservoir (table 19). The lower concentrations generally were in samples collected from the shallow bays on the western side of the reservoir (sites R4 and R5, fig. 3), and the higher concentrations were in sediments collected from the deeper sites (sites R1–R3). The variability of trace-element content in bottom sediments is a function of the distribution in particle size of the sediments. Coarse-grained sediment entrained in streamflow entering the reservoir tends to settle out first in the shallow areas, whereas the finer grained sediments settle out in the deeper areas. There is a strong positive correlation between decreasing grain size and increasing trace-element concentration (Horowitz, 1985). Smaller grain-sized particles have much more surface area per unit mass than larger particles, and trace elements are readily adsorbed to particles having large surface areas. The occurrence of higher manganese concentrations in areas of the reservoir having a higher percentage of fine-grained material is indicated in table 4. In the deeper areas of the reservoir, manganese concentrations were about 1.5 to 2 times the levels in shallow areas. In the deeper areas, more than 50 percent of the sediments were less than 2 µm in diameter. In the shallow areas, most sediments were in the 62- to 125-µm size fraction.

THE HYDROLOGIC BUDGET

The results of the hydrologic budget indicate that water inflows nearly equaled water outflow for the 1-year period from July 1, 1997, through June 30, 1998 (table 5). Most of the water inflow to the reservoir was from the Boulder Feeder Canal (about 82 percent of the total). The combined flow from the four secondary inflows contributed about 12 percent of the inflow, and precipitation about 6 percent. Releases to the Boulder Creek Supply Canal accounted for about 85 percent of outflow from the reservoir, with the remainder of outflow being attributed to evaporation and withdrawals to the drinking-water treatment plant. Water withdrawals to the treatment plant may

Table 4. Manganese concentrations and particle-size distributions of surficial bottom sediments in Boulder Reservoir (Values are averages of two samples collected in March and August 1997.)

[µg/g, microgram per gram; µm, micrometer; <, less than]

Site[1]	Manganese concentration[2] (µg/g)	Percentage of sample in particle-size fraction				
		Particle-size fraction (µm)				
		<2	2 – 4	4 – 16	16 – 62	62 – 125
R1	760	55.0	4.4	13.2	20.0	7.4
R2	690	60.6	10.5	13.9	12.6	2.4
R3	700	52.3	4.8	19.2	14.7	9.0
R4	460	19.2	1.7	4.1	10.3	64.7
R5	380	21.2	2.6	6.2	15.4	54.6

[1]Sites 1–3, deep sites; sites 4–5, shallow sites; see figure 3 for locations.
[2]Concentrations determined on <63-µm size fraction.

appear to be lower than expected because most of the water that is diverted to the plant is withdrawn directly from the Boulder Feeder Canal just upstream from the reservoir.

The value of the overall error in the hydrologic budget (about 1,795 acre-ft) primarily is influenced by the relatively large amounts of CBT water that is routed through the reservoir (table 5). The overall error represented only about 10 percent of the total water inflow or outflow. Net ground-water flux (the residual) was calculated as 773 acre-ft of seepage from the reservoir (table 5). The calculated value of ground-water seepage would account for about 4 percent of the water removed from the reservoir (total outflow plus the residual), but no definitive statement can be made about ground-water flux because its value could consist entirely of budget error.

SOURCES AND FATE OF SELECTED TRACE ELEMENTS AND NUTRIENTS IN BOULDER RESERVOIR

The sources and fate of selected trace elements and nutrients in Boulder Reservoir are discussed by constituent(s) in this section. A discussion of constituent flux from sediment pore water, a source of trace elements and nutrients in the reservoir water column, is presented at the end of the section.

Manganese

From July 1, 1997, through June 30, 1998, about 220 kg of manganese entered Boulder Reservoir through the five surface-water inflows (table 6). Little Dry Creek contributed the largest amount of manganese (69 kg or 31 percent). The combined flow from the three natural tributaries (Dry and Little Dry Creeks and the unnamed drainage) contributed about 70 percent of the manganese load to the reservoir. Manganese in the natural tributaries primarily was in the dissolved phase, as indicated by the similarity in the box plot distributions of dissolved and total recoverable manganese for these sites (fig. 12). The manganese load out of the reservoir was about 8 times the incoming load, indicating that the reservoir was a net source of manganese in reservoir outflows during the 1-year budget period (table 6). Almost all of the

Table 5. Hydrologic budget for Boulder Reservoir, July 1, 1997–June 30, 1998

[±, plus or minus]

Budget component	Volume, in acre-feet	Percentage of total	Error, in acre-feet (plus or minus)[1]
	Inflow		
Boulder Feeder Canal	16,253	82.4	1,219
Dry Creek	630	3.2	47.3
Farmers Ditch	886	4.5	66.5
Little Dry Creek	562	2.8	42.2
Unnamed drainage	226	1.2	17.0
Precipitation	1,173	5.9	176
	Outflow		
Boulder Creek Supply Canal	16,702	85.4	1,253
Drinking-water treatment plant	1,511	7.7	113
Evaporation	1,340	6.9	335
	Summary		
Change in reservoir storage	−596		44.7
Total inflow	19,730		
Total outflow	19,553		
Residual[2]	773		
Overall error in budget[3]	±1,795		

[1]Calculated with equation 3.
[2]Calculated with equation 2.
[3]Calculated with equation 4.

Table 6. Chemical budgets for selected trace elements and nutrients in Boulder Reservoir, July 1, 1997–June 30, 1998

[Loads are in kilograms; values less than 1,000 are rounded to two significant figures; values greater than 1,000 are rounded to three significant figures; percentages may not add up to 100 because of rounding of figures; --, no data]

Budget component	Manganese		Iron		Selenium		Uranium		Nitrogen		Phosphorus	
	Load	Percentage of total	Load	Percentage of total	Load	Percentage of total	Load	Percentage of total	Load	Percentage of total	Load	Percentage of total
Inflow												
Boulder Feeder Canal	55	25	2,290	61	0	0	1.7	15	7,480	76	270	81
Dry Creek	40	18	400	11	6.0	98	5.5	49	610	6.2	23	6.9
Farmers Ditch	18	8.1	900	24	0	0	0	0	320	3.3	26	7.8
Little Dry Creek	69	31	110	2.9	0.1	1.6	3.0	27	420	4.3	9.3	2.8
Unnamed drainage	39	18	62	1.6	0	0	1.0	8.9	280	2.9	4.6	1.4
Precipitation	--	--	--	--	--	--	--	--	710	7.2	0.4	0.1
Outflow												
Boulder Creek Supply Canal	1,580	92	6,580	89	0		21	90	5,000	86	220	89
Municipal treatment plant	140	8.1	850	11	0		2.3	9.9	830	14	27	11
Summary												
Total inflow	220		3,760		6.1		11		9,820		330	
Total outflow	1,720		7,430		0		23		5,830		250	
Change in reservoir storage	–1,610		350		0		–6.1		–2,960		-32	
Residual[1]	110		–4,020		6.1		–5.9		6,950		110	
Overall error[2]	380		1,190		1.0		3.8		1,620		59	

[1]Calculated with equation 6.
[2]Calculated with equation 8.

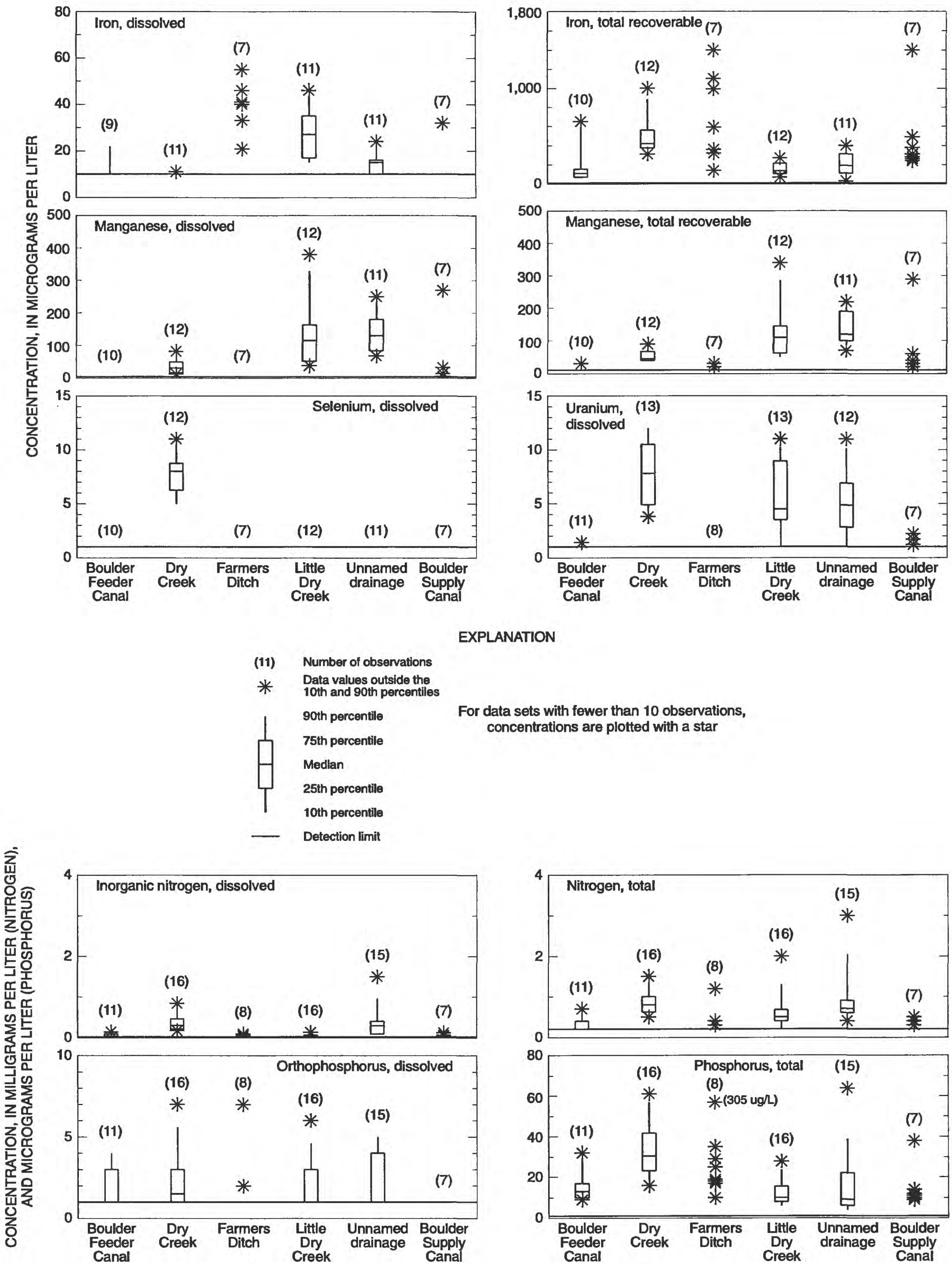

Figure 12. Distribution of selected trace-element and nutrient concentrations in Boulder Reservoir inflows and outflow, April 1997–July 1998 (Boulder Supply Canal is outflow site).

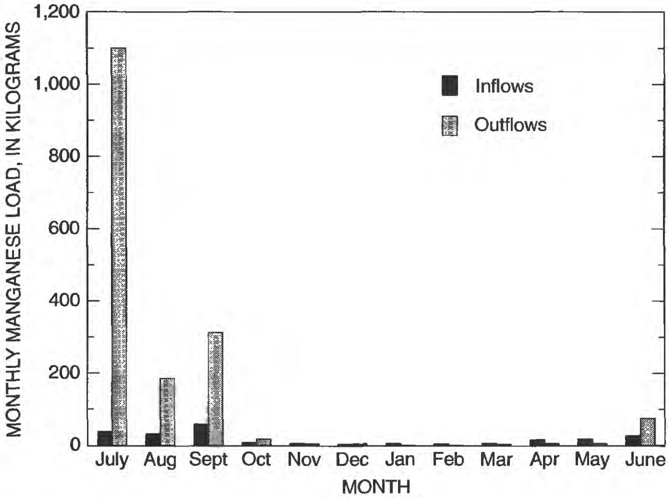

Figure 13. Manganese load in Boulder Reservoir inflows and outflow, July 1997–June 1998.

manganese was released from the reservoir in July–September 1997 (fig. 13). Large manganese loads in outflows during July–September were facilitated by the location of the outlet structure, which is situated in one of the deepest parts of the reservoir, and by the timing of release, when large reservoir withdrawals for irrigation coincided with periods of strong thermal stratification and subsequent high manganese concentrations near the bottom of the reservoir.

Mobilization from reservoir-bottom sediments was the primary source of manganese in reservoir outflows during July–September 1997, but this is not indicated by the relatively low value of the manganese residual. Typically, large net contributions of a constituent from internal loading (or ground-water inflow) would be indicated by a relatively large negative residual. This is not the case for manganese because most of the manganese flux from bottom sediments to the water column had already occurred prior to the 1-year budget period, and most of the manganese mass was already contained in the water column. The net loss of manganese from the reservoir water column is indicated by the relatively large reduction in manganese mass held in storage (change in reservoir storage, table 6).

Iron

During the 1-year budget period, about 3,760 kg of iron entered Boulder Reservoir in surface-water inflows (table 6). Flows in the Boulder Feeder Canal contributed about 61 percent of the iron, the Farmers Ditch about 24 percent, and the three natural tributaries, the remaining 15 percent. Most iron was transported in the suspended phase, as total recoverable iron concentrations were typically an order of magnitude larger than dissolved concentrations (fig. 12). The large contribution of iron from the Boulder Feeder Canal results from relatively small concentrations of iron transported in large volumes of water. Conversely, the iron load in the Farmers Ditch is more a function of high iron concentrations in a relatively small volume of water.

The amount of iron released from the reservoir was about twice the amount that entered the reservoir in surface water, indicating that the reservoir was a net source for iron in reservoir outflows (table 6). As with manganese, the location of the outlet structure near the bottom and the release of bottom water during periods of stratification facilitated the amount of iron lost from the reservoir. Sources of iron in bottom water include the settling of particulate iron from the overlying water column and the mobilization of ferrous iron from sediment pore water (with low dissolved oxygen at the bottom of the reservoir) and the subsequent precipitation of ferric hydroxides.

Selenium and Uranium

Almost all of the selenium that entered the reservoir (about 6.1 kg) (table 6) was contained in the flow of Dry Creek, which is underlain by the Pierre Shale. The absence of selenium in the two other tributaries that drain from areas underlain by the Pierre Shale (fig. 12) probably results from selenium reduction in the wetland environments located just upstream from the sampling points on these two tributaries. The City of Boulder constructed an artificial wetland on Little Dry Creek. Although small in comparison, the channel of the unnamed drainage contains many cattails that impede streamflows to less than 0.3 ft^3/s upstream from the sampling location. The combination of low dissolved oxygen (and redox potential) and high concentrations of dissolved organic compounds, which typically are present in wetlands, are effective in removing selenium from solution. The general reaction involves the reduction of selenate, the oxidized soluble form of selenium, to selenite and elemental selenium, which are highly insoluble. Because of the relatively low velocities in the wetland environments, particulate selenium probably settles out of the stream water column upstream from the sampling locations.

The budget calculations indicate that the reservoir trapped all of the selenium in inflowing water because selenium was not detected in the outflow (table 6). Selenium may be released from the reservoir at concentrations that are less than the detection limit of 1 µg/L.

Of the 11 kg of uranium that entered Boulder Reservoir over the year (table 6), about 85 percent came from the three natural tributaries that drain from the west (fig. 12). The bedrock beneath all three streams is the Pierre Shale, a marine formation that is known to contain uranium. Concentrations in the tributaries ranged from less than 1 to 12 µg/L (fig. 12 and tables 20–24); none of the concentrations exceeded the proposed drinking-water standard of 20 µg/L (U.S. Environmental Protection Agency, 1996). The amount of uranium in reservoir outflows was about twice the amount in reservoir inflows, indicating that the reservoir is a source of uranium in release water. The calculated error of the residual may be larger than indicated because many uranium concentrations in the reservoir were near the level of detection (1 µg/L) (table 2).

Nitrogen and Phosphorus

The Boulder Feeder Canal was the source of about 80 percent of nitrogen and phosphorus that entered Boulder Reservoir during the 1-year period (table 6) even though concentrations were greater in some of the other inflows (fig. 12). Most of the nitrogen and phosphorus contained in surface-water inflows was in the particulate organic phase (fig. 12). Precipitation accounted for about 7 percent of the nitrogen in the reservoir but only about one-tenth of 1 percent of the phosphorus (table 6). Almost all dissolved orthophosphorus concentrations in precipitation at the NADP site were less than the detection limit of 3 µg/L (Robert Larson, National Atmospheric Deposition Program, written commun., 1998). Collectively, the four small secondary surface-water inflows contributed about 17 and 19 percent of the nitrogen and phosphorus, respectively (table 6).

Budget calculations indicate that incoming nitrogen and phosphorus loads were about 1.5 times the loads in reservoir outflows (table 6). Additionally, positive residuals (table 6) indicate a net loss of nitrogen and phosphorus from the reservoir water column from internal processes (or ground-water outflow). Comparison of the residuals to inflow loads (table 6) indicate that the reservoir trapped about 70 percent of the incoming nitrogen load and about 30 percent of the phosphorus load. The net gain of nitrogen and phosphorus in the reservoir most likely resulted from phytoplankton (particulate organic matter containing nitrogen and phosphorus) settling out of the reservoir water column to the reservoir bottom. Denitrification of nitrate to N_2 gas in the hypolimnion during anoxia may be an additional sink for nitrogen; however, oxic rather than anoxic conditions prevail for most of the year, and denitrification may be a minor process.

Constituent Flux from Sediment Pore Water

The rates at which selected trace elements and nutrients flux from reservoir-bottom sediments to the overlying water column were computed for this study. The flux rates were calculated with data collected from two sites on August 20–21, 1997. Therefore, it is not appropriate to estimate annual flux rates from these limited data sets. The calculations do provide an indication of the magnitude of constituent flux, given the existing physical and chemical conditions. Data were collected when the reservoir was well mixed, and oxic conditions prevailed at the sediment/water interface (as indicated in fig. 5).

Flux computations were based on the concentration gradient measured between sediment pore water and the overlying water column, whereby constituents diffuse out of the sediments and into the overlying water column when concentrations are higher in the pore water, and constituents diffuse into the sediments when concentrations are higher in the overlying water column. The rates and direction of constituent flux were determined with Fick's law (Balistrieri and others, 1996; Ullman and Aller, 1982), which states that the rate of flux is directly proportional to the change in concentration per unit distance and to the porosity of the sediments:

$$J = -\Phi \, D_s \, (\delta C/\delta \chi) \qquad (9)$$

where

J is constituent flux, in milligrams per square centimeter per day,

Φ is the porosity of the sediment,

D_s is the bulk sediment diffusion coefficient, in square centimeters per day, and

$(\delta C/\delta \chi)$ is the concentration gradient, in grams per liter per centimeter.

In high-porosity sediments, as in Boulder Reservoir (80–90 percent in the top 5 cm), the relation between the bulk sediment diffusion coefficient (D_s) and the molecular diffusion coefficient for individual ions (D_0) can be expressed as (Ullman and Aller, 1982):

$$D_s = D_0 \Phi^2 \qquad (10)$$

Values of D_0 at 25°C in square centimeters per day for the selected trace elements and nutrients of interest were obtained from Li and Gregory (1974) and are as follows: manganese, 0.594; iron, 0.621; nitrogen, 1.71; and phosphorus, 0.634. The Stokes-Einstein relation is used to correct the diffusion coefficients for water temperature at the sediment/water interface (Li and Gregory, 1974):

$$(D_0\, \eta^0/T)T_1 = (D_0\, \eta^0/T)T_2 \qquad (11)$$

where

η^0 is the viscosity of water, and T is temperature in kelvins.

The concentrations measured in water extracted from the first centimeter of the sediment core were used in the calculations of the concentration gradient (assigned a depth of 0.5 cm). Although the concentrations in the overlying water column were measured at depths of 0.5 and 1.5 ft off the bottom, the depth was assumed to be 0.5 cm above the bottom in the diffusive flux calculations. Therefore, the distance in computing the concentration gradient ($\delta \chi$) is 1 cm.

Data for pore water and the overlying water column indicate that concentration gradients existed at the sediment/water interface for dissolved manganese and iron, dissolved inorganic nitrogen, and dissolved orthophosphorus (fig. 14, tables 7 and 27). In all cases, concentrations were greater in the pore water, and the direction of diffusive flux was toward the water column. The large concentrations of dissolved species in pore water (fig. 14) indicate that anoxic reducing conditions prevailed in the sediments. Manganous (Mn^{+2}) and ferrous (Fe^{+2}) ions are the predominant forms of these metals that are present in reduced anoxic pore water (Wetzel, 1983). Ammonia was the predominant form of inorganic nitrogen in pore-water samples (table 27). Concentrations of nitrate and nitrite nitrogen may have been low in pore water because under reducing conditions, dissolved nitrite and nitrate are denitrified to N_2 gas, most of which eventually is lost to the atmosphere (Wetzel, 1983). Dissolved phosphorus primarily was in the inorganic form as orthophosphorus (table 27).

The presence of dissolved species in the water column in mid-August 1997 indicates that diffusion from pore water can occur even in the presence of oxygen (dissolved oxygen was about 5.5 mg/L in reservoir water, fig. 5). The duration of reduced dissolved species in the oxic water column may be short. Dissolved manganese and iron can precipitate as particulate oxides (Stumm and Morgan, 1981), ammonia is oxidized to nitrate and nitrite through nitrification (Wetzel, 1983), and orthophosphorus is effectively assimilated by aquatic biota (Horne and Goldman, 1994).

The rates of manganese flux (table 7) were larger than those for iron, possibly because manganese is mobilized at a higher redox potential than iron. Sediments have the ability to retain phosphorus beneath an oxidized microzone at the sediment/water interface (Wetzel, 1983) and may explain why the rates of phosphorus flux were small.

