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Assessment of Historical Surface-Water Quality Data in Southwestern Colorado, 1990–2005

Scientific Investigations Report 2012–5255

U.S. Department of the Interior
U.S. Geological Survey

COVER. Animas River at Tall Timber Resort above Tacoma, Colorado, U.S. Geological Survey streamgage 09359500 (photographs taken by David Grey, U.S. Geological Survey, May 8, 2012).

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By Lisa D. Miller, Keelin R. Schaffrath, and Joshua I. Linard

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U.S. Department of the Interior
KEN SALAZAR, Secretary

U.S. Geological Survey
Suzette M. Kimball, Acting Director

U.S. Geological Survey, Reston, Virginia: 2013

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Conversion Factors

SI to Inch/Pound

Multiply	By	To obtain
	Length	
millimeter (mm)	0.03937	inch (in.)
meter (m)	3.281	foot (ft)
meter (m)	1.094	yard (yd)
	Volume	
liter (L)	0.2642	gallon (gal)
cubic meter (m^3)	264.2	gallon (gal)
liter (L)	61.02	cubic inch (in^3)
cubic meter (m^3)	35.31	cubic foot (ft^3)
	Flow rate	
cubic meter per second (m^3/s)	70.07	acre-foot per day (acre-ft/d)
meter per second (m/s)	3.281	foot per second (ft/s)
cubic meter per second (m^3/s)	35.31	cubic foot per second (ft^3/s)
	Mass	
gram (g)	0.03527	ounce, avoirdupois (oz)
kilogram (kg)	2.205	pound avoirdupois (lb)

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

°F=(1.8×°C)+32

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

°C=(°F-32)/1.8

Vertical coordinate information is referenced to the North American Vertical Datum of 1988 (NAVD 88).

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).

Altitude, as used in this report, refers to distance above the vertical datum.

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

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

Abbreviations Used in this Report

BLM	Bureau of Land Management
BOR	Bureau of Reclamation
CDPHE	Colorado Department of Public Health and Environment
Commission	Colorado Water Quality Control Commission
CWQDR	Colorado Water-Quality Data Repository
DO	dissolved oxygen
DS	dissolved solids
ESTREND	EStimate TREND
FDA	Food and Drug Administration
HUC	Hydrologic Unit Code
IQR	interquartile range (IQR)
LRL	laboratory reporting level
MWAT	maximum weekly average temperature
NWIS	National Water Information System database
ppm	parts per million
SC	specific conductance
SJRB	San Juan River Basin
STORET	STOrage and RETrieval
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
NWQL	National Water Quality Laboratory
WCD	Water Conservation District
WWTP	waste water treatment plant

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Abstract

The spatial and temporal distribution of selected physical and chemical surface-water-quality characteristics throughout southwestern Colorado were analyzed using historical data collected from 1990 through 2005 by various local, State, Tribal, and Federal agencies. This analysis was done to provide an understanding of existing water-quality conditions in the Dolores River and San Juan River basins in southwestern Colorado as part of a larger surface-water and groundwater assessment conducted by the U.S. Geological Survey in cooperation with Bureau of Land Management, Bureau of Reclamation, Southwestern Water Conservation District, San Miguel County, and Telluride Power/Water. Summary statistics were calculated for selected physical and chemical surface-water water-quality characteristics at sites with 10 or more samples. These values were then compared and described spatially. Temporal trends in surface-water water-quality characteristics were calculated at sites with adequate data to determine if changes in values had occurred over time.

Overall, streams throughout the study area were well oxygenated. Median dissolved-oxygen concentrations generally ranged from 8 to 10 milligrams per liter (mg/L) in surface water. Values of pH generally were near neutral to slightly alkaline throughout most of the study area with the exception of the upper Animas River Basin near Silverton where acidic conditions existed at some sites because of hydrothermal alteration and(or) historical mining. Mean water temperatures in the study area ranged from 5.3 to 14.1°C. Median dissolved solids (DS) concentrations ranged from 8 to 42,600 mg/L. The highest DS concentrations typically occurred in samples collected from December through March when streamflows were lowest; and the lowest DS concentrations typically occurred in samples collected from May through July when streamflows were highest. Seasonal differences in DS concentrations were more apparent in samples from the Upper San Juan River Basin (SJRB) and the Lower SJRB than the Dolores River Basin.

In southwestern Colorado, 85th percentile concentrations for dissolved aluminum ranged from less than 50 to 67,000 micrograms per liter (µg/L); and median total recoverable aluminum concentrations ranged from less than 57 to 2,000 µg/L. The highest aluminum concentrations were measured at sites located in the Cement and Mineral Creek Basins north and west of Silverton.

Median total recoverable iron concentrations ranged from 1.6 to 225,000 µg/L. It was common for total recoverable iron concentrations to vary over several orders of magnitude at a given site. The highest median total recoverable iron concentrations in the study area generally occurred at sites in the Cement Creek and Mineral Creek Basins in the Upper SJRB north and west of Silverton.

Concentrations of total mercury measured in samples ranged from less than 0.005 to 12 µg/L. Thirty-two sites had at least one measured concentration of total mercury that exceeded the chronic aquatic-life criterion of 0.01 µg/L. Determining the actual distribution of mercury in surface water throughout the study area was not possible because reporting limits often varied at sites and most concentrations were reported as less than the individual reporting limits (that is, the values were censored).

In the Dolores River Basin, only two sites had 85th percentile concentrations of dissolved lead greater than the individual reporting limits. Both sites had 85th percentile concentrations of dissolved lead equal to 1 µg/L. The 85th percentile concentrations for dissolved lead ranged from less than 1 to 250 µg/L at sites in the Upper SJRB. The highest dissolved lead concentrations in the Upper SJRB generally occurred in the Mineral and Cement Creek Basins. State criteria in these areas were based on total recoverable lead concentrations, and median concentrations of total recoverable lead did not exceed criteria. In the Lower SJRB, almost all dissolved lead concentrations were censored.

The 85th percentile concentrations for dissolved zinc ranged from less than 2 to 180,000 µg/L; although, most sites in the study area generally had concentrations less than 200 µg/L. Four sites in the Dolores River Basin had dissolved zinc concentrations that exceeded State acute and chronic hardness-based criteria. Twenty-four sites in the Upper SJRB had 85th percentile concentrations that exceeded acute and chronic hardness-based standards. Sites that exceeded State acute and chronic hardness-based standards in the Upper SJRB may not have exceeded segment-specific monthly standards, but monthly concentrations were not calculated. In the Lower SJRB, 85th percentile concentrations of dissolved zinc were well below the State hardness-based criteria.

Dissolved selenium concentrations in samples collected throughout the study area ranged from less than 0.2 to 170 µg/L. One site in the Dolores River Basin, Salt Creek at Highway 141, had an 85th percentile concentration of dissolved selenium of 23 µg/L which exceeded the State chronic (4.6 µg/L) and acute water-quality standards (18.4 µg/L). The State chronic water-quality standard was also exceeded at one site in the Upper SJRB and one site in the Lower SJRB. Dissolved selenium concentrations greater than the acute water-quality standard were measured in some samples collected from Navajo Wash in the southwestern corner of the Upper SJRB and in some samples from Mud Creek sites near Cortez; but insufficient data were available to compute summary statistics.

Concentrations of total ammonia, nitrate, nitrite, and total phosphorus generally were low throughout the study area. The 85th percentile concentrations of total ammonia were less than the calculated chronic and acute State table-value water-quality standards for total ammonia. Nitrate plus nitrite concentrations ranged from less than 0.05 to 15 mg/L in samples; and 87 percent of samples analyzed had concentrations less than or equal to 0.5 mg/L. In the Dolores River Basin, 85th percentile nitrate plus nitrite concentrations at the 21 sites analyzed ranged from less than 0.05 to 0.78 mg/L. In the Upper SJRB, 85th percentile nitrate plus nitrite concentrations ranged from less than 0.06 to 2.4 mg/L. Only 4 of the 35 sites analyzed in the Upper SJRB had 85th percentile concentrations of nitrate plus nitrite that exceeded 1 mg/L. These sites were located in the vicinity of Durango mostly on the Animas River. In the Lower SJRB, 85th percentile nitrate plus nitrite concentrations at the two sites analyzed were 1 mg/L and 2.7 mg/L. Total phosphorus concentrations ranged from less than 0.002 to 11 mg/L, though concentrations in most samples were less than 0.1 mg/L.

Only 10 sites throughout the entire study area had adequate data to calculate summary statistics for dissolved uranium. The 85th percentile concentrations of dissolved uranium ranged from less than 3 to 10 µg/L, well below the national drinking water water-quality standard of 30 µg/L. Although dissolved uranium concentrations in most samples from most streams were less than 5 µg/L, concentrations of dissolved uranium greater than 10 µg/L were measured in some samples at various locations throughout the study area, particularly at sites in the Lower SJRB and along Navajo Wash in the Upper SJRB. Many of these site locations, where dissolved uranium concentrations were elevated, coincide with areas where the Mancos Shale crops out.

Overall results from the trend analyses indicate improvement in water-quality conditions as a result of operation of the Paradox Valley Unit in the Dolores River Basin and irrigation and water-delivery system improvements made in the McElmo Creek Basin and Mancos River Valley. Other detected trends may be because of precipitation variability during the analysis period. Additional study, however, would be needed to determine the causes of the apparent changes in water-quality characteristic values over time at the sites.

Introduction

Water is a valuable resource in southwestern Colorado used for municipal, recreational, agricultural, industrial, livestock, domestic, and mining purposes. Wildfires, past and present mining activities, atmospheric deposition of chemicals, urban development, and agricultural land use, among other things, have the potential to affect water quality throughout southwestern Colorado. An understanding of the present water-quality conditions is needed to effectively manage this valuable and limited resource. In 2004, the U.S. Geological Survey (USGS) in cooperation with Bureau of Land Management (BLM), Bureau of Reclamation (BOR), Southwestern Water Conservation District (WCD), San Miguel County, and Telluride Power/Water began a surface-water and groundwater assessment of the Dolores River and San Juan River Basin in Colorado. As part of this assessment, historical water-quality data collected in the Dolores River and San Juan River Basins (Southwest Study Area) by various local, State, Tribal, and Federal agencies were compiled into a single electronic database. This database is available on the Internet at the Colorado Water-Quality Data Repository (CWQDR) Web site at *http://rmgsc.cr.usgs.gov/cwqdr/Southwest/index.shtml*. Selected surface-water water-quality data for the Southwest study area (henceforth referred to as southwestern Colorado) were retrieved from the CWQDR. These data were analyzed to determine the spatial and temporal distribution of physical and chemical water-quality characteristics throughout southwestern Colorado. Results from this analysis along with descriptions from previous work by others were used to describe environmental and land-use factors which affect surface-water water-quality conditions in southwestern Colorado.

Purpose and Scope

The purpose of this report is to (1) describe the spatial and temporal distribution of historical physical and chemical data for streams in southwestern Colorado, (2) provide a statistical summary of historical surface-water water-quality data including minimum, maximum, median, and other selected percentile values for sites with 10 or more samples, (3) compare historical surface-water water-quality data to State and(or) Federal water-quality standards, and (4) describe trends in selected water-quality characteristics with sufficient data at selected sites. This report used surface-water water-quality data from 1990 through 2005 collected by multiple entities throughout the Dolores and San Juan River Basins in southwestern Colorado.

Description of Study Area

The Dolores River and San Juan River Basins were defined topographically and by the Colorado State boundary for the purposes of this report. The San Juan River Basin was subdivided into the Upper San Juan River Basin (Upper SJRB) and Lower San Juan River Basin (Lower SJRB) (fig. 1) based on the corresponding 6-digit Hydrologic Unit Code (HUC) (Seaber and other, 1987). Elevations in the Dolores River Basin ranged from 1,359 meters to 4,345 meters above the North American Vertical Datum of 1988 (U.S. Geological Survey, 1999). In the Lower SJRB, the elevations ranged from 1,399 meters to 3,041 meters. Upper SJRB elevations ranged from 1,435 meters to 4,311 meters (U.S. Geological Survey, 1999).

Hydrology

The mean annual precipitation throughout southwestern Colorado was variable. Mean annual precipitation (1971–2000) ranged from 27 to 134 millimeters (mm) in the Dolores River Basin, from 18 to 153 mm in the Upper SJRB, and from 18 to 60 mm in the Lower SJRB (Daly and others, 2002). Most precipitation in southwestern Colorado falls in the form of snow. Annual streamflow is dominated by spring snowmelt (fig. 2). An increase in streamflow is common throughout the study area beginning in April, peaking in May or June, and decreasing into autumn as snowmelt subsides. Streamflow from November through March typically remains relatively constant (fig. 2).

Understanding hydrologic characteristics is essential to understanding water quality. Concentrations of selected water-quality characteristics are often related to the magnitude of streamflow (Leib and others, 2003). A pattern measured in many streams is a tendency for water during a rising stage to have considerably higher concentrations of selected constituents than water at an equal flow rate after peak discharge has passed (Hem, 1985). In addition to short-term changes in concentrations related to stormflow, concentrations of certain water-quality characteristics vary based on seasonal streamflow characteristics. Zinc and copper concentrations tended to be higher during periods of base flow from November through March than during periods of higher flows from April through October (Besser and Leib, 1999). Similarly, the concentration of dissolved solids (DS) often has an inverse relation to streamflow (Hem, 1985). Concentrations of DS tend to increase during base flow conditions and decrease as streamflow rises (Miller and others, 2010). The main source of streamflow during base flow conditions is typically groundwater. Higher concentrations of DS generally are present in groundwater than snowmelt and(or) rainfall runoff (the main sources of streamflow during high flows in the study area), because groundwater generally has longer contact time with rocks and soil, and thus, more time to dissolve and gain substances.

Geology

The geology underlying southwestern Colorado includes igneous, metamorphic and sedimentary rocks (fig. 3). In the San Juan Mountains, Paleogene volcanic rocks of the Silverton caldera (fig. 3) are underlain by Precambrian igneous and metamorphic rocks (Paschke and others, 2005). Leib and others (2003) and Mast and others (2000) indicated that water draining from within the boundary of the Silverton caldera could be acidic and have high concentrations of dissolved minerals. Moving west and south, Cretaceous shales and sandstones are the most common form of bedrock (Butler and others, 1997; Church and others, 2007). Cretaceous shales underlying areas of southwestern Colorado are prevalent throughout the Dolores River Basin, and exist in some near stream areas in the Lower SJRB and Upper SJRB. Morrison Formation sandstones are commonly found at lower elevations in the Dolores River Basin and Lower SJRB. In the McElmo Creek Basin near Cortez, groundwater flowing out of the Morrison Formation contributes to high in-stream concentrations of sodium, sulfate, chloride, magnesium, and calcium ions (Richards and Leib, 2011).

In the Dolores River Basin, groundwater moving through the Paradox Valley, a collapsed salt anticline, transports large amounts of DS to the Dolores River (Chafin, 2003). Under natural conditions, saline groundwater inflow contributes about 205,000 tons per year of DS to the Dolores River as it flows through the Paradox Valley (Bureau of Reclamation, 2011). The BOR constructed the Paradox Valley Unit as part of the Colorado River Basin Salinity Control Act of 1974 (Public Law 93–320, amended in 1984 as Public Law 98–569) to reduce the amount of DS (often referred to as salinity) entering the Dolores River, a tributary of the Colorado River. The Paradox Unit consists of a series of production wells that intercept the saline water before it enters the river, a surface treatment facility, an injection facility, and a deep injection well to dispose of the saline water (Bureau of Reclamation, 2011). Watts (2000) reported that “test operation of the Paradox Valley Unit began in 1990 and production operation began in 1996.” Operation of the Paradox Valley Unit was changed in about 1998 to optimize interception of the brine inflow according to Chafin (2003). As a result of operation of the Paradox Valley Unit, DS loads in the Dolores River have been reduced by as much as 90 percent of historic DS loads (Chafin, 2003).

Land Use

The effects of geology on water quality can be exacerbated by anthropogenically induced changes to the land surface. The primary land-use and land-cover classifications in the study area are forest, rangeland, tundra, and agricultural land (fig. 4) (TechniGraphics, Inc., 2004). Forests are the dominant land cover in southwestern Colorado and occupy about 75 percent of the Dolores River Basin, 65 percent of the Upper SJRB, and 37 percent of the Lower SJRB (TechniGraphics, Inc., 2004). Rangeland is the next largest land-cover category in each river basin, comprising 19 percent of the Dolores River Basin, 24 percent of the Upper SJRB and 35 percent of the Lower SJRB (TechniGraphics, Inc., 2004).

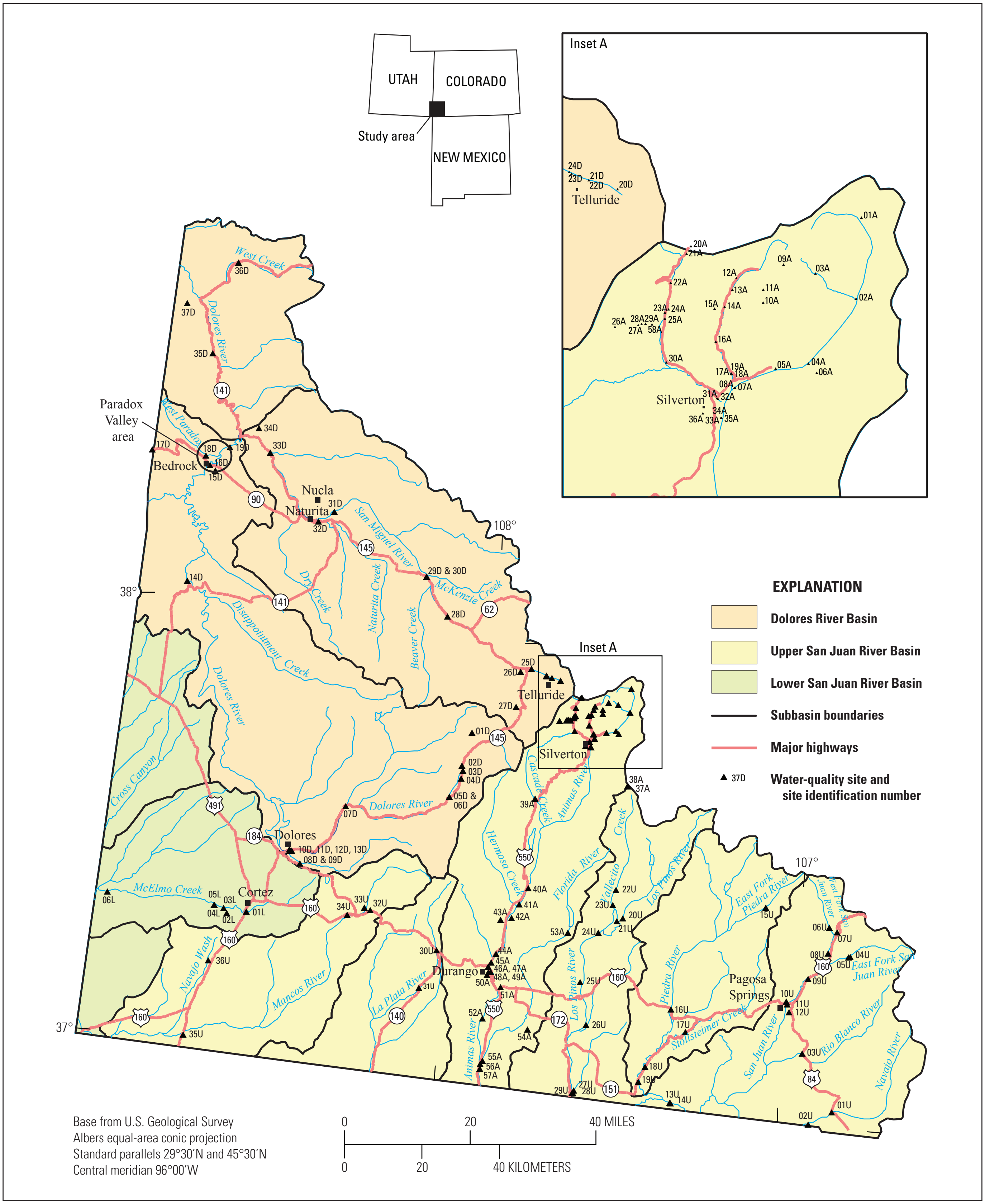


Figure 1. Map showing study area location and water-quality site locations, Dolores, Upper San Juan, and Lower San Juan River Basins, southwestern Colorado.

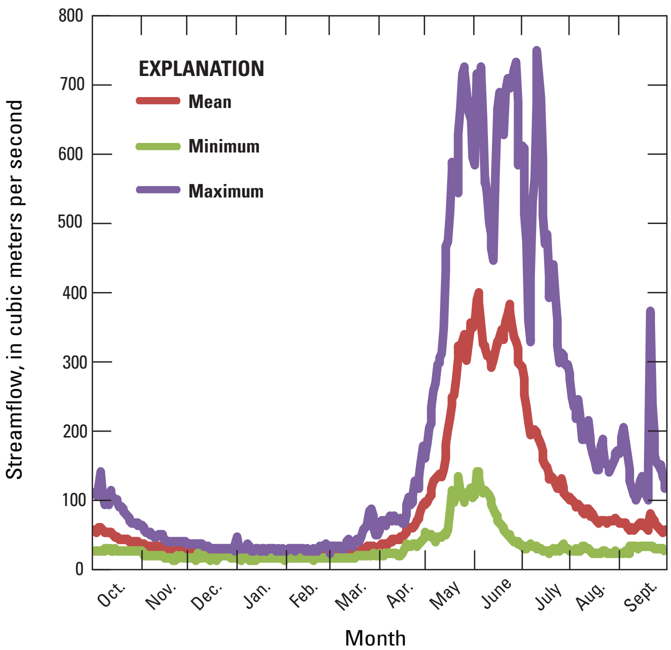


Figure 2. Graph showing daily mean streamflow hydrograph for streamflow-gaging site Animas River at Silverton, Colorado (USGS 09359020), October 1991 through December 2005.

Of the remaining land-cover and land-use categories, only tundra and agricultural land occupy greater than 1 percent of the river basin area. In the Upper SJRB, 4 percent of the land is classified as tundra and 5 percent as agricultural. Twenty-seven percent of the land in the Lower SJRB is classified as agricultural land use.

Settlements in southwestern Colorado generally began in the late 1800s with people lured by mining prospects and vast areas of grazing land. Many mines were created to extract the rich mineral wealth of the San Juan Mountains and currently (2011) their effect on downstream water quality is a concern to many stakeholders in the basin. In addition to the mines themselves, the infrastructure set up to transport and process/extract minerals has affected water quality particularly within the Animas River Basin. The abandoned mine sites increase the rate of rock weathering due to increased surface area exposure and pH changes; as a result, high concentrations of dissolved minerals drain from some of the mine areas (Leib and others, 2003). Mines also can divert groundwater from its pre-mining flow path and accelerate the weathering of more soluble rocks.

Urban and agricultural activities can often act to increase DS, nutrient, and sediment loading to streams, increase stream water temperatures, and alter channel geomorphology which may result in increased growth of aquatic organisms. Although agricultural land use was only a small part of the total land use in southwestern Colorado in 2000 (TechniGraphics, Inc., 2004), irrigated agricultural lands were often located near streams. Irrigation can accelerate the movement of agricultural chemicals to streams and increase dissolution of minerals. Dissolved solids also concentrate in water as a result of evapotranspiration from crops and other vegetation, evaporation from canals and reservoirs, and evaporation from the land surface. The variation in the magnitude of selenium concentration and load in streams in southwestern Colorado is directly related to the application of irrigation water on soils derived from the Mancos Shale (Thomas and others, 2008; Butler and others, 1996; Wright and Butler, 1993; Butler, 2001; Butler and Leib, 2002).

The Mancos Shale in southwestern Colorado is an Upper Cretaceous, massive, and fossiliferous marine shale with interbedded sandstone, siltstone, and layers of devitrified volcanic ash (Wright and Butler, 1993) and is the stratigraphic equivalent of the Pierre Shale in southeastern Colorado. Zielinski and others (1995) found that natural oxidative weathering of uranium-bearing marine shale bedrock, leaching of shale-derived soils, and evaporative concentration produces average dissolved uranium concentrations that approach or exceed 20 µg/L in surface water and shallow groundwater in southeastern Colorado. In addition, extensive use and reuse of water for irrigation further elevated dissolved uranium concentrations in irrigation return flow by increasing the amount of water/soil and water/rock interaction and the potential for evaporative concentration (Zielinski and others, 1995).

Methods of Investigation

Selection and processing of surface-water data, graphical presentations, and methods used to determine temporal trends for selected water-quality characteristics at sites with adequate data are described in this section and its subsections. Electronically available historical surface-water water-quality data for the Dolores River and San Juan River Basins in southwestern Colorado (Southwest study area) were retrieved from the CWQDR Web site *http://rmgsc.cr.usgs.gov/cwqdr/Southwest/index.shtml*. Data stored in the CWQDR were collected by multiple entities over various periods of time. Water-quality concentrations characterized throughout the report are given as dissolved unless otherwise noted in the text. Dissolved concentrations are generally determined using the portion of the sample (filtrate) remaining after it has been filtered through a 0.45-micron or smaller filter (Colorado Department of Public Health and Environment, 2010b). Dissolved solids concentration data presented in this report were either reported as residual on evaporation at 180 degrees Celsius (°C) or as the sum of constituents. The term ”sum of constituents” refers to the method for determining a DS concentration in a sample as the sum of the concentrations of the major ions in the sample. The major dissolved ions in most water samples generally are calcium, magnesium, sodium, potassium, sulfate, chloride, fluoride, nitrate, bicarbonate, and carbonate (Hem, 1985).