Using the calculated diffusive flux rates, estimates of daily loading from reservoir-bottom sediments were computed. Calculations of daily loading from sediments require an estimate of the reservoir-bottom area that is contributory to the flux. The deepest areas of the reservoir were assumed to represent the contributing area because the physical and chemical conditions at the sediment/water interface in the deep areas are probably similar to the conditions that were measured at the coring sites. Detailed bathymetric maps for Boulder Reservoir are not available for estimating this area. However, based on knowledge gained through this study on the spatial distribution of depth in the reservoir, the author conservatively estimates that the flux rates measured at sites R1 and R2 represent the flux rates that would be found in about an 80-acre area around each site. Using these areas,

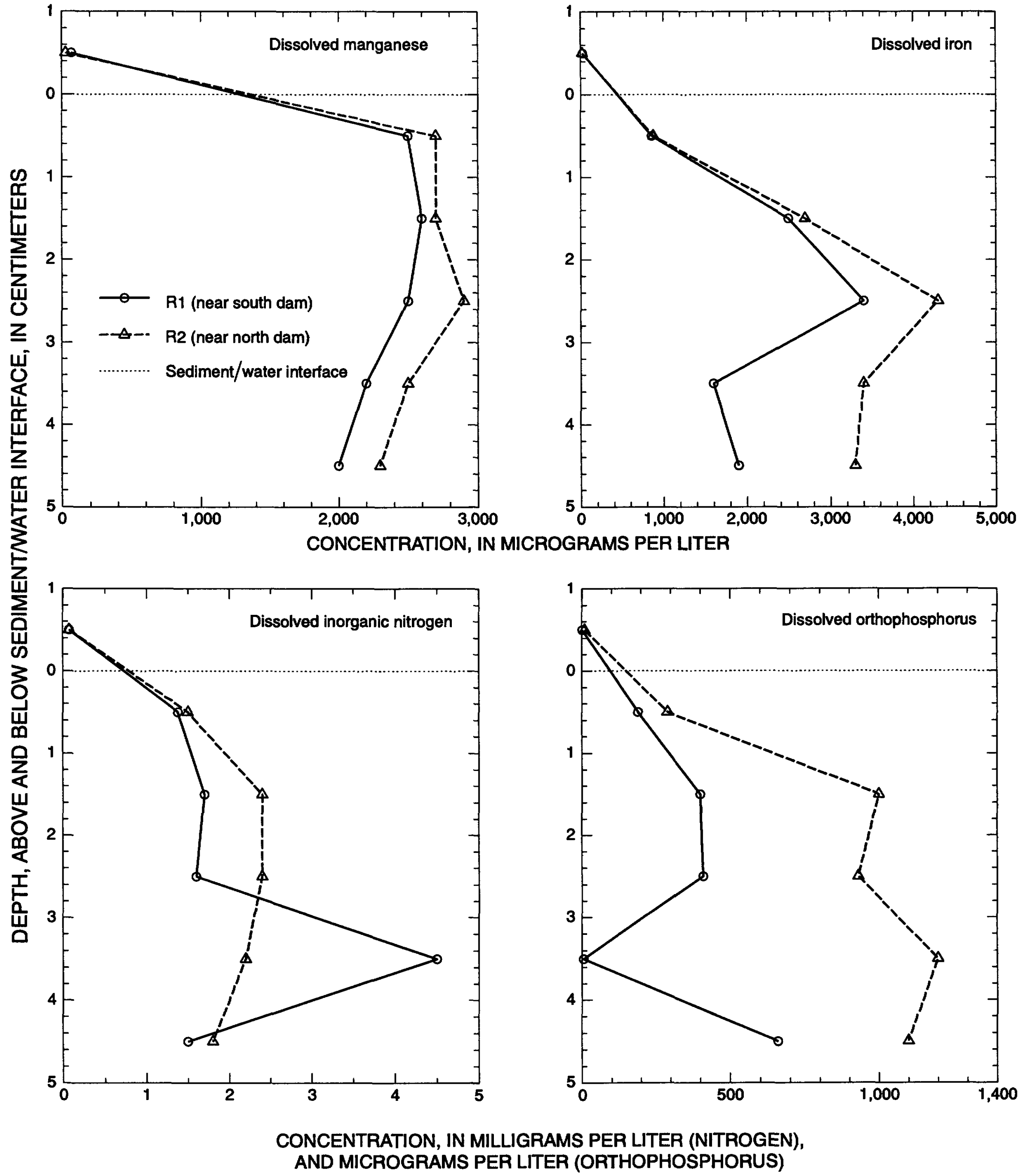

Figure 14. Concentrations of selected trace elements and nutrients in pore water and the overlying water column, Boulder Reservoir, August 20–21, 1997.

Table 7. Summary of pore-water flux data for sites R1 and R2, Boulder Reservoir, August 20–21, 1997

[Site R1, near south dam; site R2, near north dam; mg, milligrams; µg/L, micrograms per liter; cm, centimeters; kg, kilograms]

	Manganese (dissolved)		Iron (dissolved)		Nitrogen (dissolved inorganic)		Phosphorus (dissolved orthophosphorus)	
	Near south dam	Near north dam	Near south dam	Near north dam	Near south dam	Near north dam	Near south dam	Near north dam
Water temperature, at sediment/water interface	20.1	19.1	20.1	19.1	20.1	19.1	20.1	19.1
Porosity (0–1 cm)	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Concentration, reservoir water (µg/L)	67	27	24	19	[1]75	[1]75	[2]2	10
Concentration, pore water (µg/L)	2,500	2,700	860	880	1,380	1,500	190	290
Flux ($mg/cm^2/day$)	9.23×10^{-4}	1.0×10^{-3}	3.32×10^{-4}	3.40×10^{-4}	1.43×10^{-3}	1.55×10^{-3}	7.61×10^{-5}	1.13×10^{-4}
Daily load (kg)[3]	6.3		2.2		9.6		0.6	

[1]Calculated using nitrite plus nitrate nitrogen concentration at depth of 1.5 feet above reservoir bottom (concentration at depth of 0.5 foot above bottom was less than detection limit of 50 micrograms per liter).

[2]Orthophosphorus concentration at depth of 1.5 feet above reservoir bottom (concentration at depth of 0.5 foot above bottom was less than detection limit of 10 micrograms per liter).

[3]Estimated daily load from reservoir bottom to water column, mid-August 1997.

it is estimated that reservoir sediments contributed on a daily basis in mid-August 1997 about 6.3 kg of manganese, 2.2 kg of iron, 9.6 kg of inorganic nitrogen, and 0.6 kg of orthophosphorus to the overlying water column (table 7).

SUMMARY

From April through October of each year, Boulder Reservoir receives water imported from Colorado's western slope by the Colorado-Big Thompson (CBT) Project. The CBT water is released from the reservoir during the same time period for irrigation. The reservoir also receives surface-water inflow from three natural drainages and from one small irrigation ditch that terminates in the reservoir. At maximum capacity, Boulder Reservoir contains about 13,250 acre-ft of water. The reservoir has a surface area of about 540 acres, a mean depth of about 24 ft, and a maximum depth of about 32 ft.

The degree of thermal and dissolved oxygen stratification in the reservoir water column is affected by the inflow and outflow of CBT water. Stratification was most developed in July 1997 following an almost 6-week period when minimal amounts of CBT water had been routed through the reservoir. Stratification was gone by mid-August 1997 after the anoxic hypolimnion was removed in reservoir withdrawals. Throughout the winter of 1997–98, the water column stayed well mixed with regard to temperature and dissolved oxygen, primarily because of the lack of ice cover.

The variability of pH in the water column increased with stratification. The pH of the reservoir is altered primarily by the distribution of carbon dioxide in the water column. The utilization of carbon dioxide during photosynthesis increased pH in the photic zone, whereas the release of carbon dioxide during respiration and decomposition of organic matter decreased pH in the hypolimnion. Specific conductance varied little with depth but did vary seasonally in response to inflow of CBT water. The inflow of CBT water diluted the dissolved-solids concentrations in the reservoir, causing decreases in specific conductance.

Manganese in the reservoir was detected primarily in the dissolved phase and usually only during periods of stratification. The highest dissolved manganese (and dissolved iron) concentrations occurred in the deepest parts of the reservoir during hypolimnetic anoxia. An increase in dissolved concentrations during anoxia most likely resulted from the mobilization of soluble manganese and iron from bottom-sediment pore water and from the reduction of particulate iron oxides that have settled at the bottom of the reservoir. The oxidation rates for manganese are slower than the rates for iron, which may explain why, following periods of anoxia, dissolved manganese concentrations in the reservoir are higher than dissolved iron. The removal of anoxic hypolimnetic water in reservoir releases could be a tool for managing manganese concentrations in Boulder Reservoir.

In contrast to manganese, iron was consistently detected in the reservoir water column, predominantly in the particulate phase. Particulate iron concentrations varied with reservoir stratification. Particulate iron concentrations in the photic zone and bottom water generally were equivalent when the water column was well mixed. With the formation of stratification, particulate iron concentrations decreased in the photic zone and increased near the bottom, most likely from the settling of particulate iron complexes and from the release of ferrous iron from bottom sediments during anoxia and subsequent oxidation and precipitation of ferric hydroxides. The resuspension of iron-laden bottom sediments by underflowing Boulder Feeder Canal water may also be another source of particulate iron in bottom water.

The oxygenated conditions that predominated in the photic zone of the reservoir were optimal for mobilization of uranium and selenate, the soluble form of selenium. However, uranium concentrations consistently were less than 3 µg/L and selenium concentrations were less than 1 µg/L. Uranium and selenium do not appear to be a water-quality concern for the reservoir at this time.

Total nitrogen concentrations in the reservoir ranged from 0.2 to 1.1 mg/L, and total phosphorus concentrations ranged from 5 and 41 µg/L. Nitrogen and phosphorus predominantly were in the organic phase, probably contained in aquatic biomass. Dissolved inorganic nitrogen concentrations were small and ranged from less than 0.01 to 0.19 mg/L. Dissolved orthophosphorus concentrations almost always were less than the detection limit of 1 µg/L. Based on the ratio of total nitrogen to total phosphorus, phosphorus appears to be the nutrient that limits algal growth in the reservoir.

The concentration of trace elements in reservoir-bottom sediments were comparable or generally smaller than background concentrations for reservoir and streambed sediments in the South Platte River Basin. Elements that were slightly enriched as compared to local background levels are aluminum, arsenic, chromium, and mercury. Comparison of mean trace-element concentrations to Canadian sediment guidelines indicates that the reservoir sediments are marginally contaminated with respect to seven elements (arsenic, chromium, copper, iron, lead, manganese, and zinc). Trace-element bed-sediment concentrations generally were highest in the deepest areas of the reservoir, where the percentage of fine-grain-sized bed material is highest. The literature cites a strong positive correlation between decreasing grain size and increasing metal concentrations.

From July 1, 1997, through June 30, 1998, the delivery of CBT water accounted for about 82 percent of inflowing water to the reservoir. Precipitation was the second largest individual contributor (6 percent), and the combined inflow from the four secondary inflows was about 12 percent of the total. Releases to the Boulder Creek Supply Canal accounted for about 85 percent of the outflow, and the remainder of outflow was attributed to evaporation and withdrawals to the drinking-water treatment plant.

During the 1-year budget period, about 70 percent of the incoming manganese load was contained in streamflow in the three natural tributaries (Dry and Little Dry Creeks and the unnamed drainage). Manganese concentrations in the tributaries primarily were in the dissolved phase. The total manganese load removed in reservoir outflows was about 8 times the incoming load, indicating that the reservoir was a net source of manganese in reservoir outflows during the 1-year budget period. Almost all of the manganese was released from the reservoir in July–September 1997, when maximum dissolved manganese concentrations in the reservoir coincided with large reservoir releases for irrigation. The large amount of manganese released from the reservoir is facilitated by the location of the outlet structure, which is situated near the bottom of the reservoir, and by the release of water when thermal stratification and subsequent elevated manganese concentrations occurred in reservoir bottom water.

During the 1-year budget period, about 61 percent of the incoming iron load was contained in

CBT water and about 24 percent was in the Farmers Ditch. Most incoming iron was transported in the particulate phase. The amount of iron released from the reservoir was about twice the amount that entered in surface-water inflows. Almost all of the selenium that entered the reservoir (about 6.1 kg) was contained in the flow of Dry Creek, which is underlain by the Pierre Shale. Selenium was below detectable levels in the other two tributaries that drain from the shales, probably because selenium was reduced and removed from solution in wetlands that exist just upstream from the surface-water monitoring sites in these two tributaries. The reservoir trapped all inflowing selenium, as selenium was not detected in reservoir outflows. Of the 11 kg of uranium that entered Boulder Reservoir, about 85 percent came from the three natural tributaries that are underlain by the Pierre Shale. Budget calculations indicate the reservoir is a source of uranium in release water.

The Boulder Feeder Canal was a source of about 80 percent of the nitrogen and phosphorus that entered the reservoir. Most of the nitrogen and phosphorus in surface-water inflows was in the particulate organic phase. Budget calculations indicate that the incoming load of nitrogen and phosphorus was about 1.5 times that of the load removed from the reservoir. Growth and subsequent settling of phytoplankton containing nitrogen and phosphorus probably accounted for the net gain in nitrogen and phosphorus in the reservoir.

The rates at which selected trace elements and nutrients flux between the reservoir water column and bottom sediments were calculated with data collected under oxic conditions at the sediment/water interface. Compared to the water column, concentrations of dissolved manganese and iron, dissolved inorganic nitrogen, and dissolved orthophosphorus were greater in pore water, indicating that the direction of flux was out of the sediments. The presence of dissolved species in the water column at the time of pore-water sampling indicates that diffusion from pore water to the overlying water column can occur when the water column is oxygenated. Given the oxic conditions in which pore-water sampling was carried out, it is estimated that reservoir sediments contributed, on a daily basis, about 6.3 kg of manganese, 2.2 kg of iron, 9.6 kg of inorganic nitrogen, and 0.6 kg of orthophosphorus.

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SUPPLEMENTAL DATA

Table 8. Profile of onsite measurements for site R1, Boulder Reservoir near south dam, April 1997–July 1998

[C, Celsius; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter]

Depth (feet)	Temperature (degrees C)	pH (units)	Specific conductance (µS/cm)	Dissolved oxygen (mg/L)
	April 1, 1997, Secchi-disc depth, 2.0 feet			
0.5	9.3	8.0	513	8.8
1.0	9.3	8.0	514	8.8
1.6	9.3	7.9	514	8.8
2.5	9.3	7.9	515	8.8
3.6	9.3	7.9	515	8.8
4.5	9.2	7.9	516	8.8
5.5	9.2	7.9	516	8.8
6.4	9.2	7.9	516	8.8
7.5	9.2	7.9	516	8.8
8.8	9.2	7.9	516	8.8
9.5	9.2	7.9	516	8.8
10.5	9.2	7.9	516	8.8
11.5	9.2	7.9	516	8.8
12.6	9.2	7.9	516	8.8
13.8	9.2	7.9	516	8.7
14.7	9.2	7.9	517	8.7
15.5	9.2	7.9	516	8.7
	May 6, 1997, Secchi-disc depth, 4.5 feet			
0.5	14.8	8.0	365	8.3
1.0	14.4	8.0	367	8.3
1.8	14.2	8.0	365	8.3
2.7	14.2	8.0	367	8.3
3.4	13.8	8.0	365	8.4
4.8	13.7	8.0	362	8.3
5.6	13.6	8.0	359	8.3
6.6	13.1	7.9	365	8.3
7.5	12.9	7.9	365	8.3
8.6	12.6	7.9	357	8.3
9.5	12.2	7.9	357	8.1
10.5	11.9	7.9	368	8.1
11.5	11.7	7.8	370	7.9
12.4	11.5	7.8	382	7.7
13.4	11.4	7.7	386	7.4
14.4	11.1	7.7	391	7.0
15.3	10.9	7.7	391	6.9
16.4	10.9	7.7	392	6.8
17.4	10.9	7.7	392	6.8
18.5	10.8	7.7	392	6.7
19.5	10.8	7.7	394	6.5
20.6	10.8	7.7	397	6.2
21.8	10.7	7.8	400	6.2
22.9	10.8	7.8	402	6.3
	June 3, 1997, Secchi-disc depth, 8 feet			
0.4	19.7	8.0	344	7.6
1.0	19.7	8.0	344	7.6
2.0	19.5	8.0	344	7.6
3.0	19.1	8.0	343	7.6
4.1	19.0	8.0	344	7.6
5.0	18.9	8.0	344	7.6
6.1	18.8	8.0	344	7.6
7.0	18.8	8.0	344	7.6
8.0	18.8	8.0	344	7.6
9.0	18.8	7.9	344	7.5
10.0	18.6	7.8	345	7.4
11.0	18.4	7.7	346	7.0
12.0	17.8	7.7	344	6.9
13.0	17.3	7.7	342	6.7
14.0	17.1	7.6	342	6.5
15.0	16.9	7.6	343	6.3
16.0	16.8	7.5	343	6.1
16.5	16.6	7.5	343	6.0
18.0	16.5	7.5	343	5.9
19.0	16.3	7.4	343	5.7
20.0	16.1	7.3	343	4.9
21.0	16.0	7.3	343	4.8
22.1	15.7	7.3	344	4.3
23.0	15.5	7.3	345	4.0
24.0	15.5	7.3	345	3.9
25.0	15.4	7.3	346	3.8
26.0	15.4	7.3	347	3.7
27.0	15.3	7.3	347	3.7
27.5	15.2	7.4	348	3.5

Table 8. Profile of onsite measurements for site R1, Boulder Reservoir near south dam, April 1997–July 1998—Continued

[C, Celsius; μS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter]

Depth (feet)	Temperature (degrees C)	pH (units)	Specific conductance (μS/cm)	Dissolved oxygen (mg/L)
		July 2, 1997, Secchi-disc depth, 10 feet		
1.0	22.2	8.0	377	6.6
1.6	22.2	8.0	377	6.6
2.5	22.1	8.0	377	6.6
3.5	22.1	8.0	377	6.6
4.5	22.1	8.0	377	6.6
5.5	22.1	8.0	377	6.6
6.5	22.0	8.0	377	6.6
7.5	22.0	7.9	377	6.6
8.5	22.0	7.9	377	6.6
9.6	22.0	7.9	377	6.6
10.7	21.9	7.9	377	6.5
11.5	21.9	7.9	377	6.5
12.5	21.9	7.9	377	6.4
13.5	21.8	7.8	377	6.1
14.5	21.6	7.6	378	5.5
15.4	21.5	7.5	379	5.1
16.5	21.5	7.5	379	5.0
17.3	21.3	7.4	379	4.4
18.3	20.9	7.3	377	3.8
19.5	20.4	7.2	378	3.2
20.5	20.2	7.2	377	2.9
21.5	18.6	7.1	369	0.6
22.5	17.8	7.1	367	0.2
23.6	17.2	7.1	366	0.1
24.5	16.8	7.1	368	0.1
25.5	16.6	7.1	368	0.1
26.6	16.4	7.1	368	0.1
27.5	16.3	7.1	369	0.1

Depth (feet)	Temperature (degrees C)	pH (units)	Specific conductance (μS/cm)	Dissolved oxygen (mg/L)
		August 6, 1997, Secchi-disc depth, 5 feet		
0.5	21.7	7.9	280	5.9
1.0	21.7	7.9	295	5.9
2.0	21.7	7.9	295	5.9
3.0	21.7	7.9	295	5.9
4.0	21.7	7.9	295	5.9
5.0	21.7	7.9	295	5.9
6.0	21.7	7.9	295	5.9
7.0	21.7	7.9	295	5.9
8.0	21.7	7.9	295	5.9
9.0	21.7	7.9	295	5.8
10.0	21.7	7.9	296	5.8
11.0	21.7	7.9	296	5.8
12.0	21.7	7.9	296	5.8
13.0	21.7	7.9	285	5.8
14.0	21.7	7.9	296	5.8
15.0	21.7	7.8	296	5.8
16.0	21.7	7.8	296	5.8
17.0	21.7	7.8	296	5.7
18.0	21.7	7.7	295	5.6
19.0	21.6	7.5	295	4.7
20.0	20.2	7.3	284	1.8
21.0	19.9	7.3	283	1.4
22.0	19.5	7.3	283	0.8
23.0	19.4	7.3	282	0.8
24.2	19.3	7.3	283	0.7

Table 8. Profile of onsite measurements for site R1, Boulder Reservoir near south dam, April 1997–July 1998—Continued

[C, Celsius; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter]

Depth (feet)	Temperature (degrees C)	pH (units)	Specific conductance (µS/cm)	Dissolved oxygen (mg/L)	Depth (feet)	Temperature (degrees C)	pH (units)	Specific conductance (µS/cm)	Dissolved oxygen (mg/L)
August 20, 1997, Secchi-disc depth, 3.7 feet									
0.6	21.2	7.9	353	6.6	September 3, 1997, Secchi-disc depth, 6.0 feet				
1.0	21.2	7.9	353	6.6	0.8	21.5	8.1	341	6.6
2.0	21.2	7.9	353	6.6	1.0	21.5	8.1	341	6.6
3.0	20.9	7.9	352	6.5	2.0	21.5	8.1	341	6.6
4.0	20.7	7.9	352	6.5	3.0	21.5	8.1	341	6.6
5.0	20.6	7.9	352	6.5	4.0	21.5	8.1	341	6.6
6.0	20.5	7.9	353	6.4	5.0	21.5	8.1	341	6.6
7.0	20.4	7.8	353	6.3	6.0	21.5	8.1	341	6.5
8.0	20.4	7.8	353	6.3	7.0	21.4	8.0	341	6.5
9.0	20.4	7.8	353	6.2	8.0	21.4	8.0	341	6.5
10.0	20.4	7.8	354	6.2	9.1	21.4	8.0	341	6.5
10.8	20.4	7.8	354	6.2	10.2	21.4	8.0	341	6.5
12.0	20.3	7.8	354	6.2	11.0	21.4	8.1	342	6.5
13.0	20.3	7.8	354	6.2	12.0	21.4	8.0	341	6.5
14.0	20.3	7.8	353	6.2	13.0	21.4	8.0	341	6.3
15.0	20.3	7.8	353	6.2	14.0	20.9	7.4	334	2.7
16.1	20.3	7.8	353	6.2	15.0	20.6	7.3	333	2.1
17.0	20.3	7.8	354	6.1	16.1	20.4	7.2	336	0.9
18.0	20.3	7.8	354	6.1	17.1	19.8	7.2	337	0.1
19.0	20.2	7.8	354	6.1	18.0	19.7	7.2	330	0.2
19.5	20.2	7.8	355	6.0	19.0	19.7	7.2	329	0.2
20.6	20.2	7.8	355	6.0	20.0	19.5	7.2	327	0.0
21.0	20.2	7.8	355	6.0	20.2	19.5	7.2	330	0.0
22.0	20.2	7.8	356	6.0					
22.4	20.1	7.8	356	6.0					
23.3	20.1	7.8	356	5.9					
23.9	20.1	7.7	357	5.8					
24.5	20.1	7.7	357	5.8					

Table 8. Profile of onsite measurements for site R1, Boulder Reservoir near south dam, April 1997–July 1998—Continued

[C, Celsius; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter]

Depth (feet)	Temperature (degrees C)	pH (units)	Specific conductance (µS/cm)	Dissolved oxygen (mg/L)
October 7, 1997, Secchi-disc depth, 3.0 feet				
0.5	16.1	8.2	256	7.4
1.5	16.1	8.2	256	7.4
2.5	16.1	8.2	256	7.4
3.5	16.1	8.2	256	7.4
4.5	16.1	8.2	256	7.3
5.5	16.0	8.2	256	7.3
6.5	16.0	8.2	256	7.3
7.5	16.0	8.2	256	7.3
8.5	16.0	8.2	256	7.3
9.5	16.0	8.2	256	7.3
10.5	16.0	8.2	256	7.3
11.5	16.0	8.1	256	7.2
12.5	15.9	8.1	253	7.1
13.5	15.9	8.0	251	6.9
14.5	15.8	7.9	251	6.7
15.5	15.7	7.8	255	6.4
16.5	15.6	7.8	258	6.3
17.5	15.6	7.7	260	6.1
18.5	15.5	7.6	259	5.7
19.5	15.4	7.5	253	5.5
20.5	15.4	7.5	252	5.2
21.3	15.4	7.5	256	4.8
November 4, 1997, Secchi-disc depth, 2.0 feet				
0.6	7.3	7.9	273	9.2
1.0	7.3	7.9	273	9.2
2.0	7.3	7.9	273	9.2
3.0	7.3	7.9	273	9.2
4.0	7.3	7.9	273	9.2
5.0	7.3	7.9	273	9.2
6.0	7.3	7.9	273	9.2
7.0	7.2	7.9	273	9.2
8.0	7.2	7.9	273	9.2
9.0	7.2	7.9	273	9.2
10.0	7.3	7.9	274	9.2
11.0	7.2	7.9	273	9.2
12.0	7.2	7.9	272	9.2
13.0	7.2	7.9	273	9.2
14.0	7.2	7.9	272	9.2
15.0	7.2	7.9	273	9.2
16.0	7.2	7.9	273	9.2
17.0	7.2	7.9	272	9.2
18.0	7.2	7.9	273	9.2
19.0	7.2	7.8	273	9.2
20.0	7.2	7.8	272	9.2
20.9	7.2	7.9	273	9.2
22.0	7.2	7.9	273	9.2
22.6	7.2	7.9	272	9.2
December 3, 1997, Secchi-disc depth, 5.2 feet				
0.3	2.7	8.2	289	10.2
1.6	2.7	8.2	289	10.2
3.3	2.7	8.2	289	10.2
4.9	2.7	8.2	289	10.1
6.6	2.7	8.2	289	10.1
8.2	2.8	8.2	289	10.1
9.8	2.9	8.2	289	10.1
11.5	2.9	8.2	290	10.1
13.1	3.0	8.2	290	10.1
14.8	3.0	8.2	290	10.1
16.4	3.0	8.2	290	10.1
18.0	3.0	8.2	290	10.1
19.7	3.0	8.2	290	10.1
21.3	3.0	8.2	290	10.0
22.3	3.0	8.2	291	10.0
22.6	3.0	8.2	291	9.9

Table 8. Profile of onsite measurements for site R1, Boulder Reservoir near south dam, April 1997–July 1998—Continued

[C, Celsius; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter]

Depth (feet)	Temperature (degrees C)	pH (units)	Specific conductance (µS/cm)	Dissolved oxygen (mg/L)
	February 3, 1998, Secchi-disc depth, 9.5 feet			
0.4	2.8	8.1	361	10.8
1.7	2.8	8.1	360	10.8
3.3	2.9	8.1	361	10.8
3.4	3.1	8.1	361	10.8
4.9	3.0	8.1	361	10.8
6.6	3.0	8.1	361	10.8
8.3	3.0	8.1	362	10.8
10.0	3.1	8.1	361	10.8
11.5	3.1	8.1	361	10.8
14.8	3.1	8.1	361	10.8
16.5	3.1	8.1	362	10.8
18.1	3.1	8.1	361	10.8
19.7	3.9	8.0	392	10.5
	March 3, 1998, Secchi-disc depth, 5.5 feet			
0.5	2.6	7.9	371	10.4
1.0	2.7	7.9	371	10.4
2.1	2.7	7.9	372	10.3
3.0	2.7	7.9	372	10.3
4.0	2.7	7.9	372	10.3
4.9	2.7	7.9	372	10.3
6.0	2.7	7.9	372	10.3
7.0	2.7	7.9	372	10.3
8.1	2.7	7.9	372	10.3
8.9	2.7	7.9	372	10.3
10.0	2.7	7.9	372	10.3
10.9	2.7	7.9	372	10.3
12.1	2.7	7.9	372	10.3
13.0	2.7	7.9	373	10.3
13.8	2.8	8.0	372	10.3
14.8	2.8	8.0	372	10.3
16.0	2.9	8.0	373	10.3
17.0	2.9	8.0	373	10.3
18.0	3.0	8.0	373	10.3
19.0	3.0	8.0	373	10.3
20.0	3.1	8.0	372	10.3
21.1	3.1	7.9	374	10.2
22.1	3.1	7.9	373	10.2

Depth (feet)	Temperature (degrees C)	pH (units)	Specific conductance (µS/cm)	Dissolved oxygen (mg/L)
	April 7, 1998, Secchi-disc depth, 5.0 feet			
0.6	9.2	8.1	411	8.6
1.0	9.2	8.1	412	8.6
2.1	9.2	8.1	411	8.6
3.0	9.2	8.1	411	8.6
4.0	9.2	8.1	411	8.6
5.0	9.1	8.1	412	8.6
6.0	9.1	8.1	411	8.6
7.0	9.1	8.1	412	8.6
8.0	9.0	8.1	412	8.6
9.0	9.0	8.1	412	8.6
10.0	9.0	8.1	412	8.6
11.0	9.0	8.1	412	8.6
12.0	9.0	8.1	412	8.6
13.0	9.0	8.1	412	8.6
14.0	9.0	8.1	412	8.6
15.0	9.0	8.1	412	8.6
16.0	8.9	8.1	412	8.6
17.0	8.9	8.1	412	8.6
18.0	8.9	8.1	415	8.4
19.0	8.6	8.0	420	8.3
19.9	8.6	8.0	420	8.1
21.0	8.5	7.9	421	7.9
22.0	8.4	7.9	422	7.8

Table 8. Profile of onsite measurements for site R1, Boulder Reservoir near south dam, April 1997–July 1998—Continued

[C, Celsius; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter]

Depth (feet)	Temperature (degrees C)	pH (units)	Specific conductance (µS/cm)	Dissolved oxygen (mg/L)
May 5, 1998, Secchi-disc depth, 3.0 feet				
0.6	15.4	8.2	425	7.8
1.0	15.4	8.2	424	7.8
2.1	15.1	8.2	424	7.8
3.0	15.0	8.2	424	7.8
4.0	14.9	8.2	424	7.8
5.0	14.9	8.2	424	7.8
6.0	14.8	8.2	424	7.8
6.9	14.8	8.2	424	7.8
7.9	14.8	8.2	424	7.8
9.0	14.7	8.2	424	7.8
10.0	14.7	8.2	424	7.8
11.0	14.6	8.2	423	7.8
12.3	14.6	8.2	423	7.8
12.9	14.5	8.2	422	7.8
14.0	14.1	8.1	424	7.2
15.0	13.4	7.9	423	6.8
16.0	12.9	7.9	423	6.7
17.0	12.7	7.8	423	6.6
18.1	12.5	7.8	423	6.4
19.0	12.5	7.8	423	6.3
20.0	12.4	7.8	424	6.3
21.1	12.3	7.7	424	6.2
22.1	12.3	7.7	424	6.1
23.0	12.2	7.7	424	6.1
23.5	12.2	7.7	424	5.9
June 2, 1998, Secchi-disc depth, 2.0 feet				
1.0	18.9	8.0	408	7.1
2.0	18.9	8.0	409	7.0
4.0	18.8	8.0	409	7.0
6.0	18.6	8.0	408	6.9
8.0	18.4	8.0	408	6.9
10.0	18.3	8.0	408	6.9
12.0	18.3	8.0	408	6.9
14.0	18.3	8.0	408	6.9
16.0	18.3	8.0	409	6.9
18.0	18.3	8.0	409	6.9
20.0	18.2	8.0	407	6.8
22.0	17.9	8.0	399	6.7
24.0	17.7	8.0	386	6.7
25.0	17.6	7.9	383	6.7
26.0	17.6	7.9	383	6.6
July 7, 1998, Secchi-disc depth, 6.0 feet				
0.8	21.1	8.0	298	7.1
1.0	21.1	8.0	298	7.1
1.9	21.1	8.0	298	7.1
3.0	21.2	8.0	298	7.1
4.0	21.2	8.0	298	7.1
5.5	21.0	8.0	298	7.1
6.0	21.0	8.0	297	7.1
7.0	20.8	8.0	297	7.1
8.1	20.4	8.0	289	7.1
9.1	20.4	8.0	287	7.1
10.1	19.6	7.9	275	7.0
11.0	19.2	7.8	273	6.8
12.0	19.1	7.8	272	6.8
13.1	19.0	7.8	271	6.8
14.1	18.7	7.7	272	6.6
15.0	18.7	7.6	274	6.3
16.0	18.4	7.5	279	5.9
17.0	18.3	7.5	283	5.5
18.1	18.1	7.5	286	5.6
19.2	18.0	7.4	293	5.3
20.1	17.8	7.3	296	5.0
21.0	17.6	7.3	303	4.3
22.1	17.5	7.2	306	3.9
23.0	17.3	7.1	309	3.4
24.0	17.2	7.1	314	2.7
24.3	17.2	7.1	315	2.6
25.1	17.1	7.1	316	2.5
26.1	17.1	7.0	318	2.3
27.0	17.1	7.0	318	2.0

Table 9. Profile of onsite measurements for site R2, Boulder Reservoir near north dam, April 1997–July 1998

[C, Celsius; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter]

Depth (feet)	Temperature (degrees C)	pH (units)	Specific conductance (µS/cm)	Dissolved oxygen (mg/L)
		April 1, 1997, Secchi-disc depth, 1.5 feet		
0.5	9.7	8.0	518	8.7
1.0	9.7	8.0	517	8.7
2.0	9.7	8.0	517	8.7
2.8	9.6	8.0	517	8.7
3.6	9.6	8.0	518	8.8
4.6	9.6	8.0	518	8.8
5.5	9.6	8.0	518	8.7
6.4	9.6	8.0	518	8.7
7.5	9.6	8.0	518	8.7
8.0	9.6	8.0	518	8.7
8.5	9.6	8.0	518	8.7
9.5	9.6	8.0	518	8.7
10.1	9.6	8.0	519	8.7
11.0	9.5	8.0	518	8.7
12.0	9.6	8.0	518	8.7
13.0	9.5	8.0	518	8.7
13.5	9.5	8.0	518	8.7
14.6	9.5	8.0	518	8.7
15.4	9.5	7.9	518	8.8
		May 6, 1997, Secchi-disc depth, 4.5 feet		
0.5	15.0	8.0	374	8.3
0.9	14.9	8.0	374	8.3
2.0	14.7	7.9	375	8.3
3.4	13.9	8.0	377	8.4
4.5	13.7	8.0	375	8.4
5.8	13.5	8.0	378	8.4
6.9	13.4	7.9	379	8.4
8.0	13.3	7.9	380	8.4
8.9	13.3	7.9	380	8.4
10.0	13.2	7.9	381	8.3
11.0	13.2	7.9	381	8.3
12.2	13.1	7.9	378	8.2
13.3	12.7	7.8	370	8.1
14.2	12.6	7.8	368	8.0
15.3	12.1	7.8	359	7.8
16.4	11.6	7.8	364	7.7
17.4	11.5	7.8	369	7.6
18.5	11.5	7.8	373	7.5
19.8	11.2	7.8	385	7.1
21.2	10.9	7.8	389	7.0
22.3	10.8	7.8	390	7.1
22.4	10.9	7.8	390	7.1
		June 3, 1997, Secchi-disc depth, 8.0 feet		
0.4	19.4	8.0	343	7.7
1.0	19.4	8.0	343	7.7
2.0	19.3	8.0	344	7.7
3.0	19.1	8.0	343	7.7
4.0	19.1	8.0	343	7.7
5.0	19.0	8.0	343	7.7
6.0	18.9	8.0	343	7.7
7.0	18.9	8.0	343	7.6
7.9	18.8	7.9	343	7.6
8.9	18.7	7.9	343	7.6
10.2	18.3	7.9	342	7.5
11.1	17.9	7.8	342	7.4
12.0	17.7	7.8	340	7.4
13.1	17.5	7.7	341	7.0
14.0	17.2	7.5	342	6.6
15.1	16.4	7.5	341	6.2
16.1	16.2	7.5	342	6.1
17.1	16.2	7.4	342	5.9
18.0	16.1	7.4	342	5.7
18.5	16.1	7.4	342	5.4
19.9	15.8	7.3	343	4.7
20.5	15.6	7.3	344	4.6
21.5	15.5	7.3	344	4.4
22.3	15.5	7.3	345	4.4
23.3	15.4	7.3	345	4.2
24.1	15.4	7.3	345	4.1
25.2	15.4	7.3	345	4.1
25.8	15.4	7.4	345	4.1
27.5	15.3	7.4	345	4.1

Table 9. Profile of onsite measurements for site R2, Boulder Reservoir near north dam, April 1997–July 1998—Continued

[C, Celsius; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter]

Depth (feet)	Temperature (degrees C)	pH (units)	Specific conductance (µS/cm)	Dissolved oxygen (mg/L)
		July 2, 1997, Secchi-disc depth, 4.0 feet		
0.4	22.3	8.0	378	6.7
1.0	22.3	8.0	378	6.7
2.0	22.3	8.0	378	6.7
3.0	22.3	8.0	378	6.7
4.0	22.3	8.0	377	6.7
5.0	22.2	8.0	377	6.6
5.8	22.2	8.0	377	6.6
7.0	22.2	7.9	377	6.6
8.0	22.1	7.9	377	6.6
9.0	22.1	7.9	377	6.5
10.0	22.1	7.9	377	6.5
11.1	22.1	7.9	377	6.5
12.1	22.1	7.9	377	6.5
13.0	22.1	7.8	377	6.4
14.1	22.0	7.8	377	6.3
15.0	22.0	7.7	378	6.1
16.0	21.8	7.6	378	5.8
17.0	21.6	7.5	379	5.2
18.0	21.3	7.3	379	4.3
19.0	20.7	7.2	379	3.3
20.2	19.3	7.1	370	1.5
20.7	18.6	7.0	368	0.8
20.8	18.5	7.0	368	0.7
22.1	18.4	7.0	367	0.7
23.1	17.9	7.0	367	0.3
24.2	17.1	7.1	366	0.0
25.0	16.8	7.1	367	0.0
26.2	16.5	7.1	368	0.0
27.1	16.4	7.1	368	0.0
27.4	16.3	7.1	368	0.0
28.2	16.2	7.1	368	0.1

Depth (feet)	Temperature (degrees C)	pH (units)	Specific conductance (µS/cm)	Dissolved oxygen (mg/L)
		August 6, 1997, Secchi-disc depth, 4.0 feet		
0.5	21.6	7.9	294	6.2
1.0	21.6	7.9	294	6.2
2.0	21.6	7.9	294	6.2
3.0	21.6	7.9	294	6.2
4.0	21.6	7.9	294	6.2
5.0	21.6	7.9	294	6.1
6.0	21.6	7.9	294	6.1
7.0	21.6	7.9	294	6.1
8.0	21.6	7.9	294	6.1
9.0	21.6	7.9	294	6.1
10.0	21.6	7.9	294	6.1
11.0	21.6	7.9	294	6.1
12.0	21.6	7.9	294	6.1
13.0	21.6	7.9	294	6.1
14.0	21.6	7.9	294	6.1
15.0	21.6	7.9	294	6.0
16.0	21.6	7.9	294	6.0
17.0	21.6	7.9	294	6.0
18.0	21.6	7.8	294	5.9
19.0	21.6	7.8	294	5.9
20.0	21.5	7.8	293	5.8
21.0	21.5	7.7	294	5.7
22.0	21.2	7.6	293	5.0
23.0	20.9	7.5	290	4.2
24.0	19.5	7.3	282	0.7
24.5	19.7	7.2	282	0.3

Table 9. Profile of onsite measurements for site R2, Boulder Reservoir near north dam, April 1997–July 1998—Continued

[C, Celsius; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter]

Depth (feet)	Temperature (degrees C)	pH (units)	Specific conductance (µS/cm)	Dissolved oxygen (mg/L)	Depth (feet)	Temperature (degrees C)	pH (units)	Specific conductance (µS/cm)	Dissolved oxygen (mg/L)
August 21, 1997, Secchi-disc depth, 4.0 feet									
0.5	22.0	7.9	338	6.8	September 3, 1997, Secchi-disc depth, 4.0 feet				
1.0	22.0	7.9	338	6.8	0.7	21.8	8.1	342	6.7
2.0	21.8	7.9	338	6.8	1.0	21.7	8.1	341	6.7
3.0	21.6	7.9	338	6.8	2.0	21.7	8.1	341	6.7
4.0	21.5	7.9	338	6.8	3.0	21.6	8.1	342	6.7
5.0	21.4	7.9	338	6.8	4.1	21.5	8.1	342	6.7
6.0	21.3	8.0	337	6.8	5.1	21.5	8.1	342	6.7
7.0	21.2	7.9	337	6.7	6.1	21.5	8.1	342	6.7
8.0	20.9	7.9	337	6.5	7.1	21.5	8.1	342	6.7
9.0	20.7	7.8	337	6.4	8.0	21.5	8.1	342	6.6
10.0	20.5	7.8	337	6.2	9.0	21.5	8.1	342	6.6
11.1	20.3	7.7	340	6.0	10.0	21.5	8.1	342	6.5
12.0	20.2	7.7	340	6.0	11.0	21.4	8.1	341	6.4
13.1	20.2	7.7	340	6.0	12.0	21.3	7.9	338	5.6
14.0	20.2	7.7	340	6.0	13.0	21.0	7.6	328	4.4
15.0	20.2	7.7	340	5.9	14.0	20.8	7.6	324	4.1
16.0	20.2	7.7	340	5.9	15.1	20.5	7.5	321	3.3
17.0	20.2	7.7	340	5.9	16.0	20.3	7.3	324	2.5
18.0	20.1	7.7	340	6.0	17.0	20.1	7.3	328	1.5
19.0	20.1	7.7	341	6.1	18.0	19.8	7.2	323	1.3
20.0	20.1	7.7	341	6.1	18.5	19.8	7.2	321	0.8
21.0	20.0	7.7	342	5.9	19.0	19.7	7.2	328	0.5
22.0	19.9	7.7	343	5.7	19.5	19.7	7.2	326	0.8
23.0	19.9	7.7	343	5.7	19.6	19.6	7.3	325	3.0
24.0	19.9	7.7	343	5.7	20.1	19.4	7.5	311	4.3
25.0	19.9	7.7	343	5.7	20.5	19.3	7.6	308	5.2
25.4	19.9	7.7	343	5.6	20.7	19.3	7.6	301	5.5
25.8	19.9	7.7	343	5.6	21.2	19.2	7.7	295	5.5

Table 9. Profile of onsite measurements for site R2, Boulder Reservoir near north dam, April 1997–July 1998—Continued

[C, Celsius; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter]

Depth (feet)	Temperature (degrees C)	pH (units)	Specific conductance (µS/cm)	Dissolved oxygen (mg/L)
	October 7, 1997, Secchi-disc depth, 3.0 feet			
0.5	16.3	8.2	255	7.4
1.0	16.2	8.2	256	7.4
3.0	16.1	8.2	255	7.4
4.0	16.0	8.2	255	7.4
5.0	16.0	8.2	256	7.4
6.0	15.9	8.2	256	7.3
7.0	15.9	8.2	255	7.3
8.0	15.8	8.2	255	7.3
9.0	15.8	8.2	254	7.3
10.0	15.8	8.2	254	7.2
11.0	15.8	8.2	253	7.2
12.0	15.7	8.1	253	7.2
13.0	15.7	8.1	252	7.2
14.0	15.5	8.1	246	7.1
15.0	15.5	8.0	244	7.0
16.0	15.5	7.9	245	6.5
17.0	15.5	7.8	246	6.5
18.0	15.5	7.8	246	6.4
19.0	15.5	7.8	247	6.4
20.0	15.5	7.8	249	6.2
20.5	15.4	7.8	247	6.2
21.0	15.0	8.0	229	6.6
21.8	14.9	8.0	225	7.2
	November 4, 1997, Secchi-disc depth, 2.0 feet			
0.8	7.3	7.9	272	9.2
1.0	7.3	7.9	272	9.2
3.0	7.3	7.9	271	9.2
5.0	7.3	7.9	271	9.2
7.0	7.2	7.9	271	9.2
8.9	7.3	7.9	271	9.2
10.0	7.3	7.9	271	9.2
11.0	7.3	7.9	271	9.2
12.0	7.2	7.9	271	9.2
13.0	7.3	7.9	271	9.2
14.0	7.2	7.9	272	9.2
15.0	7.2	7.9	271	9.2
16.0	7.2	7.9	272	9.2
17.0	7.2	7.9	271	9.2
18.0	7.2	7.9	272	9.2
19.0	7.2	7.9	272	9.2
20.0	7.2	7.9	273	9.2
21.0	7.1	7.9	273	9.2
22.0	7.1	7.9	273	9.2
22.7	7.1	7.9	274	9.2
	December 3, 1997, Secchi-disc depth, 4.9 feet			
0.3	2.7	8.2	290	10.0
1.6	2.7	8.2	290	10.0
3.3	2.7	8.2	290	10.0
4.9	2.7	8.2	290	10.0
6.6	2.7	8.2	290	9.9
8.2	2.7	8.2	291	9.9
9.8	2.7	8.2	291	10.0
11.5	3.0	8.2	291	10.0
13.1	3.0	8.2	291	10.0
14.8	3.0	8.2	291	10.0
16.4	3.0	8.2	291	9.9
18.0	3.0	8.1	292	9.7
19.7	3.1	8.1	293	9.5
21.3	3.3	8.0	296	9.2
22.0	3.6	7.9	306	8.8
	February 3, 1998, Secchi-disc depth, 10.2 feet			
0.4	2.9	8.1	359	10.8
1.6	2.9	8.1	359	10.8
3.3	2.9	8.1	359	10.8
5.0	3.0	8.1	359	10.8
6.6	3.0	8.1	359	10.8
8.3	3.0	8.1	359	10.8
9.9	3.0	8.1	358	10.8
11.5	3.1	8.1	360	10.8
13.2	3.2	8.1	359	10.8
14.8	3.3	8.1	360	10.9
16.4	3.4	8.1	362	10.9
18.2	3.8	8.1	370	10.8
19.8	3.8	8.0	372	10.6
21.8	3.9	8.0	375	10.3