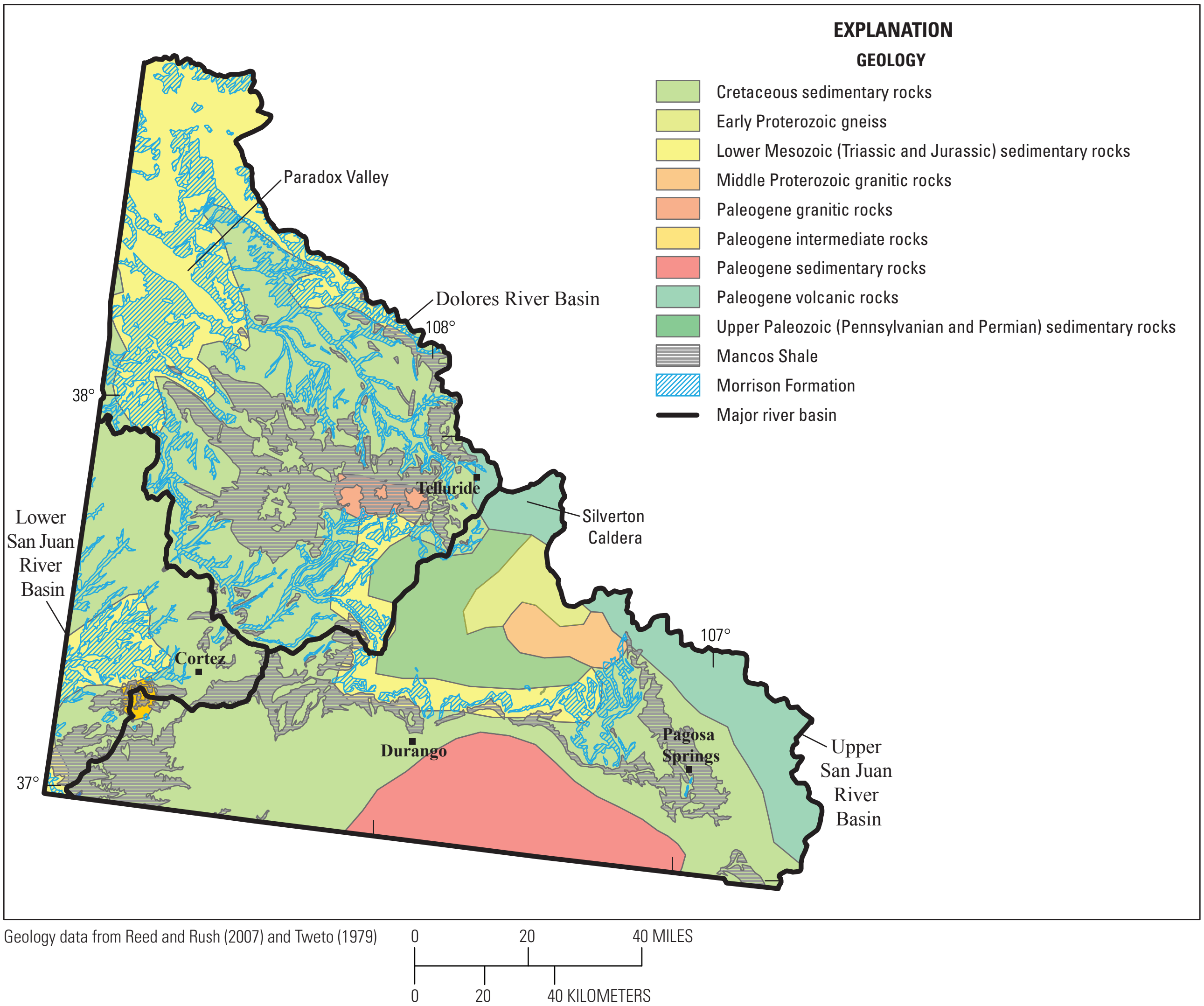
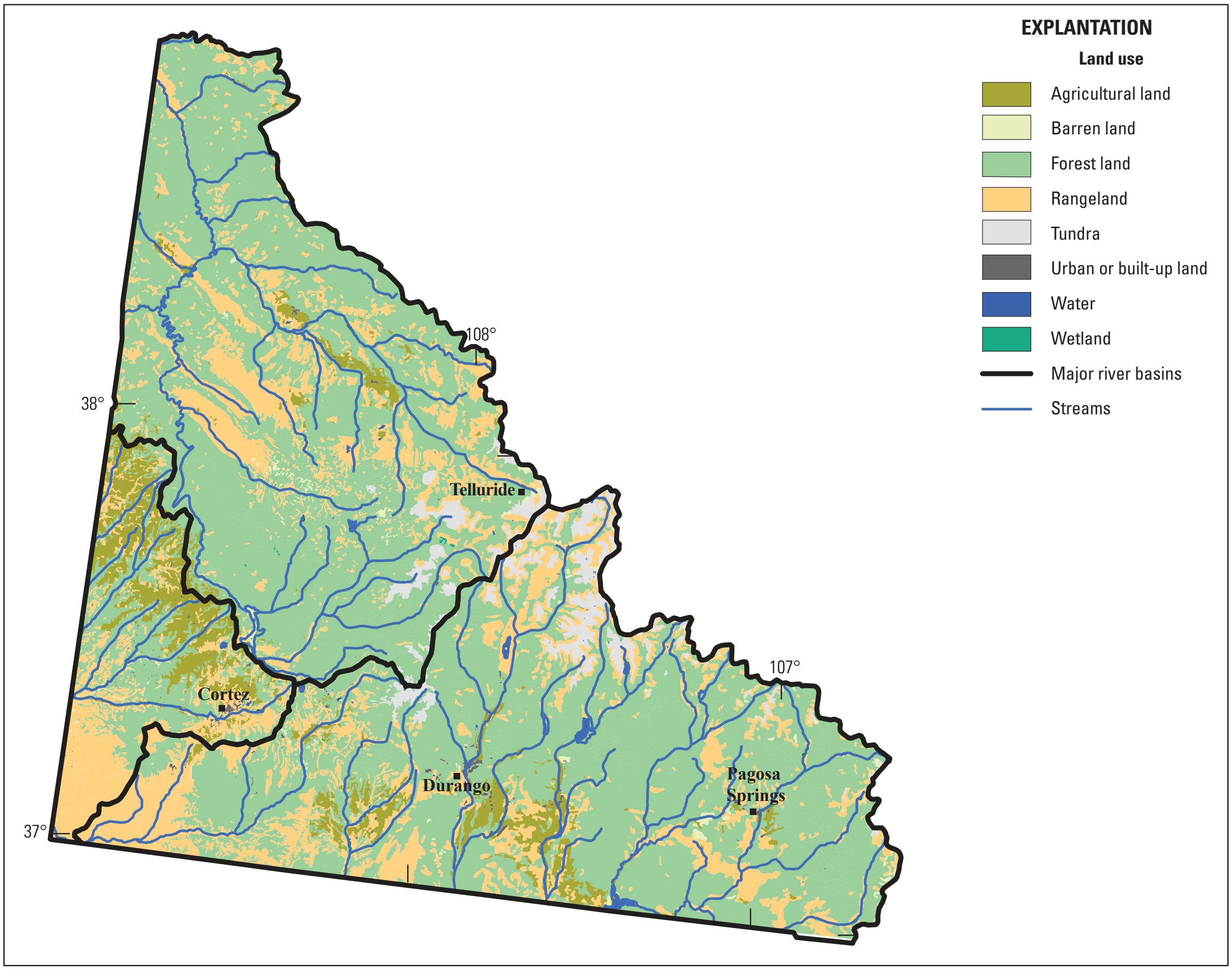


Figure 3. Map showing surface geology for southwestern Colorado.

Selection and Processing of Data

Water-quality characteristics sampled, number of samples, and site specific periods of record were summarized and plotted to choose a continuous period of time (period of analysis) in which the most data were collected at the greatest number of sites. The selected period of analysis used in this report was January 1990 through December 2005. For the purpose of this report, only stream sites with location data including the latitude and longitude were selected for analysis. In other words, water-quality data from lakes, canals, and ditches were not used, and sites without location information were excluded from the analysis.

Several quality-assurance procedures were performed prior to statistical analysis to remove suspect data. Low and high values for 190 water-quality characteristics have been established by the USEPA as an edit-checking procedure for data entered into the STOrage and RETrieval (STORET) data system (U.S. Environmental Protection Agency, 1977). These high and low values were used to determine reasonable ranges for 33 water-quality characteristics analyzed in southwestern Colorado (Appendix 1). Selected data were deleted when values exceeded reasonable ranges, for example a stream-water temperature above 300 °C. In some samples, certain trace elements had concentrations that exceeded the high values established by USEPA; however, these values were not deleted because areas with historical mining activities or with naturally high mineralization are present in the study area. There were also water-quality characteristics with zero values and no information about reporting limits. Most of the zero values were associated with nutrient and trace element results. It was not known if the zero values represented censored concentrations (that is concentrations less than the reporting limit or nondetections) or if the zero values indicated that the constituents were not analyzed. Consequently, zero concentrations for nutrients and metals were not used in the analyses presented in this report.



Landuse data from TechniGraphics, Inc. 2004

0 20 40 MILES
0 20 40 KILOMETERS

Figure 4. Map showing land use for southwestern Colorado.

Most laboratories censor data using a reporting limit that is equal to the detection limit. However, historically, the USGS National Water Quality Laboratory (NWQL) used informative censoring in an effort to provide requested information to data users and protection from false negative errors (Helsel, 2005). Numerical values were reported for concentrations greater than the detection limit yet less than the NWQL laboratory reporting level (LRL) and coded as estimated. Nondetections (that is, values less than the detection limit) were reported as less than the LRL which was generally twice the detection limit. In other words, two different reporting limits were used to report data—the detection limit and the LRL. In this way, informative censoring of the data established the reporting limit as a function of the measured concentration (Helsel, 2005). Helsel (2005) stated that informative censoring such as this invalidates the computation of percentiles (and other summary statistics) and recommended that data users recensor data before analyzing. Consequently, NWQL nondetections reported as less than the LRL were recensored and reported as less than the detection limit. Numerical values reported between the detection limit and the LRL were reported without qualification.

Reporting limits for some constituents varied substantially at some sites because samples were collected by multiple agencies for various reasons and analyzed by different laboratories. Occasionally, the reporting limit was higher than all or most of the measured concentrations at the site. For example, reporting limits for dissolved aluminum at McElmo Creek above Trail Canyon at gage site (05L) ranged from 1 µg/L to 2,500 µg/L. Most of the reporting limits at McElmo Creek site 05L were between 30 and 500 µg/L. A dissolved aluminum concentration of 2.9 µg/L was measured in 1 of the 45 samples collected (1990–2005) at the site; the remaining 44 samples were coded as not detected (less than the reporting limit).

Water-quality criteria for select constituents were reported as table values (Colorado Department of Public Health and Environment, 2010b) and required computation based on the site-specific hardness values. Mean hardness values were used to approximate the site-specific hardness values, because limited data were available. The mean hardness value was calculated for each site where data were available and input into the corresponding constituent equations to determine the acute and(or) chronic water-quality criteria. The maximum hardness value used in computations of water-quality criteria for lead and zinc was 400 mg/L and for aluminum was 200 mg/L (Colorado Department of Public Health and Environment, 2010b).

Boxplots, scatter plots, and maps were used in this report to depict the variability of selected surface-water-quality characteristics. Boxplots were generated to show simple graphical summaries of selected water-quality characteristic values. The upper horizontal line of the box is the 75th percentile or upper quartile (75 percent of the data are less than this value). The horizontal line within the box represents the median value (50 percent of the data are greater than this value and 50 percent of the data are less than this value). The lower horizontal line of the box is the 25th percentile or lower quartile (25 percent of the data are less than this value). The interquartile range (IQR) contains the values between the 25th and 75th percentiles and is the difference between the 25th and 75th percentiles. The bottom of the vertical line on the boxplot is the smallest value within 1.5 times the IQR of the box. The top of the vertical line on the boxplot is the largest value within 1.5 times the IQR of the box. Outside values are greater than 1.5 times the IQR from the box and outlier values are greater than 3 times the IQR from the box.

A trilinear diagram was constructed to classify and compare water types based on ionic composition (Hem, 1985). The most abundant cations in water generally are calcium, magnesium, sodium, and potassium; and the most abundant anions are sulfate, chloride, and bicarbonate (Bartos and Ogle, 2002). If a site had more than one sample with adequate major dissolved ion data, an average concentration for each major ion was calculated. Concentrations of major ions were converted to percent millequivalents per liter and plotted on the trilinear diagram to determine the dominant water types at selected sites.

The nonparametric Kruskal-Wallis test was used to determine whether there were statistical differences between winter (November–March) and summer (April–October) values of selected water-quality characteristics within the selected river basins in the study area (SYSTAT Software, Inc., 2004). Nonparametric statistical tests allow the user to analyze data without assuming an underlying distribution and are not strongly affected by outliers (Helsel and Hirsch, 2002). For the purpose of this analysis, the Kruskal-Wallis null hypothesis assumed that the distribution of the data groups (that is, the water-quality characteristic values for the winter period and the summer period) were identical. The alternate hypothesis assumed that one distribution differed from the other. The probability value (p-value) is the probability of rejecting the null hypothesis if it is true. A p-value of less than or equal to 0.05 was used in this report to indicate if a statistical test was significant. A p-value less than 0.01 was considered highly significant.

Computation of Summary Statistics

Existing water quality standards from the Colorado Department of Public Health and Environment (CDPHE) Colorado Water Quality Control Commission (henceforth referred to as Commission) are defined as “the 85th percentile of the data for total ammonia, nitrate, and dissolved metals, the 50th percentile for total recoverable metals, the 15th percentile for dissolved oxygen (DO), and the range between the 15th and 85th percentiles for pH” (Colorado Department of Public Health and Environment, 2010a). For purposes of comparison, the appropriate statistical values (described in the previous sentence) for each constituent discussed in this report were calculated for sites with 10 or more samples.

Methods used to calculate summary statistics including the minimum, maximum, mean, and 15th, 50th, and 85th percentile values varied based on the amount of censored data. Summary statistics were calculated using the statistical package SYSTAT (SYSTAT Software, Inc., 2004) for water-quality characteristics such as DO, pH, water temperature, specific conductance (SC), DS, and major ions with less than 10 percent censored data. For water-quality characteristics with higher occurrences of censored values including trace elements, nutrients, and uranium, the “left-censored data analysis” interface developed by the USGS (Slack and others, 2003) for the statistical software package Spotfire S+ (TIBCO, 2008) was used to calculate summary statistics. Three different methods were used to calculate summary statistics for trace element, nutrient, and uranium concentrations based on the amount of censored data. The nonparametric Kaplan-Meier method modified for left-censored data, described by Helsel (2005), was used to calculate summary statistics when less than 50 percent of the data were censored. When 50 to 80 percent of the data were censored, the robust “regression on order statistics” or ROS method was used (Helsel, 2005). Finally, when more than 80 percent of the data were censored, summary statistics were reported as less than the maximum reporting limit for the water-quality characteristic at the site.

Analysis of Temporal Trends

Nonparametric statistical methods were used to test for temporal trends in various water-quality characteristic values where data were available. Specifically, the seasonal Kendall test was used to test for monotonic trends (Hirsch and Slack, 1984), or trends in one direction (upward or downward) that were not necessarily linear. The seasonal Kendall test was performed using a USGS statistical program, ESTREND (ESTimate TREND) (Shertz and others, 1991) for which a graphical user interface was developed to be run as a “plug-in” to Spotfire S+ (Slack and others, 2003). The trend slope is a measure of the monotonic trend and an estimate of the median rate of change in water-quality characteristic values for the study period. The trend slope is an approximation of the change in constituent concentration over time which may be linear, may be in steps, or may show reversals during the study period (Schertz and others, 1991).

The initial selection criteria for site and parameter selection for analysis of temporal trends were that (1) the site had at least 10 samples, (2) the samples were evenly distributed over a 10-year period between 1990 and 2005, and (3) the sample had an associated streamflow value. Two study periods were chosen based on results from the initial selection criteria: 1993 to 2003 for field properties, major ions, and nutrients and 1991 to 2004 for trace elements. The study periods refer to calendar years that begin January 1 and end December 31. Site and parameter pairs were further culled based on sample distribution over the study period and amount of censored data. ESTREND requires sufficient samples in the beginning and ending fifths of the study period for analysis; consequently, site and parameter combinations were eliminated that had less than two samples in the first two years and(or) last two years of the study period. Finally, site and parameter combinations were eliminated from analysis when 8 percent or more of the results were censored.

The data were analyzed using four seasons when adequate data were available. When adequate data were not available, the number of seasons analyzed was reduced. There were sufficient data to account for four seasons for all of the water-quality characteristics analyzed for trends over the 1993 to 2003 study period. There were not sufficient data to account for four seasons in the 1991 to 2004 study period for all water-quality characteristics; as a result, the trend analysis included one, two, three, and four seasons. One season referred to a calendar year; two seasons referred to a winter (November 1–March 31) and summer (April 1–October 31) season; three seasons referred to November 1–March 31 (low flow), April 1–June 30 (peak flow), and July 1–October 31 (summer rainstorms); and the four seasons were three calendar months each beginning January 1. Within the ESTREND interface, additional selection criteria were applied to the data that ensured adequate seasonal comparisons. A subset of the data were used for the trend test that consisted of one sample for each season to account for sampling bias and ensure that each observation was independent. Results were reported for the analysis that included the most seasons.

Trends in water-quality characteristic values may be masked by variability in streamflow from year to year because of the possible correlation between the water-quality characteristics and streamflow (Hirsch and others, 1982). For the purpose of this report, characteristic values with 8 percent or less censored data were flow adjusted before analysis to remove the possible effects of streamflow variability on trends for all characteristics except pH and water temperature. Flow adjustment of concentrations is a parametric procedure that assumes normality and constant variance in the distributions of the concentration and streamflow data. To meet these assumptions, both parameters were log transformed. Flow-adjusted concentrations are the residuals of the regression of the log-transformed concentrations on log-transformed streamflow (Smith and others, 1982). The regression is of the form (model 12, Schertz and others, 1991):

$$\ln \hat{C} = \hat{b}_0 + \hat{b}_1 \ln Q + \hat{b}_2 (\ln Q)^2 \quad (1)$$

$\hat{C}$ is the estimate concentration;
Q is the streamflow in cubic feet per second;
ln is the natural logarithm; and
$\hat{b}_0$, $\hat{b}_1$, and $\hat{b}_2$ are the parameters estimated from the regression procedure.

Streamflow data were often not associated with samples. For a site colocated with a USGS streamflow-gaging station, the corresponding mean daily streamflow value from the USGS streamflow-gaging station was used to approximate the streamflow for each sample (U.S. Geological Survey, 2011). This was done to increase the number of sites/water-quality characteristics that met selection criteria for trend analysis. Instantaneous streamflow measurements are usually made by the USGS when water-quality samples are collected (Rantz and others, 1982). As a result, most samples collected by the USGS have instantaneous streamflow data associated with them. For sites sampled by agencies other than the USGS that had streamflow data associated with samples, the streamflows were assumed to be instantaneous values.

Trend results from the seasonal Kendall test were reported in terms of the percent change relative to the unadjusted median value of the data used for the trend analysis (henceforth referred to as typical value). The trend analysis, however, used flow-adjusted concentrations. The calculations were performed within the ESTREND program. ESTREND calculates an adjusted p-value that takes into account that seasons may be serially correlated. The p-value, adjusted for serial dependence, was an estimate of the probability that there was no change in concentration or value over time.

Surface-Water Quality in Southwestern Colorado

The spatial and temporal distribution of DO, pH, water temperature, DS, major ions, selected trace elements, nutrients, and uranium data are discussed in this section and its subsections. These water-quality characteristics are described spatially by location within the Dolores River Basin, Upper SJRB, and Lower SJRB (fig. 1). Site identification numbers, names, and location information for sites used in the analyses are shown in table 1. In order to provide an overview of existing surface-water water-quality conditions in each river basin, selected physical and chemical water-quality characteristics were compared to State water-quality standards. The temporal

Table 1. List of sites and site location information, southwestern Colorado, 1990–2005.

[Site ID, identification number shown in figure 1; Database ID, data repository identification number (http://rmgsc.cr.usgs.gov/cwqdr/Southwest/index.shtml); LatitudeDD, latitude in decimal degrees; LongitudeDD, longitude in decimal degrees; USGS, U.S. Geological Survey; WWTP, wastewater treatment plant]

Site ID	Database ID	Site name	Subbasin name	LatitudeDD	LongitudeDD
		Dolores River Basin			
01D	10784R	Coal Creek at FR 535 below Lizard Head Wilderness Area	Upper Dolores	37.790	-108.018
02D	10782	Horse Creek at Highway 145	Upper Dolores	37.713	-108.035
03D	10718	Dolores River above Horse Creek	Upper Dolores	37.702	-108.031
04D	10780	Silver Creek at Highway 145	Upper Dolores	37.683	-108.033
05D	10716	Dolores River below Rico	Upper Dolores	37.639	-108.060
06D	09165000	Dolores River below Rico	Upper Dolores	37.639	-108.060
07D	10770	West Dolores River near Stoner at Highway 145	Upper Dolores	37.588	-108.357
08D	10901A	Lost Canyon Creek near Dolores	Upper Dolores	37.446	-108.469
09D	09166950	Lost Canyon Creek near Dolores	Upper Dolores	37.446	-108.469
10D	09166500	Dolores River at Dolores	Upper Dolores	37.472	-108.498
11D	DRDOL12T	Dolores River at Dolores	Upper Dolores	37.474	-108.504
12D	000080	Dolores River near town of Dolores	Upper Dolores	37.471	-108.504
13D	10701	Dolores River at Dolores above Mcphee Reservoir	Upper Dolores	37.471	-108.504
14D	09168730	Dolores River near Slick Rock	Upper Dolores	38.044	-108.905
15D	000085	Dolores River above confluence with San Miguel River	Upper Dolores	38.300	-108.867
16D	09169500	Dolores River at Bedrock	Upper Dolores	38.310	-108.885
17D	4958900	Lasal Creek at Utah-Colorado State Line	Upper Dolores	38.328	-109.060
18D	09170800	West Paradox Creek above Bedrock	Upper Dolores	38.332	-108.900
19D	09171100	Dolores River near Bedrock	Upper Dolores	38.357	-108.833
20D	10818	San Miguel River above Marshall Creek	San Miguel	37.931	-107.779
21D	BC1	(2), Bear Creek	San Miguel	37.935	-107.804
22D	1	Upstream, SMIG above Bear	San Miguel	37.935	-107.804
23D	C1-SW	(7), Coronet	San Miguel	37.937	-107.820
24D	14	Downstream, SMMAHONEY	San Miguel	37.938	-107.822
25D	10815	San Miguel River at Society Turn	San Miguel	37.950	-107.869
26D	10871	South Fork San Miguel River near mouth	San Miguel	37.940	-107.899
27D	10875	Howard Fork San Miguel River at Ophir	San Miguel	37.860	-107.899
28D	09172500	San Miguel River near Placerville	San Miguel	38.043	-108.132
29D	000101	San Miguel River near Norwood	San Miguel	38.126	-108.208
30D	10860	McKenzie Creek at mouth above confluence with San Miguel River	San Miguel	38.126	-108.208
31D	09174600	San Miguel River at Brooks Bridge near Nucla	San Miguel	38.244	-108.502
32D	10831	Naturita Creek at Naturita	San Miguel	38.218	-108.545
33D	09177000	San Miguel River at Uravan	San Miguel	38.357	-108.713
34D	000084	San Miguel River at confluence with Dolores River	San Miguel	38.409	-108.755
35D	10903	Salt Creek at Highway 141	Lower Dolores	38.562	-108.921
36D	10915	West Creek in Unaweep Canyon	Lower Dolores	38.773	-108.881
37D	000061	Dolores River at Gateway	Lower Dolores	38.667	-109.017
		Upper San Juan River Basin			
01A	A09	North Fork above Cal. Gulch	Animas	37.933	-107.569
02A	A33	Animas River at Eureka	Animas	37.879	-107.565
03A	A39	Eureka below Ben Franklin	Animas	37.892	-107.602
04A	A53	Animas River at Howardsville	Animas	37.833	-107.599
05A	A60	Animas River downstream from Arrastra Gulch	Animas	37.827	-107.626
06A	AN68	Animas River at USGS gaging station above 14th Street	Animas	37.828	-107.591

Table 1. List of sites and site location information, southwestern Colorado, 1990–2005.—Continued

[Site ID, identification number shown in figure 1; Database ID, data repository identification number (http://rmgsc.cr.usgs.gov/cwqdr/Southwest/index.shtml); LatitudeDD, latitude in decimal degrees; LongitudeDD, longitude in decimal degrees; USGS, U.S. Geological Survey; WWTP, wastewater treatment plant]

Site ID	Database ID	Site name	Subbasin name	LatitudeDD	LongitudeDD
		Upper San Juan River Basin—Continued			
07A	A68	Animas River at Silverton	Animas	37.811	-107.659
08A	09358000	Animas River at Silverton (USGS)	Animas	37.811	-107.659
09A	CC18	North Fork Cement Creek upstream from Gold King mine, #7 level (AMLI mine # 103)	Animas	37.896	-107.630
10A	CC32	South Fork Cement Creek downstream from Velocity Lake	Animas	37.869	-107.644
11A	CC31	South Fork Cement Creek downstream from Big Colorado mine (AMLI mine # 150)	Animas	37.878	-107.645
12A	CC23	Prospect Gulch upstream from Red Spring	Animas	37.883	-107.669
13A	C31	Cement Creek at Fairview Gulch Bridge	Animas	37.875	-107.671
14A	CC14	Minnesota Gulch near mouth	Animas	37.863	-107.676
15A	CC20	Porcupine Gulch upstream from mines	Animas	37.861	-107.684
16A	CC17	Niagara Gulch near mouth	Animas	37.840	-107.680
17A	09358550	Cement Creek at Silverton	Animas	37.820	-107.664
18A	C48	Cement Creek at Silverton	Animas	37.820	-107.663
19A	CEM48	Cement Creek at USGS gaging station	Animas	37.820	-107.663
20A	M02	Mineral Creek near headwaters	Animas	37.900	-107.711
21A	M02A	Highway 550 drainage ditch above M01 confluence-east side of Highway 550	Animas	37.895	-107.714
22A	M07	Mineral Creek at Chattanooga	Animas	37.874	-107.724
23A	M13	Mineral Creek just below confluence with Browns Gulch	Animas	37.854	-107.726
24A	M12	Browns Gulch above confluence with Mineral Creek	Animas	37.857	-107.723
25A	M13A	Mineral Creek at Burro Bridge	Animas	37.851	-107.725
26A	375028107455801	A43 Paradise Basin above confluence above mines	Animas	37.841	-107.767
27A	375039107444801	W39 Middle Fork above Red tributary	Animas	37.844	-107.747
28A	375042107443801	W41 Sheep Lake Tributary at confluence with Middle Fork	Animas	37.845	-107.745
29A	M20	Middle Fork Mineral Creek above Bonner Mine	Animas	37.846	-107.741
30A	M27	Mineral Creek above confluence with South Fork Mineral Creek	Animas	37.822	-107.719
31A	09359010	Mineral Creek at Silverton (USGS)	Animas	37.803	-107.673
32A	M34	Mineral Creek at Silverton	Animas	37.803	-107.672
33A	09359020	Animas River below Silverton	Animas	37.790	-107.668
34A	AN72	Animas River at USGS gaging station just above railroad bridge	Animas	37.790	-107.667
35A	A72	Animas River downstream from Silverton	Animas	37.790	-107.667
36A	000082	Animas River near Silverton	Animas	37.792	-107.683
37A	374248107323601	Big Eldorado inflow	Animas	37.713	-107.544
38A	374248107324501	Little Eldorado inflow	Animas	37.713	-107.546
39A	9445	Cascade Creek at Highway 550	Animas	37.659	-107.810
40A	000081	Animas River above Durango	Animas	37.457	-107.798
41A	DRALP003	Animas at Durango Mall	Animas	37.419	-107.819
42A	89	Trimble Lane Bridge	Animas	37.385	-107.836
43A	9440	Falls Creek at 0.65 Road	Animas	37.378	-107.868
44A	135	Animas at 32nd Street Bridge	Animas	37.300	-107.868
45A	09361500	Animas River at Durango (USGS)	Animas	37.279	-107.880
46A	9420	Animas River at Durango	Animas	37.268	-107.886
47A	DRALPLC2	Lightner Creek at mouth at Durango	Animas	37.268	-107.887
48A	DRALP001	DRALP001	Animas	37.257	-107.883