Table 9. Profile of onsite measurements for site R2, Boulder Reservoir near north dam, April 1997–July 1998—Continued

[C, Celsius; μS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter]

Depth (feet)	Temperature (degrees C)	pH (units)	Specific conductance (μS/cm)	Dissolved oxygen (mg/L)
	March 3, 1998, Secchi-disc depth, 5.5 feet			
0.7	3.1	8.0	372	10.3
1.0	3.1	8.0	372	10.4
2.0	3.1	8.0	372	10.4
3.1	3.0	8.0	372	10.4
4.0	3.0	8.0	372	10.4
5.0	3.1	8.0	372	10.4
5.9	3.0	8.0	373	10.5
7.0	3.0	8.0	372	10.5
8.0	3.0	8.0	373	10.5
9.1	3.0	8.0	373	10.5
10.0	3.0	8.0	372	10.5
11.0	3.0	8.0	373	10.5
11.9	3.0	8.0	373	10.5
13.0	3.0	8.0	373	10.5
14.1	3.0	8.0	373	10.5
15.1	3.0	8.0	373	10.5
16.0	3.0	8.0	373	10.5
17.0	3.0	8.0	373	10.5
18.0	3.0	8.0	373	10.5
19.0	3.0	8.0	373	10.5
20.1	3.1	8.0	373	10.5
20.9	3.1	8.0	373	10.4
22.0	3.2	8.0	374	10.3
	April 7, 1998, Secchi-disc depth 2.5 feet			
0.5	9.7	8.1	407	8.6
1.0	9.7	8.1	407	8.6
3.0	9.6	8.1	406	8.6
5.0	9.3	8.1	403	8.6
7.0	9.2	8.1	404	8.6
8.1	9.2	8.1	404	8.6
9.0	9.2	8.1	404	8.6
10.0	9.2	8.1	405	8.6
11.0	9.2	8.1	404	8.6
12.0	9.2	8.1	404	8.5
13.0	9.2	8.1	402	8.5
14.0	9.1	8.1	402	8.5
15.0	9.1	8.1	404	8.5
16.0	9.0	8.1	399	8.4
17.0	9.0	8.1	411	8.4
18.0	9.0	8.1	415	8.3
19.0	8.8	8.0	416	8.2
20.1	8.8	8.0	416	8.2
21.1	8.6	8.0	417	8.0
22.0	8.6	8.0	417	8.0
	May 5, 1998, Secchi-disc depth, 4.0 feet			
0.7	15.8	8.2	422	7.8
1.0	15.6	8.2	423	7.8
2.0	15.2	8.2	422	7.8
3.1	15.0	8.2	422	7.9
4.0	14.8	8.2	422	7.9
5.0	14.7	8.2	421	7.9
5.9	14.6	8.2	421	7.9
6.9	14.6	8.2	421	7.9
8.3	14.5	8.2	421	7.9
9.0	14.4	8.2	421	7.9
9.9	14.4	8.2	421	7.9
11.0	14.3	8.2	421	7.8
12.0	14.3	8.2	421	7.8
12.9	14.2	8.2	421	7.8
13.9	14.2	8.2	421	7.8
15.1	14.2	8.2	421	7.8
16.1	14.0	8.1	419	7.4
17.1	12.8	8.0	418	6.9
18.1	12.6	7.9	419	6.7
19.1	12.5	7.8	420	6.4
20.1	12.4	7.8	422	6.2
21.1	12.2	7.7	424	5.9
22.0	12.1	7.7	423	5.8
22.9	12.0	7.7	424	5.7
24.1	12.0	7.7	424	5.6
24.8	11.9	7.6	424	5.2

Table 9. Profile of onsite measurements for site R2, Boulder Reservoir near north dam, April 1997–July 1998—Continued

[C, Celsius; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter]

Depth (feet)	Temperature (degrees C)	pH (units)	Specific conductance (µS/cm)	Dissolved oxygen (mg/L)	Depth (feet)	Temperature (degrees C)	pH (units)	Specific conductance (µS/cm)	Dissolved oxygen (mg/L)
	June 2, 1998, Secchi-disc depth, 2.5 feet								
1.0	18.8	8.1	410	7.0		July 7, 1998, Secchi-disc depth, 5.5 feet			
2.0	18.8	8.1	410	7.0	1.0	21.7	8.1	298	7.1
3.1	18.7	8.1	410	7.0	2.0	21.6	8.1	297	7.2
4.1	18.7	8.1	410	7.0	2.9	21.5	8.1	297	7.2
5.2	18.5	8.1	410	7.0	4.1	21.3	8.1	296	7.2
6.2	18.4	8.1	410	7.0	5.0	21.3	8.1	297	7.2
7.1	18.4	8.1	410	7.0	6.0	21.2	8.1	296	7.2
8.1	18.3	8.1	410	7.0	7.1	21.0	8.1	294	7.2
9.0	18.3	8.0	410	7.0	7.9	20.9	8.1	293	7.2
10.0	18.3	8.0	411	6.9	9.5	20.8	8.1	285	7.2
11.0	18.3	8.0	411	6.9	9.9	20.2	8.0	277	7.2
11.8	18.3	8.0	411	6.9	11.1	19.8	8.0	278	7.1
13.0	18.3	8.0	411	6.9	12.0	19.5	7.9	278	7.0
14.1	18.3	8.0	411	6.9	13.1	19.0	7.8	274	6.7
15.1	18.3	8.0	411	6.9	14.1	18.8	7.7	275	6.6
16.1	18.2	8.0	411	6.9	15.1	18.7	7.7	278	6.5
17.2	18.2	8.0	411	6.9	16.0	18.6	7.7	280	6.3
18.1	18.2	8.0	411	6.9	17.0	18.3	7.5	284	5.8
18.9	18.2	8.0	411	6.9	18.0	18.1	7.5	286	5.7
19.9	18.2	8.0	410	6.9	19.0	18.0	7.4	288	5.5
20.9	18.1	8.0	410	6.9	20.0	18.0	7.4	292	5.2
22.2	18.1	8.0	409	6.9	21.0	17.8	7.3	298	4.8
23.4	18.0	8.0	405	6.8	22.1	17.6	7.3	304	4.3
24.1	17.9	8.0	404	6.8	23.3	17.4	7.2	308	3.5
24.9	17.1	8.0	378	6.8	24.2	17.3	7.1	311	3.3
26.0	16.6	7.9	361	7.0	25.0	17.3	7.1	311	3.2
					26.0	17.0	7.1	318	2.3
					27.1	16.9	7.0	320	1.9
					27.5	16.9	7.0	321	1.7

Table 10. Profile of onsite measurements for site R3, Boulder Reservoir near center of reservoir, April 1997–July 1998

[C, Celsius; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter]

Depth (feet)	Temperature (degrees C)	pH (units)	Specific conductance (µS/cm)	Dissolved oxygen (mg/L)
April 1, 1997, Secchi-disc depth, 1.5 feet				
0.5	8.9	7.9	516	8.7
1.2	8.9	7.9	517	8.7
2.0	8.9	7.9	517	8.7
3.0	8.9	7.9	517	8.7
4.0	8.9	7.9	517	8.8
5.2	8.9	7.9	517	8.7
6.3	8.8	7.9	517	8.7
7.4	8.9	7.9	518	8.8
8.5	8.9	7.9	518	8.8
9.6	8.8	7.9	518	8.8
10.4	8.9	7.9	518	8.8
May 6, 1997, Secchi-disc depth, 4.5 feet				
0.6	14.9	8.0	361	8.4
1.0	14.9	8.0	361	8.4
2.0	14.9	8.0	361	8.3
3.0	14.8	8.0	361	8.3
4.1	14.0	8.0	365	8.3
5.0	13.5	8.0	369	8.3
6.1	12.9	8.0	368	8.4
7.0	12.6	8.0	360	8.4
8.0	12.5	8.0	366	8.4
8.9	12.3	8.0	380	8.3
10.0	12.1	8.0	378	8.4
11.0	12.0	8.0	369	8.4
12.0	12.0	8.0	369	8.4
13.0	12.1	8.0	378	8.4
13.9	12.1	8.0	380	8.3
15.0	11.9	8.0	372	8.3
16.0	11.8	8.0	371	8.1
17.0	11.7	8.0	383	7.9
17.3	11.6	8.0	388	7.8
18.0	11.5	8.0	390	7.8
June 3, 1997, Secchi-disc depth, 8.0 feet				
0.5	20.0	8.0	345	7.7
1.1	20.0	8.0	345	7.7
2.0	19.9	8.0	345	7.7
3.0	19.8	8.0	345	7.7
4.0	19.3	8.0	345	7.7
5.0	19.2	8.0	345	7.7
6.1	19.1	8.0	345	7.7
7.0	19.0	8.0	344	7.7
8.0	18.9	8.0	344	7.7
8.9	18.9	8.0	344	7.6
10.2	18.8	8.0	344	7.6
11.0	18.8	7.9	344	7.4
12.1	18.5	7.8	345	7.1
13.0	17.4	7.7	344	6.8
14.0	17.2	7.7	344	6.7
15.0	17.1	7.7	343	6.7
16.0	17.0	7.7	341	6.7
17.0	16.8	7.6	338	6.6
18.0	16.5	7.4	341	5.2
19.0	16.0	7.4	343	4.7
20.0	15.6	7.3	344	4.5
20.6	15.5	7.3	345	4.1
21.0	15.5	7.3	345	4.0
21.5	15.4	7.3	346	3.8
22.0	15.4	7.4	347	3.8
22.6	15.3	7.4	347	3.8
23.1	15.3	7.4	347	3.7

Table 10. Profile of onsite measurements for site R3, Boulder Reservoir near center of reservoir, April 1997–July 1998 —Continued

[C, Celsius; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter]

Depth (feet)	Temperature (degrees C)	pH (units)	Specific conductance (µS/cm)	Dissolved oxygen (mg/L)
July 2, 1997, Secchi-disc depth, 9.0 feet				
0.3	23.1	8.0	378	6.6
1.0	23.0	7.9	379	6.6
2.0	22.7	8.0	378	6.6
3.0	22.6	8.0	377	6.6
4.0	22.4	8.0	378	6.6
5.0	22.4	8.0	377	6.6
6.1	22.3	8.0	377	6.6
7.0	22.2	8.0	377	6.6
8.0	22.2	8.0	378	6.6
8.9	22.0	8.0	377	6.7
10.0	22.0	8.0	377	6.7
11.1	22.0	8.0	378	6.7
12.1	21.9	8.0	377	6.7
13.1	21.8	8.0	377	6.7
13.9	21.8	8.0	377	6.6
15.0	21.7	7.9	378	6.3
16.0	21.6	7.8	378	6.1
17.0	21.5	7.6	378	5.4
18.0	21.0	7.3	379	4.1
19.0	20.6	7.3	377	3.3
20.1	19.7	7.2	372	2.1
21.0	18.8	7.1	373	1.1
22.0	18.5	7.1	371	0.6
22.2	18.0	7.1	372	0.1
22.5	17.7	7.1	371	0.1
23.4	17.2	7.1	371	0.0
August 6, 1997, Secchi-disc depth, 5.0 feet				
0.5	21.7	8.0	295	6.2
1.0	21.8	7.9	295	6.2
2.0	21.8	7.9	295	6.2
3.0	21.8	7.9	295	6.2
4.0	21.7	7.9	295	6.2
5.0	21.8	7.9	295	6.2
6.1	21.8	7.9	296	6.2
7.0	21.7	7.9	295	6.2
8.0	21.7	7.9	295	6.2
9.0	21.7	7.9	295	6.1
10.0	21.7	7.9	295	6.1
11.0	21.7	7.9	295	6.1
12.0	21.7	7.9	295	6.1
13.0	21.7	7.9	295	6.1
14.0	21.7	7.9	295	6.0
15.0	21.7	7.9	294	5.9
16.0	21.6	7.9	295	5.9
17.0	21.6	7.8	295	5.8
18.0	21.5	7.8	292	5.6
19.0	21.0	7.7	286	5.2
20.2	20.9	7.7	286	5.2
September 3, 1997, Secchi-disc depth, 4.0 feet				
0.7	21.9	8.1	343	6.7
1.0	21.9	8.1	343	6.7
2.0	21.8	8.1	343	6.7
3.1	21.8	8.1	343	6.7
4.0	21.7	8.1	343	6.7
5.0	21.7	8.1	343	6.7
6.2	21.5	8.1	343	6.6
6.9	21.5	8.1	344	6.6
8.0	21.4	8.1	345	6.6
9.0	21.4	8.1	345	6.6
10.0	21.4	8.1	346	6.6
11.0	21.3	8.1	347	6.5
12.0	21.3	8.1	349	6.0
13.1	20.9	7.7	338	4.2
14.0	20.6	7.4	330	2.6
15.0	20.4	7.3	334	1.9
15.8	20.1	7.2	327	1.3

Table 10. Profile of onsite measurements for site R3, Boulder Reservoir near center of reservoir, April 1997–July 1998 —Continued

[C, Celsius; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter]

Depth (feet)	Temperature (degrees C)	pH (units)	Specific conductance (µS/cm)	Dissolved oxygen (mg/L)
October 7, 1997, Secchi-disc depth, 3.0 feet				
0.5	17.6	8.2	254	7.4
1.0	17.2	8.2	256	7.4
2.0	16.4	8.3	256	7.4
3.0	16.2	8.2	257	7.4
4.0	16.1	8.2	256	7.4
5.0	16.0	8.2	257	7.3
6.0	16.0	8.2	257	7.3
7.0	16.0	8.2	256	7.2
8.0	16.0	8.1	256	7.2
9.0	16.0	8.1	256	7.2
10.0	15.9	8.1	255	7.1
11.0	15.9	8.0	254	7.0
12.0	15.8	8.0	252	6.9
13.0	15.8	8.0	251	6.8
14.0	15.6	7.9	249	6.7
15.0	15.6	7.9	247	6.7
16.0	15.5	7.9	246	6.5
16.3	15.4	7.8	244	6.2
November 4, 1997, Secchi-disc depth, 2.0 feet				
0.7	7.4	7.9	272	9.2
0.9	7.4	7.9	272	9.2
1.0	7.4	7.9	272	9.2
2.0	7.4	7.9	272	9.2
3.0	7.4	7.9	272	9.2
4.0	7.4	7.9	272	9.2
5.0	7.4	7.9	272	9.2
6.0	7.3	7.9	272	9.2
7.0	7.3	7.9	272	9.2
8.0	7.4	7.9	272	9.2
9.0	7.4	7.9	272	9.2
10.0	7.4	7.9	272	9.2
11.0	7.4	7.9	272	9.2
12.0	7.4	7.9	272	9.2
13.0	7.3	7.9	272	9.2
14.0	7.4	7.9	272	9.2
15.0	7.3	7.9	272	9.2
16.0	7.3	7.9	271	9.2
17.0	7.3	7.9	272	9.2
17.9	7.3	7.9	272	9.2
18.6	7.3	7.9	271	9.2

Depth (feet)	Temperature (degrees C)	pH (units)	Specific conductance (µS/cm)	Dissolved oxygen (mg/L)
December 3, 1997, Secchi-disc depth, 4.6 feet				
0.3	3.0	8.3	289	10.0
1.6	2.9	8.3	289	10.0
3.3	2.9	8.3	289	9.9
4.9	2.9	8.3	289	10.0
6.6	2.9	8.3	289	10.0
8.2	2.9	8.3	289	9.9
9.8	2.9	8.3	289	9.9
11.5	3.0	8.2	290	9.9
13.1	3.1	8.2	292	9.9
15.1	3.2	8.2	294	9.8
February 3, 1998, Secchi-disc depth, 9.8 feet				
0.4	3.2	8.1	359	10.9
1.7	3.2	8.2	359	10.9
3.3	3.2	8.2	359	10.9
5.0	3.1	8.2	359	10.9
6.6	3.1	8.2	360	10.9
8.3	3.1	8.2	359	10.9
9.9	3.1	8.2	359	10.9
11.5	3.2	8.2	359	10.9
13.2	3.2	8.2	359	10.9
14.8	3.3	8.2	360	10.9
16.9	3.3	8.2	360	10.9
March 3, 1998, Secchi-disc depth, 5.5 feet				
1.0	3.2	8.0	372	10.4
2.0	3.1	8.0	372	10.4
3.0	3.1	8.0	373	10.4
4.0	3.1	8.0	372	10.4
5.0	3.1	8.0	372	10.4
6.0	3.1	8.0	372	10.4
7.1	3.1	8.0	372	10.4
8.1	3.1	8.0	372	10.4
8.9	3.1	8.0	372	10.4
9.9	3.1	8.0	372	10.4
11.1	3.1	8.0	372	10.4
12.1	3.1	8.0	373	10.4
13.1	3.1	8.0	372	10.4
14.1	3.1	8.0	372	10.4
15.0	3.2	8.0	373	10.4
16.0	3.2	8.0	372	10.4
16.5	3.1	8.0	373	10.4

Table 10. Profile of onsite measurements for site R3, Boulder Reservoir near center of reservoir, April 1997–July 1998 —Continued

[C, Celsius; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter]

Depth (feet)	Temperature (degrees C)	pH (units)	Specific conductance (µS/cm)	Dissolved oxygen (mg/L)	Depth (feet)	Temperature (degrees C)	pH (units)	Specific conductance (µS/cm)	Dissolved oxygen (mg/L)
	April 7, 1998, Secchi-disc depth, 4.0 feet								
0.6	9.8	8.1	412	8.8		June 2, 1998, Secchi-disc depth, 2.5 feet			
1.0	9.9	8.1	412	8.7	1.0	18.9	8.1	410	7.0
2.0	9.8	8.1	412	8.8	2.0	18.9	8.1	410	7.0
3.0	9.8	8.1	413	8.8	4.0	18.8	8.1	410	7.0
4.0	9.9	8.1	412	8.9	6.0	18.8	8.1	411	7.0
5.0	9.8	8.1	412	8.9	8.0	18.4	8.1	412	6.9
5.9	9.7	8.1	413	8.9	10.0	18.4	8.0	412	6.9
7.1	9.7	8.1	412	8.9	12.0	18.4	8.0	412	6.8
8.1	9.5	8.1	413	8.8	14.0	18.3	8.0	412	6.8
9.0	9.3	8.1	412	8.8	16.0	18.1	8.0	406	6.8
9.9	9.2	8.1	411	8.8	18.0	18.0	8.0	403	6.8
11.0	9.2	8.1	411	8.7	19.0	17.9	8.0	403	6.8
12.1	9.2	8.1	411	8.7	20.0	17.9	8.0	399	6.7
13.0	9.2	8.1	412	8.7	21.0	17.7	8.0	394	6.6
14.0	9.2	8.1	411	8.6		July 7, 1998, Secchi-disc depth, 6.0 feet			
15.0	9.2	8.1	411	8.5	1.2	22.2	8.1	296	7.2
16.0	9.1	8.1	414	8.2	2.1	22.2	8.1	296	7.2
	May 5, 1998, Secchi-disc depth, 2.5 feet				3.0	21.9	8.1	296	7.2
0.6	16.8	8.2	426	7.7	4.1	21.6	8.1	295	7.2
1.1	16.7	8.2	426	7.7	5.1	21.3	8.1	295	7.3
2.1	15.6	8.2	427	7.7	6.1	21.1	8.1	295	7.3
3.0	15.1	8.2	422	7.8	7.2	21.1	8.1	295	7.3
4.2	14.7	8.2	423	7.9	8.1	20.8	8.1	292	7.2
5.2	14.7	8.2	422	7.9	9.1	20.4	8.0	283	7.2
6.1	14.6	8.2	422	7.8	10.0	20.2	8.0	276	7.3
7.2	14.5	8.2	421	7.8	11.1	19.8	8.0	272	7.3
8.2	14.5	8.2	421	7.8	11.9	19.7	8.0	274	7.3
9.2	14.3	8.2	421	7.8	13.0	19.5	8.0	274	7.2
10.1	14.2	8.2	420	7.8	14.1	19.2	7.9	269	7.1
11.0	14.1	8.2	421	7.7	15.2	19.0	7.8	269	7.0
12.5	14.1	8.2	420	7.7	16.1	18.9	7.8	267	6.9
13.2	14.0	8.2	420	7.7	17.3	18.2	7.6	270	6.2
14.2	13.9	8.1	418	7.6	18.1	18.1	7.5	284	5.7
15.0	13.8	8.1	419	7.5	18.9	18.0	7.5	286	5.6
16.0	13.8	8.1	420	7.5	19.9	17.9	7.4	289	5.2
17.0	13.8	8.1	420	7.4	21.0	17.7	7.2	295	4.3
18.0	13.7	8.1	421	7.4	22.1	17.5	7.2	305	3.5
19.0	13.7	8.1	422	7.2					

Table 11. Profile of onsite measurements for site R4, Boulder Reservoir near Dry Creek, April 1997–July 1998

[C, Celsius; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter]