Table 1. List of sites and site location information, southwestern Colorado, 1990–2005.—Continued

[Site ID, identification number shown in figure 1; Database ID, data repository identification number (http://rmgsc.cr.usgs.gov/cwqdr/Southwest/index.shtml); LatitudeDD, latitude in decimal degrees; LongitudeDD, longitude in decimal degrees; USGS, U.S. Geological Survey; WWTP, wastewater treatment plant]

Site ID	Database ID	Site name	Subbasin name	LatitudeDD	LongitudeDD
		Upper San Juan River Basin—Continued			
49A	DRALP002	Animas River at Durango	Animas	37.258	-107.877
50A	DRALP209	Animas River behind BMX track at Durango	Animas	37.250	-107.887
51A	09362550	Wilson Gulch near Durango	Animas	37.227	-107.843
52A	93	Weaselskin	Animas	37.152	-107.884
53A	000138	Florida River below Lemon Reservoir	Animas	37.368	-107.667
54A	9415	Salt Creek at 309A Road	Animas	37.139	-107.750
55A	000106	Florida River at confluence with Las Animas River	Animas	37.057	-107.869
56A	148	Animas River at Bondad	Animas	37.049	-107.875
57A	000066	Animas River near Bondad	Animas	37.038	-107.874
58A	375044107440601	W38 Stream below W16	Animas	37.846	-107.736
01U	9850	Little Navajo River at Highway 84	Upper San Juan	37.036	-106.844
02U	09346000	Navajo River at Edith	Upper San Juan	37.003	-106.908
03U	9860	Rio Blanco at Highway 84	Upper San Juan	37.161	-106.948
04U	09339900	East Fork San Juan River above Sand Creek, near Pagosa Springs	Upper San Juan	37.390	-106.841
05U	9165	Sand Creek at mouth above East Fork San Juan River	Upper San Juan	37.388	-106.847
06U	09340800	West Fork San Juan River at West Fork Campground near Pagosa Springs	Upper San Juan	37.450	-106.912
07U	09341300	Wolf Creek at Wolf Creek Campground near Pagosa Springs	Upper San Juan	37.442	-106.887
08U	09341500	West Fork San Juan River near Pagosa Springs	Upper San Juan	37.392	-106.907
09U	000137	San Juan River above Pagosa Springs	Upper San Juan	37.329	-106.956
10U	9120	McCabe Creek above Pagosa Springs	Upper San Juan	37.273	-107.012
11U	09342500	San Juan River at Pagosa Springs	Upper San Juan	37.267	-107.008
12U	000119	San Juan River below Pagosa Springs	Upper San Juan	37.250	-107.000
13U	09346400	San Juan River near Carracas	Upper San Juan	37.014	-107.312
14U	000068	San Juan River above Navajo Reservoir	Upper San Juan	37.014	-107.314
15U	9290	East Fork Piedra River below Piedra Falls	Piedra	37.479	-107.102
16U	9250	Piedra River at Highway 160	Piedra	37.224	-107.342
17U	9245	Stollsteimer Creek at Highway 151	Piedra	37.178	-107.293
18U	09349800	Piedra River near Arboles	Piedra	37.088	-107.398
19U	000069	Piedra River northeast of Arboles	Piedra	37.053	-107.412
20U	09352800	Los Pinos River above Vallecito Reservoir near Bayfield	Upper San Juan	37.415	-107.513
21U	9380	Los Pinos River above Vallecito Reservoir	Upper San Juan	37.407	-107.529
22U	09352900	Vallecito Creek near Bayfield	Upper San Juan	37.478	-107.544
23U	9370	Vallecito Creek near mouth	Upper San Juan	37.442	-107.547
24U	372236107344400	Los Pinos River below Vallecito Reservoir near Bayfield	Upper San Juan	37.377	-107.580
25U	9355	Wallace Gulch at 502 Road north of Bayfield	Upper San Juan	37.260	-107.614
26U	09353800	Los Pinos River near Ignacio	Upper San Juan	37.166	-107.583
27U	09355000	Spring Creek at La Boca	Upper San Juan	37.015	-107.595
28U	000067	Los Pinos River near La Boca	Upper San Juan	37.010	-107.597
29U	09354500	Los Pinos River at La Boca	Upper San Juan	37.009	-107.599
30U	9680	La Plata at Hesperus	Middle San Juan	37.292	-108.042
31U	9610	Spring Creek near Breen	Middle San Juan	37.202	-108.079
32U	9720	East Fork Mancos River at 44 Road	Mancos	37.361	-108.248
33U	000103	Mancos River at Mancos	Mancos	37.367	-108.267

Table 1. List of sites and site location information, southwestern Colorado, 1990–2005.—Continued

[Site ID, identification number shown in figure 1; Database ID, data repository identification number (http://rmgsc.cr.usgs.gov/cwqdr/Southwest/index.shtml); LatitudeDD, latitude in decimal degrees; LongitudeDD, longitude in decimal degrees; USGS, U.S. Geological Survey; WWTP, wastewater treatment plant]

Site ID	Database ID	Site name	Subbasin name	LatitudeDD	LongitudeDD
		Upper San Juan River Basin—Continued			
34U	9715	Chicken Creek at Mancos	Mancos	37.345	-108.314
35U	09371000	Mancos River near Towaoc	Mancos	37.027	-108.741
36U	09371002	Navajo Wash near Towaoc	Mancos	37.201	-108.698
		Lower San Juan River Basin			
01L	9887	McElmo Creek above Cortez Sanitation District, Southwest WWTP	McElmo	37.322	-108.606
02L	09371492	Mud Creek at State Highway 32, near Cortez	McElmo	37.313	-108.661
03L	09371500	McElmo Creek near Cortez	McElmo	37.323	-108.673
04L	09371520	McElmo Creek above Trail Canyon near Cortez	McElmo	37.327	-108.701
05L	9871	McElmo Creek above Trail Canyon at gage	McElmo	37.328	-108.702
06L	09372000	McElmo Creek near Colorado-Utah State Line	McElmo	37.324	-109.016

distribution of water-quality characteristics typically was discussed in reference to seasonal differences or changes in values over time (trends) if adequate data were available. Temporal trend analyses were done for sites meeting the criteria described in the "Analysis of Temporal Trends" section of the report. Trend analyses for DO, pH, water temperature, SC, DS, chloride, and sulfate data were done for the period January 1993 through December 2003 and for selected trace metals data for the period January 1991 through December 2004.

Urban and agricultural activities can often increase nutrient and sediment loading to streams, increase stream-water temperatures, and alter channel geomorphology which may result in increased growth of aquatic organisms such as algae and loss of aquatic habitat. Photosynthesis by aquatic organisms uses up hydrogen molecules causing the concentration of hydrogen to decrease and therefore the pH to increase; whereas, respiration and decay processes lower pH (Washington State Department of Ecology, 1994). In aquatic systems, these processes (photosynthesis, respiration, and decay) can produce diurnal fluctuations in pH and DO (Hem, 1985). Kuwabara and others (2003) noted that, for the most part, the amplitudes of diurnal pH cycles increased (that is pH values were higher during the daylight hours and lower during the night) with increasing biomass. In turn, changes in pH affect sorption and precipitation characteristics of metals in water.

Dissolved Oxygen

Overall, streams throughout the study area were well oxygenated. Median DO concentrations generally ranged from 8 to 10 mg/L in surface water (table 2). Instantaneous DO concentrations ranged from 0 to 23 mg/L. Dissolved oxygen concentrations in surface water in the study area were generally lowest from July through September and highest from November through February corresponding to seasonal changes in air and water temperature. The solubility of oxygen increases as temperature decreases; as a result, DO concentrations would be expected to be higher during the winter months when temperatures are cooler and lower during the summer months when temperatures are warmer.

Adequate DO concentrations in surface water are required for healthy aquatic communities. The existing water quality for DO was defined by the Commission as the 15th percentile concentration. The Commission established physical and biological water-quality standards for DO in streams in southwestern Colorado that varied from 3.0 mg/L in selected segments of the Animas and Florida River Basin (Colorado Department of Public Health and Environment, 2010a) to 7.0 mg/L during periods of spawning in certain designated cold water segments (Colorado Department of Public Health and Environment, 2010b) of the study area. For most segments, the standard was either 5 or 6 mg/L (Colorado Department of Public Health and Environment, 2010a). The 15th percentile DO value for most sites was greater than 7 mg/L.

Dolores River Basin.—Dissolved oxygen data were analyzed at 25 sites. The 15th percentile concentrations ranged from 5.0 to 8.9 mg/L (table 2). The lowest 15th percentile DO concentrations, values less than 6 mg/L, occurred at several sites in the upper San Miguel River Basin near Telluride and at one site on Salt Creek (table 2). Sufficient data were not available to calculate temporal trends.

Upper San Juan River Basin.—Dissolved oxygen data were analyzed at 40 sites. The 15th percentile concentrations ranged from 0.1 to 9.7 mg/L (table 2). Only one stream site, South Fork Cement Creek downstream from Velocity Lake (10A), had a 15th percentile DO concentration less than 5 mg/L (table 2). This site was located in the upper Animas River Basin in the vicinity of Silverton. Most other sites had 15th percentile DO concentrations that exceeded 7 mg/L.

Table 2. Statistical summary for dissolved oxygen, pH, and water-temperature data for sites with 10 or more samples in the Dolores, Upper San Juan, and Lower San Juan River Basins, southwestern Colorado, 1990–2005.

[Site ID, site identification number shown on figure 1; No., number of samples; Min, minimum value; Max, maximum value; --, not applicable; gray shaded columns indicate statistics that were used for comparison to State water-quality standards and values shown in red represent instances when State water-quality standards were not met; WWTP, wastewater treatment plant]

Site ID	Site name	Dissolved oxygen, milligrams per liter						
		No.	Min	Max	Mean	Percentiles 15	Percentiles 50	Percentiles 85
	Dolores River Basin							
01D	Coal Creek at FR 535 below Lizard Head Wilderness Area	--	--	--	--	--	--	--
02D	Horse Creek at Highway 145	10	8.0	11.6	9.4	8.5	9.3	10.1
03D	Dolores River above Horse Creek	15	8.3	11.6	9.8	8.7	9.9	10.8
04D	Silver Creek at Highway 145	38	7.7	15.6	10.8	8.8	10.5	12.8
05D	Dolores River below Rico	42	6.6	15.2	10.1	8.2	9.9	11.9
06D	Dolores River below Rico	--	--	--	--	--	--	--
07D	West Dolores River near Stoner at Highway 145	20	7.6	12.4	10.2	8.2	10.6	11.9
08D	Lost Canyon Creek near Dolores	12	6.3	11.3	9.0	6.3	9.7	10.7
09D	Lost Canyon Creek near Dolores	--	--	--	--	--	--	--
10D	Dolores River at Dolores	--	--	--	--	--	--	--
12D	Dolores River near town of Dolores	13	8.2	12.0	10.4	8.7	10.6	11.8
13D	Dolores River at Dolores above Mcphee Reservoir	25	6.0	13.7	9.5	7.1	9.4	11.5
14D	Dolores River near Slick Rock	--	--	--	--	--	--	--
15D	Dolores River above confluence with San Miguel River	40	6.8	13.4	10.2	8.1	9.7	12.7
16D	Dolores River at Bedrock	--	--	--	--	--	--	--
17D	Lasal Creek at Utah-Colorado State Line	23	5.8	12.8	9.3	7.4	9.3	11.4
18D	West Paradox Creek above Bedrock	--	--	--	--	--	--	--
19D	Dolores River near Bedrock	--	--	--	--	--	--	--
20D	San Miguel River above Marshall Creek	11	8.4	13.7	9.6	8.5	9.0	10.8
21D	(2), Bear Creek	11	0.4	13.8	9.5	5.7	10.1	13.2
22D	Upstream, SMIG above Bear	11	0.4	13.3	9.4	6.1	9.8	12.9
23D	(7), Coronet	11	0.4	13.2	9.1	5.7	9.4	12.7
24D	Downstream, SMMAHONEY	11	0.4	13.2	9.0	5.6	9.5	12.2
25D	San Miguel River at Society Turn	70	7.1	14.6	9.4	7.9	9.1	10.6
26D	South Fork San Miguel River near mouth	24	8.1	12.4	9.8	8.5	9.5	11.8
27D	Howard Fork San Miguel River at Ophir	17	8.1	11.7	9.9	8.9	9.8	11.0
28D	San Miguel River near Placerville	--	--	--	--	--	--	--
29D	San Miguel River near Norwood	33	6.8	14.0	9.9	8.2	9.6	12.7
30D	McKenzie Creek at mouth above confluence with San Miguel River	17	5.2	10.2	8.0	6.6	8.1	9.4
31D	San Miguel River at Brooks Bridge near Nucla	--	--	--	--	--	--	--
32D	Naturita Creek at Naturita	18	6.5	13.8	9.8	7.7	8.8	12.8
33D	San Miguel River at Uravan	--	--	--	--	--	--	--
34D	San Miguel River at confluence with Dolores River	63	6.7	13.8	10.1	8.0	10.0	12.5
35D	Salt Creek at Highway 141	13	4.7	9.0	6.9	5.0	6.3	8.6
36D	West Creek in Unaweep Canyon	14	7.8	11.0	9.4	8.2	9.5	10.6
37D	Dolores River at Gateway	19	7.3	13.2	9.8	7.7	9.4	12.5
	Upper San Juan River Basin							
02A	Animas River at Eureka	10	7.6	10.6	8.6	7.8	8.3	9.6
03A	Eureka below Ben Franklin	--	--	--	--	--	--	--
04A	Animas River at Howardsville	10	6.9	9.4	8.0	7.4	7.9	8.9
06A	Animas River at USGS gaging station above 14th Street	--	--	--	--	--	--	--
07A	Animas River at Silverton	51	5.4	10.6	8.4	6.8	8.5	9.8
08A	Animas River at Silverton	--	--	--	--	--	--	--
09A	North Fork Cement Creek upstream from Gold King mine, #7 level (AMLI mine # 103)	--	--	--	--	--	--	--
10A	South Fork Cement Creek downstream from Velocity Lake	10	0.0	8.1	1.1	0.1	0.3	1.2
11A	South Fork Cement Creek downstream from Big Colorado mine (AMLI mine # 150)	10	7.0	11.0	8.5	7.4	8.6	9.3
13A	Cement Creek at Fairview Gulch Bridge	--	--	--	--	--	--	--
15A	Porcupine Gulch upstream from mines	--	--	--	--	--	--	--
16A	Niagara Gulch near mouth	--	--	--	--	--	--	--
17A	Cement Creek at Silverton	--	--	--	--	--	--	--
18A	Cement Creek at Silverton	51	5.6	13.9	8.4	7.0	8.3	9.6
19A	Cement Creek at USGS gaging station	--	--	--	--	--	--	--
21A	Highway 550 drainage ditch above M01 confluence-east side of Highway 550	--	--	--	--	--	--	--
23A	Mineral Creek just below confluence with Browns Gulch	--	--	--	--	--	--	--
25A	Mineral at Burro Bridge	--	--	--	--	--	--	--
31A	Mineral Creek at Silverton	--	--	--	--	--	--	--

Table 2. Statistical summary for dissolved oxygen, pH, and water-temperature data for sites with 10 or more samples in the Dolores, Upper San Juan, and Lower San Juan River Basins, southwestern Colorado, 1990–2005.—Continued

[Site ID, site identification number shown on figure 1; No., number of samples; Min, minimum value; Max, maximum value; --, not applicable; gray shaded columns indicate statistics that were used for comparison to State water-quality standards and values shown in red represent instances when State water-quality standards were not met; WWTP, wastewater treatment plant]

Site ID	pH, standard units							Water temperature, degrees Celsius						
	No.	Min	Max	Mean	Percentiles 15	Percentiles 50	Percentiles 85	No.	Min	Max	Mean	Percentiles 15	Percentiles 50	Percentiles 85
Dolores River Basin														
01D	10	7.1	8.5	8.1	7.9	8.1	8.4	10	2.1	14.7	9.1	4.5	10.1	14.1
02D	--	--	--	--	--	--	--	12	1.1	12.3	6.3	2.1	6.1	11.4
03D	16	7.8	8.5	8.1	8.0	8.1	8.3	16	0.6	16.7	7.5	1.6	7.8	12.3
04D	42	7.5	8.5	8.1	7.8	8.1	8.3	47	-0.3	14.7	6.0	1.2	5.0	11.9
05D	43	7.1	8.6	8.1	7.8	8.1	8.5	48	-0.3	18.3	7.7	0.4	6.9	15.6
06D	--	--	--	--	--	--	--	118	0.0	18.1	5.7	0.0	4.8	11.5
07D	20	8.0	8.7	8.4	8.2	8.4	8.7	20	-0.2	20.6	8.5	0.9	7.0	17.4
08D	13	6.9	8.1	7.6	7.3	7.6	7.8	14	-0.2	25.4	8.3	0.2	6.7	18.9
09D	--	--	--	--	--	--	--	87	0.0	25.3	9.0	1.0	5.5	19.5
10D	--	--	--	--	--	--	--	123	0.0	22.9	8.1	0.5	6.7	16.5
12D	13	7.5	8.7	8.1	7.6	8.0	8.6	13	0.6	19.4	7.9	1.6	7.2	14.4
13D	25	7.5	8.8	8.2	7.9	8.2	8.5	25	-0.3	23.8	8.5	-0.2	6.4	19.1
14D	--	--	--	--	--	--	--	38	2.8	26.5	13.3	6.5	10.5	22.6
15D	40	7.3	8.6	8.2	7.8	8.3	8.4	40	0.0	24.4	10.1	1.1	10.8	18.6
16D	155	7.7	8.8	8.3	8.1	8.3	8.5	184	-0.1	27.0	13.0	3.3	13.3	22.0
17D	23	7.7	9.6	8.4	7.8	8.4	8.9	23	0.4	23.5	10.4	1.1	9.1	19.0
18D	101	7.8	8.6	8.3	8.1	8.3	8.4	104	0.0	22.0	10.0	1.6	9.3	18.0
19D	152	7.8	8.6	8.2	8.1	8.2	8.4	177	-0.5	29.8	14.1	4.5	15.0	23.0
20D	11	7.3	7.8	7.5	7.3	7.5	7.7	11	-0.2	10.0	6.6	3.4	7.3	10.0
21D	11	7.2	8.5	7.8	7.4	7.7	8.3	11	4.9	9.5	7.2	5.9	7.6	8.7
22D	11	7.2	8.1	7.6	7.3	7.7	7.9	11	6.9	13.9	9.7	7.0	9.2	12.1
23D	11	7.2	8.5	7.9	7.4	7.7	8.4	11	4.1	13.4	9.3	7.6	9.4	11.6
24D	11	7.2	7.9	7.6	7.4	7.6	7.8	11	6.1	12.3	9.1	7.3	8.6	11.6
25D	71	7.2	8.3	7.7	7.5	7.8	8.0	75	-0.2	18.1	8.0	2.0	8.8	12.8
26D	24	7.3	8.3	7.9	7.7	8.0	8.2	25	0.0	16.1	8.1	1.3	8.3	12.9
27D	17	7.2	8.1	7.7	7.6	7.8	7.9	17	1.1	11.7	6.6	2.3	7.8	10.5
28D	--	--	--	--	--	--	--	139	0.0	20.0	7.3	0.5	7.3	13.4
29D	33	7.6	8.7	8.3	8.1	8.3	8.6	33	0.0	23.1	9.8	0.6	11.7	17.3
30D	17	7.2	8.2	7.7	7.5	7.7	8.0	17	2.4	16.9	9.8	4.5	9.8	16.3
31D	--	--	--	--	--	--	--	89	0.0	27.6	11.3	1.2	11.0	21.0
32D	18	8.1	8.9	8.4	8.2	8.4	8.5	18	-0.2	28.3	13.5	1.1	14.4	23.9
33D	--	--	--	--	--	--	--	121	0.0	26.9	12.6	2.5	13.0	22.0
34D	64	7.3	9.1	8.3	8.0	8.3	8.5	64	-0.2	28.7	10.6	1.0	10.1	20.9
35D	13	7.5	8.4	8.1	7.9	8.2	8.3	13	-2.9	27.6	11.6	-0.4	12.4	20.7
36D	14	8.1	8.8	8.5	8.1	8.5	8.7	14	2.3	18.9	10.8	5.6	10.0	16.8
37D	19	7.9	8.6	8.3	8.1	8.4	8.4	19	1.7	24.4	11.3	3.2	11.4	19.0
Upper San Juan River Basin														
02A	24	6.2	7.7	7.1	6.5	7.1	7.5	24	0.0	19.1	7.4	2.1	7.8	11.0
03A	24	6.5	8.0	7.2	6.8	7.1	7.6	--	--	--	--	--	--	--
04A	18	5.3	7.8	7.1	6.9	7.1	7.6	17	0.2	11.7	7.8	4.9	8.2	11.4
06A	12	6.3	7.9	7.3	6.5	7.6	7.8	12	4.5	12.8	7.9	5.3	7.7	11.5
07A	161	5.2	8.4	6.9	6.4	7.0	7.5	132	0.0	22.6	5.9	2.0	5.7	10.0
08A	--	--	--	--	--	--	--	112	0.0	15.9	6.4	1.8	6.5	10.3
09A	95	2.5	5.1	3.6	3.1	3.6	4.0	95	0.3	13.9	5.7	2.7	5.2	9.1
10A	16	6.1	7.8	6.9	6.5	7.0	7.2	15	3.0	15.8	13.6	11.9	14.8	15.2
11A	14	3.5	5.8	4.2	3.8	4.0	4.7	14	3.8	10.7	7.4	4.4	7.6	10.6
13A	11	3.5	5.0	4.0	3.6	4.0	4.1	11	4.2	10.7	7.4	4.7	7.0	10.4
15A	124	2.7	10.3	6.8	4.0	7.6	8.6	--	--	--	--	--	--	--
16A	33	3.5	6.7	5.6	5.0	5.8	6.4	32	1.8	14.2	6.0	2.8	5.3	8.9
17A	--	--	--	--	--	--	--	107	0.0	15.7	6.6	2.9	6.5	10.7
18A	60	3.1	5.7	4.3	3.8	4.2	4.8	60	0.0	15.0	7.4	3.9	7.5	11.2
19A	12	4.1	5.1	4.7	4.4	4.6	5.1	12	3.5	14.4	8.2	4.0	8.3	11.6
21A	14	1.5	2.7	2.2	1.6	2.4	2.6	14	3.0	15.0	8.1	4.6	7.5	12.0
23A	15	5.2	7.1	6.5	6.2	6.5	6.9	15	0.1	14.5	7.7	4.4	7.8	11.8
25A	11	6.1	7.1	6.6	6.3	6.6	6.9	11	0.1	13.7	6.5	3.0	6.3	10.0
31A	--	--	--	--	--	--	--	106	0.0	16.6	5.3	1.0	5.0	9.1

Table 2. Statistical summary for dissolved oxygen, pH, and water-temperature data for sites with 10 or more samples in the Dolores, Upper San Juan, and Lower San Juan River Basins, southwestern Colorado, 1990–2005.—Continued

[Site ID, site identification number shown on figure 1; No., number of samples; Min, minimum value; Max, maximum value; --, not applicable; gray shaded columns indicate statistics that were used for comparison to State water-quality standards and values shown in red represent instances when State water-quality standards were not met; WWTP, wastewater treatment plant]

Site ID	Site name	Dissolved oxygen, milligrams per liter						
		No.	Min	Max	Mean	Percentiles 15	Percentiles 50	Percentiles 85
	Upper San Juan River Basin—Continued							
32A	Mineral Creek at Silverton	54	5.5	12.5	8.4	6.9	8.3	9.8
33A	Animas River below Silverton	83	7.5	11.8	9.7	8.1	9.6	11.1
34A	Animas River at USGS gaging station just above railroad bridge	--	--	--	--	--	--	--
35A	Animas River downstream from Silverton	55	5.4	11.8	9.0	7.5	9.0	10.6
36A	Animas River near Silverton	74	6.3	12.8	9.3	8.0	9.2	10.9
37A	Big Eldorado inflow	--	--	--	--	--	--	--
38A	Little Eldorado inflow	--	--	--	--	--	--	--
39A	Cascade Creek at Highway 550	15	7.3	14.2	9.7	8.0	9.4	11.2
40A	Animas River above Durango	35	8.2	12.4	10.6	9.1	10.8	12.0
41A	Animas at Durango Mall	--	--	--	--	--	--	--
42A	Trimble Lane Bridge	--	--	--	--	--	--	--
43A	Falls Creek at 0.65 Road	12	6.4	12.6	10.0	8.0	10.3	11.9
44A	Animas at 32nd Street Bridge	--	--	--	--	--	--	--
45A	Animas River at Durango	--	--	--	--	--	--	--
46A	Animas River at Durango	29	6.4	15.6	9.6	7.7	9.5	11.2
47A	Lightner Creek at mouth at Durango	--	--	--	--	--	--	--
48A	DRALP001	--	--	--	--	--	--	--
49A	Animas River at Durango	--	--	--	--	--	--	--
50A	Animas River behind BMX track at Durango	--	--	--	--	--	--	--
51A	Wilson Gulch near Durango	--	--	--	--	--	--	--
52A	Weaselskin	--	--	--	--	--	--	--
53A	Florida River below Lemon Reservoir	24	7.4	11.9	9.8	8.4	9.9	11.1
54A	Salt Creek at 309A Road	15	5.6	12.3	8.7	5.8	9.2	11.8
55A	Florida River at confluence with Las Animas River	15	8.3	12.2	10.2	8.4	9.9	11.9
56A	Animas River at Bondad	--	--	--	--	--	--	--
57A	Animas River near Bondad	--	--	--	--	--	--	--
01U	Little Navajo River at Highway 84	16	6.6	16.1	9.5	6.9	9.8	10.8
02U	Navajo River at Edith	--	--	--	--	--	--	--
03U	Rio Blanco at Highway 84	16	6.7	17.4	9.8	7.8	9.4	10.8
04U	East Fork San Juan River above Sand Creek, near Pagosa Springs	--	--	--	--	--	--	--
05U	Sand Creek at mouth above East Fork San Juan River	12	7.6	11.9	9.5	8.1	9.5	11.3
06U	West Fork San Juan River at West Fork Campground near Pagosa Springs	--	--	--	--	--	--	--
07U	Wolf Creek at Wolf Creek Campground near Pagosa Springs	--	--	--	--	--	--	--
08U	West Fork San Juan River near Pagosa Springs	--	--	--	--	--	--	--
09U	San Juan River above Pagosa Springs	41	6.5	13.7	10.2	8.4	10.6	11.6
10U	McCabe Creek above Pagosa Springs	16	7.0	12.5	9.6	8.3	9.4	11.0
11U	San Juan River at Pagosa Springs	--	--	--	--	--	--	--
12U	San Juan River below Pagosa Springs	10	8.8	14.5	11.4	9.7	11.4	13.9
13U	San Juan River near Carracas	--	--	--	--	--	--	--
14U	San Juan River above Navajo Reservoir	21	7.5	13.4	10.3	8.0	10.4	12.5
15U	East Fork Piedra River below Piedra Falls	12	6.6	12.0	9.6	6.8	10.1	11.6
16U	Piedra River at Highway 160	53	4.8	21.1	10.0	7.6	10.1	12.0
17U	Stollsteimer Creek at Highway 151	17	6.0	23.3	10.0	7.3	9.4	11.4
18U	Piedra River near Arboles	--	--	--	--	--	--	--
19U	Piedra River northeast of Arboles	22	7.5	13.2	10.3	8.3	10.3	12.5
20U	Los Pinos River above Vallecito Reservoir near Bayfield	17	6.9	10.9	8.5	7.5	8.3	9.5
21U	Los Pinos River above Vallecito Reservoir	50	5.5	12.8	9.7	7.9	9.9	11.8
22U	Vallecito Creek near Bayfield	94	7.8	11.6	9.7	8.1	10.2	10.8
23U	Vallecito Creek near mouth	54	6.0	13.0	9.8	8.4	10.0	11.0
24U	Los Pinos River below Vallecito Reservoir near Bayfield	14	6.0	9.1	7.6	6.8	7.4	8.4
25U	Wallace Gulch at 502 Road north of Bayfield	16	5.9	9.7	7.8	6.0	8.1	9.0
26U	Los Pinos River near Ignacio	--	--	--	--	--	--	--
27U	Spring Creek at La Boca	--	--	--	--	--	--	--
28U	Los Pinos River near La Boca	10	7.6	15.3	10.6	8.2	10.5	12.3

Table 2. Statistical summary for dissolved oxygen, pH, and water-temperature data for sites with 10 or more samples in the Dolores, Upper San Juan, and Lower San Juan River Basins, southwestern Colorado, 1990–2005.—Continued

[Site ID, site identification number shown on figure 1; No., number of samples; Min, minimum value; Max, maximum value; --, not applicable; gray shaded columns indicate statistics that were used for comparison to State water-quality standards and values shown in red represent instances when State water-quality standards were not met; WWTP, wastewater treatment plant]

Site ID	pH, standard units							Water temperature, degrees Celsius						
	No.	Min	Max	Mean	Percentiles			No.	Min	Max	Mean	Percentiles		
					15	50	85					15	50	85
Upper San Juan River Basin—Continued														
32A	166	4.0	7.7	6.1	4.9	6.3	6.9	138	0.0	15.6	6.0	1.5	6.3	10.0
33A	86	6.0	7.8	6.7	6.4	6.7	7.0	172	0.0	14.6	5.6	1.0	5.5	10.9
34A	12	6.2	7.4	6.8	6.3	6.8	7.3	12	3.5	11.5	7.3	4.2	8.0	9.9
35A	213	4.6	8.0	6.5	5.7	6.5	7.2	208	0.0	21.0	6.0	2.0	5.7	10.0
36A	73	5.2	7.9	6.9	6.4	7.1	7.5	74	–0.2	17.0	6.6	0.6	7.1	11.8
37A	13	5.5	7.1	6.3	5.6	6.3	6.8	24	2.0	14.0	7.3	3.1	7.6	10.9
38A	13	5.0	6.2	5.5	5.1	5.6	5.8	26	3.0	18.0	9.3	5.0	8.8	13.3
39A	16	6.8	8.4	7.9	7.4	8.1	8.4	16	0.3	13.5	6.1	1.3	5.2	11.0
40A	35	6.7	8.2	7.7	7.4	7.8	8.0	35	0.0	15.6	7.2	1.1	7.8	13.5
41A	80	6.5	8.8	7.6	7.1	7.6	8.2	94	–0.7	25.0	10.2	3.1	9.7	16.9
42A	15	6.0	8.3	7.1	6.9	7.0	7.7	--	--	--	--	--	--	--
43A	12	7.5	8.6	8.1	7.8	8.2	8.4	13	0.0	16.2	6.9	0.7	7.6	12.8
44A	16	6.4	8.1	7.2	6.8	7.1	7.5	--	--	--	--	--	--	--
45A	--	--	--	--	--	--	--	117	0.0	18.0	9.1	4.8	8.0	15.0
46A	29	7.5	8.4	7.9	7.6	8.0	8.1	29	0.7	19.9	9.0	4.2	8.0	16.7
47A	52	6.5	8.6	7.9	7.4	7.9	8.3	44	0.3	27.8	12.4	4.8	12.6	20.0
48A	99	5.4	8.3	7.3	6.6	7.3	7.8	91	0.0	25.0	9.5	3.4	9.0	16.0
49A	140	5.5	8.2	7.4	7.0	7.5	7.8	120	0.0	25.0	9.4	3.9	8.0	16.0
50A	21	1.7	7.9	7.0	6.8	7.2	7.6	--	--	--	--	--	--	--
51A	--	--	--	--	--	--	--	45	2.2	24.0	12.3	5.5	11.5	19.4
52A	14	6.1	8.1	7.4	7.2	7.4	7.9	--	--	--	--	--	--	--
53A	24	6.8	8.8	7.7	7.1	7.7	8.3	24	0.1	18.6	7.1	0.6	6.4	14.3
54A	14	7.6	8.7	8.3	7.9	8.4	8.6	15	0.1	26.3	12.2	1.9	10.2	23.6
55A	13	7.2	8.5	7.9	7.3	8.1	8.4	15	0.6	20.0	10.1	1.5	11.0	18.6
56A	13	6.3	8.2	7.6	7.2	7.7	8.0	--	--	--	--	--	--	--
57A	63	7.5	8.9	8.2	7.8	8.2	8.6	67	0.0	24.2	9.3	2.3	9.4	16.2
01U	16	6.5	8.2	7.5	6.8	7.7	8.2	16	–0.2	21.6	7.2	0.0	2.8	16.6
02U	--	--	--	--	--	--	--	43	0.0	21.0	9.7	1.5	10.5	15.5
03U	17	6.7	8.8	7.7	7.0	7.9	8.4	16	–0.3	20.9	6.5	0.0	3.3	17.5
04U	--	--	--	--	--	--	--	81	0.0	23.6	9.1	3.3	9.0	14.5
05U	12	7.3	8.3	7.8	7.3	7.9	8.3	12	2.0	20.4	10.8	2.4	12.2	18.4
06U	--	--	--	--	--	--	--	18	1.7	13.5	7.2	3.1	6.8	11.5
07U	--	--	--	--	--	--	--	18	2.5	15.5	8.1	3.4	7.4	12.9
08U	--	--	--	--	--	--	--	12	1.0	15.5	7.2	3.3	5.8	11.7
09U	41	7.0	9.0	7.9	7.4	7.8	8.4	41	–0.2	22.2	7.2	0.4	5.7	16.5
10U	16	6.8	8.5	7.9	7.0	8.0	8.5	16	–0.2	22.8	9.4	0.1	6.6	21.8
11U	--	--	--	--	--	--	--	122	0.0	26.0	7.3	0.7	6.2	13.6
12U	15	7.6	8.9	8.3	7.8	8.3	8.7	10	–0.3	14.0	6.0	0.0	6.8	10.8
13U	--	--	--	--	--	--	--	111	0.0	26.5	10.8	4.2	10.0	19.0
14U	21	6.7	8.7	8.0	7.5	8.0	8.4	21	0.6	23.9	10.0	1.1	10.6	20.4
15U	12	7.2	8.7	7.8	7.3	7.8	8.0	12	0.3	25.0	9.1	1.6	8.5	17.0
16U	48	7.1	8.9	8.1	7.5	8.1	8.6	52	0.0	22.9	8.0	0.7	5.7	16.6
17U	18	6.4	8.7	8.0	7.3	8.2	8.5	18	0.0	28.5	11.3	0.2	10.5	23.0
18U	--	--	--	--	--	--	--	118	0.0	27.8	10.4	3.2	9.3	19.5
19U	22	7.4	8.7	8.1	7.6	8.2	8.5	21	1.1	24.4	10.9	2.0	11.7	19.7
20U	17	6.5	8.3	7.7	7.2	7.7	8.1	17	–0.2	21.0	11.8	6.1	12.0	18.5
21U	49	7.0	8.7	7.8	7.3	7.8	8.3	52	–0.3	20.1	6.7	0.0	6.2	13.5
22U	112	6.1	8.3	7.5	7.1	7.5	7.8	284	0.0	15.5	6.3	1.5	6.0	11.2
23U	51	6.7	8.7	7.6	7.3	7.5	8.0	54	–0.2	18.1	6.0	1.1	5.4	10.8
24U	14	6.5	9.1	7.4	7.0	7.4	7.7	15	7.6	18.3	11.6	7.8	10.3	15.8
25U	15	7.0	8.6	7.7	7.4	7.6	8.1	16	2.7	20.1	10.5	5.6	9.5	15.4
26U	--	--	--	--	--	--	--	35	0.0	26.1	11.7	3.5	10.9	22.0
27U	--	--	--	--	--	--	--	101	0.0	28.0	11.5	0.5	13.0	20.0
28U	10	7.2	8.6	8.0	7.5	7.9	8.5	10	0.6	19.4	8.2	1.1	8.1	15.0

Table 2. Statistical summary for dissolved oxygen, pH, and water-temperature data for sites with 10 or more samples in the Dolores, Upper San Juan, and Lower San Juan River Basins, southwestern Colorado, 1990–2005.—Continued

[Site ID, site identification number shown on figure 1; No., number of samples; Min, minimum value; Max, maximum value; --, not applicable; gray shaded columns indicate statistics that were used for comparison to State water-quality standards and values shown in red represent instances when State water-quality standards were not met; WWTP, wastewater treatment plant]

Site ID	Site name	Dissolved oxygen, milligrams per liter						
		No.	Min	Max	Mean	Percentiles 15	Percentiles 50	Percentiles 85
	Upper San Juan River Basin—Continued							
29U	Los Pinos River at La Boca	--	--	--	--	--	--	--
30U	La Plata at Hesperus	34	7.3	14.3	10.5	8.2	10.2	12.6
31U	Spring Creek near Breen	11	5.9	9.4	7.9	6.4	8.3	9.3
32U	East Fork Mancos River at 44 Road	20	6.7	16.1	10.9	8.1	10.8	15.5
33U	Mancos River at Mancos	13	7.6	12.4	10.3	8.5	10.7	11.9
34U	Chicken Creek at Mancos	16	7.1	14.0	9.6	7.8	9.1	11.8
35U	Mancos River near Towaoc	--	--	--	--	--	--	--
36U	Navajo Wash near Towaoc	--	--	--	--	--	--	--
	Lower San Juan River Basin							
01L	McElmo Creek above Cortez Sanitation District, Southwest WWTP	15	7.0	12.9	9.8	7.6	9.5	12.4
02L	Mud Creek at State Highway 32, near Cortez	--	--	--	--	--	--	--
03L	McElmo Creek near Cortez	--	--	--	--	--	--	--
04L	McElmo Creek above Trail Canyon near Cortez	--	--	--	--	--	--	--
05L	McElmo Creek above Trail Canyon at gage	44	5.7	14.9	10.1	7.2	10.0	12.9
06L	McElmo Creek near Colorado-Utah State Line	--	--	--	--	--	--	--

Table 2. Statistical summary for dissolved oxygen, pH, and water-temperature data for sites with 10 or more samples in the Dolores, Upper San Juan, and Lower San Juan River Basins, southwestern Colorado, 1990–2005.—Continued

[Site ID, site identification number shown on figure 1; No., number of samples; Min, minimum value; Max, maximum value; --, not applicable; gray shaded columns indicate statistics that were used for comparison to State water-quality standards and values shown in red represent instances when State water-quality standards were not met; WWTP, wastewater treatment plant]

Site ID	pH, standard units							Water temperature, degrees Celsius						
	No.	Min	Max	Mean	Percentiles 15	Percentiles 50	Percentiles 85	No.	Min	Max	Mean	Percentiles 15	Percentiles 50	Percentiles 85
Upper San Juan River Basin—Continued														
29U	--	--	--	--	--	--	--	108	0.0	24.6	11.1	2.4	11.0	18.7
30U	38	6.9	8.4	7.7	7.4	7.8	8.1	43	0.0	20.7	7.4	1.8	5.6	13.9
31U	11	7.3	8.3	7.9	7.4	7.9	8.2	11	1.2	23.4	11.1	1.9	11.7	19.2
32U	18	7.1	8.2	7.6	7.2	7.7	7.9	22	0.0	18.5	5.6	0.3	5.4	13.3
33U	--	--	--	--	--	--	--	13	0.6	20.6	8.5	1.4	7.2	16.5
34U	17	7.6	8.5	8.1	7.7	8.0	8.4	18	0.1	21.4	10.3	3.1	12.0	16.2
35U	--	--	--	--	--	--	--	111	0.0	31.5	12.0	2.1	11.5	22.0
36U	--	--	--	--	--	--	--	46	0.0	21.5	11.3	4.9	11.5	18.9
Lower San Juan River Basin														
01L	15	7.6	8.4	8.0	7.8	8.1	8.2	15	0.0	19.3	9.1	0.2	9.7	16.3
02L	116	8.0	8.4	8.2	8.2	8.2	8.3	125	-0.5	24.7	12.0	0.0	14.4	20.9
03L	42	8.0	8.8	8.4	8.3	8.4	8.6	42	0.0	24.0	12.3	2.4	14.3	19.5
04L	125	8.0	8.7	8.4	8.2	8.4	8.5	139	-0.2	25.0	12.4	0.3	15.0	20.3
05L	41	7.7	9.1	8.4	8.1	8.4	8.6	46	-0.3	25.6	12.4	1.3	12.3	21.8
06L	153	7.6	9.0	8.3	8.2	8.3	8.4	176	-0.1	27.0	13.0	4.0	14.4	21.0

In the Upper SJRB, there were sufficient data to analyze for temporal trends in DO at only one site, Vallecito Creek near Bayfield (site 22U). This site was located west of Durango and upstream from Vallecito Reservoir. The typical DO concentration at this site was 10.0 mg/L (1993–2003), and there was no significant trend in DO concentrations (table 3).

Lower San Juan River Basin.— Only the McElmo Creek above Cortez Sanitation District, Southwest Wastewater Treatment Plant (WWTP) (site 01L) and McElmo Creek above Trail Canyon at gage (site 05L) sites had sufficient data to calculate summary statistics for DO (table 2 and fig. 1). The 15th percentile DO concentrations were 7.6 mg/L at McElmo Creek above Cortez Sanitation District, Southwest WWTP and 7.2 at McElmo Creek above Trail Canyon at gage (table 2). Sufficient data were not available to calculate trends.

pH

Values of pH in surface water generally were near neutral to slightly alkaline throughout most of the study area with the exception of the upper Animas River Basin near Silverton where acidic conditions existed at some sites because of hydrothermal alteration and(or) historical mining (Wright and others, 2007). Evaluation of existing water-quality conditions for pH was based on the range between the 15th percentile and 85th percentile values (Colorado Department of Public Health and Environment, 2010b). The pH range used for the water-quality standard in most of the stream segments within the study area was 6.5 to 9.0 standard units (Colorado Department of Public Health and Environment, 2010a). However, several stream segments along Cement Creek and Mineral Creek in the upper Animas River Basin had designated water-quality standards for pH that ranged from 3.7 to 9.0 and 4.5 to 9.0, respectively (Colorado Department of Public Health and Environment, 2010b).

Dolores River Basin.— Twenty-eight sites had adequate data to calculate summary statistics for pH values. The 15th percentile values for pH ranged from 7.3 to 8.2, and 85th percentile values ranged from 7.7 to 8.9 (table 2 and fig. 5). Consequently, based on available data, pH values were within the physical and biological water-quality standard range for pH of 6.5 to 9.0 for sites in the Dolores River Basin.

Temporal trends in pH values were analyzed at three sites in the Dolores River Basin (table 3). Highly significant ($p<0.01$) small (0.3 percent) upward trends in pH occurred at the Dolores River at Bedrock (site 16D) and Dolores River near Bedrock (site 19D) sites (fig. 1). The typical pH for the trend analysis period (1993–2003) was 8.3 at the two sites. These small upward trends in pH values may result from a systematic shift in the time of day in which pH was measured at the sites or, perhaps, changes in geochemical characteristics resulting from operation of the Paradox Valley Unit.

Upper San Juan River Basin.—Adequate data were available to calculate summary statistics for pH values at 62 sites. The 15th percentile values for pH ranged from 1.6 to 7.9; and 85th percentile pH values ranged from 2.6 to 8.7 (table 2). The lowest pH values (15th percentile less than 4.5) occurred in the upper Animas River Basin in the Cement and Mineral Creek basins (fig. 5) which have been affected by historical mining activities. One site in the Mineral Creek basin and two sites in the Cement Creek basin had 15th percentile values for pH less than the surface-water-quality standard of 3.7 (table 2), the lowest designated State surface-water-quality standard value for pH in the study area (Colorado Department of Public Health and Environment, 2010a).

Seven sites in the Upper SJRB were analyzed for trends in pH values (table 3). The Animas River downstream from Silverton (site 35A), site had a highly significant ($p<0.01$) downward trend in pH values (table 3). The typical pH value at the site for the analysis period was 6.3. The reason for this trend is unknown. No other significant trends in pH values were measured at the other sites located in the Animas River near Silverton or at sites located in other areas of the Upper SJRB (table 3).

Lower San Juan River Basin.— Adequate data were available to calculate summary statistics for pH values at 6 sites. The 15th percentile values for pH ranged from 7.8 to 8.3; and 85th percentile values ranged from 8.2 to 8.6 (table 2). Consequently, pH values were within the State physical and biological water-quality standard range for pH of 6.5 to 9.0 at sites in the Lower SJRB (fig. 5).

Trends in pH values were analyzed at three sites in the Lower SJRB (table 3). Statistically significant upward trends in pH values occurred at Mud Creek at State Highway 32, near Cortez (site 02L), a tributary to McElmo Creek, and McElmo Creek above Trail Canyon near Cortez (site 04L). The upward trends in pH values at these sites could be the result of changes in stream-water quality resulting from urban and(or) agricultural activities or simply be an artifact of changes in sampling routines. During the latter part of the analysis period, the sites were consistently sampled later in the day when pH values may have been slightly higher. Additional data collection designed to address these issues would be needed to determine the cause of the upward trends in pH values.

Water Temperature

Mean water temperatures in the study area ranged from 5.3 to 14.1 °C (table 2). Instantaneous water temperatures varied from less than 0 to 31.5 °C. Sites located in the headwaters of the Dolores River Basin and the Upper SJRB typically had mean water temperatures less than 10 °C. Lower elevation sites throughout the study area generally had mean water temperatures between 9 and 13 °C.

As part of the 2007 rule making hearing, the Commission adopted 17 °C as the maximum weekly average temperature (MWAT) interim chronic standard for small, high elevation streams (above 7,000 feet) that are likely to be habitat for brook trout and cutthroat trout, 18.2 °C (MWAT) as an interim chronic standard for waters designated by the Colorado

Table 3. Summary of trend analysis results for dissolved-oxygen concentrations and pH and water-temperature values in the Dolores, Upper San Juan, and Lower San Juan River Basins, southwestern Colorado, 1993–2003.

[ID, site identification number shown on figure 1; milligrams per liter, mg/L; °C, degrees Celsius; nt, not a significant trend; p-value, probability value; statistically significant trend at p-value less than or equal to 0.05; "--", available data did not meet the selection criteria; typical value is the median value for the trend analysis period; yr, year]

Site ID	Site name	Dissolved oxygen, unfiltered					pH					Water temperature				
		Typical value (mg/L)	Trend	p-value	Trend slope (percent)	Trend slope (mg/L per yr)	Typical value (standard units)	Trend	p-value	Trend slope (percent)	Trend slope (standard units per yr)	Typical value (°C)	Trend	p-value	Trend slope (percent)	Trend slope (°C/yr)
	Dolores River Basin															
06D	Dolores River below Rico	--	--	--	--	--	--	--	--	--	--	nt	nt	nt	nt	nt
10D	Dolores River at Dolores	--	--	--	--	--	--	--	--	--	--	nt	nt	nt	nt	nt
16D	Dolores River at Bedrock	--	--	--	--	--	8.3	up	0.009	0.3	0.02	nt	nt	nt	nt	nt
19D	Dolores River near Bedrock	--	--	--	--	--	8.3	up	0.008	0.3	0.03	nt	nt	nt	nt	nt
25D	San Miguel River at Society Turn	--	--	--	--	--	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt
28D	San Miguel River near Placerville	--	--	--	--	--	--	--	--	--	--	nt	nt	nt	nt	nt
33D	San Miguel River at Uravan	--	--	--	--	--	--	--	--	--	--	nt	nt	nt	nt	nt
	Upper San Juan River Basin															
07A	Animas River at Silverton (Agency ID A68)	--	--	--	--	--	nt	nt	nt	nt	nt	--	--	--	--	--
08A	Animas River at Silverton (Agency ID 09358000)	--	--	--	--	--	--	--	--	--	--	nt	nt	nt	nt	nt
17A	Cement Creek at Silverton	--	--	--	--	--	--	--	--	--	--	nt	nt	nt	nt	nt
31A	Mineral Creek at Silverton	--	--	--	--	--	--	--	--	--	--	nt	nt	nt	nt	nt
32A	USGS gaging station site – below Highway 550	--	--	--	--	--	nt	nt	nt	nt	nt	--	--	--	--	--
33A	Animas River below Silverton	--	--	--	--	--	--	--	--	--	--	nt	nt	nt	nt	nt
35A	Animas River downstream from Silverton	--	--	--	--	--	6.3	down	0.005	-2.4	-0.15	nt	nt	nt	nt	nt
36A	Animas River near Silverton	--	--	--	--	--	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt
45A	Animas River at Durango	--	--	--	--	--	--	--	--	--	--	nt	nt	nt	nt	nt
47A	Lightner Creek at Mouth At Durango	--	--	--	--	--	nt	nt	nt	nt	nt	--	--	--	--	--
49A	Animas River at Durango	--	--	--	--	--	nt	nt	nt	nt	nt	--	--	--	--	--
04U	East Fork San Juan River at Sand Creek, Near Pagosa Springs	--	--	--	--	--	--	--	--	--	--	nt	nt	nt	nt	nt

Table 3. Summary of trend analysis results for dissolved-oxygen concentrations and pH and water-temperature values in the Dolores, Upper San Juan, and Lower San Juan River Basins, southwestern Colorado, 1993–2003.—Continued

[ID, site identification number shown on figure 1; milligrams per liter, mg/L; °C, degrees Celsius; nt, not a significant trend; p-value, probability value; statistically significant trend at p-value less than or equal to 0.05; "--", available data did not meet the selection criteria; typical value is the median value for the trend analysis period; yr, year]

Site ID	Site name	Dissolved oxygen, unfiltered					pH				
		Typical value (mg/L)	Trend	p-value	Trend slope (per-cent)	Trend slope (mg/L per yr)	Typical value (standard units)	Trend	p-value	Trend slope (per-cent)	Trend slope (stan-dard units per yr)
	Upper San Juan River Basin—Continued										
11U	San Juan River at Pagosa Springs	--	--	--	--	--	--	--	--	--	--
13U	San Juan River near Carracas	--	--	--	--	--	--	--	--	--	--
18U	Piedra River near Arboles	--	--	--	--	--	--	--	--	--	--
22U	Vallecito Creek near Bayfield	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt
27U	Spring Creek at La Boca	--	--	--	--	--	--	--	--	--	--
29U	Los Pinos River at La Boca	--	--	--	--	--	--	--	--	--	--
35U	Mancos River near Towaoc	--	--	--	--	--	--	--	--	--	--
	Lower San Juan River Basin										
02L	Mud Creek at State Highway 32, near Cortez	--	--	--	--	--	8.3	up	0.020	0.2	0.02
04L	McElmo Creek above Trail Canyon near Cortez	--	--	--	--	--	8.4	up	0.009	0.3	0.03
06L	McElmo Creek near Colorado-Utah State Line	--	--	--	--	--	nt	nt	nt	nt	nt

Site ID	Site name	Water temperature				
		Typical value (°C)	Trend	p-value	Trend slope (per-cent)	Trend slope (°C/yr)
	Upper San Juan River Basin—Continued					
11U	San Juan River at Pagosa Springs	5.7	up	0.049	3.9	0.2
13U	San Juan River near Carracas	nt	nt	nt	nt	nt
18U	Piedra River near Arboles	nt	nt	nt	nt	nt
22U	Vallecito Creek near Bayfield	nt	nt	nt	nt	nt
27U	Spring Creek at La Boca	nt	nt	nt	nt	nt
29U	Los Pinos River at La Boca	10.9	up	0.041	3.5	0.4
35U	Mancos River near Towaoc	nt	nt	nt	nt	nt
	Lower San Juan River Basin					
02L	Mud Creek at State Highway 32, near Cortez	nt	nt	nt	nt	nt
04L	McElmo Creek above Trail Canyon near Cortez	nt	nt	nt	nt	nt
06L	McElmo Creek near Colorado-Utah State Line	nt	nt	nt	nt	nt