Depth (feet)	Temperature (degrees C)	pH (units)	Specific conductance (µS/cm)	Dissolved oxygen (mg/L)
April 1, 1997, Secchi-disc depth, 1.5 feet				
0.8	9.4	8.0	521	9.0
1.4	9.4	8.0	520	9.0
2.2	9.4	8.0	521	9.0
3.2	9.4	8.0	521	9.0
4.2	9.4	8.0	521	9.0
5.4	9.4	8.0	520	9.0
May 6, 1997, Secchi-disc depth, 3.8 feet				
1.1	14.7	8.0	383	8.4
2.0	14.6	8.0	383	8.4
3.0	14.6	8.0	384	8.3
4.0	14.4	8.0	384	8.4
5.0	14.2	8.1	385	8.3
6.0	14.1	8.1	386	8.4
7.0	13.7	8.1	387	8.4
8.0	12.6	8.1	412	8.6
8.6	12.5	8.1	446	8.6
8.7	12.5	8.1	460	8.6
June 3, 1997, Secchi-disc depth, 4.0 feet				
0.6	20.3	8.0	349	7.5
1.0	20.4	8.0	349	7.5
2.0	20.3	8.0	349	7.5
3.0	20.3	8.0	350	7.4
4.0	20.0	8.0	352	7.4
5.0	20.0	8.0	354	7.3
6.0	19.6	8.0	363	7.2
7.1	19.3	8.0	353	7.1
8.0	19.3	7.9	357	6.8
8.9	19.3	7.9	378	6.9
July 2, 1997, Secchi-disc depth, 6.0 feet				
0.9	23.5	8.0	379	6.6
1.1	23.5	8.0	379	6.6
2.0	23.3	8.0	379	6.6
3.0	23.2	8.0	377	6.6
4.0	22.6	8.0	378	6.6
5.0	22.6	8.0	378	6.6
6.0	22.5	8.0	378	6.7
6.9	22.4	8.0	377	6.7
8.0	22.4	8.0	377	6.7
9.0	22.2	8.0	379	6.8
10.0	21.7	8.0	415	6.9
August 6, 1997, Secchi-disc depth, 2.0 feet				
0.5	21.4	8.0	304	6.4
1.0	21.4	8.0	304	6.4
2.0	21.5	8.0	304	6.4
3.0	21.5	8.0	305	6.4
4.0	21.5	8.0	305	6.4
5.0	21.5	8.0	304	6.4
6.0	21.4	8.0	304	6.3
6.4	21.4	8.0	304	6.3
September 3, 1997, Secchi-disc depth, 3.0 feet				
0.9	22.4	8.1	345	6.9
2.0	22.1	8.1	346	6.9
3.0	22.0	8.1	346	6.9
4.0	21.9	8.1	345	6.9
5.0	21.9	8.1	345	7.1
6.0	21.8	8.2	351	8.0
6.2	21.7	8.2	366	7.8
October 7, 1997, Secchi-disc depth, 2.0 feet				
0.5	16.9	8.1	260	7.2
1.0	16.6	8.1	261	7.3
2.0	16.4	8.1	261	7.3
3.0	15.9	8.2	261	7.3
4.0	15.7	8.2	261	7.4
5.0	15.6	8.2	273	7.6
6.0	15.3	8.2	267	7.8
November 4, 1997, Secchi-disc depth, 2.0 feet				
0.7	7.6	8.0	271	9.2
1.0	7.6	7.9	271	9.2
2.0	7.6	8.0	273	9.2
3.0	7.6	7.9	272	9.2
4.0	7.6	7.9	271	9.2
5.0	7.6	7.9	272	9.3
6.0	7.6	7.9	272	9.3
6.4	7.6	7.9	271	9.3
6.9	7.6	7.9	271	9.3

Table 11. Profile of onsite measurements for site R4, Boulder Reservoir near Dry Creek, April 1997–July 1998—Continued

[C, Celsius; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter]

Depth (feet)	Temperature (degrees C)	pH (units)	Specific conductance (µS/cm)	Dissolved oxygen (mg/L)
March 3, 1998, Secchi-disc depth, 6.5 feet				
0.7	3.7	8.0	379	10.6
1.9	3.7	8.0	380	10.5
2.9	3.7	8.0	378	10.5
3.8	3.7	8.0	378	10.5
4.8	3.7	8.0	378	10.5
5.7	3.7	8.0	379	10.5
6.8	3.6	8.1	383	10.6
7.2	3.7	8.1	382	10.7
April 7, 1998, Secchi-disc depth, 2.5 feet				
1.0	9.7	8.2	413	8.6
1.8	9.7	8.2	414	8.6
3.0	9.7	8.2	414	8.6
4.1	9.7	8.2	414	8.6
5.1	9.7	8.2	415	8.6
6.0	9.6	8.2	417	8.6
6.5	9.7	8.2	415	8.6
May 5, 1998, Secchi-disc depth, 2.5 feet				
1.0	16.3	8.2	424	7.7
2.0	15.9	8.2	423	7.8
3.0	15.7	8.2	423	7.7
4.0	14.6	8.2	422	7.8
5.0	14.4	8.2	421	7.7
6.0	14.0	8.2	420	7.7
7.0	13.9	8.2	420	7.8
7.5	13.9	8.2	425	7.8
June 2, 1998, Secchi-disc depth, 2.0 feet				
1.0	19.8	8.1	413	7.2
2.0	19.8	8.1	414	7.2
3.0	19.8	8.1	414	7.2
4.0	19.7	8.1	414	7.2
5.0	19.7	8.1	414	7.2
6.0	19.6	8.1	414	7.1
7.0	19.6	8.1	414	7.2
7.9	19.5	8.1	415	7.2
July 7, 1998, Secchi-disc depth, 5.5 feet				
1.2	22.5	8.1	296	7.2
2.0	22.0	8.1	295	7.2
3.0	21.9	8.0	296	7.2
4.1	21.7	8.1	295	7.2
5.0	21.6	8.1	295	7.2
6.1	21.4	8.1	296	7.1
7.1	21.3	8.1	295	7.1
8.0	21.2	8.1	295	7.1
8.0	20.7	8.0	293	6.9
10.0	20.4	8.0	287	7.0
11.0	19.7	7.9	272	7.0
12.0	19.5	7.9	268	6.8

Table 12. Profile of onsite measurements for site R5, Boulder Reservoir near Little Dry Creek, April 1997–July 1998

[C, Celsius; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter]

Depth (feet)	Temperature (degrees C)	pH (units)	Specific conductance (µS/cm)	Dissolved oxygen (mg/L)
April 1, 1997, Secchi-disc depth, 1.5 feet				
0.7	9.0	8.0	518	8.8
1.3	9.0	8.0	518	8.8
2.4	9.0	8.0	518	8.8
3.1	9.0	8.0	518	8.8
4.5	9.0	8.0	518	8.8
5.2	9.0	8.0	518	8.8
May 6, 1997, Secchi-disc depth, 3.8 feet				
0.8	14.5	8.0	393	8.3
1.0	14.5	8.0	392	8.3
2.0	14.5	8.0	393	8.3
3.0	14.5	8.0	392	8.3
4.0	14.5	8.0	393	8.3
5.0	14.5	8.0	393	8.3
6.0	14.4	8.1	393	8.4
7.1	14.3	8.1	394	8.4
8.0	14.3	8.1	394	8.4
8.4	13.7	8.1	397	8.5
8.8	12.7	8.1	395	8.5
June 3, 1997, Secchi-disc depth, 4.0 feet				
0.6	20.6	8.0	351	7.6
1.0	20.6	8.0	351	7.6
2.1	20.5	8.0	352	7.6
3.0	20.3	8.0	353	7.6
3.9	20.1	8.0	354	7.6
5.0	20.0	8.0	354	7.6
6.0	20.0	8.0	355	7.6
7.0	19.8	8.0	355	7.6
8.0	19.5	8.0	356	7.6
8.8	19.3	8.1	352	7.6
July 2, 1997, Secchi-disc depth, 8.0 feet				
1.0	23.5	8.0	379	6.4
1.9	23.4	8.0	379	6.4
3.0	23.0	8.0	378	6.4
3.9	22.4	8.0	378	6.5
5.0	22.4	8.0	378	6.5
6.1	22.4	8.0	378	6.5
7.1	22.3	8.0	378	6.5
8.0	22.3	8.0	378	6.5
9.2	22.3	8.0	378	6.6
August 6, 1997, Secchi-disc depth, 2.0 feet				
0.5	21.8	8.0	305	6.6
1.0	21.8	8.1	305	6.6
2.0	21.9	8.1	305	6.6
3.0	21.9	8.0	306	6.6
4.0	21.9	8.0	305	6.6
5.0	21.9	8.0	306	6.6
6.0	21.9	8.0	305	6.6
7.1	21.8	8.0	305	6.6
September 3, 1997, Secchi-disc depth, 3.0 feet				
1.0	22.2	8.1	351	7.2
2.0	22.2	8.1	351	7.5
3.0	22.1	8.1	351	7.7
4.0	22.1	8.1	351	7.8
5.0	21.9	8.2	351	8.1
6.0	21.7	8.2	350	8.2
6.9	21.7	8.2	350	8.3
October 7, 1997, Secchi-disc depth, 2.5 feet				
0.5	16.9	8.2	261	7.5
1.0	16.8	8.3	261	7.5
2.0	16.4	8.3	261	7.5
3.0	16.4	8.3	261	7.5
4.0	16.3	8.3	261	7.5
5.0	16.0	8.2	260	7.5
6.0	16.0	8.2	258	7.5
7.0	15.9	8.2	259	7.5
November 4, 1997, Secchi-disc depth, 2.0 feet				
0.8	7.9	8.0	278	9.5
1.0	7.9	8.0	278	9.5
2.0	7.9	8.0	279	9.4
3.0	7.8	8.0	276	9.4
4.0	7.7	8.0	278	9.4
5.0	7.9	8.0	278	9.4
6.0	7.7	8.0	278	9.4
7.0	7.8	8.0	278	9.4
7.6	7.7	8.0	278	9.5

Table 12. Profile of onsite measurements for site R5, Boulder Reservoir near Little Dry Creek, April 1997–July 1998 —Continued

[C, Celsius; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter]

Depth (feet)	Temperature (degrees C)	pH (units)	Specific conductance (µS/cm)	Dissolved oxygen (mg/L)
	March 3, 1998, Secchi-disc depth, 6.0 feet			
1.0	4.1	8.1	380	10.6
2.1	4.1	8.1	381	10.5
3.0	4.2	8.1	381	10.5
4.0	4.1	8.1	380	10.6
5.0	4.1	8.1	380	10.6
6.0	4.1	8.1	380	10.6
7.0	4.0	8.1	380	10.6
7.5	4.0	8.1	379	10.6
	April 7, 1998, Secchi-disc depth, 2.5 feet			
0.8	9.6	8.1	415	8.6
1.0	9.6	8.1	416	8.6
2.2	9.6	8.1	415	8.6
3.1	9.6	8.1	416	8.6
4.0	9.6	8.1	416	8.6
5.1	9.6	8.1	416	8.6
5.9	9.6	8.1	416	8.6
7.0	9.5	8.2	417	8.6
	May 5, 1998, Secchi-disc depth, 2.0 feet			
1.0	16.4	8.2	426	7.7
2.0	16.3	8.2	426	7.7
3.0	16.3	8.2	426	7.7
4.0	16.3	8.2	426	7.7
4.9	15.9	8.2	425	7.7
6.0	14.9	8.2	424	7.7
7.0	14.8	8.1	423	7.7
7.3	14.7	8.1	424	7.6
	June 2, 1998, Secchi-disc depth, 2.0 feet			
1.0	19.5	8.1	416	7.2
2.0	19.5	8.1	415	7.1
3.0	19.5	8.1	416	7.1
4.0	19.5	8.1	416	7.1
5.0	19.4	8.1	416	7.1
5.8	19.3	8.1	416	7.2
	July 7, 1998, Secchi-disc depth 4.0 feet			
1.5	23.2	8.0	302	7.1
2.1	22.8	8.0	303	7.0
3.0	22.5	8.0	306	7.0
4.0	22.2	8.0	309	7.0
5.0	22.0	8.0	312	7.0
5.7	21.9	8.0	310	6.9
6.2	21.9	8.0	322	6.9
7.1	21.7	7.8	328	6.6
8.0	21.6	7.8	331	6.4
9.1	21.3	7.7	334	6.3
10.0	20.9	7.8	314	6.6

Table 13. Concentrations of selected trace elements at site R1, Boulder Reservoir near south dam, April 1997–July 1998

[Concentrations are in micrograms per liter; --, no data; <, less than]

Date	Time	Total depth (feet)	Sample depth (feet)	Alu-minum, dis-solved	Anti-mony, dis-solved	Arsenic, dis-solved	Barium, dis-solved	Beryl-lium, dis-solved	Cad-mium, dis-solved	Chro-mium, dis-solved	Cobalt, dis-solved
04/01/97	0900	16.0	0-4.0	4	<1	<1	56	<1	<1	2	<1
	0905		14.0	3	<1	<1	55	<1	<1	1	<1
06/03/97	1050	28.0	0-16.0	--	--	--	--	--	--	--	--
	1105		25.0	--	--	--	--	--	--	--	--
07/02/97	1130	28.0	0-20.0	--	--	--	--	--	--	--	--
	1200		25.0	--	--	--	--	--	--	--	--
08/06/97	1145	24.2	0-10.0	--	--	--	--	--	--	--	--
	1150		21.0	--	--	--	--	--	--	--	--
09/03/97	0950	20.6	0-12.0	--	--	--	--	--	--	--	--
	1010		18.0	--	--	--	--	--	--	--	--
10/07/97	0930	21.8	0-6.0	--	--	--	--	--	--	--	--
	0950		19.0	--	--	--	--	--	--	--	--
11/04/97	0920	23.0	0-4.0	--	--	--	--	--	--	--	--
	0940		20.0	--	--	--	--	--	--	--	--
03/03/98	1000	22.8	0-11.0	--	--	--	--	--	--	--	--
	1030		20.0	--	--	--	--	--	--	--	--
04/07/98	1000	22.9	0-10.0	--	--	--	--	--	--	--	--
	1045		20.0	--	--	--	--	--	--	--	--
05/05/98	0930	24.5	0-6.0	--	--	--	--	--	--	--	--
	1000		21.5	--	--	--	--	--	--	--	--
06/02/98	1145	26.8	0-4.0	--	--	--	--	--	--	--	--
	1200		24.0	--	--	--	--	--	--	--	--
07/07/98	1000	27.9	0-12.0	--	--	--	--	--	--	--	--
	1030		24.9	--	--	--	--	--	--	--	--

Table 13. Concentrations of selected trace elements at site R1, Boulder Reservoir near south dam, April 1997–July 1998—Continued

Date	Sample depth (feet)	Copper, dis-solved	Iron, dis-solved	Lead, dis-solved	Manga-nese, dis-solved	Molyb-denum, dis-solved	Nickel, dis-solved	Sele-nium, dis-solved	Silver, dis-solved	Ura-nium, natural, dis-solved	Zinc, dis-solved
04/01/97	0-4.0	2	--	<1	<4	1	<1	<1	<1	3.0	1
	14.0	2	--	<1	<4	1	<1	<1	<1	3.0	<1
06/03/97	0-16.0	--	<10	--	<4	--	--	--	--	--	--
	25.0	--	<10	--	13	--	--	--	--	--	--
07/02/97	0-20.0	--	<10	--	14	--	--	--	--	--	--
	25.0	--	130	--	930	--	--	--	--	--	--
08/06/97	0-10.0	--	<10	--	5	--	--	--	--	--	--
	21.0	--	<10	--	45	--	--	--	--	--	--
09/03/97	0-12.0	--	<10	--	<4	--	--	--	--	--	--
	18.0	--	<10	--	330	--	--	--	--	--	--
10/07/97	0-6.0	--	<10	--	<4	--	--	--	--	--	--
	19.0	--	<10	--	<4	--	--	--	--	--	--
11/04/97	0-4.0	--	<10	--	<4	--	--	--	--	--	--
	20.0	--	<10	--	<4	--	--	--	--	--	--
03/03/98	0-11.0	--	<10	--	<4	--	--	--	--	--	--
	20.0	--	<10	--	<4	--	--	--	--	--	--
04/07/98	0-10.0	--	<10	--	<4	--	--	--	--	--	--
	20.0	--	<10	--	<4	--	--	--	--	--	--
05/05/98	0-6.0	--	<10	--	<4	--	--	--	--	--	--
	21.5	--	<10	--	<4	--	--	--	--	--	--
06/02/98	0-4.0	--	<10	--	<4	--	--	--	--	--	--
	24.0	--	<10	--	11	--	--	--	--	--	--
07/07/98	0-12.0	--	<10	--	<4	--	--	--	--	--	--
	24.9	--	<10	--	81	--	--	--	--	--	--

Table 14. Concentrations of selected trace elements at site R2, Boulder Reservoir near north dam, April 1997–July 1998

[Concentrations are in micrograms per liter; --, no data; <, less than]

Date	Time	Total depth (feet)	Sample depth (feet)	Alu-minum, dis-solved	Alu-minum, total recov-erable	Anti-mony, dis-solved	Anti-mony, total	Arsenic, dis-solved	Arsenic, total	Barium, dis-solved	Barium, total recov-erable
04/01/97	1000	15.9	0-3.0	3	340	<1	<2	<1	1	60	<100
	1005		14.0	4	390	<1	<2	<1	1	55	<100
05/06/97	1115	23.0	0-9.0	--	--	--	--	--	--	--	--
	1120		20.0	--	--	--	--	--	--	--	--
06/03/97	0950	28.1	0-16.0	--	--	--	--	--	--	--	--
	1015		25.0	--	--	--	--	--	--	--	--
07/02/97	1020	28.6	0-8.0	--	--	--	--	--	--	--	--
	1040		25.5	--	--	--	--	--	--	--	--
08/06/97	1500	25.1	0-8.0	--	--	--	--	--	--	--	--
	1510		22.1	1	240	<1	--	--	1	44	--
09/03/97	1035	21.5	0-8.0	--	--	--	--	--	--	--	--
	1100		18.5	<1	560	<1	--	--	1	51	--
10/07/97	1020	22.3	0-6.0	--	--	--	--	--	--	--	--
	1045		19.0	--	--	--	--	--	--	--	--
11/04/97	1010	22.9	0-4.0	--	--	--	--	--	--	--	--
	1030		20.0	--	--	--	--	--	--	--	--
03/03/98	1050	22.5	0-11.0	--	--	--	--	--	--	--	--
	1110		20.0	--	--	--	--	--	--	--	--
04/07/98	1110	22.6	0-6.0	--	--	--	--	--	--	--	--
	1130		20.0	--	--	--	--	--	--	--	--
05/05/98	1030	25.3	0-8.0	--	--	--	--	--	--	--	--
	1045		22.3	--	--	--	--	--	--	--	--
06/02/98	1000	26.5	0-5.0	--	--	--	--	--	--	--	--
	1025		23.5	--	--	--	--	--	--	--	--
07/07/98	1100	28.5	0-11.0	--	--	--	--	--	--	--	--
	1130		25.5	--	--	--	--	--	--	--	--

Table 14. Concentrations of selected trace elements at site R2, Boulder Reservoir near north dam, April 1997–July 1998—Continued

Date	Sample depth (feet)	Beryllium, dissolved	Beryllium, total recoverable	Cadmium, dissolved	Cadmium, total	Chromium, dissolved	Chromium, total recoverable	Cobalt, dissolved	Cobalt, total recoverable	Copper, dissolved	Copper, total recoverable
04/01/97	0-3.0	<1	<10	<1	<1	2	<1	<1	<1	1	2
	14.0	<1	<10	<1	<1	2	<1	<1	<1	2	2
05/06/97	0-9.0	--	--	--	--	--	--	--	--	--	--
	20.0	--	--	--	--	--	--	--	--	--	--
06/03/97	0-16.0	--	--	--	--	--	--	--	--	--	--
	25.0	--	--	--	--	--	--	--	--	--	--
07/02/97	0-8.0	--	--	--	--	--	--	--	--	--	--
	25.5	--	--	--	--	--	--	--	--	--	--
08/06/97	0-8.0	--	--	--	--	--	--	--	--	--	--
	22.1	<1	--	<1	<1	1	<1	<1	--	2	2
09/03/97	0-8.0	--	--	--	--	--	--	--	--	--	--
	18.5	<1	--	<1	<1	<1	<1	<1	--	1	2
10/07/97	0-6.0	--	--	--	--	--	--	--	--	--	--
	19.0	--	--	--	--	--	--	--	--	--	--
11/04/97	0-4.0	--	--	--	--	--	--	--	--	--	--
	20.0	--	--	--	--	--	--	--	--	--	--
03/03/98	0-11.0	--	--	--	--	--	--	--	--	--	--
	20.0	--	--	--	--	--	--	--	--	--	--
04/07/98	0-6.0	--	--	--	--	--	--	--	--	--	--
	20.0	--	--	--	--	--	--	--	--	--	--
05/05/98	0-8.0	--	--	--	--	--	--	--	--	--	--
	22.3	--	--	--	--	--	--	--	--	--	--
06/02/98	0-5.0	--	--	--	--	--	--	--	--	--	--
	23.5	--	--	--	--	--	--	--	--	--	--
07/07/98	0-11.0	--	--	--	--	--	--	--	--	--	--
	25.5	--	--	--	--	--	--	--	--	--	--

Table 14. Concentrations of selected trace elements at site R2, Boulder Reservoir near north dam, April 1997–July 1998—Continued

Date	Sample depth (feet)	Iron, dis-solved	Iron, total recov-erable	Lead, dis-solved	Lead, total recov-erable	Lithium, total recov-erable	Manga-nese, dis-solved	Manga-nese, total recov-erable	Molyb-denum, dis-solved	Molyb-denum, total recov-erable	Nickel, dis-solved
04/01/97	0-3.0	--	410	<1	<1	20	<4	50	1	<1	1
	14.0	--	490	<1	<1	20	4	60	1	<1	<1
05/06/97	0-9.0	--	--	--	--	--	--	--	--	--	--
	20.0	--	--	--	--	--	--	--	--	--	--
06/03/97	0-16.0	<10	140	--	--	--	<4	10	--	--	--
	25.0	<10	600	--	--	--	57	80	--	--	--
07/02/97	0-8.0	<10	130	--	--	--	7	20	--	--	--
	25.5	44	590	--	--	--	390	730	--	--	--
08/06/97	0-8.0	<10	210	--	--	--	4	20	--	--	--
	22.1	<10	220	<1	<1	--	12	20	1	1	<1
09/03/97	0-8.0	10	180	--	--	--	<4	<10	--	--	--
	18.5	<10	660	<1	<1	--	242	230	1	1	<1
10/07/97	0-6.0	<10	330	--	--	--	<4	<10	--	--	--
	19.0	<10	480	--	--	--	<4	20	--	--	--
11/04/97	0-4.0	<10	540	--	--	--	<4	20	--	--	--
	20.0	<10	570	--	--	--	<4	10	--	--	--
03/03/98	0-11.0	<10	150	--	--	--	<4	<10	--	--	--
	20.0	<10	150	--	--	--	<4	<10	--	--	--
04/07/98	0-6.0	<10	230	--	--	--	<4	<10	--	--	--
	20.0	<10	370	--	--	--	<4	20	--	--	--
05/05/98	0-8.0	<10	150	--	--	--	<4	<10	--	--	--
	22.3	<10	210	--	--	--	7	10	--	--	--
06/02/98	0-5.0	<10	210	--	--	--	<4	20	--	--	--
	23.5	<10	320	--	--	--	<4	20	--	--	--
07/07/98	0-11.0	<10	130	--	--	--	<4	<10	--	--	--
	25.5	<10	500	--	--	--	20	50	--	--	--