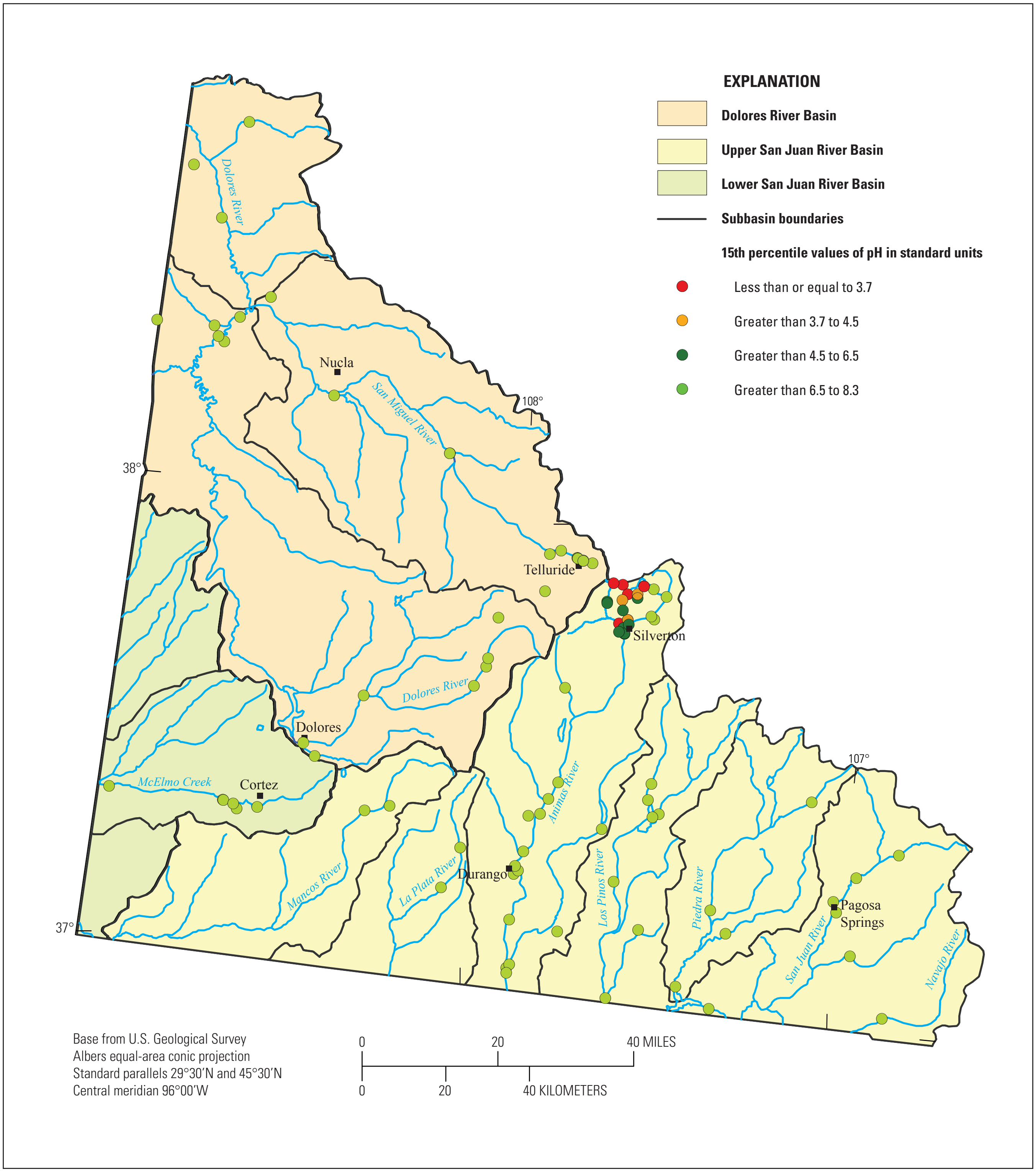


Figure 5. Map showing spatial distribution of 15th percentile pH values in the Dolores, Upper San Juan, and Lower San Juan River Basins, southwestern Colorado, 1990–2005.

Wildlife Commission as "Gold Medal Fisheries," 20 °C (MWAT) as an interim chronic standard for the remainder of the cold-water segments, and 30 °C (MWAT) as an interim chronic standard for warm-water segments (Colorado Department of Public Health and Environment, 2010a). Mean water temperatures were calculated for each site using available data. These mean values, along with the other summary statistic values shown in table 2, likely do not represent the actual range in water temperature or the MWAT at each site, because these samples were collected sporadically over long periods of time.

Dolores River Basin.—Water temperature data were analyzed at 36 sites in the Dolores River Basin. Mean water temperatures ranged from 5.7 to 14.1 °C (table 2). As expected, the lowest mean water temperatures occurred at sites in the mountainous upper part of the Dolores River Basin where air temperatures were cooler. The highest mean water temperatures occurred at sites in the lower part of the basin. Temporal trends in water temperature were evaluated at seven sites (table 3). No significant trends in water temperature occurred.

Upper San Juan River Basin.—Water temperature data were analyzed at 74 sites in the Upper SJRB. Mean water temperatures ranged from 5.3 to 13.6 °C (table 2). Sites located in the upper Animas River Basin in the vicinity of Silverton and in the San Juan River Basin upstream from Pagosa Springs typically had mean water temperatures less than 10 °C. Lower elevation sites, near the Colorado-New Mexico State line generally had mean water temperatures between 9 and 12 °C.

Fifteen sites were analyzed for trends in water temperature in the Upper SJRB (table 3). Two of the 15 sites had statistically significant upward trends in water temperatures. An increase of 3.9 percent occurred at the San Juan River at Pagosa Springs (site 11U) site where the typical water temperature for the period of analysis was 5.7 °C. A 3.5 percent increase in water temperature occurred at the Los Pinos River at La Boca (site 29U) site where the typical water temperature for the period of analysis (1993–2003) was 10.9 °C. Instantaneous streamflow values measured when water-quality samples were collected were generally lower during the last half of the analysis period than during the first half of the analysis period. These upward trends in water temperature may result from changes in groundwater and surface water interactions and(or) changes in stream velocities and depths because of drought conditions during the latter part of the analysis period.

Lower San Juan River Basin. Water temperature data were analyzed at 6 sites in the Lower SJRB. All sites were located in the McElmo Creek basin. Five of the six sites had mean water temperatures that ranged from 12 to 13.0 °C (table 2). The remaining site, McElmo Creek above Cortez Sanitation District, Southwest WWTP, had a mean water temperature of 9.1 °C. Water temperature data were analyzed for trends at Mud Creek at State Highway 32, near Cortez (site 02L), McElmo Creek above Trail Canyon near Cortez (site 04L), and McElmo Creek near Colorado-Utah State line (site 06L) (table 3 and fig. 1). No significant trends in water temperature data occurred at these sites.

Dissolved Solids

As with most water-quality characteristic data in the study area, more sites were analyzed for dissolved solids (DS) in the Upper SJRB than the Dolores River Basin and the Lower SJRB (table 4). No State surface-water-quality standards were listed for DS concentrations in southwestern Colorado (Colorado Department of Public Health and Environment, 2010a). The national secondary standard for DS in drinking water was 500 mg/L (U.S. Environmental Protection Agency, 2010b). In the study area, median DS concentrations ranged from 8 to 42,600 mg/L. Median DS concentrations equal to or greater than 500 mg/L were measured at some sites in the Dolores River Basin, at one site in the Upper SJRB, and at all sites in the Lower SJRB. The highest DS concentrations typically occurred in samples collected from December through March when streamflows were lowest and groundwater inflow was the dominant source of flow. The lowest DS concentrations typically occurred in samples collected from May through July when streamflows were highest and snowmelt was the dominant source of the flow (fig. 6). Seasonal differences in DS concentrations were more apparent in samples from the Upper SJRB and the Lower SJRB than the Dolores River Basin (fig. 6). Generally, SC values are highly correlated with DS concentrations. Throughout the study area, more sites had adequate SC data than DS data; consequently, both SC values and DS concentrations were analyzed for temporal trends. Trend analyses for SC values and DS concentrations are described in this section of the report and shown in table 5.

Dolores River Basin.—Dissolved-solids data were analyzed at 22 sites. Median DS concentrations ranged from 120 to 42,600 mg/L (table 4). Fourteen of the 22 sites analyzed in the Dolores River Basin had median DS concentrations less than 500 mg/L (table 4 and fig. 7). The highest median DS concentration (42,600 mg/L) occurred at Salt Creek at Highway 141 (site 35D) downstream from the confluence of the Dolores and San Miguel Rivers (fig. 7). In the Dolores River between the Dolores River at Bedrock (16D) and Dolores River near Bedrock (19D) sites, median DS concentrations in the river almost tripled going from 426 to 1,275 mg/L (table 4 and fig. 7). The increase in DS in the Dolores River between these two sites is mostly because of increases in dissolved sodium and chloride concentrations resulting from inflow of saline groundwater to the river as it flows through the Paradox Valley (Watts, 2000).

In the Dolores River Basin, trends in DS concentrations were analyzed at only two sites; whereas, trends in SC values were analyzed at six sites (table 5). Significant downward trends in DS concentrations and SC values occurred at Dolores River near Bedrock (site 19D).

Table 4. Statistical summary for dissolved solids and specific conductance data for sites with 10 or more samples in the Dolores, Upper San Juan, and Lower San Juan River Basins, southwestern Colorado, 1990–2005.

[Site ID, number identifying location on figure 1; mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius; No., number of samples; Min, minimum value; Max, maximum value; Med, median value; --, no value; Agency ID was added in parenthesis to the site name when sites had identical names; WWTP, wastewater treatment plant; gray shaded column indicates statistic that was used for comparison to National water-quality standards and values shown in red represent instances when water-quality standard was not met]

Site ID	Site name	Subbasin name	Dissolved solids, in mg/L					Specific conductance, in µS/cm				
			Number	Minimum	Maximum	Mean	Median	Number	Minimum	Maximum	Mean	Median
	Dolores River Basin											
02D	Horse Creek at Highway 145	Upper Dolores	--	--	--	--	--	10	113	274	208	222
03D	Dolores River above Horse Creek	Upper Dolores	13	129	85	130	170	--	--	--	--	--
04D	Silver Creek at Highway 145	Upper Dolores	42	82	520	287	305	12	132	594	378	364
05D	Dolores River below Rico (Agency ID 09165000)	Upper Dolores	--	--	--	--	--	115	106	696	326	322
06D	Dolores River below Rico (Agency ID 10716)	Upper Dolores	43	78	410	247	260	20	128	589	371	358
07D	West Dolores River near Stoner at Highway 145	Upper Dolores	14	237	130	225	350	--	--	--	--	--
08D	Lost Canyon Creek near Dolores	Upper Dolores	--	--	--	--	--	88	48	1,280	303	187
09D	Lost Canyon Creek near Dolores	Upper Dolores	11	84	160	119	120	13	63	283	177	186
10D	Dolores River at Dolores	Upper Dolores	--	--	--	--	--	123	123	1,230	309	304
12D	Dolores River near town of Dolores	Upper Dolores	14	184	91	170	280	--	--	--	--	--
13D	Dolores River at Dolores above Mcphee Reservoir	Upper Dolores	21	110	310	216	240	25	139	503	329	315
14D	Dolores River near Slick Rock	Upper Dolores	--	--	--	--	--	38	264	960	491	427
15D	Dolores River above confluence with San Miguel River	Upper Dolores	38	220	7,010	2,524	2,395	25	366	11,800	4,519	4,040
16D	Dolores River at Bedrock	Upper Dolores	158	158	2,260	478	426	184	283	2,490	788	687
17D	Lasal Creek at Utah-Colorado State Line	Upper Dolores	23	142	368	252	248	36	203	544	412	417
18D	West Paradox Creek above Bedrock	Upper Dolores	102	149	1,520	737	760	104	257	2,140	1,069	1,110
19D	Dolores River near Bedrock	Upper Dolores	156	174	12,200	1,890	1,275	177	304	20,767	3,130	2,007
21D	(2), Bear Creek	San Miguel	--	--	--	--	--	11	0.09	0.18	0.13	0.12
22D	Upstream, SMIG above Bear	San Miguel	--	--	--	--	--	12	0.14	244	21	0.25
23D	(7), Coronet	San Miguel	--	--	--	--	--	11	0.12	0.25	0.20	0.21
24D	Downstream, SMMAHONEY	San Miguel	--	--	--	--	--	12	0.14	253	21	0.24
25D	San Miguel River at Society Turn	San Miguel	73	52	1,600	198	200	36	136	376	287	312
26D	South Fork San Miguel River near mouth	San Miguel	21	170	650	332	340	12	293	523	442	471
27D	Howard Fork San Miguel River at Ophir	San Miguel	16	484	270	515	610	--	--	--	--	--
28D	San Miguel River near Placerville	San Miguel	--	--	--	--	--	139	178	566	343	367
29D	San Miguel River near Norwood	San Miguel	31	120	300	238	260	19	230	489	370	380
30D	McKenzie Creek at mouth above confluence with San Miguel River	San Miguel	16	130	370	322	345	16	174	605	530	578
31D	San Miguel River at Brooks Bridge near Nucla	San Miguel	--	--	--	--	--	89	178	665	361	353

Table 4. Statistical summary for dissolved solids and specific conductance data for sites with 10 or more samples in the Dolores, Upper San Juan, and Lower San Juan River Basins, southwestern Colorado, 1990–2005.—Continued

[Site ID, number identifying location on figure 1; mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius; No., number of samples; Min, minimum value; Max, maximum value; Med, median value; --, no value; Agency ID was added in parenthesis to the site name when sites had identical names; WWTP, wastewater treatment plant; gray shaded column indicates statistic that was used for comparison to National water-quality standards and values shown in red represent instances when water-quality standard was not met]

Site ID	Site name	Subbasin name	Dissolved solids, in mg/L					Specific conductance, in µS/cm				
			Number	Minimum	Maximum	Mean	Median	Number	Minimum	Maximum	Mean	Median
					Dolores River Basin—Continued							
32D	Naturita Creek at Naturita	San Miguel	16	1,490	220	1,570	2,300	--	--	--	--	--
33D	San Miguel River at Uravan	San Miguel	--	--	--	--	--	123	217	1,922	738	721
34D	San Miguel River at confluence with Dolores River	San Miguel	60	180	1,610	637	610	49	292	1,951	804	780
35D	Salt Creek at Highway 141	Lower Dolores	12	4,100	59,200	43,040	42,600	12	3,727	83,500	36,561	29,846
36D	West Creek in Unaweep Canyon	Lower Dolores	13	214	170	220	240					
37D	Dolores River at Gateway	Lower Dolores	17	570	3,090	1,241	1,040	19	346	5,200	1,838	1,570
					Upper San Juan River Basin							
02A	Animas River at Eureka	Animas	--	--	--	--	--	23	71	282	133	122
03A	Eureka below Ben Franklin	Animas	--	--	--	--	--	21	127	333	210	213
04A	Animas River at Howardsville	Animas	--	--	--	--	--	16	94	305	191	177
05A	Animas River downstream from Arrastra Gulch	Animas	--	--	--	--	--	10	106	270	173	160
07A	Animas River at Silverton (Agency ID A68)	Animas	--	--	--	--	--	139	76	433	245	250
08A	Animas River at Silverton (Agency ID 09358000)	Animas	--	--	--	--	--	112	108	430	257	269
17A	Cement Creek at Silverton (Agency ID 09358550)	Animas	--	--	--	--	--	107	166	1,274	736	850
20A	Mineral Creek near headwaters	Animas	--	--	--	--	--	14	500	3,800	2,153	2,375
21A	Highway 550 drainage ditch above M01 confluence-east side of Highway 550	Animas	--	--	--	--	--	14	290	2,900	1,511	1,695
22A	Mineral Creek at Chattanooga	Animas	--	--	--	--	--	15	62	593	186	115
25A	Mineral Creek at Burro Bridge (Agency ID M13A)	Animas	--	--	--	--	--	11	91	691	269	187
30A	Mineral Creek above confluence with South Fork Mineral Creek	Animas	--	--	--	--	--	11	165	942	430	293
31A	Mineral Creek at Silverton (Agency ID 09359010)	Animas	--	--	--	--	--	106	103	730	350	373
32A	Mineral Creek at Silverton (Agency ID M34)	Animas	--	--	--	--	--	144	87	649	313	305
33A	Animas River below Silverton	Animas	44	78	425	231	220	172	84	662	369	370
35A	Animas River downstream from Silverton	Animas	--	--	--	--	--	177	110	642	335	340
36A	Animas River near Silverton	Animas	72	61	530	277	280	51	130	699	376	370
37A	Big Eldorado inflow	Animas	24	3.6	47.2	17	12	13	2	59	28	28
38A	Little Eldorado inflow	Animas	14	4.7	9.7	8	8	13	10	18	13	13
39A	Cascade Creek at Highway 550	Animas	14	110	230	198	210	14	135	397	324	351
40A	Animas River above Durango	Animas	35	192	58	190	370	--	--	--	--	--

Table 4. Statistical summary for dissolved solids and specific conductance data for sites with 10 or more samples in the Dolores, Upper San Juan, and Lower San Juan River Basins, southwestern Colorado, 1990–2005.—Continued

[Site ID, number identifying location on figure 1; mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius; No., number of samples; Min, minimum value; Max, maximum value; Med, median value; --, no value; Agency ID was added in parenthesis to the site name when sites had identical names; WWTP, wastewater treatment plant; gray shaded column indicates statistic that was used for comparison to National water-quality standards and values shown in red represent instances when water-quality standard was not met]

Site ID	Site name	Subbasin name	Dissolved solids, in mg/L					Specific conductance, in µS/cm				
			Number	Minimum	Maximum	Mean	Median	Number	Minimum	Maximum	Mean	Median
			Upper San Juan River Basin—Continued									
42A	Trimble Lane Bridge	Animas	--	--	--	--	--	15	155	651	345	347
43A	Falls Creek at 0.65 Road	Animas	11	150	270	215	220	12	175	404	311	322
44A	Animas at 32nd Street Bridge	Animas	--	--	--	--	--	16	138	669	374	397
45A	Animas River at Durango (Agency ID 09361500)	Animas	--	--	--	--	--	117	123	898	413	420
46A	Animas River at Durango (Agency ID 9420)	Animas	27	100	560	328	360	29	160	910	506	554
51A	Wilson Gulch near Durango	Animas	--	--	--	--	--	45	310	949	632	660
52A	Weaselskin	Animas	--	--	--	--	--	14	159	726	416	412
53A	Florida River below Lemon Reservoir	Animas	22	58	190	99	93	13	120	280	183	160
54A	Salt Creek at 309A Road	Animas	14	110	660	278	160	12	194	1,086	490	366
55A	Florida River at confluence with Las Animas River	Animas	15	245	110	240	340	--	--	--	--	--
56A	Animas River at Bondad	Animas	--	--	--	--	--	13	152	760	417	429
57A	Animas River near Bondad	Animas	66	75	470	282	315	24	174	740	432	417
01U	Little Navajo River at Highway 84	Upper San Juan	15	130	400	231	240	15	141	587	379	389
02U	Navajo River at Edith	Upper San Juan	--	--	--	--	--	43	92	421	226	234
03U	Rio Blanco at Highway 84	Upper San Juan	15	110	400	263	280	17	93	797	395	448
04U	East Fork San Juan River above Sand Creek, near Pagosa Springs	Upper San Juan	--	--	--	--	--	81	72	241	123	120
05U	Sand Creek at mouth above East Fork San Juan River	Upper San Juan	11	38	77	61	62	12	51	101	78	78
06U	West Fork San Juan River at West Fork Campground near Pagosa Springs	Upper San Juan	--	--	--	--	--	18	30	56	43	45
07U	Wolf Creek at Wolf Creek Campground near Pagosa Springs	Upper San Juan	--	--	--	--	--	18	30	67	51	53
08U	West Fork San Juan River near Pagosa Springs	Upper San Juan	--	--	--	--	--	11	34	98	57	56
09U	San Juan River above Pagosa Springs	Upper San Juan	36	30	100	75	78	33	52	151	100	100
10U	McCabe Creek above Pagosa Springs	Upper San Juan	16	300	700	432	390	16	470	917	664	575
11U	San Juan River at Pagosa Springs	Upper San Juan	--	--	--	--	--	121	48	523	138	137
12U	San Juan River below Pagosa Springs	Upper San Juan	--	--	--	--	--	10	72	380	212	190
13U	San Juan River near Carracas	Upper San Juan	--	--	--	--	--	109	72	758	260	236
14U	San Juan River above Navajo Reservoir	Upper San Juan	21	187	63	190	350	--	--	--	--	--
15U	East Fork Piedra River below Piedra Falls	Piedra	11	26	56	45	44	12	36	84	53	48

Table 4. Statistical summary for dissolved solids and specific conductance data for sites with 10 or more samples in the Dolores, Upper San Juan, and Lower San Juan River Basins, southwestern Colorado, 1990–2005. —Continued

[Site ID, number identifying location on figure 1; mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius; No., number of samples; Min, minimum value; Max, maximum value; Med, median value; --, no value; Agency ID was added in parenthesis to the site name when sites had identical names; WWTP, wastewater treatment plant; gray shaded column indicates statistic that was used for comparison to National water-quality standards and values shown in red represent instances when water-quality standard was not met]

Site ID	Site name	Subbasin name	Dissolved solids, in mg/L					Specific conductance, in µS/cm				
			Number	Minimum	Maximum	Mean	Median	Number	Minimum	Maximum	Mean	Median
			Upper San Juan River Basin—Continued									
16U	Piedra River at Highway 160	Piedra	50	59	550	230	245	51	93	815	336	347
17U	Stollsteimer Creek at Highway 151	Piedra	17	340	840	652	680	18	487	1,144	876	915
18U	Piedra River near Arboles	Piedra	--	--	--	--	--	118	89	626	290	289
19U	Piedra River northeast of Arboles	Piedra	22	194	66	180	350	--	--	--	--	--
20U	Los Pinos River above Vallecito Reservoir near Bayfield	Upper San Juan	--	--	--	--	--	17	43	107	73	71
21U	Los Pinos River above Vallecito Reservoir	Upper San Juan	47	34	2,710	118	63	51	48	129	93	97
22U	Vallecito Creek near Bayfield	Upper San Juan	185	20	65	36	36	164	34	112	65	63
23U	Vallecito Creek near mouth	Upper San Juan	47	22	69	48	47	52	43	112	79	82
24U	Los Pinos River below Vallecito Reservoir near Bayfield	Upper San Juan	--	--	--	--	--	15	64	135	86	78
25U	Wallace Gulch at 502 Road north of Bayfield	Upper San Juan	14	81	250	177	195	16	134	449	296	310
26U	Los Pinos River near Ignacio	Upper San Juan	--	--	--	--	--	35	80	280	181	175
27U	Spring Creek at La Boca	Upper San Juan	--	--	--	--	--	100	245	1,290	614	479
28U	Los Pinos River near La Boca	Upper San Juan	10	134	90	130	220	--	--	--	--	--
29U	Los Pinos River at La Boca	Upper San Juan	--	--	--	--	--	108	106	436	238	227
30U	La Plata at Hesperus	Middle San Juan	38	63	140	107	110	19	104	198	166	168
31U	Spring Creek near Breen	Middle San Juan	12	230	340	268	255	10	338	492	417	420
32U	East Fork Mancos River at 44 Road	Mancos	20	88	310	212	225	17	125	434	292	322
33U	Mancos River at Mancos	Mancos	13	198	100	190	320	--	--	--	--	--
34U	Chicken Creek at Mancos	Mancos	16	270	1490	777	490	16	278	1,740	903	708
35U	Mancos River near Towaoc	Mancos	--	--	--	--	--	111	362	2,656	1,382	1,450
36U	Navajo Wash near Towaoc	Mancos	--	--	--	--	--	47	773	8,670	3,411	1,990
			Lower San Juan River Basin									
01L	McElmo Creek above Cortez Sanitation District, Southwest WWTP	McElmo	14	940	4,010	2,790	3,385	14	1,057	4,417	3,020	3,577
02L	Mud Creek at State Highway 32, near Cortez	McElmo	119	1,090	10,200	2,849	1,760	125	1,510	10,659	3,451	2,410
03L	McElmo Creek near Cortez	McElmo	42	1,010	3,450	1,864	1,525	42	1,430	3,490	2,174	1,935
04L	McElmo Creek above Trail Canyon near Cortez	McElmo	129	784	3,090	1,651	1,340	139	1,139	3,330	2,122	1,880
05L	McElmo Creek above Trail Canyon at gage	McElmo	41	840	3,100	2,027	2,340	42	169	3,421	2,101	2,253
06L	McElmo Creek near Colorado-Utah State Line	McElmo	156	727	3,280	1,867	1,750	176	1,063	3,640	2,333	2,396

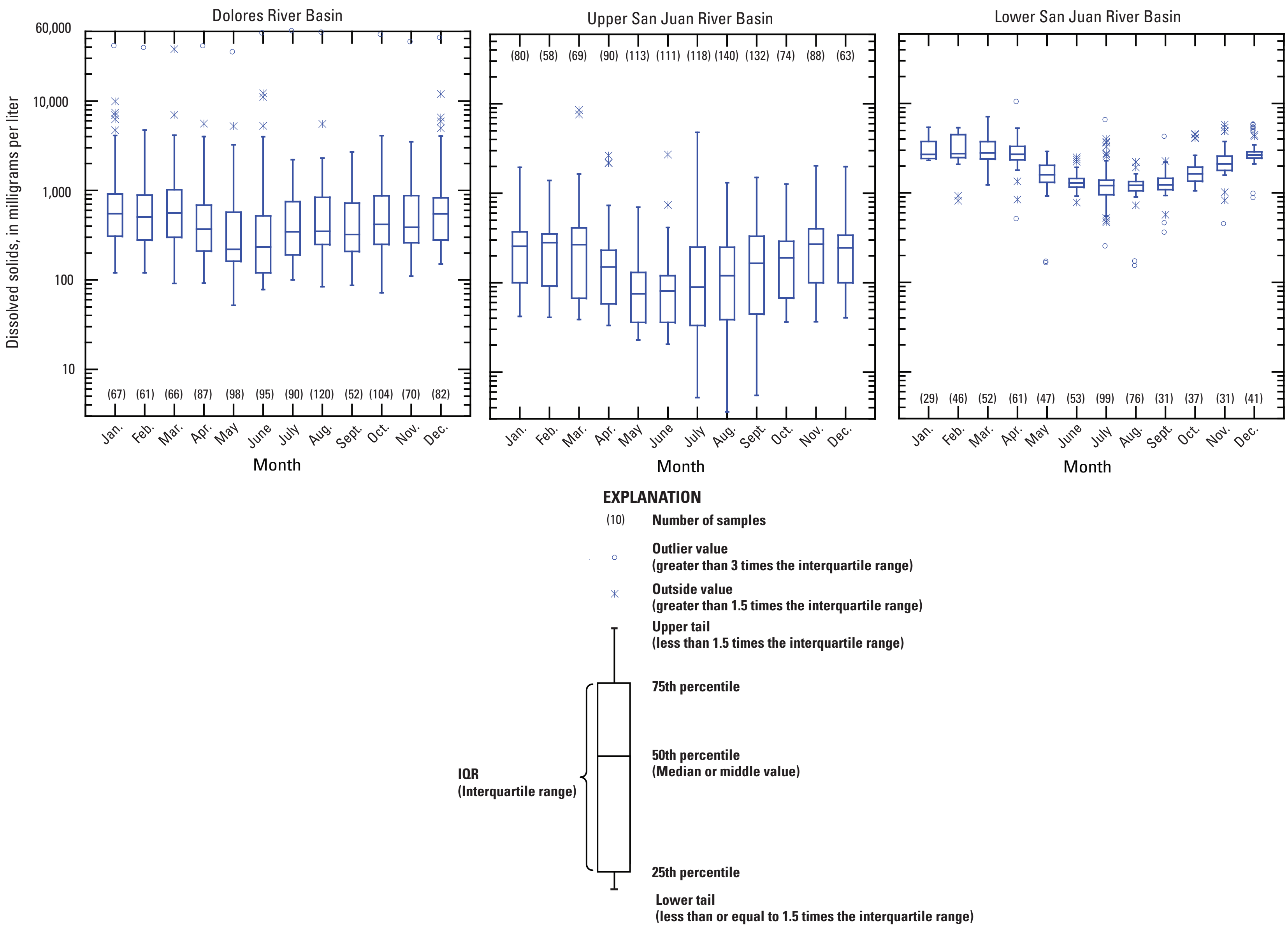


Figure 6. Graph showing monthly distribution of instantaneous dissolved-solids concentrations in surface water in the Dolores, Upper San Juan, and Lower San Juan River Basins, southwestern Colorado, 1990–2005.

Table 5. Summary of trend analysis results for dissolved-solids concentrations and specific-conductance values at selected sites in the Dolores, Upper San Juan, and Lower San Juan River Basins, southwestern Colorado, 1993–2003.

[Site ID, site identification number shown on figure 1; USGS ID, U.S. Geological Survey identification number; mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius; p-value, probability value; nt, not a significant trend; statistically significant trend at p-value less than or equal to 0.05; "--", available data did not meet the selection criteria; typical value is the median value for the trend analysis period; yr, year]

Site ID	USGS ID	Site name	Dissolved solids					Specific conductance				
			Typical value (mg/L)	Trend	p-value	Trend slope (percent)	Trend slope (mg/L per yr)	Typical value (µS/cm)	Trend	p-value	Trend slope (percent)	Trend slope (µS/cm per yr)
		Dolores River Basin										
28D	09172500	San Miguel River near Placerville	--	--	--	--	--	nt	nt	nt	nt	nt
33D	09177000	San Miguel River at Uravan	--	--	--	--	--	nt	nt	nt	nt	nt
06D	09165000	Dolores River below Rico	--	--	--	--	--	nt	nt	nt	nt	nt
10D	09166500	Dolores River at Dolores	--	--	--	--	--	nt	nt	nt	nt	nt
16D	09169500	Dolores River at Bedrock	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt
19D	09171100	Dolores River near Bedrock	1,230	down	0.013	-8.3	-101.5	2,260	down	0.005	-8.9	-201.8
		Upper San Juan River Basin										
08A	09358000	Animas River at Silverton	--	--	--	--	--	nt	nt	nt	nt	nt
17A	09358550	Cement Creek at Silverton	--	--	--	--	--	nt	nt	nt	nt	nt
31A	09359010	Mineral Creek at Silverton	--	--	--	--	--	nt	nt	nt	nt	nt
33A	09359020	Animas River below Silverton	--	--	--	--	--	435	down	0.050	-1.1	-4.9
45A	09361500	Animas River at Durango	--	--	--	--	--	nt	nt	nt	nt	nt
04U	09339900	East Fork San Juan River above Sand Creek, near Pagosa Springs	--	--	--	--	--	nt	nt	nt	nt	nt
11U	09342500	San Juan River at Pagosa Springs	--	--	--	--	--	nt	nt	nt	nt	nt
13U	09346400	San Juan River near Carracas	--	--	--	--	--	nt	nt	nt	nt	nt
18U	09349800	Piedra River near Arboles	--	--	--	--	--	nt	nt	nt	nt	nt
22U	09352900	Vallecito Creek near Bayfield	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt
27U	09355000	Spring Creek at La Boca	--	--	--	--	--	431	down	0.022	-3.3	-14.0
29U	09354500	Los Pinos River at La Boca	--	--	--	--	--	233	down	0.023	-1.5	-3.6
35U	09371000	Mancos River near Towaoc	--	--	--	--	--	1,610	down	0.017	-4.1	-66.4
		Lower San Juan River Basin										
02L	09371492	Mud Creek at State Highway 32, near Cortez	2,410	down	0.033	-2.2	-51.9	nt	nt	nt	nt	nt
04L	09371520	McElmo Creek above Trail Canyon near Cortez	1,750	down	0.029	-2.4	-41.8	2,170	down	0.031	-3.1	-66.1
06L	09372000	McElmo Creek near Colorado-Utah State line	1,900	down	0.021	-2.8	-52.4	2,230	down	0.011	-2.3	-52.0

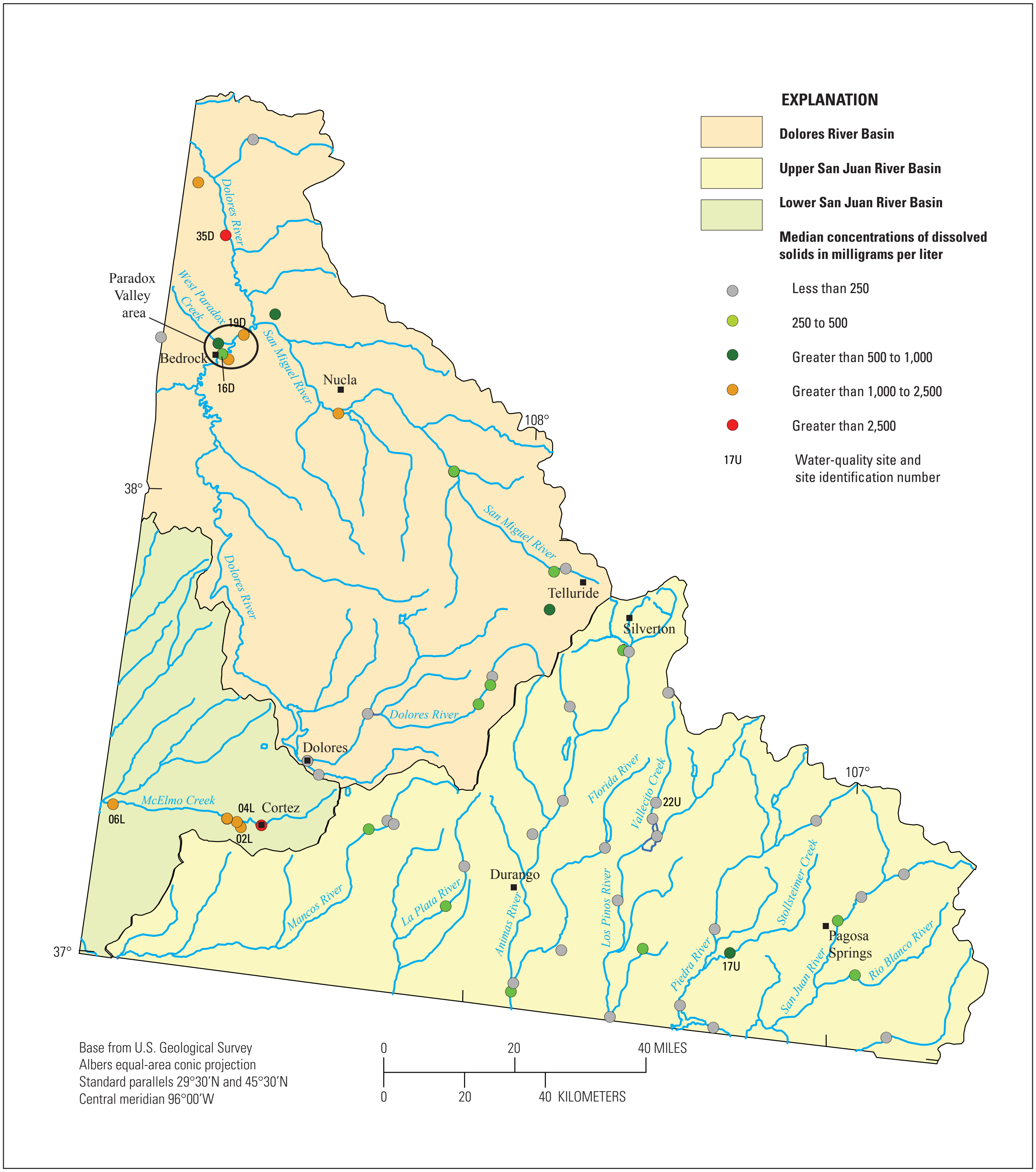


Figure 7. Map showing spatial distribution of median dissolved-solids concentrations in the Dolores, Upper San Juan, and Lower San Juan River Basins, southwestern Colorado, 1990–2005.

Dissolved-solids concentrations decreased by 8.3 percent, and SC values decreased by 8.9 percent (table 5). These decreases in DS concentrations and SC values are likely because of the operation of the Paradox Valley Unit (described in the Geology section) upstream from the Dolores River near Bedrock site (19D). Chafin (2003) evaluated the effectiveness of the Paradox Valley Unit using data collected from 1988 through September 2001, and the average DS load contributed by the saline inflow to the Dolores River had decreased by about 90 percent by September 30, 2001 compared to the average DS load before the Paradox Valley Unit began production operation. Chafin (2003) also stated that this decrease may have been due, in part, to the lower than average precipitation during the latter part of the analysis period producing less saline inflow to the river. No significant trends in DS concentrations or SC values occurred at any other site in the Dolores River Basin.

Upper San Juan River Basin.—Dissolved-solids data were analyzed at 32 sites. Median DS concentrations ranged from 8 to 680 mg/L (table 4). Thirty-one of the 32 sites analyzed in the Upper SJRB had median DS concentrations less than 500 mg/L; and many sites had median DS concentrations less than 250 mg/L (table 4 and fig. 7). Only Stollsteimer Creek at Highway 151 (site 17U) had a median DS concentration greater than 500 mg/L. Vallecito Creek near Bayfield (site 22U) was the only site in the Upper SJRB that had sufficient data to perform trend analyses for DS. No significant trends in DS occurred at the site (table 5). Thirteen sites in the Upper SJRB had sufficient SC data to analyze for trends. Four sites had significant downward trends in SC values (table 5). Decreases in SC values ranged from 1.1 to 4.1 percent. The largest decrease in SC values of 4.1 percent occurred at the Mancos River near Towaoc site. This decrease may be the result of salinity control modifications done by the Natural Resources Conservation Service (Environmental Quality Improvement Program) and the Bureau of Reclamation (Colorado River Basin Salinity Control Program) as part of the Mancos Valley Salinity Control Project (Natural Resources Conservation Service, 2004). Richards and Leib (2011) reported that significant decreases in DS occurred in the adjacent McElmo Creek basin as a result of salinity control work that began in the mid-1980s.

Lower San Juan River Basin.—Dissolved-solids data were analyzed at 6 sites. All sites were located in the McElmo Creek basin. Median DS concentrations ranged from 1,340 to 3,385 mg/L (table 4). Dissolved solids and SC data were analyzed for trends at Mud Creek at State Highway 32, near Cortez (02L), McElmo Creek above Trail Canyon near Cortez (04L), and McElmo Creek near Colorado-Utah State line (06L). Downward trends in DS occurred at all three sites and in SC at two sites (table 5). These decreases in DS concentrations and SC values may be because of irrigation and water-delivery system improvements made by the BOR in the McElmo Creek basin as part Colorado River Basin Salinity Control Program (Richards and Leib, 2011; Voggesser, 2001). Richards and Leib (2011) reported decreases in salinity (DS) loads in the McElmo Creek basin following salinity control modifications.

Major Ions

Limited major ion data were available with only 13 sites throughout the study area having enough major ion data to determine the relative ionic composition in samples to classify and compare water types (table 6). Three of these sites were located in the Dolores River Basin, seven in the Upper SJRB, and three in the Lower SJRB (table 6). Trends in chloride and sulfate concentrations were analyzed at selected sites with sufficient data from 1993 through 2003. Sufficient data were not available to analyze for trends in other major ion concentrations.

Dolores River Basin.—Dolores River Basin sites were located in close proximity to each other and in an area of transition surrounding the Paradox Valley. In this area, water type varied spatially. Dolores River at Bedrock (site 16D), upstream from the Paradox Valley Unit, showed no dominant water type; whereas, at Dolores River near Bedrock (site 19D), downstream from the Paradox Valley Unit, the dominant cation was sodium/potassium and the dominant anion was chloride. At West Paradox Creek above Bedrock (site 18D), sulfate was the dominant anion and there was no dominant cation (figs. 1 and 8).

Temporal trends in chloride and sulfate concentrations were evaluated at Dolores River at Bedrock and Dolores River near Bedrock sites (table 7). No significant trends in chloride or sulfate concentrations occurred at Dolores River at Bedrock. Downstream from the Paradox Valley Unit at the Dolores River near Bedrock site, a significant decrease of 10.5 percent in chloride concentrations occurred; but no trend in sulfate concentrations occurred (table 7). This decrease of chloride concentration in samples from the Dolores River near Bedrock site is likely because of the operation of the Paradox Valley Unit.

Upper San Juan River Basin.—All seven sites analyzed in the Upper SJRB had calcium as the dominant cation. The dominant anion varied depending on location of the site (fig. 8). Sites located in the upper Animas River Basin near the headwaters tended to have sulfate as the dominant anion; whereas, the two sites located outside of the Animas River Basin [Los Pinos River above Vallecito Reservoir near Bayfield (site 20U) and Vallecito Creek near Bayfield (site 22U)] had bicarbonate as the dominant anion. Only the Vallecito Creek near Bayfield site had sufficient data to perform trend analyses for chloride and sulfate (table 7). No significant trends in chloride concentrations occurred at the site; however, a significant upward trend in sulfate concentrations of 4.0 percent was measured. This trend in sulfate concentrations may be related to the drought conditions

Table 6. Average major ion concentrations at selected sites in the Dolores, Upper San Juan, and Lower San Juan River Basins, southwestern Colorado, 1990–2005.

[Site ID, site identification number on figure 1; USGS ID, U.S. Geological Survey identification number; N, number of samples; Ca, calcium; Mg, magnesium; Na, sodium; K, potassium; CO_3, carbonate; HCO_3, bicarbonate; C_l, chloride; SO_4, sulfate; DS, dissolved solids; e, estimated; average concentrations are given in milligrams per liter]

Site ID	USGS ID	Site name	N	Ca	Mg	Na	K	CO_3	HCO_3	C_l	SO_4	DS
		Dolores River Basin										
16D	09169500	Dolores River at Bedrock	18	67.7	17.7	76.1	4.3	8.73	139	96.9	141	485
18D	09170800	West Paradox Creek above Bedrock	12	98.6	54.3	27.0	3.2	27.5	218	26.3	260	615
19D	09171100	Dolores River near Bedrock	20	80.5	26.4	371	19.8	8.22	148	609	194	1,385
		Upper San Juan River Basin										
26A	375028107455801	A43 Paradise Basin above confluence above mines	1	89.0	5.2	3.0	0.3	e0.0001	6.1	0.1	240	389
27A	375039107444801	W39 Middle Fork above Red tributary	1	140	9.0	4.2	0.5	e0.002	23.0	0.4	430	603
28A	375042107443801	W41 Sheep Lake Tributary at confluence with Middle Fork	1	25.0	1.4	0.7	0.4	e0.18	47.0	0.1	28.0	82
33A	09359020	Animas River below Silverton	31	52.4	3.4	2.2	0.6	e0.002	13.5	0.8	134	229
58A	375044107440601	W38 Stream below W16	1	30.0	3.1	3.6	0.4	e0.005	21.0	0.2	68.0	137
20U	09352800	Los Pinos River above Vallecito Reservoir near Bayfield	1	16.6	2.4	2.0	1.2	e0.088	61.0	1.0	3.7	65.1
22U	09352900	Vallecito Creek near Bayfield	51	8.2	1.8	0.8	0.5	0.02	26.0	0.4	7.1	37.2
		Lower San Juan River Basin										
02L	09371492	Mud Creek at State Highway 32, near Cortez	18	305	240	373	7.5	13.4	346	65.3	1,993	3,174
04L	09371520	McElmo Creek above Trail Canyon near Cortez	19	266	132	126	5.6	15.6	272	29.6	1,109	1,829
06L	09372000	McElmo Creek near Colorado-Utah State line	20	270	144	146	5.8	16.3	302	32.2	1,199	1,970

Table 7. Summary of trend analysis results for chloride, sulfate, and nitrate plus nitrite concentrations for selected sites in the Dolores, Upper San Juan, and Lower San River Basins, southwestern Colorado, 1993–2003.

[Site ID, identification number shown on figure 1; USGS ID; U.S. Geological Survey identification number; mg/L, milligrams per liter; p-value, probability value; nt, not a significant trend; statistically significant trend at p-value less than or equal to 0.05; "--", available data did not meet the selection criteria; typical value is the median value for the trend analysis period; yr, year]

Site ID	USGS ID	Site name	Chloride, filtered					Sulfate, filtered					Nitrate plus nitrite, filtered				
			Typical value (mg/L)	Trend	p-value	Trend slope (percent)	Trend slope (mg/L per yr)	Typical value (mg/L)	Trend	p-value	Trend slope (percent)	Trend slope (mg/L per yr)	Typical value (mg/L)	Trend	p-value	Trend slope (percent)	Trend slope (mg/L per yr)
							Dolores River Basin										
16D	09169500	Dolores River at Bedrock	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt	--	--	--	--	--
19D	09171100	Dolores River near Bedrock	566	down	0.013	-10.5	-59.4	nt	nt	nt	nt	nt	--	--	--	--	--
							Upper San Juan River Basin										
22U	09352900	Vallecito Creek near Bayfield	nt	nt	nt	nt	nt	6.2	up	0.040	4.0	0.2	nt	nt	nt	nt	nt
							Lower San Juan River Basin										
02L	09371492	Mud Creek at State Highway 32, near Cortez	nt	nt	nt	nt	nt	1,530	down	0.022	-2.3	-35.5	--	--	--	--	--
04L	09371520	McElmo Creek above Trail Canyon near Cortez	nt	nt	nt	nt	nt	1,070	down	0.022	-2.6	-28.0	--	--	--	--	--
06L	09372000	McElmo Creek near Colorado-Utah State line	27.8	down	0.024	-2.4	-0.7	1,180	down	0.020	-2.9	-34.4	--	--	--	--	--

during the latter part of the analysis period. Additional study, however, would be needed to determine the cause of the change in sulfate concentrations at the site.

Lower San Juan River Basin.—Sufficient major ion data were available to classify water type for three sites in the Lower SJRB. These sites were all located in the McElmo Creek basin. There was no dominant cation; and sulfate was the dominant anion in samples from all three sites (fig. 8). Downward trends in sulfate concentrations ranging from 2 to 3 percent occurred at all three sites (table 7). Only the McElmo Creek near Colorado-Utah State line (06L) site showed a significant downward trend in chloride concentrations (1993–2003). Downward trends of 2.4 percent in chloride concentrations and 2.9 percent in sulfate concentrations occurred at the McElmo Creek near Colorado-Utah State line site. These downward trends in chloride and sulfate concentrations may be because of irrigation and water-delivery system improvements made by the BOR in the McElmo Creek basin as part of the Colorado River Basin Salinity Control Program (Richards and Leib, 2011; Voggesser, 2001).

Trace Elements

The occurrence and distribution of aluminum, iron, mercury, lead, zinc, and selenium are discussed in this section and its subsections. Median and 85th percentile trace element concentrations were calculated for sites with 10 or more samples. The median concentration for total recoverable metals and the 85th percentile concentration for dissolved metals were compared to applicable State aquatic-life water-quality criteria to provide some context to the existing water-quality data. Water-quality criteria for select constituents were reported as table values (Colorado Department of Public Health and Environment, 2010b) and required computation

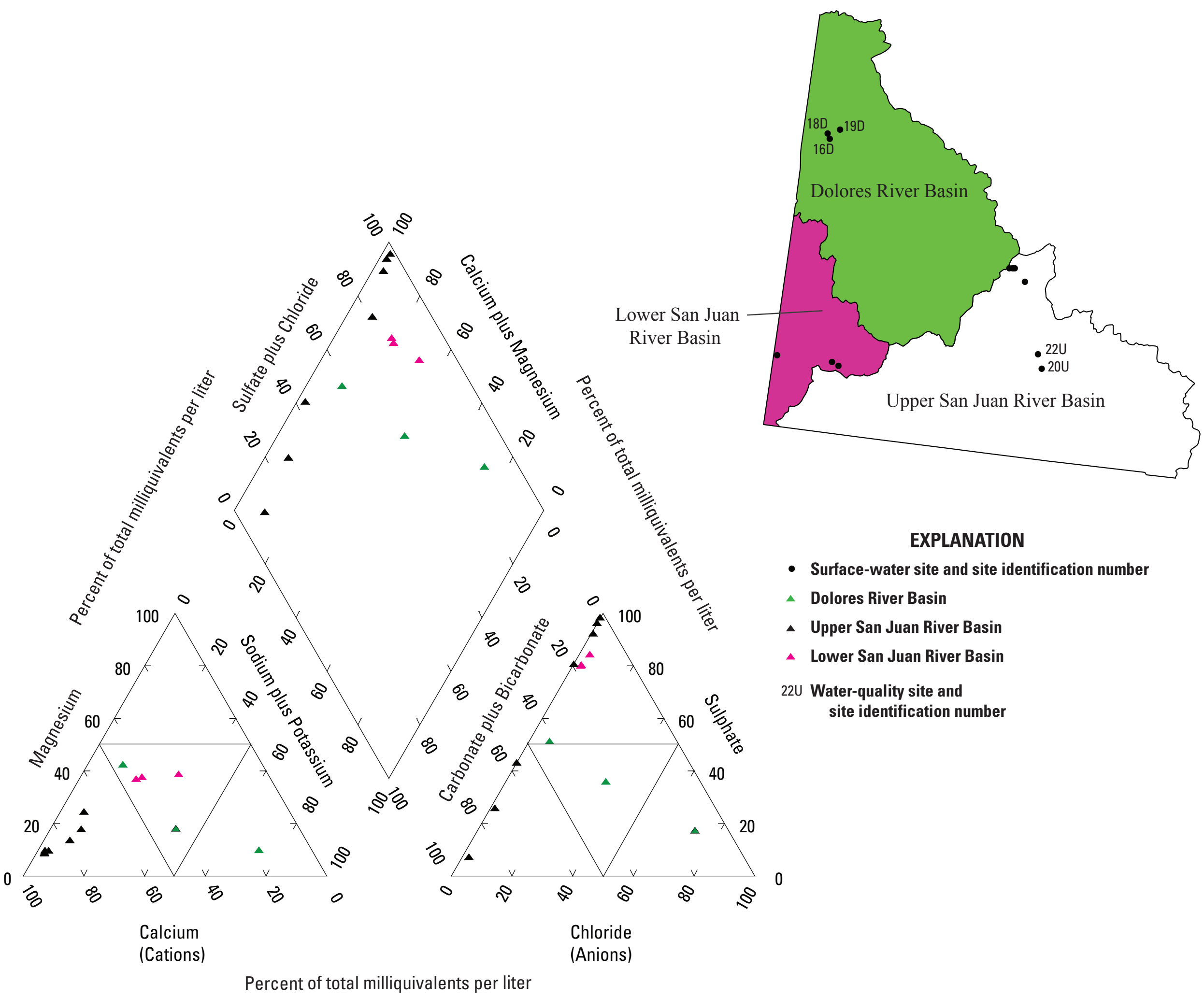


Figure 8. Piper diagram and location map showing water types for selected surface-water sites in the Dolores, Upper San Juan, and Lower San Juan River Basins, southwestern Colorado, 1990–2005.

based on hardness values as described in the “Selection and Processing of Data” section of the report. Extensive studies have been conducted by Church and others (1997) and Church and others (2007) regarding the occurrence, distribution, and sources of metals in the Animas River Basin.

Aluminum

In southwestern Colorado, 85th percentile concentrations for dissolved aluminum in surface-water samples ranged from less than 50 to 67,000 µg/L; and median total recoverable aluminum concentrations ranged from 57 to 2,000 µg/L (table 8). Colorado State acute and chronic criteria for aluminum were based on total recoverable aluminum concentrations (Colorado Department of Public Health and Environment, 2010b). Total recoverable aluminum concentrations were analyzed in the Upper SJRB only. About twice as many samples were analyzed for dissolved aluminum than total recoverable aluminum, and more sites throughout the study area were sampled and analyzed for dissolved aluminum than total recoverable aluminum. The total recoverable aluminum concentration includes the dissolved fraction (that is, the dissolved aluminum concentration); therefore, if the dissolved aluminum concentration exceeds the criteria, the total recoverable aluminum concentration will also exceed the criteria. For these reasons, the 85th percentile concentrations of dissolved aluminum were calculated for sites with 10 or more samples and compared to Colorado State criteria for aluminum to provide a general overview of existing water-quality conditions.