Table 14. Concentrations of selected trace elements at site R2, Boulder Reservoir near north dam, April 1997–July 1998—Continued

Date	Sample depth (feet)	Nickel, total, recov-erable	Sele-nium, dis-solved	Sele-nium, total	Silver, dis-solved	Silver, total recov-erable	Stron-tium, total recov-erable	Ura-nium, natural, dis-solved	Zinc, dis-solved	Zinc, total recov-erable
04/01/97	0-3.0	1	<1	1	<1	<1	530	3.0	<1	<10
	14.0	1	<1	<1	<1	<1	540	2.8	1	<10
05/06/97	0-9.0	--	--	--	--	--	--	1.3	--	--
	20.0	--	--	--	--	--	--	1.6	--	--
06/03/97	0-16.0	--	<1	<1	--	--	--	1.7	--	--
	25.0	--	<1	<1	--	--	--	1.6	--	--
07/02/97	0-8.0	--	<1	<1	--	--	--	1.7	--	--
	25.5	--	<1	<1	--	--	--	1.2	--	--
08/06/97	0-8.0	--	<1	<1	--	--	--	1.1	--	--
	22.1	1	<1	<1	<1	<1	--	1.0	<1	<10
09/03/97	0-8.0	--	<1	<1	--	--	--	1.1		--
	18.5	1	<1	<1	<1	<1	--	1.0	<1	<10
10/07/97	0-6.0	--	<1	<1	--	--	--	1.1	--	--
	19.0	--	<1	<1	--	--	--	<1.0	--	--
11/04/97	0-4.0	--	<1	<1	--	--	--	1.1	--	--
	20.0	--	<1	<1	--	--	--	1.4	--	--
03/03/98	0-11.0	--	<1	<1	--	--	--	1.4	--	--
	20.0	--	<1	<1	--	--	--	1.1	--	--
04/07/98	0-6.0	--	<1	<1	--	--	--	1.8	--	--
	20.0	--	<1	<1	--	--	--	1.1	--	--
05/05/98	0-8.0	--	<1	<1	--	--	--	1.9	--	--
	22.3	--	<1	<1	--	--	--	2.0	--	--
06/02/98	0-5.0	--	<1	<1	--	--	--	2.1	--	--
	23.5	--	<1	<1	--	--	--	2.2	--	--
07/07/98	0-11.0	--	<1	<1	--	--	--	1.3	--	--
	25.5	--	<1	<1	--	--	--	1.1	--	--

Table 15. Concentrations of selected trace elements at site R3, Boulder Reservoir near center of reservoir, April 1997–July 1998

[Concentrations are in micrograms per liter; --, no data; <, less than]

Date	Time	Total depth (feet)	Sample depth (feet)	Alu-minum, dis-solved	Anti-mony, dis-solved	Arsenic, dis-solved	Barium, dis-solved	Beryl-lium, dis-solved	Cad-mium, dis-solved	Chro-mium, dis-solved	Cobalt, dis-solved
04/01/97	1030	11.0	0-3.0	3	<1	<1	57	<1	<1	2	<1
	1035		9.0	4	<1	<1	56	<1	<1	2	<1
06/03/97	1140	23.5	0-16.0	--	--	--	--	--	--	--	--
	1200		20.0	--	--	--	--	--	--	--	--
07/02/97	1240	23.8	0-18.0	--	--	--	--	--	--	--	--
	1300		21.0	--	--	--	--	--	--	--	--
08/06/97	1420	20.7	0-10.0	--	--	--	--	--	--	--	--
	1430		17.7	--	--	--	--	--	--	--	--
09/03/97	1135	16.1	0-8.0	--	--	--	--	--	--	--	--
	1150		13.0	--	--	--	--	--	--	--	--
10/07/97	1200	16.8	0-6.0	--	--	--	--	--	--	--	--
	1215		14.0	--	--	--	--	--	--	--	--
11/04/97	1105	19.0	0-4.0	--	--	--	--	--	--	--	--
	1120		16.0	--	--	--	--	--	--	--	--
03/03/98	1140	17.3	0-11.0	--	--	--	--	--	--	--	--
	1150		15.0	--	--	--	--	--	--	--	--
04/07/98	1200	16.6	0-8.0	--	--	--	--	--	--	--	--
	1230		14.0	--	--	--	--	--	--	--	--
05/05/98	1120	20.0	0-5.0	--	--	--	--	--	--	--	--
	1130		17.0	--	--	--	--	--	--	--	--
06/02/98	1100	21.7	0-5.0	--	--	--	--	--	--	--	--
	1120		19.0	--	--	--	--	--	--	--	--
07/07/98	1210	23.3	0-12.0	--	--	--	--	--	--	--	--
	1230		20.3	--	--	--	--	--	--	--	--

Table 15. Concentrations of selected trace elements at site R3, Boulder Reservoir near center of reservoir, April 1997–July 1998—Continued

Date	Sample depth (feet)	Copper, dis-solved	Iron, dis-solved	Lead, dis-solved	Manga-nese, dis-solved	Molyb-denum, dis-solved	Nickel, dis-solved	Sele-nium, dis-solved	Silver, dis-solved	Ura-nium, natural, dis-solved	Zinc, dis-solved
04/01/97	0-3.0	1	--	<1	<4	1	<1	<1	<1	3.0	<1
	9.0	1	--	<1	<4	1	<1	<1	<1	3.0	<1
06/03/97	0-16.0	--	<10	--	<4	--	--	--	--	--	--
	20.0	--	<10	--	4	--	--	--	--	--	--
07/02/97	0-18.0	--	<10	--	6	--	--	--	--	--	--
	21.0	--	<10	--	110	--	--	--	--	--	--
08/06/97	0-10.0	--	<10	--	8	--	--	--	--	--	--
	17.7	--	<10	--	26	--	--	--	--	--	--
09/03/97	0-8.0	--	<10	--	<4	--	--	--	--	--	--
	13.0	--	<10	--	<4	--	--	--	--	--	--
10/07/97	0-6.0	--	<10	--	<4	--	--	--	--	--	--
	14.0	--	<10	--	<4	--	--	--	--	--	--
11/04/97	0-4.0	--	<10	--	<4	--	--	--	--	--	--
	16.0	--	<10	--	<4	--	--	--	--	--	--
03/03/98	0-11.0	--	<10	--	<4	--	--	--	--	--	--
	15.0	--	<10	--	<4	--	--	--	--	--	--
04/07/98	0-8.0	--	<10	--	<4	--	--	--	--	--	--
	14.0	--	<10	--	<4	--	--	--	--	--	--
05/05/98	0-5.0	--	<10	--	<4	--	--	--	--	--	--
	17.0	--	<10	--	<4	--	--	--	--	--	--
06/02/98	0-5.0	--	<10	--	<4	--	--	--	--	--	--
	19.0	--	<10	--	<4	--	--	--	--	--	--
07/07/98	0-12.0	--	<10	--	<4	--	--	--	--	--	--
	20.3	--	<10	--	9	--	--	--	--	--	--

Table 16. Concentrations of selected trace elements at site R4, Boulder Reservoir near Dry Creek, April 1997–July 1998

[Concentrations are in micrograms per liter; --, no data; <, less than]

Date	Time	Total depth (feet)	Sample depth (feet)	Aluminum, dissolved	Antimony, dissolved	Arsenic, dissolved	Barium, dissolved	Beryllium, dissolved	Cadmium, dissolved	Chromium, dissolved	Cobalt, dissolved
04/01/97	1100	5.8	0-3.0	3	<1	<1	58	<1	<1	2	<1
06/03/97	1240	9.5	0-8.0	--	--	--	--	--	--	--	--
07/02/97	1330	10.5	0-8.0	--	--	--	--	--	--	--	--
08/06/97	1400	6.8	0-4.0	--	--	--	--	--	--	--	--
09/03/97	1225	6.6	0-4.5	--	--	--	--	--	--	--	--
10/07/97	1115	6.5	0-5.0	--	--	--	--	--	--	--	--
11/04/97	1230	7.4	0-4.0	--	--	--	--	--	--	--	--
03/03/98	1315	7.7	0-5.0	--	--	--	--	--	--	--	--
04/07/98	1250	7.0	0-5.0	--	--	--	--	--	--	--	--
05/05/98	1230	8.0	0-5.0	--	--	--	--	--	--	--	--
06/02/98	1340	8.5	0-4.0	--	--	--	--	--	--	--	--
07/07/98	1300	13.0	0-11.0	--	--	--	--	--	--	--	--

Date	Sample depth (feet)	Copper, dissolved	Iron, dissolved	Lead, dissolved	Manganese, dissolved	Molybdenum, dissolved	Nickel, dissolved	Selenium, dissolved	Silver, dissolved	Uranium, natural, dissolved	Zinc, dissolved
04/01/97	0-3.0	2	--	<1	<4	1	<1	<1	<1	3.0	<1
06/03/97	0-8.0	--	<10	--	<4	--	--	--	--	--	--
07/02/97	0-8.0	--	<10	--	<4	--	--	--	--	--	--
08/06/97	0-4.0	--	<10	--	<4	--	--	--	--	--	--
09/03/97	0-4.5	--	<10	--	<4	--	--	--	--	--	--
10/07/97	0-5.0	--	<10	--	<4	--	--	--	--	--	--
11/04/97	0-4.0	--	<10	--	<4	--	--	--	--	--	--
03/03/98	0-5.0	--	<10	--	<4	--	--	--	--	--	--
04/07/98	0-5.0	--	<10	--	<4	--	--	--	--	--	--
05/05/98	0-5.0	--	<10	--	<4	--	--	--	--	--	--
06/02/98	0-4.0	--	<10	--	<4	--	--	--	--	--	--
07/07/98	0-11.0	--	<10	--	<4	--	--	--	--	--	--

Table 17. Concentrations of selected trace elements at site R5, Boulder Reservoir near Little Dry Creek, April 1997–July 1998

[Concentrations are in micrograms per liter; --, no data; <, less than]

Date	Time	Total depth (feet)	Sample depth (feet)	Alu-minum, dis-solved	Alu-minum, total recov-erable	Anti-mony, dis-solved	Anti-mony, total	Arsenic, dis-solved	Arsenic, total	Barium, dis-solved	Barium, total recov-erable
04/01/97	1120	5.6	0-3.0	3	450	<1	<2	<1	1	57	<100
05/06/97	1340	9.3	0-7.0	--	--	--	--	--	--	--	--
06/03/97	1310	10.0	0-8.0	--	--	--	--	--	--	--	--
07/02/97	1400	9.7	0-8.0	--	--	--	--	--	--	--	--
08/06/97	1330	7.5	0-4.0	--	--	--	--	--	--	--	--
09/03/97	1245	7.4	0-6.0	--	--	--	--	--	--	--	--
10/07/97	1300	7.5	0-4.0	--	--	--	--	--	--	--	--
11/04/97	1300	8.1	0-4.0	--	--	--	--	--	--	--	--
03/03/98	1340	7.7	0-5.0	--	--	--	--	--	--	--	--
04/07/98	1315	7.5	0-5.0	--	--	--	--	--	--	--	--
05/05/98	1250	7.8	0-4.0	--	--	--	--	--	--	--	--
06/02/98	1300	6.3	0-4.0	--	--	--	--	--	--	--	--
07/07/98	1330	10.5	0-8.0	--	--	--	--	--	--	--	--

Date	Sample depth (feet)	Beryl-lium, dis-solved	Beryl-lium, total recov-erable	Cad-mium, dis-solved	Cad-mium, total	Chro-mium, dis-solved	Chro-mium, total recov-erable	Cobalt, dis-solved	Cobalt, total recov-erable	Copper, dis-solved	Copper, total recov-erable
04/01/97	0-3.0	<1	<10	<1	<1	2	<1	<1	<1	1	2
05/06/97	0-7.0	--	--	--	--	--	--	--	--	--	--
06/03/97	0-8.0	--	--	--	--	--	--	--	--	--	--
07/02/97	0-8.0	--	--	--	--	--	--	--	--	--	--
08/06/97	0-4.0	--	--	--	--	--	--	--	--	--	--
09/03/97	0-6.0	--	--	--	--	--	--	--	--	--	--
10/07/97	0-4.0	--	--	--	--	--	--	--	--	--	--
11/04/97	0-4.0	--	--	--	--	--	--	--	--	--	--
03/03/98	0-5.0	--	--	--	--	--	--	--	--	--	--
04/07/98	0-5.0	--	--	--	--	--	--	--	--	--	--
05/05/98	0-4.0	--	--	--	--	--	--	--	--	--	--
06/02/98	0-4.0	--	--	--	--	--	--	--	--	--	--
07/07/98	0-8.0	--	--	--	--	--	--	--	--	--	--

Table 17. Concentrations of selected trace elements at site R5, Boulder Reservoir near Little Dry Creek, April 1997–July 1998—Continued

Date	Sample depth (feet)	Iron, dis-solved	Iron, total recov-erable	Lead, dis-solved	Lead, total recov-erable	Lithium, total recov-erable	Manga-nese, dis-solved	Manga-nese, total recov-erable	Molyb-denum, dis-solved	Molyb-denum, total recov-erable	Nickel, dis-solved
04/01/97	0-3.0	--	510	<1	<1	20	<4	50	1	1	1
05/06/97	0-7.0	--	--	--	--	--	--	--	--	--	--
06/03/97	0-8.0	<10	170	--	--	--	<4	10	--	--	--
07/02/97	0-8.0	<10	90	--	--	--	<4	20	--	--	--
08/06/97	0-4.0	<10	380	--	--	--	<4	20	--	--	--
09/03/97	0-6.0	<10	280	--	--	--	<4	20	--	--	--
10/07/97	0-4.0	<10	410	--	--	--	<4	20	--	--	--
11/04/97	0-4.0	<10	580	--	--	--	<4	10	--	--	--
03/03/98	0-5.0	<10	140	--	--	--	<4	<10	--	--	--
04/07/98	0-5.0	<10	230	--	--	--	<4	10	--	--	--
05/05/98	0-4.0	<10	340	--	--	--	<4	10	--	--	--
06/02/98	0-4.0	<10	290	--	--	--	<4	20	--	--	--
07/07/98	0-8.0	<10	190	--	--	--	<4	<10	--	--	--

Date	Sample depth (feet)	Nickel, total, recov-erable	Sele-nium, dis-solved	Sele-nium, total	Silver, dis-solved	Silver, total recov-erable	Stron-tium, total recov-erable	Ura-nium, natural, dis-solved	Zinc, dis-solved	Zinc, total recov-erable
04/01/97	0-3.0	1	<1	<1	<1	<1	530	3.0	<1	<10
05/06/97	0-7.0	--	--	--	--	--	--	1.9	--	--
06/03/97	0-8.0	--	<1	<1	--	--	--	1.6	--	--
07/02/97	0-8.0	--	<1	<1	--	--	--	1.8	--	--
08/06/97	0-4.0	--	<1	<1	--	--	--	<1.0	--	--
09/03/97	0-6.0	--	<1	<1	--	--	--	1.4	--	--
10/07/97	0-4.0	--	<1	<1	--	--	--	1.0	--	--
11/04/97	0-4.0	--	<1	<1	--	--	--	1.2	--	--
03/03/98	0-5.0	--	<1	<1	--	--	--	1.6	--	--
04/07/98	0-5.0	--	<1	<1	--	--	--	1.5	--	--
05/05/98	0-4.0	--	<1	<1	--	--	--	2.1	--	--
06/02/98	0-4.0	--	<1	<1	--	--	--	2.1	--	--
07/07/98	0-8.0	--	<1	<1	--	--	--	1.4	--	--

Table 18. Concentrations of nitrogen and phosphorus in Boulder Reservoir determined by the City of Boulder Drinking Water and Wastewater Laboratories, April 1997–July 1998

[NO_2+NO_3, nitrite plus nitrate; +, plus; mg/L, milligrams per liter; µg/L, micrograms per liter; --, no data; <, less than]

Date	Sampling depth (feet)	Nitrogen, NO_2+NO_3, dissolved (mg/L)	Nitrogen, ammonia, dissolved (mg/L)	Nitrogen, ammonia + organic, total (mg/L)	Phosphorus, ortho, dissolved (µg/L)	Phosphorus, total (µg/L)
			Site R1, Boulder Reservoir near south dam			
04/01/97	0-4.0	<0.01	<0.01	0.5	<1	30
	14.0	<0.01	<0.01	0.6	<1	32
05/06/97	0-9.0	<0.01	0.02	0.3	<1	14
	20.0	0.01	<0.01	0.4	1	30
06/03/97	0-16.0	<0.01	<0.01	0.3	2	9
	25.0	0.01	0.03	0.4	2	16
07/02/97	0-20.0	<0.01	<0.01	0.7	<1	8
	25.0	0.01	0.11	0.5	4	34
08/06/97	0-10.0	0.01	0.01	0.2	<1	28
	21.0	0.02	0.06	0.4	<1	8
09/03/97	0-12.0	0.02	<0.01	1.0	<1	10
	18.0	0.13	<0.01	0.6	<1	11
10/07/97	0-6.0	0.02	0.06	0.4	<1	15
	19.0	0.03	<0.01	0.2	<1	22
11/04/97	0-4.0	0.01	<0.01	0.3	<1	17
	20.0	0.01	<0.01	0.7	<1	21
12/03/97	0-10.0	0.03	<0.01	0.2	<1	12
	20.0	0.03	0.05	0.4	<1	11
02/03/98	0-19.0	0.07	0.12	0.4	<1	5
	17.0	0.06	<0.01	0.2	<1	9
03/03/98	0-11.0	0.04	0.07	0.3	<1	10
	20.0	0.04	<0.01	0.2	<1	10
04/07/98	0-10.0	0.03	0.02	0.4	<1	10
	20.0	0.03	0.07	0.5	1	9
05/05/98	0-6.0	0.05	<0.01	0.3	<1	10
	21.5	0.07	<0.01	0.4	<1	17
06/02/98	0-4.0	0.04	<0.01	0.3	<1	15
	24.0	0.04	0.08	0.4	<1	25
07/07/98	0-12.0	<0.01	<0.01	0.2	<1	9
	24.9	0.04	0.07	0.6	1	21

Table 18. Concentrations of nitrogen and phosphorus in Boulder Reservoir determined by the City of Boulder Drinking Water and Wastewater Laboratories, April 1997–July 1998—Continued

[NO_2+NO_3, nitrite plus nitrate; +, plus; mg/L, milligrams per liter; µg/L, micrograms per liter; --, no data; <, less than]

Date	Sampling depth (feet)	Nitrogen, NO_2+NO_3, dissolved (mg/L)	Nitrogen, ammonia, dissolved (mg/L)	Nitrogen, ammonia + organic, total (mg/L)	Phosphorus, ortho, dissolved (µg/L)	Phosphorus, total (µg/L)
			Site R2, Boulder Reservoir near north dam			
04/01/97	0-3.0	<0.01	<0.01	0.5	<1	30
	14.0	<0.01	<0.01	0.4	<1	34
05/06/97	0-9.0	<0.01	0.01	0.4	1	16
	20.0	<0.01	<0.01	0.2	1	18
06/03/97	0-16.0	<0.01	0.01	0.3	2	9
	25.0	0.02	0.02	0.3	2	16
07/02/97	0-8.0	0.01	<0.01	0.5	<1	9
	25.5	0.01	<0.01	0.9	2	5
08/06/97	0-8.0	0.01	<0.01	0.3	<1	9
	22.1	0.02	0.01	0.3	<1	9
09/03/97	0-8.0	0.03	<0.01	0.6	<1	11
	18.5	0.12	<0.01	0.2	<1	13
10/07/97	0-6.0	0.02	0.03	0.4	<1	18
	19.0	0.02	0.07	0.4	<1	18
11/04/97	0-4.0	0.01	<0.01	0.5	<1	27
	20.0	0.02	<0.01	0.4	1	20
12/03/97	0-10.0	0.04	<0.01	0.3	<1	14
	19.0	0.04	--	--	<1	10
02/03/98	0-20.0	0.07	<0.01	0.3	<1	8
	19.0	0.06	<0.01	0.2	<1	10
03/03/98	0-11.0	0.03	0.01	0.2	<1	8
	20.0	0.04	<0.01	0.3	<1	10
04/07/98	0-6.0	0.03	<0.01	0.3	<1	8
	20.0	0.02	<0.01	0.3	1	13
05/05/98	0-8.0	0.05	<0.01	0.2	<1	10
	22.3	0.08	<0.01	0.3	<1	18
06/02/98	0-5.0	0.06	0.04	0.3	<1	10
	23.5	0.05	0.06	0.4	<1	14
07/07/98	0-11.0	<0.01	0.03	0.3	<1	7
	25.5	0.04	<0.01	0.2	1	8

Table 18. Concentrations of nitrogen and phosphorus in Boulder Reservoir determined by the City of Boulder Drinking Water and Wastewater Laboratories, April 1997–July 1998—Continued

[NO_2+NO_3, nitrite plus nitrate; +, plus; mg/L, milligrams per liter; µg/L, micrograms per liter; --, no data; <, less than]

Date	Sampling depth (feet)	Nitrogen, NO_2+NO_3, dissolved (mg/L)	Nitrogen, ammonia, dissolved (mg/L)	Nitrogen, ammonia + organic, total (mg/L)	Phosphorus, ortho, dissolved (µg/L)	Phosphorus, total (µg/L)
			Site R3, Boulder Reservoir near center of reservoir			
04/01/97	0-3.0	<0.01	<0.01	0.5	<1	35
	9.0	<0.01	<0.01	0.6	<1	38
05/06/97	0-9.0	<0.01	<0.01	0.2	1	14
	16.0	<0.01	<0.01	0.4	<1	38
06/03/97	0-16.0	<0.01	0.05	0.4	1	9
	20.0	<0.01	<0.01	0.4	1	12
07/02/97	0-18.0	0.01	0.02	0.3	<1	10
	21.0	<0.01	0.01	0.3	<1	15
08/06/97	0-10.0	0.01	<0.01	0.3	<1	6
	17.7	0.01	0.06	0.4	<1	5
09/03/97	0-8.0	0.02	<0.01	0.2	<1	10
	13.0	0.03	<0.01	1.1	<1	13
10/07/97	0-6.0	0.02	0.06	0.5	<1	16
	14.0	0.03	<0.01	0.5	<1	19
11/04/97	0-4.0	0.01	<0.01	0.2	1	19
	16.0	0.02	<0.01	0.6	<1	21
12/03/97	0-9.0	0.04	<0.01	0.2	<1	15
	12.0	0.04	<0.01	0.2	<1	12
02/03/98	0-15.0	0.07	<0.01	0.1	<1	7
	14.0	0.07	<0.01	0.3	<1	9
03/03/98	0-11.0	0.04	0.15	0.4	<1	10
	15.0	0.05	<0.01	0.3	<1	12
04/07/98	0-8.0	0.02	0.03	0.5	1	11
	14.0	0.02	0.02	0.4	<1	10
05/05/98	0-5.0	0.05	<0.01	0.9	<1	9
	17.0	0.06	<0.01	0.4	<1	14
06/02/98	0-5.0	0.04	0.08	0.3	<1	13
	19.0	0.05	<0.01	0.4	<1	17
07/07/98	0-12.0	<0.01	<0.01	0.2	<1	6
	20.3	0.02	<0.01	0.3	1	25