Colorado State aquatic life acute and chronic criteria for total recoverable aluminum are, for the most part, hardness based; however, in some instances, the Commission established site-specific criteria and(or) pH dependent criteria. Overall, the acute criteria for total recoverable aluminum ranged from 512 to 10,071 µg/L; and the chronic criteria ranged from 73 to 1,438 µg/L at hardness concentrations of 25 to 220 mg/L, respectively (Colorado Department of Public Health and Environment, 2010b). The upper bound of hardness calculations was 220 mg/L for total recoverable aluminum, rather than the standard 400 mg/L for other metals equations (Colorado Department of Public Health and Environment, 2010b). The Commission published acute and chronic standards by month for total recoverable aluminum for several segments in the upper Animas River Basin (Colorado Department of Public Health and Environment, 2010a).

Dolores River Basin.—Dissolved aluminum concentrations were analyzed at 11 sites (table 8 and fig. 9). Reporting limits for dissolved aluminum varied from less than 50 to less than 5,000 µg/L. Six of the 11 sites had 80 percent or more censored data. For sites with less than 80 percent censored data, 85th percentile concentrations of dissolved aluminum ranged from 61 to 210 µg/L (table 8). Though none of the dissolved data exceeded the State standards, the total concentrations are unknown. No trends in aluminum concentrations were analyzed because of insufficient data.

Upper San Juan River Basin.—Dissolved aluminum concentrations were analyzed at 44 sites in the Upper SJRB (table 8). Only 2 sites had 85th percentile concentrations of dissolved aluminum (used as surrogate for total recoverable aluminum) that exceeded the acute hardness-based criteria, and 11 sites had 85th percentile concentrations of dissolved aluminum that exceeded the chronic hardness-based criteria. All of the sites that exceeded the acute criteria and all but one site that exceeded the chronic criteria were located in the Cement and Mineral Creek basins north of Silverton (fig. 9). The one site [Sand Creek at Mouth above East Fork San Juan River (site 05U)] outside of the upper Animas River Basin that exceeded criteria was located at the confluence of Sand Creek and the East Fork of the San Juan River upstream from Pagosa Springs. This site had an 85th percentile dissolved aluminum concentration of 93 µg/L; whereas, the hardness-based chronic criterion was 81 µg/L. Neither of the two sites with adequate data indicated trends in dissolved aluminum concentrations (table 9).

Lower San Juan River Basin.— Dissolved aluminum concentrations were analyzed at two sites (McElmo Creek above Cortez Sanitation District, Southwest WWTP and McElmo Creek above Trail Canyon at gage) in the Lower SJRB (table 8). More than 90 percent of the data at both sites were censored. Reporting limits generally ranged from 30 to 2,500 µg/L. A dissolved aluminum concentration of 12 µg/L was measured in 1 of the 15 samples collected at McElmo Creek above Cortez Sanitation District, Southwest WWTP. The remaining 14 samples were coded as less than the reporting limit. A dissolved aluminum concentration of 2.9 µg/L was measured in 1 of the 45 samples collected (1990–2005) at McElmo Creek above Trail Canyon at gage. The remaining 44 samples were coded as less than the reporting limit. Because of insufficient data, aluminum concentrations were not compared to State standards, and trends in aluminum concentrations were not evaluated.

Iron

Within the study area, median total recoverable iron concentrations ranged from 1.6 to 225,000 µg/L (table 8). It was common for total recoverable iron concentrations to vary over several orders of magnitude at a given site. The highest median total recoverable iron concentrations in the study area generally occurred at sites in the Cement Creek and Mineral Creek Basins in the Upper SJRB north and west of Silverton. The chronic aquatic-life criterion for total recoverable iron was 1,000 µg/L throughout most of the study area except for several segments where the Commission adopted different standards based on site-specific conditions: no acute

Table 8. Summary of selected trace element concentrations at sites with 10 or more samples in the Dolores, Upper San Juan, and Lower San Juan River Basins, southwestern Colorado, 1990–2005.

[Site ID, site identification number shown on figure 1; Database ID, data repository identification number; <, less than; concentrations are given in micrograms per liter; K-M flipped, Kaplan-Meier method modified for left-censored data used to compute summary statistics; ROS, the robust "regression on order statistics" method used to compute summary statistics; Estimate, summary statistics were reported as less than the maximum reporting limit; N, number of samples; NC, number of samples with concentrations reported as less than the reporting limit; Min, minimum value; Max, maximum value; Med, median; C_{85}, 85th percentile concentration; Al.wf, dissolved aluminum; Al.wu, total recoverable aluminum; Fe.wf, dissolved iron; Fe.wu, total recoverable iron; Hg.wf, dissolved mercury; Hg.wu, total recoverable mercury; Pb.wf, dissolved lead; Pb.wu, total recoverable lead; Se.wf, dissolved selenium; Se.wu, total recoverable selenium; Ur.wf, dissolved uranium; Zn.wf, dissolved zinc; Zn.wu, total recoverable zinc; WWTP, wastewater treatment plant; values shown in blue indicate that chronic State water-quality standards were not met and values shown in red indicate that acute and chronic State water-quality standards were not met]

Site ID	Database ID	Site name	Subbasin name	Constituent	Method	N	NC	Min	Max	Med	C_{85}
		Dolores River Basin									
01D	10784R	Coal Creek at FR 535 below Lizard Head Wilderness Area	Upper Dolores	Al.wf	Estimate	10	8	<50	<50	<50	<50
02D	10782	Horse Creek at Highway 145	Upper Dolores	Al.wf	ROS	12	8	<50	62	24	62
04D	10780	Silver Creek at Highway 145	Upper Dolores	Al.wf	ROS	36	26	<50	140	27	61
05D	10716	Dolores River below Rico	Upper Dolores	Al.wf	ROS	35	28	<30	87	35	63
08D	10901A	Lost Canyon Creek near Dolores	Upper Dolores	Al.wf	ROS	14	8	<50	510	75	210
13D	10701	Dolores River at Dolores above Mcphee Reservoir	Upper Dolores	Al.wf	ROS	25	19	<30	300	28	100
25D	10815	San Miguel River at Society Turn	San Miguel	Al.wf	Estimate	60	55	<30	<250	<250	<250
26D	10871	South Fork San Miguel River near mouth	San Miguel	Al.wf	ROS	12	9	<50	<500	32	65
30D	10860	McKenzie Creek at mouth above confluence with San Miguel River	San Miguel	Al.wf	Estimate	17	16	<50	<500	<500	<500
35D	10903	Salt Creek at Highway 141	Lower Dolores	Al.wf	Estimate	13	13	<50	<5,000	<5,000	<5,000
36D	10915	West Creek in Unaweep Canyon	Lower Dolores	Al.wf	Estimate	14	12	<50	<50	<50	<50
01D	10784R	Coal Creek at FR 535 below Lizard Head Wilderness Area	Upper Dolores	Fe.wf	K-M flipped	10	2	<10	140	19	32
02D	10782	Horse Creek at Highway 145	Upper Dolores	Fe.wf	K-M flipped	12	4	<10	76	28	63
05D	10716	Dolores River below Rico	Upper Dolores	Fe.wf	K-M flipped	16	4	<10	69	26	59
08D	10901A	Lost Canyon Creek near Dolores	Upper Dolores	Fe.wf	K-M flipped	14	0	37	3,400	225	320
11D	DRDOL12T	Dolores River at Dolores	Upper Dolores	Fe.wf	K-M flipped	10	4	<3	101	20	61
13D	10701	Dolores River at Dolores above Mcphee Reservoir	Upper Dolores	Fe.wf	K-M flipped	25	4	<10	180	19	62
25D	10815	San Miguel River at Society Turn	San Miguel	Fe.wf	K-M flipped	30	3	<10	160	50	87
26D	10871	South Fork San Miguel River near mouth	San Miguel	Fe.wf	K-M flipped	12	5	<10	<100	12	24
30D	10860	McKenzie Creek at mouth above confluence with San Miguel River	San Miguel	Fe.wf	Estimate	17	16	<10	<100	<100	<100
35D	10903	Salt Creek at Highway 141	Lower Dolores	Fe.wf	Estimate	13	13	<10	<1,000	<1,000	<1,000
01D	10784R	Coal Creek at FR 535 below Lizard Head Wilderness Area	Upper Dolores	Fe.wu	K-M flipped	10	0	16	730	265	690
02D	10782	Horse Creek at Highway 145	Upper Dolores	Fe.wu	K-M flipped	12	0	85	1,300	220	840
03D	10718	Dolores River above Horse Creek	Upper Dolores	Fe.wu	K-M flipped	16	3	<10	780	72	450
04D	10780	Silver Creek at Highway 145	Upper Dolores	Fe.wu	K-M flipped	47	12	<10	1,900	99	760
05D	10716	Dolores River below Rico	Upper Dolores	Fe.wu	K-M flipped	48	6	<10	810	115	290
07D	10770	West Dolores River near Stoner at Highway 145	Upper Dolores	Fe.wu	K-M flipped	19	0	13	7,000	100	700
08D	10901A	Lost Canyon Creek near Dolores	Upper Dolores	Fe.wu	K-M flipped	13	0	60	1,600	450	870
11D	DRDOL12T	Dolores River at Dolores	Upper Dolores	Fe.wu	K-M flipped	10	1	<3	696	156	258
13D	10701	Dolores River at Dolores above Mcphee Reservoir	Upper Dolores	Fe.wu	K-M flipped	25	0	15	2,200	93	580
20D	10818	San Miguel River above Marshall Creek	San Miguel	Fe.wu	K-M flipped	11	5	<10	130	10	92
25D	10815	San Miguel River at Society Turn	San Miguel	Fe.wu	K-M flipped	76	2	<50	3,300	145	500
26D	10871	South Fork San Miguel River near mouth	San Miguel	Fe.wu	K-M flipped	25	1	<50	1,200	200	500

Table 8. Summary of selected trace element concentrations at sites with 10 or more samples in the Dolores, Upper San Juan, and Lower San Juan River Basins, southwestern Colorado, 1990–2005.—Continued

[Site ID, site identification number shown on figure 1; Database ID, data repository identification number; <, less than; concentrations are given in micrograms per liter; K-M flipped, Kaplan-Meier method modified for left-censored data used to compute summary statistics; ROS, the robust "regression on order statistics" method used to compute summary statistics; Estimate, summary statistics were reported as less than the maximum reporting limit; N, number of samples; NC, number of samples with concentrations reported as less than the reporting limit; Min, minimum value; Max, maximum value; Med, median; C_{85}, 85th percentile concentration; Al.wf, dissolved aluminum; Al.wu, total recoverable aluminum; Fe.wf, dissolved iron; Fe.wu, total recoverable iron; Hg.wf, dissolved mercury; Hg.wu, total recoverable mercury; Pb.wf, dissolved lead; Pb.wu, total recoverable lead; Se.wf, dissolved selenium; Se.wu, total recoverable selenium; Ur.wf, dissolved uranium; Zn.wf, dissolved zinc; Zn.wu, total recoverable zinc; WWTP, wastewater treatment plant; values shown in blue indicate that chronic State water-quality standards were not met and values shown in red indicate that acute and chronic State water-quality standards were not met]

Site ID	Database ID	Site name	Subbasin name	Constituent	Method	N	NC	Min	Max	Med	C_{85}
		Dolores River Basin—Continued									
27D	10875	Howard Fork San Miguel River at Ophir	San Miguel	Fe.wu	K-M flipped	17	0	90	1,900	170	660
30D	10860	McKenzie Creek at mouth above confluence with San Miguel River	San Miguel	Fe.wu	ROS	17	9	<10	690	4.8	24
32D	10831	Naturita Creek at Naturita	San Miguel	Fe.wu	K-M flipped	18	0	38	8,300	215	930
35D	10903	Salt Creek at Highway 141	Lower Dolores	Fe.wu	ROS	13	7	<1000	4,100	142	3,500
36D	10915	West Creek in Unaweep Canyon	Lower Dolores	Fe.wu	K-M flipped	14	0	15	520	97	190
03D	10718	Dolores River above Horse Creek	Upper Dolores	Hg.wf	Estimate	14	14	<0.1	<0.2	<0.2	<0.2
04D	10780	Silver Creek at Highway 145	Upper Dolores	Hg.wf	Estimate	20	19	<0.1	<0.2	<0.2	<0.2
05D	10716	Dolores River below Rico	Upper Dolores	Hg.wf	Estimate	28	28	<0.1	<0.2	<0.2	<0.2
07D	10770	West Dolores River near Stoner at Highway 145	Upper Dolores	Hg.wf	Estimate	13	13	<0.1	<0.2	<0.2	<0.2
13D	10701	Dolores River at Dolores above Mcphee Reservoir	Upper Dolores	Hg.wf	Estimate	21	21	<0.1	<0.2	<0.2	<0.2
25D	10815	San Miguel River at Society Turn	San Miguel	Hg.wf	Estimate	53	53	<0.1	<0.2	<0.2	<0.2
26D	10871	South Fork San Miguel River near mouth	San Miguel	Hg.wf	Estimate	14	14	<0.1	<0.2	<0.2	<0.2
27D	10875	Howard Fork San Miguel River at Ophir	San Miguel	Hg.wf	Estimate	16	16	<0.1	<0.2	<0.2	<0.2
32D	10831	Naturita Creek at Naturita	San Miguel	Hg.wf	Estimate	16	16	<0.1	<0.2	<0.2	<0.2
04D	10780	Silver Creek at Highway 145	Upper Dolores	Hg.wu	Estimate	22	22	<0.2	<0.2	<0.2	<0.2
05D	10716	Dolores River below Rico	Upper Dolores	Hg.wu	Estimate	17	17	<0.2	<0.2	<0.2	<0.2
08D	10901A	Lost Canyon Creek near Dolores	Upper Dolores	Hg.wu	Estimate	10	10	<0.2	<0.2	<0.2	<0.2
25D	10815	San Miguel River at Society Turn	San Miguel	Hg.wu	Estimate	19	19	<0.2	<0.2	<0.2	<0.2
30D	10860	McKenzie Creek at mouth above confluence with San Miguel River	San Miguel	Hg.wu	Estimate	14	14	<0.2	<0.2	<0.2	<0.2
35D	10903	Salt Creek at Highway 141	Lower Dolores	Hg.wu	Estimate	10	10	<0.2	<0.2	<0.2	<0.2
01D	10784R	Coal Creek at FR 535 below Lizard Head Wilderness Area	Upper Dolores	Pb.wf	Estimate	10	10	<1	<1	<1	<1
02D	10782	Horse Creek at Highway 145	Upper Dolores	Pb.wf	Estimate	12	12	<0.1	<1	<1	<1
03D	10718	Dolores River above Horse Creek	Upper Dolores	Pb.wf	Estimate	16	14	<1	<5	<5	<5
04D	10780	Silver Creek at Highway 145	Upper Dolores	Pb.wf	ROS	47	40	<1	5.7	0.37	1
05D	10716	Dolores River below Rico	Upper Dolores	Pb.wf	Estimate	48	45	<0.1	<5	<5	<5
07D	10770	West Dolores River near Stoner at Highway 145	Upper Dolores	Pb.wf	Estimate	20	20	<1	<5	<5	<5
08D	10901A	Lost Canyon Creek near Dolores	Upper Dolores	Pb.wf	Estimate	14	14	<1	<1	<1	<1
11D	DRDOL12T	Dolores River at Dolores	Upper Dolores	Pb.wf	Estimate	10	10	<0.5	<30	<30	<30
13D	10701	Dolores River at Dolores above Mcphee Reservoir	Upper Dolores	Pb.wf	Estimate	24	23	<1	9	<1	<1
20D	10818	San Miguel River above Marshall Creek	San Miguel	Pb.wf	Estimate	11	11	<1	<5	<5	<5
25D	10815	San Miguel River at Society Turn	San Miguel	Pb.wf	ROS	75	64	<0.1	12	0.37	1
26D	10871	South Fork San Miguel River near mouth	San Miguel	Pb.wf	Estimate	25	25	<1	<5	<5	<5
27D	10875	Howard Fork San Miguel River at Ophir	San Miguel	Pb.wf	Estimate	17	17	<1	<5	<5	<5

Table 8. Summary of selected trace element concentrations at sites with 10 or more samples in the Dolores, Upper San Juan, and Lower San Juan River Basins, southwestern Colorado, 1990–2005.—Continued

[Site ID, site identification number shown on figure 1; Database ID, data repository identification number; <, less than; concentrations are given in micrograms per liter; K-M flipped, Kaplan-Meier method modified for left-censored data used to compute summary statistics; ROS, the robust "regression on order statistics" method used to compute summary statistics; Estimate, summary statistics were reported as less than the maximum reporting limit; N, number of samples; NC, number of samples with concentrations reported as less than the reporting limit; Min, minimum value; Max, maximum value; Med, median; C_{85}, 85th percentile concentration; Al.wf, dissolved aluminum; Al.wu, total recoverable aluminum; Fe.wf, dissolved iron; Fe.wu, total recoverable iron; Hg.wf, dissolved mercury; Hg.wu, total recoverable mercury; Pb.wf, dissolved lead; Pb.wu, total recoverable lead; Se.wf, dissolved selenium; Se.wu, total recoverable selenium; Ur.wf, dissolved uranium; Zn.wf, dissolved zinc; Zn.wu, total recoverable zinc; WWTP, wastewater treatment plant; values shown in blue indicate that chronic State water-quality standards were not met and values shown in red indicate that acute and chronic State water-quality standards were not met]

Site ID	Database ID	Site name	Subbasin name	Constituent	Method	N	NC	Min	Max	Med	C_{85}
		Dolores River Basin—Continued									
30D	10860	McKenzie Creek at mouth above confluence with San Miguel River	San Miguel	Pb.wf	Estimate	17	17	<1	<1	<1	<1
32D	10831	Naturita Creek at Naturita	San Miguel	Pb.wf	Estimate	18	18	<1	<5	<5	<5
35D	10903	Salt Creek at Highway 141	Lower Dolores	Pb.wf	Estimate	13	13	<1	<40	<40	<40
36D	10915	West Creek in Unaweep Canyon	Lower Dolores	Pb.wf	Estimate	14	14	<1	<1	<1	<1
01D	10784R	Coal Creek at FR 535 below Lizard Head Wilderness Area	Upper Dolores	Zn.wf	K-M flipped	10	2	<10	14	11	13
02D	10782	Horse Creek at Highway 145	Upper Dolores	Zn.wf	K-M flipped	12	4	<10	<100	17	28
03D	10718	Dolores River above Horse Creek	Upper Dolores	Zn.wf	ROS	16	13	<8	6,100	2.85	24
04D	10780	Silver Creek at Highway 145	Upper Dolores	Zn.wf	K-M flipped	47	1	<1.8	1,700	540	**720**
05D	10716	Dolores River below Rico	Upper Dolores	Zn.wf	K-M flipped	48	5	<10	780	58	120
07D	10770	West Dolores River near Stoner at Highway 145	Upper Dolores	Zn.wf	ROS	20	14	<8	23	5.95	11
08D	10901A	Lost Canyon Creek near Dolores	Upper Dolores	Zn.wf	ROS	14	9	<10	<100	9.75	14
11D	DRDOL12T	Dolores River at Dolores	Upper Dolores	Zn.wf	ROS	10	5	<4	157	3.18	21
13D	10701	Dolores River at Dolores above Mcphee Reservoir	Upper Dolores	Zn.wf	ROS	25	18	<10	39	5.11	15
20D	10818	San Miguel River above Marshall Creek	San Miguel	Zn.wf	K-M flipped	11	0	55	480	250	**430**
25D	10815	San Miguel River at Society Turn	San Miguel	Zn.wf	K-M flipped	75	2	<8	370	170	**240**
26D	10871	South Fork San Miguel River near mouth	San Miguel	Zn.wf	K-M flipped	25	3	<10	<500	35	61
27D	10875	Howard Fork San Miguel River at Ophir	San Miguel	Zn.wf	K-M flipped	17	0	16	130	89	120
30D	10860	McKenzie Creek at mouth above confluence with San Miguel River	San Miguel	Zn.wf	K-M flipped	17	4	<10	<100	20	27
32D	10831	Naturita Creek at Naturita	San Miguel	Zn.wf	Estimate	18	17	<8	<16	<16	<16
35D	10903	Salt Creek at Highway 141	Lower Dolores	Zn.wf	ROS	13	10	<10	1,600	583	**1,300**
36D	10915	West Creek in Unaweep Canyon	Lower Dolores	Zn.wf	Estimate	14	14	<8	<10	<10	<10
11D	DRDOL12T	Dolores River at Dolores	Upper Dolores	Zn.wu	K-M flipped	10	2	<4	25	13.5	21
01D	10784R	Coal Creek at FR 535 below Lizard Head Wilderness Area	Upper Dolores	Se.wf	Estimate	10	10	<1	<1	<1	<1
02D	10782	Horse Creek at Highway 145	Upper Dolores	Se.wf	Estimate	12	12	<0.4	<1	<1	<1
04D	10780	Silver Creek at Highway 145	Upper Dolores	Se.wf	Estimate	36	33	<0.4	<1	<1	<1
05D	10716	Dolores River below Rico	Upper Dolores	Se.wf	Estimate	35	33	<0.4	<1	<1	<1
08D	10901A	Lost Canyon Creek near Dolores	Upper Dolores	Se.wf	Estimate	14	14	<1	<1	<1	<1
11D	DRDOL12T	Dolores River at Dolores	Upper Dolores	Se.wf	Estimate	10	9	<1	62.1	<40	<40
13D	10701	Dolores River at Dolores above Mcphee Reservoir	Upper Dolores	Se.wf	Estimate	25	25	<1	<1	<1	<1
15D	000085	Dolores River above confluence with San Miguel River	Upper Dolores	Se.wf	ROS	11	6	<1	8.9	0.66	3
25D	10815	San Miguel River at Society Turn	San Miguel	Se.wf	Estimate	45	39	<1	3.1	<1	<1
26D	10871	South Fork San Miguel River near mouth	San Miguel	Se.wf	Estimate	17	15	<1	<1	<1	<1
27D	10875	Howard Fork San Miguel River at Ophir	San Miguel	Se.wf	Estimate	10	10	<1	<1	<1	<1
29D	000101	San Miguel River near Norwood	San Miguel	Se.wf	Estimate	25	24	<1	<10	<10	<10

Table 8. Summary of selected trace element concentrations at sites with 10 or more samples in the Dolores, Upper San Juan, and Lower San Juan River Basins, southwestern Colorado, 1990–2005.—Continued

[Site ID, site identification number shown on figure 1; Database ID, data repository identification number; <, less than; concentrations are given in micrograms per liter; K-M flipped, Kaplan-Meier method modified for left-censored data used to compute summary statistics; ROS, the robust "regression on order statistics" method used to compute summary statistics; Estimate, summary statistics were reported as less than the maximum reporting limit; N, number of samples; NC, number of samples with concentrations reported as less than the reporting limit; Min, minimum value; Max, maximum value; Med, median; C_{85}, 85th percentile concentration; Al.wf, dissolved aluminum; Al.wu, total recoverable aluminum; Fe.wf, dissolved iron; Fe.wu, total recoverable iron; Hg.wf, dissolved mercury; Hg.wu, total recoverable mercury; Pb.wf, dissolved lead; Pb.wu, total recoverable lead; Se.wf, dissolved selenium; Se.wu, total recoverable selenium; Ur.wf, dissolved uranium; Zn.wf, dissolved zinc; Zn.wu, total recoverable zinc; WWTP, wastewater treatment plant; values shown in blue indicate that chronic State water-quality standards were not met and values shown in red indicate that acute and chronic State water-quality standards were not met]

Site ID	Database ID	Site name	Subbasin name	Constituent	Method	N	NC	Min	Max	Med	C_{85}
		Dolores River Basin—Continued									
30D	10860	McKenzie Creek at mouth above confluence with San Miguel River	San Miguel	Se.wf	K-M flipped	17	6	<1	2	1	2
32D	10831	Naturita Creek at Naturita	San Miguel	Se.wf	K-M flipped	11	4	<1	2.6	1	1.8
34D	000084	San Miguel River at confluence with Dolores River	San Miguel	Se.wf	ROS	34	18	<1	<10	0.68	1.2
35D	10903	Salt Creek at Highway 141	Lower Dolores	Se.wf	ROS	13	8	<1	<25	20	**23**
13D	10701	Dolores River at Dolores above Mcphee Reservoir	Upper Dolores	Ur.wf	Estimate	10	9	<1	<3	<3	<3
15D	000085	Dolores River above confluence with San Miguel River	Upper Dolores	Ur.wf	K-M flipped	12	5	3	8	3	4
34D	000084	San Miguel River at confluence with Dolores River	San Miguel	Ur.wf	K-M flipped	21	3	1	12	3.6	6
		Upper San Juan River Basin									
02A	A33	Animas River at Eureka	Animas	Al.wf	K-M flipped	18	7	<40	200	55	95
03A	A39	Eureka below Ben Franklin	Animas	Al.wf	K-M flipped	23	7	<10	200	100	200
04A	A53	Animas River at Howardsville	Animas	Al.wf	ROS	14	8	<40	113	49	84
07A	A68	Animas River at Silverton	Animas	Al.wf	K-M flipped	133	52	<0.062	<230	50	89
09A	CC18	North Fork Cement Creek upstream from Gold King mine, #7 level (AMLI mine # 103)	Animas	Al.wf	K-M flipped	96	0	100	44,200	3,490	**5,390**
10A	CC32	South Fork Cement Creek downstream from Velocity Lake	Animas	Al.wf	K-M flipped	11	5	<40	125	48	123
11A	CC31	South Fork Cement Creek downstream from Big Colorado mine (AMLI mine # 150)	Animas	Al.wf	K-M flipped	14	0	88	7,850	4,262	**6,564**
12A	CC23	Prospect Gulch upstream from Red Spring	Animas	Al.wf	K-M flipped	15	0	57	1,310	57	**830**
14A	CC14	Minnesota Gulch near mouth	Animas	Al.wf	K-M flipped	13	0	45	2,877	1,039	2,300
15A	CC20	Porcupine Gulch upstream from mines	Animas	Al.wf	K-M flipped	123	8	<40	11,500	500	2,400
16A	CC17	Niagara Gulch near mouth	Animas	Al.wf	K-M flipped	32	0	55	3,200	1,000	**1,859**
19A	CEM48	Cement Creek at USGS gaging station	Animas	Al.wf	K-M flipped	12	0	13	4,500	2,550	**4,400**
20A	M02	Mineral Creek near headwaters	Animas	Al.wf	K-M flipped	16	0	3,900	85,000	43,150	**67,000**
21A	M02A	Highway 550 drainage ditch above M01 confluence-east side of Highway 550	Animas	Al.wf	K-M flipped	14	0	3,280	63,700	24,600	**57,700**
22A	M07	Mineral Creek at Chattanooga	Animas	Al.wf	K-M flipped	16	2	<40	2,700	243	**1,800**
23A	M13	Mineral Creek just below confluence with Browns Gulch	Animas	Al.wf	ROS	13	8	<40	180	36	90
30A	M27	Mineral Creek above confluence with South Fork Mineral Creek	Animas	Al.wf	K-M flipped	12	0	52	11,700	749	**6,310**
32A	M34	Mineral Creek at Silverton	Animas	Al.wf	K-M flipped	143	34	<1	5,230	88	**2,360**
33A	09359020	Animas River below Silverton	Animas	Al.wf	K-M flipped	43	0	10	370	31	107
35A	A72	Animas River downstream from Silverton	Animas	Al.wf	K-M flipped	169	49	<1	1,900	77	634
39A	9445	Cascade Creek at Highway 550	Animas	Al.wf	Estimate	16	14	<50	<50	<50	<50
43A	9440	Falls Creek at 0.65 Road	Animas	Al.wf	Estimate	13	11	<50	<250	<250	<250
46A	9420	Animas River at Durango	Animas	Al.wf	ROS	30	24	<30	<250	28	54