Table 18. Concentrations of nitrogen and phosphorus in Boulder Reservoir determined by the City of Boulder Drinking Water and Wastewater Laboratories, April 1997–July 1998—Continued

[NO_2+NO_3, nitrite plus nitrate; +, plus; mg/L, milligrams per liter; µg/L, micrograms per liter; --, no data; <, less than]

Date	Sampling depth (feet)	Nitrogen, NO_2+NO_3, dissolved (mg/L)	Nitrogen, ammonia, dissolved (mg/L)	Nitrogen, ammonia + organic, total (mg/L)	Phosphorus, ortho, dissolved (µg/L)	Phosphorus, total (µg/L)
			Site R4, Boulder Reservoir near Dry Creek			
04/01/97	0-3.0	<0.01	<0.01	0.6	<1	32
05/06/97	0-7.0	<0.01	0.02	0.3	2	14
06/03/97	0-8.0	<0.01	0.03	0.3	1	11
07/02/97	0-8.0	--	<0.01	0.2	<1	11
08/06/97	0-4.0	0.01	0.11	0.5	<1	14
09/03/97	0-4.5	0.01	<0.01	0.2	<1	15
10/07/97	0-5.0	0.03	0.02	0.4	<1	20
11/04/97	0-4.0	0.02	<0.01	1.0	<1	19
03/03/98	0-5.0	0.04	<0.01	0.2	<1	10
04/07/98	0-5.0	0.02	<0.01	0.2	<1	9
05/05/98	0-5.0	0.06	<0.01	0.8	<1	11
06/02/98	0-4.0	0.03	0.09	0.4	<1	13
07/07/98	0-11.0	<0.01	<0.01	0.4	<1	8
			Site R5, Boulder Reservoir near Little Dry Creek			
04/01/97	0-3.0	<0.01	<0.01	0.6	<1	41
05/06/97	0-7.0	<0.01	<0.01	0.3	1	15
06/03/97	0-8.0	<0.01	0.01	0.3	1	9
07/02/97	0-8.0	--	<0.01	0.4	<1	9
08/06/97	0-4.0	--	<0.01	0.3	<1	12
09/03/97	0-6.0	0.01	<0.01	0.9	<1	10
10/07/97	0-4.0	0.02	<0.01	0.3	<1	17
11/04/97	0-4.0	0.01	<0.01	0.2	<1	21
03/03/98	0-5.0	0.02	<0.01	0.3	<1	9
04/07/98	0-5.0	0.02	0.04	0.4	<1	9
05/05/98	0-4.0	0.06	<0.01	0.5	2	12
06/02/98	0-4.0	0.05	<0.01	0.3	<1	14
07/07/98	0-8.0	<0.01	<0.01	0.2	<1	8

Table 19. Concentrations of selected constituents in surficial bottom sediments in Boulder Reservoir, March and August 1997

[Analyses determined on less than 63-micrometer-size fraction; concentrations are in microgram per gram unless noted as percent; %, percent]

Date	Time	Aluminum (%)	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cadmium	Calcium (%)	Carbon, inorganic (%)	Carbon, organic (%)	Cerium
Site R1, Boulder Reservoir near south dam												
03/28/97	0950	8.2	1	9.5	680	2	<10	0.5	1.0	0.18	1.4	82
08/07/97	1045	8.3	1	9.1	620	2	<10	0.6	0.8	0.13	1.3	79
Site R2, Boulder Reservoir near north dam												
03/28/97	1030	8.0	1	9.6	620	2	<10	0.6	0.9	0.11	1.6	83
08/07/97	1015	8.8	1	9.4	610	2	<10	0.7	0.8	0.08	1.6	79
Site R3, Boulder Reservoir near center of reservoir												
03/28/97	1155	7.3	1	9.2	600	2	<10	0.7	0.8	0.08	1.5	87
08/07/97	1130	8.4	1	8.5	610	2	<10	0.8	0.8	0.07	1.5	80
Site R4, Boulder Reservoir near Dry Creek												
03/28/97	1110	7.5	2	13	610	2	<10	0.6	1.4	0.26	1.1	82
08/07/97	1215	6.7	1	9.1	530	2	<10	0.7	1.2	0.28	1.1	93
Site R5, Boulder Reservoir near Little Dry Creek												
03/28/97	1240	7.2	1	7.3	670	2	<10	0.3	1.1	0.18	1.3	88
08/07/97	0930	8.0	1	6.8	650	2	<10	0.4	1.0	0.17	1.2	74

Date	Chromium	Cobalt	Copper	Europium	Gallium	Gold	Holmium	Iron (%)	Lanthanum	Lead	Lithium	Magnesium (%)
Site R1, Boulder Reservoir near south dam												
03/28/97	79	12	42	<2	16	<8	<4	3.7	45	36	50	1.4
08/07/97	77	13	46	<2	20	<8	<4	3.6	48	40	50	1.3
Site R2, Boulder Reservoir near north dam												
03/28/97	83	13	46	<2	23	<8	<4	3.7	47	36	50	1.4
08/07/97	85	13	46	<2	23	<8	<4	4.0	49	36	50	1.3
Site R3, Boulder Reservoir near center of reservoir												
03/28/97	81	14	48	<2	18	<8	<4	3.4	48	36	50	1.3
08/07/97	77	13	59	<2	22	<8	<4	3.6	48	40	50	1.2
Site R4, Boulder Reservoir near Dry Creek												
03/28/97	78	12	35	<2	20	<8	<4	3.7	44	24	50	1.3
08/07/97	67	12	36	<2	22	<8	<4	3.0	54	31	30	1.1
Site R5, Boulder Reservoir near Little Dry Creek												
03/28/97	68	10	18	<2	20	<8	<4	2.9	47	24	40	1.2
08/07/97	67	10	24	<2	20	<8	<4	3.1	44	25	40	1.2

Table 19. Concentrations of selected constituents in surficial bottom sediments in Boulder Reservoir, March and August 1997—Continued

Date	Manga-nese	Mercury	Molyb-denum	Neodym-ium	Nickel	Nio-bium	Phos-phorus (%)	Potas-sium (%)	Scan-dium	Sele-nium	Silver	Sodium (%)
					Site R1, Boulder Reservoir near south dam							
03/28/97	930	0.04	<2	41	28	10	0.11	2.5	13	1.4	0.2	0.80
08/07/97	600	0.04	<2	37	29	18	0.11	2.4	14	1.4	0.2	0.80
					Site R2, Boulder Reservoir near north dam							
03/28/97	700	0.04	<2	42	29	15	0.11	2.4	14	1.6	0.2	0.66
08/07/97	680	0.04	<2	36	30	17	0.11	2.5	15	1.6	0.3	0.61
					Site R3, Boulder Reservoir near center of reservoir							
03/28/97	810	0.04	<2	35	29	7	0.11	2.2	13	1.5	0.2	0.70
08/07/97	580	0.05	<2	37	29	18	0.10	2.5	13	1.5	0.3	0.79
					Site R4, Boulder Reservoir near Dry Creek							
03/28/97	420	<0.02	<2	43	29	12	0.10	2.3	12	1.1	0.2	0.73
08/07/97	490	0.03	<2	42	28	15	0.11	2.0	11	1.0	0.2	0.86
					Site R5, Boulder Reservoir near Little Dry Creek							
03/28/97	360	<0.02	<2	38	22	5	0.08	2.2	11	2.1	0.2	0.93
08/07/97	390	0.03	<2	33	22	16	0.08	2.4	12	1.7	0.2	1.0

Date	Strontium	Sulfur	Tanta-lum	Thorium	Tin	Titanium (%)	Uranium	Vanadium	Yttrium	Ytterbium	Zinc
					Site R1, Boulder Reservoir near south dam						
03/28/97	160	0.07	<40	18	<5	0.39	4.8	150	22	2	140
08/07/97	150	0.07	<40	14	<5	0.41	5.3	150	34	3	140
					Site R2, Boulder Reservoir near north dam						
03/28/97	160	0.10	<40	16	<5	0.40	5.3	160	23	2	150
08/07/97	150	0.15	<40	20	<5	0.42	5.3	160	35	3	150
					Site R3, Boulder Reservoir near center of reservoir						
03/28/97	160	0.07	<40	16	<5	0.39	5.4	150	23	2	150
08/07/97	150	0.08	<40	12	<5	0.39	5.4	150	36	3	140
					Site R4, Boulder Reservoir near Dry Creek						
03/28/97	190	0.05	<40	16	<5	0.37	4.8	150	23	2	130
08/07/97	170	<0.05	<40	16	<5	0.32	5.2	130	33	2	120
					Site R5, Boulder Reservoir near Little Dry Creek						
03/28/97	180	0.11	<40	14	<5	0.35	5.6	120	20	2	110
08/07/97	170	0.09	<40	14	<5	0.33	4.9	120	29	2	110

Table 20. Onsite measurements and concentrations of selected trace elements at site I1, Boulder Feeder Canal above Boulder Reservoir, April 1997–July 1998

[Concentrations of trace elements are in micrograms per liter; ft^3/s, cubic feet per second; µS/cm, microsiemens per centimeter at 25 degrees Celsius; deg C, degrees Celsius; mg/L, milligrams per liter; <, less than; --, no data]

Date	Time	Discharge (ft^3/s)	Specific conductance (µS/cm)	pH (standard units)	Water temperature (deg C)	Oxygen, dissolved (mg/L)	Aluminum, dissolved	Aluminum, total recoverable	Antimony, dissolved	Antimony, total	Arsenic, dissolved
04/02/97	1510	92	73	8.1	5.0	10.7	40	490	<1	<2	<1
05/07/97	1000	140	68	7.9	6.0	12.5	--	--	--	--	--
06/04/97	1415	44	86	8.7	15.5	8.9	--	--	--	--	--
07/01/97	1520	0.66	290	8.6	28.5	12.1	--	--	--	--	--
08/05/97	1345	14	108	8.5	18.0	10.7	--	--	--	--	--
09/09/97	1500	90	68	8.4	11.0	11.6	--	--	--	--	--
10/08/97	1415	28	83	8.7	11.0	10.2	--	--	--	--	--
04/08/98	1000	13	84	8.2	5.5	10.5	--	--	--	--	--
05/06/98	0845	19	94	8.2	11.0	9.5	--	--	--	--	--
06/03/98	0840	40	78	7.8	8.5	9.9	--	--	--	--	--
07/08/98	0845	126	65	7.9	8.0	10.7	--	--	--	--	--

Date	Arsenic, total	Barium, dissolved	Barium, total recoverable	Beryllium, dissolved	Beryllium, total recoverable	Cadmium, dissolved	Cadmium, total	Chromium, dissolved	Chromium, total recoverable	Cobalt, dissolved	Cobalt, total recoverable
04/02/97	<1	19	<100	<1	<10	<1	<1	<1	<1	<1	1
05/07/97	--	--	--	--	--	--	--	--	--	--	--
06/04/97	--	--	--	--	--	--	--	--	--	--	--
07/01/97	--	--	--	--	--	--	--	--	--	--	--
08/05/97	--	--	--	--	--	--	--	--	--	--	--
09/09/97	--	--	--	--	--	--	--	--	--	--	--
10/08/97	--	--	--	--	--	--	--	--	--	--	--
04/08/98	--	--	--	--	--	--	--	--	--	--	--
05/06/98	--	--	--	--	--	--	--	--	--	--	--
06/03/98	--	--	--	--	--	--	--	--	--	--	--
07/08/98	--	--	--	--	--	--	--	--	--	--	--

Table 20. Onsite measurements and concentrations of selected trace elements at site I1, Boulder Feeder Canal above Boulder Reservoir, April 1997–July 1998—Continued

Date	Copper, dis-solved	Copper, total recov-erable	Iron, dis-solved	Iron, total recov-erable	Lead, dis-solved	Lead, total recov-erable	Lithium, total recov-erable	Manga-nese, dis-solved	Manga-nese, total recov-erable	Molyb-denum, dis-solved	Molyb-denum, total recov-erable
04/02/97	2	4	--	650	<1	1	<10	<4	30	<1	<1
05/07/97	--	--	--	--	--	--	--	--	--	--	--
06/04/97	--	--	<10	120	--	--	--	<4	<10	--	--
07/01/97	--	--	14	70	--	--	--	<4	<10	--	--
08/05/97	--	--	<10	70	--	--	--	<4	<10	--	--
09/09/97	--	--	<10	160	--	--	--	<4	10	--	--
10/08/97	--	--	22	100	--	--	--	<4	<10	--	--
04/08/98	--	--	<10	70	--	--	--	<4	<10	--	--
05/06/98	--	--	<10	150	--	--	--	<4	<10	--	--
06/03/98	--	--	<10	100	--	--	--	<4	<10	--	--
07/08/98	--	--	<10	140	--	--	--	<4	<10	--	--

Date	Nickel, dis-solved	Nickel, total, recov-erable	Sele-nium, dis-solved	Sele-nium, total	Silver, dis-solved	Silver, total recov-erable	Stron-tium, total recov-erable	Ura-nium, natural, dis-solved	Zinc, dis-solved	Zinc, total recov-erable
04/02/97	<1	2	<1	<1	<1	<1	50	<1.0	<1	<10
05/07/97	--	--	--	--	--	--	--	<1.0	--	--
06/04/97	--	--	<1	<1	--	--	--	<1.0	--	--
07/01/97	--	--	<1	<1	--	--	--	1.4	--	--
08/05/97	--	--	<1	<1	--	--	--	<1.0	--	--
09/09/97	--	--	<1	<1	--	--	--	<1.0	--	--
10/08/97	--	--	<1	<1	--	--	--	<1.0	--	--
04/08/98	--	--	<1	<1	--	--	--	<1.0	--	--
05/06/98	--	--	<1	<1	--	--	--	<1.0	--	--
06/03/98	--	--	<1	<1	--	--	--	<1.0	--	--
07/08/98	--	--	<1	<1	--	--	--	<1.0	--	--

Table 21. Onsite measurements and concentrations of selected trace elements at site I2, Dry Creek above Boulder Reservoir, April 1997–July 1998

[Concentrations of trace elements are in micrograms per liter; ft^3/s, cubic feet per second; µS/cm, microsiemens per centimeter at 25 degrees Celsius; deg C, degrees Celsius; mg/L, milligrams per liter; <, less than; --, no data]

Date	Time	Discharge (ft^3/s)	Specific conductance (µS/cm)	pH (standard units)	Water temperature (deg C)	Oxygen, dissolved (mg/L)	Aluminum, dissolved	Aluminum, total recoverable	Antimony, dissolved	Antimony, total	Arsenic, dissolved
04/02/97	1330	0.45	1,690	8.3	8.5	11.0	7	230	<1	<2	<1
05/07/97	1315	0.78	1,310	8.4	18.0	8.9	--	--	--	--	--
06/04/97	1300	0.66	1,240	8.2	24.0	10.1	--	--	--	--	--
07/01/97	1350	0.68	1,210	8.2	23.5	9.2	--	--	--	--	--
08/05/97	1205	1.1	870	7.9	23.0	6.7	--	--	--	--	--
09/09/97	1325	0.95	822	8.3	21.0	8.2	--	--	--	--	--
10/08/97	1250	0.37	1,410	8.2	14.0	8.3	--	--	--	--	--
11/05/97	1230	0.52	1,400	8.2	8.5	10.5	--	--	--	--	--
03/04/98	1010	0.32	1,640	8.3	5.5	11.0	--	--	--	--	--
04/08/98	1140	1.3	1,580	8.3	9.0	10.7	--	--	--	--	--
05/06/98	1250	2.4	1,080	8.3	15.0	8.2	--	--	--	--	--
06/03/98	1320	1.7	888	8.3	16.0	7.5	--	--	--	--	--
07/08/98	1220	0.78	1,180	8.3	20.5	7.3	--	--	--	--	--

Date	Arsenic, total	Barium, dissolved	Barium, total recoverable	Beryllium, dissolved	Beryllium, total recoverable	Cadmium, dissolved	Cadmium, total	Chromium, dissolved	Chromium, total recoverable	Cobalt, dissolved	Cobalt, total recoverable
04/02/97	1	51	<100	<1	<10	<1	<1	3	<1	<1	<1
05/07/97	--	--	--	--	--	--	--	--	--	--	--
06/04/97	--	--	--	--	--	--	--	--	--	--	--
07/01/97	--	--	--	--	--	--	--	--	--	--	--
08/05/97	--	--	--	--	--	--	--	--	--	--	--
09/09/97	--	--	--	--	--	--	--	--	--	--	--
10/08/97	--	--	--	--	--	--	--	--	--	--	--
11/05/97	--	--	--	--	--	--	--	--	--	--	--
03/04/98	--	--	--	--	--	--	--	--	--	--	--
04/08/98	--	--	--	--	--	--	--	--	--	--	--
05/06/98	--	--	--	--	--	--	--	--	--	--	--
06/03/98	--	--	--	--	--	--	--	--	--	--	--
07/08/98	--	--	--	--	--	--	--	--	--	--	--

Table 21. Onsite measurements and concentrations of selected trace elements at site I2, Dry Creek above Boulder Reservoir, April 1997–July 1998--Continued

Date	Copper, dis-solved	Copper, total recov-erable	Iron, dis-solved	Iron, total recov-erable	Lead, dis-solved	Lead, total recov-erable	Lithium, total recov-erable	Manga-nese, dis-solved	Manga-nese, total recov-erable	Molyb-denum, dis-solved	Molyb-denum, total recov-erable
04/02/97	<1	<1	--	420	<1	<1	80	82	90	4	4
05/07/97	--	--	--	--	--	--	--	--	--	--	--
06/04/97	--	--	11	330	--	--	--	29	40	--	--
07/01/97	--	--	<10	420	--	--	--	12	40	--	--
08/05/97	--	--	<10	1,000	--	--	--	32	60	--	--
09/09/97	--	--	<10	610	--	--	--	15	40	--	--
10/08/97	--	--	<10	430	--	--	--	31	40	--	--
11/05/97	--	--	<10	500	--	--	--	31	50	--	--
03/04/98	--	--	<10	310	--	--	--	55	70	--	--
04/08/98	--	--	<10	580	--	--	--	60	70	--	--
05/06/98	--	--	10	390	--	--	--	30	50	--	--
06/03/98	--	--	<10	370	--	--	--	18	40	--	--
07/08/98	--	--	<10	410	--	--	--	15	40	--	--

Date	Nickel, dis-solved	Nickel, total, recov-erable	Sele-nium, dis-solved	Sele-nium, total	Silver, dis-solved	Silver, total recov-erable	Stron-tium, total recov-erable	Ura-nium, natural, dis-solved	Zinc, dis-solved	Zinc, total recov-erable
04/02/97	2	2	5	6	<1	<1	2,300	12	<1	<10
05/07/97	--	--	--	--	--	--	--	7.1	--	--
06/04/97	--	--	8	8	--	--	--	9.1	--	--
07/01/97	--	--	8	8	--	--	--	8.2	--	--
08/05/97	--	--	8	7	--	--	--	5.9	--	--
09/09/97	--	--	8	7	--	--	--	3.8	--	--
10/08/97	--	--	10	11	--	--	--	11	--	--
11/05/97	--	--	9	12	--	--	--	10	--	--
03/04/98	--	--	8	10	--	--	--	7.8	--	--
04/08/98	--	--	7	8	--	--	--	12	--	--
05/06/98	--	--	5	5	--	--	--	5.4	--	--
06/03/98	--	--	6	5	--	--	--	4.4	--	--
07/08/98	--	--	11	12	--	--	--	5.7	--	--

Table 22. Onsite measurements and concentrations of selected trace elements at site I3, Farmers Ditch above Boulder Reservoir, April 1997–July 1998

[Concentrations of trace elements are in micrograms per liter; ft^3/s, cubic feet per second; µS/cm, microsiemens per centimeter at 25 degrees Celsius; deg C, degrees Celsius; mg/L, milligrams per liter; <, less than; --, no data]

Date	Time	Discharge (ft^3/s)	Specific conductance (µS/cm)	pH (standard units)	Water temperature (deg C)	Oxygen, dissolved (mg/L)	Aluminum, dissolved	Aluminum, total recoverable	Antimony, dissolved	Arsenic, total	Barium, dissolved	Beryllium, dissolved
05/07/97	1220	1.3	183	8.4	20.0	7.2	--	--	--	--	--	--
06/04/97	1145	0.34	90	8.3	27.0	6.6	--	--	--	--	--	--
07/01/97	1240	3.9	67	9.0	19.5	7.6	22	750	<1	<1	17	<1
08/05/97	1120	0.08	111	8.6	25.5	8.2	--	--	--	--	--	--
09/09/97	1200	3.4	66	8.8	18.5	7.5	--	--	--	--	--	--
10/08/97	1100	0.19	132	8.5	13.0	8.7	--	--	--	--	--	--
05/06/98	1215	3.3	195	8.7	15.0	8.1	--	--	--	--	--	--
07/08/98	1145	5.5	53	8.8	17.0	8.2	--	--	--	--	--	--

Date	Cadmium, dissolved	Cadmium, total	Chromium, dissolved	Chromium, total recoverable	Cobalt, dissolved	Copper, dissolved	Copper, total recoverable	Iron, dissolved	Iron, total recoverable	Lead, dissolved	Lead, total recoverable	Manganese, dissolved
05/07/97	--	--	--	--	--	--	--	--	--	--	--	--
06/04/97	--	--	--	--	--	--	--	55	360	--	--	<4
07/01/97	<1	<1	<1	1	<1	1	1	41	990	<1	2	<4
08/05/97	--	--	--	--	--	--	--	21	320	--	--	<4
09/09/97	--	--	--	--	--	--	--	40	1,100	--	--	<4
10/08/97	--	--	--	--	--	--	--	46	140	--	--	<4
05/06/98	--	--	--	--	--	--	--	33	1,400	--	--	<4
07/08/98	--	--	--	--	--	--	--	46	590	--	--	<4

Date	Manganese, total recoverable	Molybdenum, dissolved	Molybdenum, total recoverable	Nickel, dissolved	Nickel, total, recoverable	Selenium, dissolved	Selenium, total	Silver, dissolved	Silver, total recoverable	Uranium, natural, dissolved	Zinc, dissolved	Zinc, total recoverable
05/07/97	--	--	--	--	--	--	--	--	--	<1.0	--	--
06/04/97	<10	--	--	--	--	<1	<1	--	--	<1.0	--	--
07/01/97	20	<1	1	<1	<1	<1	<1	<1	<1	<1.0	1	<10
08/05/97	<10	--	--	--	--	<1	<1	--	--	<1.0	--	--
09/09/97	20	--	--	--	--	<1	<1	--	--	<1.0	--	--
10/08/97	<10	--	--	--	--	<1	<1	--	--	<1.0	--	--
05/06/98	30	--	--	--	--	<1	<1	--	--	<1.0	--	--
07/08/98	10	--	--	--	--	<1	<1	--	--	<1.0	--	--

Table 23. Onsite measurements and concentrations of selected trace elements at site I4, Little Dry Creek above Boulder Reservoir, April 1997–July 1998

[Concentrations of trace elements are in micrograms per liter; ft^3/s, cubic feet per second; µS/cm, microsiemens per centimeter at 25 degrees Celsius; deg C, degrees Celsius; mg/L, milligrams per liter; <, less than; --, no data]

Date	Time	Discharge (ft^3/s)	Specific conductance (µS/cm)	pH (standard units)	Water temperature (deg C)	Oxygen, dissolved (mg/L)	Aluminum, dissolved	Aluminum, total recoverable	Antimony, dissolved	Antimony, total	Arsenic, dissolved
04/02/97	1100	0.29	2,250	7.9	5.0	10.7	4	70	<1	<2	<1
05/07/97	1400	0.10	2,320	8.0	18.5	6.3	--	--	--	--	--
06/04/97	1100	0.50	1,580	7.8	19.0	7.1	--	--	--	--	--
07/01/97	1140	0.02	1,760	7.8	20.5	8.0	--	--	--	--	--
08/05/97	1045	2.1	636	7.8	23.5	7.3	--	--	--	--	--
09/09/97	1040	0.64	835	7.8	16.5	6.8	--	--	--	--	--
10/08/97	1000	0.30	1,370	7.9	11.5	7.9	--	--	--	--	--
11/05/97	1130	0.36	1,750	7.9	6.0	9.4	--	--	--	--	--
03/04/98	0930	0.28	2,020	7.9	0.5	8.6	--	--	--	--	--
04/08/98	1255	2.2	2,400	8.2	10.0	10.3	--	--	--	--	--
05/06/98	1115	0.21	2,230	8.0	17.0	6.6	--	--	--	--	--
06/03/98	1125	0.22	1,730	8.0	13.0	6.8	--	--	--	--	--
07/08/98	1100	1.8	679	8.1	19.5	6.1	--	--	--	--	--

Date	Arsenic, total	Barium, dissolved	Barium, total recoverable	Beryllium, dissolved	Beryllium, total recoverable	Cadmium, dissolved	Cadmium, total	Chromium, dissolved	Chromium, total recoverable	Cobalt, dissolved	Cobalt, total recoverable
04/02/97	<1	65	<100	<1	<10	<1	<1	3	<1	<1	<1
05/07/97	--	--	--	--	--	--	--	--	--	--	--
06/04/97	--	--	--	--	--	--	--	--	--	--	--
07/01/97	--	--	--	--	--	--	--	--	--	--	--
08/05/97	--	--	--	--	--	--	--	--	--	--	--
09/09/97	--	--	--	--	--	--	--	--	--	--	--
10/08/97	--	--	--	--	--	--	--	--	--	--	--
11/05/97	--	--	--	--	--	--	--	--	--	--	--
03/04/98	--	--	--	--	--	--	--	--	--	--	--
04/08/98	--	--	--	--	--	--	--	--	--	--	--
05/06/98	--	--	--	--	--	--	--	--	--	--	--
06/03/98	--	--	--	--	--	--	--	--	--	--	--
07/08/98	--	--	--	--	--	--	--	--	--	--	--

Table 23. Onsite measurements and concentrations of selected trace elements at site I4, Little Dry Creek above Boulder Reservoir, April 1997–July 1998—Continued

Date	Copper, dis-solved	Copper, total recov-erable	Iron, dis-solved	Iron, total recov-erable	Lead, dis-solved	Lead, total recov-erable	Lithium, total recov-erable	Manga-nese, dis-solved	Manga-nese, total recov-erable	Molyb-denum, dis-solved	Molyb-denum, total recov-erable
04/02/97	2	<1	--	140	<1	<1	100	164	120	<1	<1
05/07/97	--	--	--	--	--	--	--	--	--	--	--
06/04/97	--	--	27	120	--	--	--	120	110	--	--
07/01/97	--	--	17	250	--	--	--	380	340	--	--
08/05/97	--	--	35	150	--	--	--	64	70	--	--
09/09/97	--	--	46	130	--	--	--	160	150	--	--
10/08/97	--	--	20	100	--	--	--	110	110	--	--
11/05/97	--	--	17	160	--	--	--	47	50	--	--
03/04/98	--	--	31	270	--	--	--	82	90	--	--
04/08/98	--	--	<30	230	--	--	--	38	60	--	--
05/06/98	--	--	<30	120	--	--	--	210	160	--	--
06/03/98	--	--	36	70	--	--	--	150	130	--	--
07/08/98	--	--	28	80	--	--	--	47	50	--	--

Date	Nickel, dis-solved	Nickel, total, recov-erable	Sele-nium, dis-solved	Sele-nium, total	Silver, dis-solved	Silver, total recov-erable	Stron-tium, total recov-erable	Ura-nium, natural, dis-solved	Zinc, dis-solved	Zinc, total recov-erable
04/02/97	2	1	<1	<1	<1	<1	3,100	11	1	<10
05/07/97	--	--	--	--	--	--	--	6.5	--	--
06/04/97	--	--	<1	<1	--	--	--	4.8	--	--
07/01/97	--	--	<1	<1	--	--	--	4.5	--	--
08/05/97	--	--	<1	<1	--	--	--	<1.0	--	--
09/09/97	--	--	<1	<1	--	--	--	1.3	--	--
10/08/97	--	--	<1	<1	--	--	--	3.7	--	--
11/05/97	--	--	<1	<1	--	--	--	9.0	--	--
03/04/98	--	--	<1	<1	--	--	--	9.1	--	--
04/08/98	--	--	<1	1	--	--	--	3.4	--	--
05/06/98	--	--	<1	<1	--	--	--	8.9	--	--
06/03/98	--	--	<1	<1	--	--	--	3.6	--	--
07/08/98	--	--	<1	<1	--	--	--	1.8	--	--

Table 24. Onsite measurements and concentrations of selected trace elements at site I5, Unnamed Drainage above Boulder Reservoir, April 1997–July 1998

[Concentrations of trace elements are in micrograms per liter; ft^3/s, cubic feet per second; µS/cm, microsiemens per centimeter at 25 degrees Celsius; deg C, degrees Celsius; mg/L, milligrams per liter; <, less than; --, no data]

Date	Time	Discharge (ft^3/s)	Specific conductance (µS/cm)	pH (standard units)	Water temperature (deg C)	Oxygen dissolved (mg/L)	Aluminum, dissolved	Aluminum, total recoverable	Antimony, dissolved
05/07/97	1440	0.70	1,760	8.2	20.0	7.5	--	--	--
06/04/97	1010	0.11	1,290	7.7	20.0	6.6	1	170	<1
07/01/97	1035	0.24	1,260	7.7	19.5	6.6	--	--	--
08/05/97	0955	1.0	981	7.8	22.5	7.6	--	--	--
09/09/97	0945	0.62	1,080	7.9	18.0	6.3	--	--	--
10/08/97	0900	0.10	1,380	8.0	13.5	6.7	--	--	--
11/05/97	0950	0.10	1,730	8.0	8.0	9.2	--	--	--
03/04/98	0850	0.01	2,320	8.2	1.5	10.5	--	--	--
04/08/98	1350	0.19	1,710	8.2	13.0	9.5	--	--	--
05/06/98	1045	0.01	2,260	8.2	16.0	9.0	--	--	--
06/03/98	1045	0.67	945	7.8	14.5	6.9	--	--	--
07/08/98	1010	0.82	727	8.0	20.0	5.8	--	--	--

Date	Arsenic, total	Barium, dissolved	Beryllium, dissolved	Cadmium, dissolved	Cadmium, total	Chromium, dissolved	Chromium, total recoverable	Cobalt, dissolved	Copper, dissolved
05/07/97	--	--	--	--	--	--	--	--	--
06/04/97	<1	36	<1	<1	<1	3	4	<1	1
07/01/97	--	--	--	--	--	--	--	--	--
08/05/97	--	--	--	--	--	--	--	--	--
09/09/97	--	--	--	--	--	--	--	--	--
10/08/97	--	--	--	--	--	--	--	--	--
11/05/97	--	--	--	--	--	--	--	--	--
03/04/98	--	--	--	--	--	--	--	--	--
04/08/98	--	--	--	--	--	--	--	--	--
05/06/98	--	--	--	--	--	--	--	--	--
06/03/98	--	--	--	--	--	--	--	--	--
07/08/98	--	--	--	--	--	--	--	--	--

Table 24. Onsite measurements and concentrations of selected trace elements at site I5, Unnamed Drainage above Boulder Reservoir, April 1997–July 1998

Date	Copper, total recov-erable	Iron, dis-solved	Iron, total recov-erable	Lead, dis-solved	Lead, total recov-erable	Manga-nese, dis-solved	Manga-nese, total recov-erable	Molyb-denum, dis-solved	Molyb-denum, total recov-erable
05/07/97	--	--	--	--	--	--	--	--	--
06/04/97	<1	14	310	<1	<1	170	160	1	1
07/01/97	--	10	320	--	--	210	210	--	--
08/05/97	--	15	270	--	--	84	100	--	--
09/09/97	--	<10	290	--	--	73	100	--	--
10/08/97	--	<10	110	--	--	120	120	--	--
11/05/97	--	<10	100	--	--	130	110	--	--
03/04/98	--	<30	30	--	--	68	70	--	--
04/08/98	--	20	400	--	--	180	220	--	--
05/06/98	--	<30	110	--	--	250	190	--	--
06/03/98	--	24	120	--	--	150	140	--	--
07/08/98	--	16	190	--	--	97	120	--	--

Date	Nickel, dis-solved	Nickel, total, recov-erable	Sele-nium, dis-solved	Sele-nium, total	Silver, dis-solved	Silver, total recov-erable	Ura-nium, natural, dis-solved	Zinc, dis-solved	Zinc, total recov-erable
05/07/97	--	--	--	--	--	--	7.2	--	--
06/04/97	2	2	<1	<1	<1	<1	5.0	5	<10
07/01/97	--	--	<1	<1	--	--	4.7	--	--
08/05/97	--	--	<1	<1	--	--	3.3	--	--
09/09/97	--	--	<1	<1	--	--	2.2	--	--
10/08/97	--	--	<1	<1	--	--	5.0	--	--
11/05/97	--	--	<1	<1	--	--	5.9	--	--
03/04/98	--	--	<1	<1	--	--	11	--	--
04/08/98	--	--	<1	1	--	--	<1.0	--	--
05/06/98	--	--	<1	<1	--	--	8.0	--	--
06/03/98	--	--	<1	<1	--	--	2.8	--	--
07/08/98	--	--	<1	<1	--	--	2.2	--	--

Table 25. Onsite measurements and concentrations of selected trace elements at site O1, Boulder Creek Supply Canal below Boulder Reservoir, April 1997–July 1998

[Concentrations of trace elements are in micrograms per liter; ft^3/s, cubic feet per second; μS/cm, microsiemens per centimeter at 25 degrees Celsius; deg C, degrees Celsius; mg/L, milligrams per liter; <, less than; --, no data]

Date	Time	Discharge (ft^3/s)	Specific conductance (μS/cm)	pH (standard units)	Water temperature (deg C)	Oxygen, dissolved (mg/L)	Iron, dissolved
07/02/97	1505	1.5	369	7.1	19.5	1.9	<10
08/05/97	1430	25	332	8.0	22.5	7.0	<10
09/09/97	1620	106	331	8.1	21.5	7.2	<10
10/08/97	1515	9.1	263	8.3	16.0	7.6	32
05/06/98	0940	1.9	439	8.2	13.5	7.2	<10
06/03/98	0945	73	423	8.4	18.0	8.2	<10
07/08/98	0930	112	292	8.2	19.5	7.4	<10

Date	Iron, total recoverable	Manganese, dissolved	Manganese, total recoverable	Selenium, dissolved	Selenium, total	Uranium, natural, dissolved
07/02/97	380	270	290	<1	<1	1.2
08/05/97	240	14	30	<1	<1	<1.0
09/09/97	310	32	60	<1	<1	1.0
10/08/97	1,400	<4	40	<1	<1	<1.0
05/06/98	490	5	20	<1	<1	2.2
06/03/98	260	<4	20	<1	<1	1.7
07/08/98	280	<4	10	<1	<1	1.5

Table 26. Concentrations of nitrogen and phosphorus in inflows and outflow determined by the City of Boulder Drinking Water and Wastewater Laboratories, April 1997–July 1998

[NO_2+NO_3, nitrite plus nitrate; +, plus; mg/L, milligrams per liter; µg/L, micrograms per liter; <, less than]

Date	Nitrogen, NO_2+NO_3, dissolved (mg/L)	Nitrogen, ammonia, dissolved (mg/L)	Nitrogen, ammonia + organic, total (mg/L)	Phosphorus, ortho, dissolved (µg/L)	Phosphorus, total (µg/L)
		Site I1, Boulder Feeder Canal above Boulder Reservoir			
04/02/97	0.04	0.05	0.4	3	32
05/07/97	0.01	0.02	0.2	1	22
06/04/97	<0.01	0.03	0.3	2	9
07/01/97	<0.01	<0.01	0.4	<1	13
08/05/97	0.02	<0.01	0.4	4	17
09/09/97	0.08	0.06	0.4	1	13
10/08/97	0.04	0.01	0.2	<1	10
04/08/98	0.02	0.07	0.3	1	12
05/06/98	0.02	<0.01	0.7	<1	10
06/03/98	0.03	<0.01	0.2	4	14
07/08/98	0.03	<0.01	0.4	2	14
		Site I2, Dry Creek above Boulder Reservoir			
04/02/97	0.28	0.01	0.5	2	37
05/07/97	0.28	<0.01	0.4	5	55
06/04/97	0.24	<0.01	0.5	3	27
07/01/97	0.20	<0.01	0.4	3	31
08/05/97	0.30	<0.01	0.5	2	37
09/09/97	0.28	<0.01	0.3	1	24
10/08/97	0.46	<0.01	0.4	<1	23
11/05/97	0.44	<0.01	0.6	5	52
12/02/97	0.84	<0.01	0.6	7	61
01/06/98	0.68	<0.01	0.8	1	17
02/04/98	0.56	0.07	0.6	1	42
03/04/98	0.36	<0.01	0.3	1	16
04/08/98	0.44	0.02	0.6	3	30
05/06/98	0.20	<0.01	0.4	<1	19
06/03/98	0.17	<0.01	0.4	<1	27
07/08/98	0.18	<0.01	0.6	1	41
		Site I3, Farmers Ditch above Boulder Reservoir			
05/07/97	0.03	<0.01	1.2	7	305
06/04/97	0.01	<0.01	0.3	2	17
07/01/97	0.02	<0.01	0.4	1	29
08/05/97	<0.01	<0.01	0.2	<1	18
09/09/97	0.01	0.01	0.2	1	19
10/08/97	<0.01	0.07	0.4	<1	10
05/06/98	0.03	<0.01	0.2	1	35
07/08/98	0.01	0.08	0.4	1	25

Table 26. Concentrations of nitrogen and phosphorus in inflows and outflow determined by the City of Boulder Drinking Water and Wastewater Laboratories, April 1997–July 1998—Continued

[NO_2+NO_3, nitrite plus nitrate; +, plus; mg/L, milligrams per liter; µg/L, micrograms per liter; <, less than]

Date	Nitrogen, NO_2+NO_3, dissolved (mg/L)	Nitrogen, ammonia, dissolved (mg/L)	Nitrogen, ammonia + organic, total (mg/L)	Phosphorus, ortho, dissolved (µg/L)	Phosphorus, total (µg/L)
		Site I4, Little Dry Creek above Boulder Reservoir			
04/02/97	0.04	<0.01	0.4	1	6
05/07/97	0.05	<0.01	0.4	3	10
06/04/97	0.06	<0.01	0.5	3	8
07/01/97	0.06	<0.01	0.9	4	18
08/05/97	0.05	<0.01	0.4	3	16
09/09/97	0.05	<0.01	0.2	1	8
10/08/97	0.06	<0.01	0.4	<1	8
11/05/97	0.05	<0.01	2.0	2	10
12/02/97	0.03	<0.01	0.2	1	10
01/06/98	0.04	<0.01	1.0	2	22
02/04/98	0.04	0.09	0.4	<1	10
03/04/98	0.02	<0.01	0.2	1	13
04/08/98	<0.01	<0.01	0.6	6	28
05/06/98	<0.01	<0.01	0.6	<1	7
06/03/98	0.01	<0.01	0.4	1	6
07/08/98	<0.01	<0.01	0.4	1	14
		Site I5, Unnamed drainage above Boulder Reservoir			
05/07/97	0.08	<0.01	0.8	5	64
06/04/97	0.08	<0.01	0.5	1	14
07/01/97	1.50	<0.01	1.5	4	22
08/05/97	0.14	<0.01	0.5	1	19
09/09/97	0.17	<0.01	0.2	5	22
10/08/97	0.29	<0.01	0.4	1	9
11/05/97	0.34	<0.01	0.3	1	7
12/02/97	0.56	<0.01	0.2	<1	4
01/06/98	0.36	<0.01	1.1	<1	5
02/04/98	0.37	0.03	0.4	<1	8
03/04/98	0.60	<0.01	0.3	1	6
04/08/98	0.12	<0.01	0.6	5	22
05/06/98	0.35	<0.01	1.1	<1	4
06/03/98	0.09	<0.01	0.4	3	14
07/08/98	0.08	<0.01	0.5	4	9
		Site O1, Boulder Creek Supply Canal below Boulder Reservoir			
07/02/97	0.01	<0.01	0.3	<1	11
08/05/97	0.01	<0.01	0.2	<1	9
09/09/97	0.04	<0.01	0.1	<1	10
10/08/97	0.04	<0.01	0.4	<1	38
05/06/98	0.06	<0.01	0.3	<1	14
06/03/98	0.04	0.08	0.4	<1	12
07/08/98	<0.01	<0.01	0.2	1	10

Table 27. Concentrations of selected constituents in the water column and pore water of Boulder Reservoir, August 20–21, 1997

[--, no data; <, less than]

		Concentration, in milligrams per liter					Concentration, in micrograms per liter								
		Nitrogen, ammonia, dis-solved	Nitrogen, nitrite plus nitrate, dis-solved	Nitrogen, ammonia plus organic, dis-solved	Phos-phorus, ortho, dis-solved	Phos-phorus, dis-solved	Alu-minum, dis-solved	Cad-mium, dis-solved	Chro-mium, dis-solved	Copper, dis-solved	Iron, dis-solved	Lead, dis-solved	Manga-nese, dis-solved	Nickel, dis-solved	Zinc, dis-solved
		Site R1, Boulder Reservoir near south dam, August 20, 1997, total depth, 24.5 feet													
Sampling depth below water surface (feet)	0-7	0.016	0.024	--	0.001	--	36	<1	<1	2	23	<1	2	<1	<1
	21.5	0.037	0.024	--	0.002	--	27	<1	<1	<1	19	<1	39	<1	<1
	23.0	0.038	0.025	--	0.002	--	24	<1	<1	1	16	<1	54	<1	<1
	24.0	0.05	<0.05	<0.2	<0.01	<0.01	34	<1	<1	1	24	<1	67	<1	<1
Sampling depth below sediment/ water interface (centimeters)	0-1	1.3	0.08	2.0	0.19	0.16	76	2	<5	<10	860	30	2,500	<10	10
	1-2	1.7	<0.05	2.9	0.40	0.40	122	5	<5	<10	2,500	50	2,600	<10	10
	2-3	1.6	<0.05	2.2	0.41	0.36	41	8	<5	<10	3,400	40	2,500	<10	7
	3-4	4.5	<0.05	2.3	<0.01	<0.01	43	2	<5	<10	1,600	20	2,200	<10	4
	4-5	1.5	<0.05	2.3	0.66	0.67	51	2	<5	<10	1,900	10	2,000	<10	48
		Site R2, Boulder Reservoir near north dam, August 21, 1997, total depth, 26.0 feet													
Sampling depth below water surface (feet)	0-8	0.012	0.022	--	0.001	--	24	<1	<1	2	14	<1	<1	<1	1
	23.0	0.034	0.026	--	0.003	--	31	<1	<1	1	20	<1	16	<1	<1
	24.5	0.033	0.025	--	0.002	--	25	<1	<1	<1	17	<1	19	<1	<1
	25.5	0.05	<0.05	<0.2	0.01	<0.01	25	<1	<1	1	19	<1	27	<1	<1
Sampling depth below sediment/ water interface (centimeters)	0-1	1.5	<0.05	2.7	0.29	0.34	31	2	<5	<10	880	20	2,700	<10	5
	1-2	2.4	<0.05	3.5	1.0	1.1	23	1	<5	<10	2,700	<10	2,700	<10	6
	2-3	2.4	<0.05	3.5	0.93	1.0	21	2	<5	<10	4,300	20	2,900	<10	7
	3-4	2.2	<0.05	3.3	1.2	1.4	<5	2	<5	<10	3,400	10	2,500	<10	<3
	4-5	1.8	<0.05	3.1	1.1	1.6	7	3	<5	<10	3,300	30	2,300	<10	<3

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