Table 8. Summary of selected trace element concentrations at sites with 10 or more samples in the Dolores, Upper San Juan, and Lower San Juan River Basins, southwestern Colorado, 1990–2005.—Continued

[Site ID, site identification number shown on figure 1; Database ID, data repository identification number; <, less than; concentrations are given in micrograms per liter; K-M flipped, Kaplan-Meier method modified for left-censored data used to compute summary statistics; ROS, the robust “regression on order statistics” method used to compute summary statistics; Estimate, summary statistics were reported as less than the maximum reporting limit; N, number of samples; NC, number of samples with concentrations reported as less than the reporting limit; Min, minimum value; Max, maximum value; Med, median; C_{85}, 85th percentile concentration; Al.wf, dissolved aluminum; Al.wu, total recoverable aluminum; Fe.wf, dissolved iron; Fe.wu, total recoverable iron; Hg.wf, dissolved mercury; Hg.wu, total recoverable mercury; Pb.wf, dissolved lead; Pb.wu, total recoverable lead; Se.wf, dissolved selenium; Se.wu, total recoverable selenium; Ur.wf, dissolved uranium; Zn.wf, dissolved zinc; Zn.wu, total recoverable zinc; WWTP, wastewater treatment plant; values shown in blue indicate that chronic State water-quality standards were not met and values shown in red indicate that acute and chronic State water-quality standards were not met]

Site ID	Database ID	Site name	Subbasin name	Constituent	Method	N	NC	Min	Max	Med	C_{85}
		Upper San Juan River Basin—Continued									
48A	DRALP001	DRALP001	Animas	Al.wf	K-M flipped	21	3	<1	86	18.5	29
49A	DRALP002	Animas River at Durango	Animas	Al.wf	K-M flipped	31	5	<1	166	22	58
50A	DRALP209	Animas River behind BMX track at Durango	Animas	Al.wf	K-M flipped	21	0	7.3	128	34	68
54A	9415	Salt Creek at 309A Road	Animas	Al.wf	K-M flipped	15	7	<50	<250	76	100
01U	9850	Little Navajo River at Highway 84	Upper San Juan	Al.wf	Estimate	16	14	<50	<500	<500	<500
03U	9860	Rio Blanco at Highway 84	Upper San Juan	Al.wf	ROS	17	12	<50	400	38	120
05U	9165	Sand Creek at mouth above East Fork San Juan River	Upper San Juan	Al.wf	ROS	12	8	<50	110	62	**93**
10U	9120	McCabe Creek above Pagosa Springs	Upper San Juan	Al.wf	Estimate	17	16	<50	<500	<500	<500
15U	9290	East Fork Piedra River below Piedra Falls	Piedra	Al.wf	Estimate	12	11	<50	<50	<50	<50
16U	9250	Piedra River at Highway 160	Piedra	Al.wf	ROS	53	40	<30	<250	23	68
17U	9245	Stollsteimer Creek at Highway 151	Piedra	Al.wf	Estimate	18	17	<50	<500	<500	<500
20U	09352800	Los Pinos River above Vallecito Reservoir near Bayfield	Upper San Juan	Al.wf	K-M flipped	14	5	<7.5	34	4.66	27
21U	9380	Los Pinos River above Vallecito Reservoir	Upper San Juan	Al.wf	ROS	52	46	<30	110	28	52
22U	09352900	Vallecito Creek near Bayfield	Upper San Juan	Al.wf	K-M flipped	44	2	<10	80	40	70
23U	9370	Vallecito Creek near mouth	Upper San Juan	Al.wf	ROS	51	34	<30	170	38	75
24U	372236107344400	Los Pinos River below Vallecito Reservoir near Bayfield	Upper San Juan	Al.wf	K-M flipped	16	4	<10	51	19	32
25U	9355	Wallace Gulch at 502 Road north of Bayfield	Upper San Juan	Al.wf	Estimate	16	15	<50	<250	<250	<250
30U	9680	La Plata at Hesperus	Middle San Juan	Al.wf	ROS	43	38	<11	82	15	33
31U	9610	Spring Creek near Breen	Middle San Juan	Al.wf	Estimate	12	12	<50	<250	<250	<250
32U	9720	East Fork Mancos River at 44 Road	Mancos	Al.wf	ROS	22	15	<30	160	41	100
34U	9715	Chicken Creek at Mancos	Mancos	Al.wf	ROS	18	13	<50	<500	19	120
02A	A33	Animas River at Eureka	Animas	Al.wu	K-M flipped	12	0	210	472	**332**	429
07A	A68	Animas River at Silverton	Animas	Al.wu	K-M flipped	94	14	<20	600	130	300
10A	CC32	South Fork Cement Creek downstream from Velocity Lake	Animas	Al.wu	ROS	10	5	<40	249	57	241
12A	CC23	Prospect Gulch upstream from Red Spring	Animas	Al.wu	K-M flipped	14	0	285	1,279	285	790
32A	M34	Mineral Creek at Silverton	Animas	Al.wu	K-M flipped	108	0	1.58	7,000	**2,000**	4,500
33A	09359020	Animas River below Silverton	Animas	Al.wu	K-M flipped	36	0	428	2,792	**1,281**	2,213
35A	A72	Animas River downstream from Silverton	Animas	Al.wu	K-M flipped	66	0	1.31	3,707	**1,242**	2,322
48A	DRALP001	DRALP001	Animas	Al.wu	K-M flipped	21	1	<1	1,056	144	420
49A	DRALP002	Animas River at Durango	Animas	Al.wu	K-M flipped	31	1	<1	1,528	164	606
50A	DRALP209	Animas River behind BMX track at Durango	Animas	Al.wu	K-M flipped	21	0	30	880	185	463
02A	A33	Animas River at Eureka	Animas	Fe.wf	Estimate	13	11	<30	<30	<30	<30
03A	A39	Eureka below Ben Franklin	Animas	Fe.wf	ROS	21	13	<50	150	31	60

Table 8. Summary of selected trace element concentrations at sites with 10 or more samples in the Dolores, Upper San Juan, and Lower San Juan River Basins, southwestern Colorado, 1990–2005.—Continued

[Site ID, site identification number shown on figure 1; Database ID, data repository identification number; <, less than; concentrations are given in micrograms per liter; K-M flipped, Kaplan-Meier method modified for left-censored data used to compute summary statistics; ROS, the robust "regression on order statistics" method used to compute summary statistics; Estimate, summary statistics were reported as less than the maximum reporting limit; N, number of samples; NC, number of samples with concentrations reported as less than the reporting limit; Min, minimum value; Max, maximum value; Med, median; C_{85}, 85th percentile concentration; Al.wf, dissolved aluminum; Al.wu, total recoverable aluminum; Fe.wf, dissolved iron; Fe.wu, total recoverable iron; Hg.wf, dissolved mercury; Hg.wu, total recoverable mercury; Pb.wf, dissolved lead; Pb.wu, total recoverable lead; Se.wf, dissolved selenium; Se.wu, total recoverable selenium; Ur.wf, dissolved uranium; Zn.wf, dissolved zinc; Zn.wu, total recoverable zinc; WWTP, wastewater treatment plant; values shown in blue indicate that chronic State water-quality standards were not met and values shown in red indicate that acute and chronic State water-quality standards were not met]

Site ID	Database ID	Site name	Subbasin name	Constituent	Method	N	NC	Min	Max	Med	C_{85}
		Upper San Juan River Basin—Continued									
04A	A53	Animas River at Howardsville	Animas	Fe.wf	K-M flipped	16	6	<30	171	40	57
05A	A60	Animas River downstream from Arrastra Gulch	Animas	Fe.wf	ROS	10	7	<30	69	14	31
07A	A68	Animas River at Silverton	Animas	Fe.wf	K-M flipped	153	29	<10	<500	38	90
09A	CC18	North Fork Cement Creek upstream from Gold King mine, #7 level (AMLI mine # 103)	Animas	Fe.wf	K-M flipped	95	1	<30	27,500	1,000	6,590
10A	CC32	South Fork Cement Creek downstream from Velocity Lake	Animas	Fe.wf	K-M flipped	15	1	<30	3,634	3,452	3,585
11A	CC31	South Fork Cement Creek downstream from Big Colorado mine (AMLI mine # 150)	Animas	Fe.wf	K-M flipped	13	0	3,068	20,896	6,796	17,452
12A	CC23	Prospect Gulch upstream from Red Spring	Animas	Fe.wf	K-M flipped	14	0	83	4,400	147	456
14A	CC14	Minnesota Gulch near mouth	Animas	Fe.wf	K-M flipped	11	1	<30	22,970	12,719	14,000
15A	CC20	Porcupine Gulch upstream from mines	Animas	Fe.wf	K-M flipped	120	56	<20	34,200	40	2,100
16A	CC17	Niagara Gulch near mouth	Animas	Fe.wf	K-M flipped	31	0	702	4,850	2,460	3,620
20A	M02	Mineral Creek near headwaters	Animas	Fe.wf	K-M flipped	14	0	42,200	683,000	309,500	454,000
21A	M02A	Highway 550 drainage ditch above M01 confluence-east side of Highway 550	Animas	Fe.wf	K-M flipped	14	0	23,500	543,000	207,500	354,000
22A	M07	Mineral Creek at Chattanooga	Animas	Fe.wf	K-M flipped	15	0	33	12,000	660	2,200
23A	M13	Mineral Creek just below confluence with Browns Gulch	Animas	Fe.wf	K-M flipped	13	3	<30	262	47	210
30A	M27	Mineral Creek above confluence with South Fork Mineral Creek	Animas	Fe.wf	K-M flipped	11	0	430	7,600	2,670	4,690
32A	M34	Mineral Creek at Silverton	Animas	Fe.wf	K-M flipped	162	2	<30	6,230	1,855	3,400
33A	09359020	Animas River below Silverton	Animas	Fe.wf	K-M flipped	39	0	55	2,960	870	2,236
35A	A72	Animas River downstream from Silverton	Animas	Fe.wf	K-M flipped	183	3	<30	4,600	950	2,600
37A	374248107323601	Big Eldorado inflow	Animas	Fe.wf	K-M flipped	15	4	<3	36	6	11
38A	374248107324501	Little Eldorado inflow	Animas	Fe.wf	K-M flipped	14	1	<3	13	6	9
39A	9445	Cascade Creek at Highway 550	Animas	Fe.wf	ROS	16	12	<10	28	6.31	16
41A	DRALP003	Animas at Durango Mall	Animas	Fe.wf	ROS	62	44	<50	198	31	62
43A	9440	Falls Creek at 0.65 Road	Animas	Fe.wf	ROS	13	9	<10	75	2.98	23
46A	9420	Animas River at Durango	Animas	Fe.wf	K-M flipped	30	6	<10	110	17	59
47A	DRALPLC2	Lightner Creek at mouth at Durango	Animas	Fe.wf	ROS	41	32	<50	404	25	84
48A	DRALP001	DRALP001	Animas	Fe.wf	ROS	64	52	<50	255	20	61
49A	DRALP002	Animas River at Durango	Animas	Fe.wf	ROS	87	65	<30	339	27	68
54A	9415	Salt Creek at 309A Road	Animas	Fe.wf	K-M flipped	15	1	<50	120	61	93
01U	9850	Little Navajo River at Highway 84	Upper San Juan	Fe.wf	K-M flipped	16	1	<10	130	50	120
03U	9860	Rio Blanco at Highway 84	Upper San Juan	Fe.wf	K-M flipped	17	3	<10	200	30	100
05U	9165	Sand Creek at mouth above East Fork San Juan River	Upper San Juan	Fe.wf	K-M flipped	12	5	<10	87	16	52

Table 8. Summary of selected trace element concentrations at sites with 10 or more samples in the Dolores, Upper San Juan, and Lower San Juan River Basins, southwestern Colorado, 1990–2005.—Continued

[Site ID, site identification number shown on figure 1; Database ID, data repository identification number; <, less than; concentrations are given in micrograms per liter; K-M flipped, Kaplan-Meier method modified for left-censored data used to compute summary statistics; ROS, the robust "regression on order statistics" method used to compute summary statistics; Estimate, summary statistics were reported as less than the maximum reporting limit; N, number of samples; NC, number of samples with concentrations reported as less than the reporting limit; Min, minimum value; Max, maximum value; Med, median; C_{85}, 85th percentile concentration; Al.wf, dissolved aluminum; Al.wu, total recoverable aluminum; Fe.wf, dissolved iron; Fe.wu, total recoverable iron; Hg.wf, dissolved mercury; Hg.wu, total recoverable mercury; Pb.wf, dissolved lead; Pb.wu, total recoverable lead; Se.wf, dissolved selenium; Se.wu, total recoverable selenium; Ur.wf, dissolved uranium; Zn.wf, dissolved zinc; Zn.wu, total recoverable zinc; WWTP, wastewater treatment plant; values shown in blue indicate that chronic State water-quality standards were not met and values shown in red indicate that acute and chronic State water-quality standards were not met]

Site ID	Database ID	Site name	Subbasin name	Constituent	Method	N	NC	Min	Max	Med	C_{85}
		Upper San Juan River Basin—Continued									
10U	9120	McCabe Creek above Pagosa Springs	Upper San Juan	Fe.wf	K-M flipped	17	4	<10	60	36	56
15U	9290	East Fork Piedra River below Piedra Falls	Piedra	Fe.wf	K-M flipped	12	3	<10	30	12.5	30
16U	9250	Piedra River at Highway 160	Piedra	Fe.wf	K-M flipped	45	2	<10	200	42	100
17U	9245	Stollsteimer Creek at Highway 151	Piedra	Fe.wf	ROS	18	12	<10	73	10.1	30
20U	09352800	Los Pinos River above Vallecito Reservoir near Bayfield	Upper San Juan	Fe.wf	K-M flipped	12	1	<13	39	19.75	25
21U	9380	Los Pinos River above Vallecito Reservoir	Upper San Juan	Fe.wf	K-M flipped	46	7	<10	73	19.5	45
22U	09352900	Vallecito Creek near Bayfield	Upper San Juan	Fe.wf	K-M flipped	45	16	<3	51	9	23
23U	9370	Vallecito Creek near mouth	Upper San Juan	Fe.wf	ROS	44	30	<10	170	6.78	20
24U	372236107344400	Los Pinos River below Vallecito Reservoir near Bayfield	Upper San Juan	Fe.wf	K-M flipped	16	3	<4.4	17	8.35	15
25U	9355	Wallace Gulch at 502 Road north of Bayfield	Upper San Juan	Fe.wf	K-M flipped	16	2	<50	160	32	100
30U	9680	La Plata at Hesperus	Middle San Juan	Fe.wf	K-M flipped	14	4	<10	50,000	12	24
31U	9610	Spring Creek near Breen	Middle San Juan	Fe.wf	K-M flipped	12	1	<50	130	54	110
32U	9720	East Fork Mancos River at 44 Road	Mancos	Fe.wf	K-M flipped	11	3	<10	110	27	46
34U	9715	Chicken Creek at Mancos	Mancos	Fe.wf	K-M flipped	17	2	<100	250	47	76
02A	A33	Animas River at Eureka	Animas	Fe.wu	K-M flipped	13	0	46	179	69	166
06A	AN68	Animas River at USGS gaging station above 14th Street	Animas	Fe.wu	K-M flipped	11	0	43	710	99	430
07A	A68	Animas River at Silverton	Animas	Fe.wu	K-M flipped	107	2	<50	2,810	200	470
10A	CC32	South Fork Cement Creek downstream from Velocity Lake	Animas	Fe.wu	K-M flipped	13	0	3,438	15,435	3,888	8,955
12A	CC23	Prospect Gulch upstream from Red Spring	Animas	Fe.wu	K-M flipped	14	0	286	5,700	286	740
15A	CC20	Porcupine Gulch upstream from mines	Animas	Fe.wu	K-M flipped	12	0	320	34,400	2,485	34,300
19A	CEM48	Cement Creek at USGS gaging station	Animas	Fe.wu	K-M flipped	12	0	4,200	8,600	6,100	8,100
20A	M02	Mineral Creek near headwaters	Animas	Fe.wu	K-M flipped	10	0	52,000	910,000	225,000	580,000
30A	M27	Mineral Creek above confluence with South Fork Mineral Creek	Animas	Fe.wu	K-M flipped	11	0	900	9,500	3,387	6,412
32A	M34	Mineral Creek at Silverton	Animas	Fe.wu	K-M flipped	114	0	190	12,100	3,361	5,800
33A	09359020	Animas River below Silverton	Animas	Fe.wu	K-M flipped	43	0	669	6,600	2,892	4,400
34A	AN72	Animas River at USGS gaging station just above railroad bridge	Animas	Fe.wu	K-M flipped	10	0	78	3,000	1,350	2,700
35A	A72	Animas River downstream from Silverton	Animas	Fe.wu	K-M flipped	92	0	78	20,000	2,590	4,280
39A	9445	Cascade Creek at Highway 550	Animas	Fe.wu	ROS	16	12	<10	1,200	1.6	51
41A	DRALP003	Animas at Durango Mall	Animas	Fe.wu	K-M flipped	86	29	<50	10,050	116	600
43A	9440	Falls Creek at 0.65 Road	Animas	Fe.wu	K-M flipped	13	5	<10	460	31	120
46A	9420	Animas River at Durango	Animas	Fe.wu	K-M flipped	30	0	85	6,500	215	2,600
47A	DRALPLC2	Lightner Creek at mouth at Durango	Animas	Fe.wu	K-M flipped	42	4	<50	3,700	297	768
48A	DRALP001	DRALP001	Animas	Fe.wu	K-M flipped	87	25	<50	6,169	108	490
49A	DRALP002	Animas River at Durango	Animas	Fe.wu	K-M flipped	112	28	<50	5,395	204	720

Table 8. Summary of selected trace element concentrations at sites with 10 or more samples in the Dolores, Upper San Juan, and Lower San Juan River Basins, southwestern Colorado, 1990–2005.—Continued

[Site ID, site identification number shown on figure 1; Database ID, data repository identification number; <, less than; concentrations are given in micrograms per liter; K-M flipped, Kaplan-Meier method modified for left-censored data used to compute summary statistics; ROS, the robust "regression on order statistics" method used to compute summary statistics; Estimate, summary statistics were reported as less than the maximum reporting limit; N, number of samples; NC, number of samples with concentrations reported as less than the reporting limit; Min, minimum value; Max, maximum value; Med, median; C_{85}, 85th percentile concentration; Al.wf, dissolved aluminum; Al.wu, total recoverable aluminum; Fe.wf, dissolved iron; Fe.wu, total recoverable iron; Hg.wf, dissolved mercury; Hg.wu, total recoverable mercury; Pb.wf, dissolved lead; Pb.wu, total recoverable lead; Se.wf, dissolved selenium; Se.wu, total recoverable selenium; Ur.wf, dissolved uranium; Zn.wf, dissolved zinc; Zn.wu, total recoverable zinc; WWTP, wastewater treatment plant; values shown in blue indicate that chronic State water-quality standards were not met and values shown in red indicate that acute and chronic State water-quality standards were not met]

Site ID	Database ID	Site name	Subbasin name	Constituent	Method	N	NC	Min	Max	Med	C_{85}
			Upper San Juan River Basin—Continued								
54A	9415	Salt Creek at 309A Road	Animas	Fe.wu	K-M flipped	15	0	270	5,300	770	2,200
01U	9850	Little Navajo River at Highway 84	Upper San Juan	Fe.wu	K-M flipped	16	0	81	18,000	325	1,000
03U	9860	Rio Blanco at Highway 84	Upper San Juan	Fe.wu	K-M flipped	17	2	<50	12,000	140	490
05U	9165	Sand Creek at mouth above East Fork San Juan River	Upper San Juan	Fe.wu	K-M flipped	12	0	16	1,500	34	160
10U	9120	McCabe Creek above Pagosa Springs	Upper San Juan	Fe.wu	K-M flipped	17	0	140	2,500	**1,000**	1,500
15U	9290	East Fork Piedra River below Piedra Falls	Piedra	Fe.wu	K-M flipped	12	0	17	270	43	130
16U	9250	Piedra River at Highway 160	Piedra	Fe.wu	K-M flipped	53	0	41	2,500	160	620
17U	9245	Stollsteimer Creek at Highway 151	Piedra	Fe.wu	K-M flipped	18	0	81	2,300	335	1,500
21U	9380	Los Pinos River above Vallecito Reservoir	Upper San Juan	Fe.wu	K-M flipped	52	0	12	560	48	160
23U	9370	Vallecito Creek near mouth	Upper San Juan	Fe.wu	K-M flipped	51	12	<10	750	26	89
25U	9355	Wallace Gulch at 502 Road north of Bayfield	Upper San Juan	Fe.wu	K-M flipped	16	0	260	2,400	620	2,000
30U	9680	La Plata at Hesperus	Middle San Juan	Fe.wu	K-M flipped	41	4	<10	2,500	32	62
31U	9610	Spring Creek near Breen	Middle San Juan	Fe.wu	K-M flipped	12	0	130	830	230	350
32U	9720	East Fork Mancos River at 44 Road	Mancos	Fe.wu	K-M flipped	22	1	<10	5,000	45.5	500
34U	9715	Chicken Creek at Mancos	Mancos	Fe.wu	K-M flipped	18	0	180	1,200	325	1,100
07A	A68	Animas River at Silverton	Animas	Hg.wf	Estimate	31	29	<0.1	<1	<1	<1
09A	CC18	North Fork Cement Creek upstream from Gold King mine, #7 level (AMLI mine # 103)	Animas	Hg.wf	Estimate	91	90	<1	<2	<2	<2
15A	CC20	Porcupine Gulch upstream from mines	Animas	Hg.wf	Estimate	113	107	<0.2	<2	<2	<2
32A	M34	Mineral Creek at Silverton	Animas	Hg.wf	Estimate	30	29	<0.05	<1	<1	<1
33A	09359020	Animas River below Silverton	Animas	Hg.wf	Estimate	36	33	<0.0055	<0.23	<0.23	<0.23
41A	DRALP003	Animas at Durango Mall	Animas	Hg.wf	Estimate	60	58	<0.1	<1	<1	<1
46A	9420	Animas River at Durango	Animas	Hg.wf	Estimate	27	27	<0.1	<0.2	<0.2	<0.2
47A	DRALPLC2	Lightner Creek at mouth at Durango	Animas	Hg.wf	Estimate	49	46	<0.05	0.22	<0.2	<0.2
48A	DRALP001	DRALP001	Animas	Hg.wf	Estimate	84	83	<0.06	2.27	<1	<1
49A	DRALP002	Animas River at Durango	Animas	Hg.wf	Estimate	124	119	<0.05	2	<1	<1
50A	DRALP209	Animas River behind BMX track at Durango	Animas	Hg.wf	Estimate	21	21	<0.06	<0.2	<0.2	<0.2
16U	9250	Piedra River at Highway 160	Piedra	Hg.wf	Estimate	29	29	<0.01	<0.2	<0.2	<0.2
21U	9380	Los Pinos River above Vallecito Reservoir	Upper San Juan	Hg.wf	Estimate	29	29	<0.1	<0.2	<0.2	<0.2
23U	9370	Vallecito Creek near mouth	Upper San Juan	Hg.wf	Estimate	28	28	<0.1	<0.2	<0.2	<0.2
30U	9680	La Plata at Hesperus	Middle San Juan	Hg.wf	Estimate	17	17	<0.1	<0.2	<0.2	<0.2
07A	A68	Animas River at Silverton	Animas	Hg.wu	ROS	33	29	<0.05	<1	0.11	0.18
32A	M34	Mineral Creek at Silverton	Animas	Hg.wu	Estimate	32	31	<0.05	<1	<1	<1

Table 8. Summary of selected trace element concentrations at sites with 10 or more samples in the Dolores, Upper San Juan, and Lower San Juan River Basins, southwestern Colorado, 1990–2005.—Continued

[Site ID, site identification number shown on figure 1; Database ID, data repository identification number; <, less than; concentrations are given in micrograms per liter; K-M flipped, Kaplan-Meier method modified for left-censored data used to compute summary statistics; ROS, the robust "regression on order statistics" method used to compute summary statistics; Estimate, summary statistics were reported as less than the maximum reporting limit; N, number of samples; NC, number of samples with concentrations reported as less than the reporting limit; Min, minimum value; Max, maximum value; Med, median; C_{85}, 85th percentile concentration; Al.wf, dissolved aluminum; Al.wu, total recoverable aluminum; Fe.wf, dissolved iron; Fe.wu, total recoverable iron; Hg.wf, dissolved mercury; Hg.wu, total recoverable mercury; Pb.wf, dissolved lead; Pb.wu, total recoverable lead; Se.wf, dissolved selenium; Se.wu, total recoverable selenium; Ur.wf, dissolved uranium; Zn.wf, dissolved zinc; Zn.wu, total recoverable zinc; WWTP, wastewater treatment plant; values shown in blue indicate that chronic State water-quality standards were not met and values shown in red indicate that acute and chronic State water-quality standards were not met]

Site ID	Database ID	Site name	Subbasin name	Constituent	Method	N	NC	Min	Max	Med	C_{85}
		Upper San Juan River Basin—Continued									
36A	000082	Animas River near Silverton	Animas	Hg.wu	Estimate	11	11	<0.2	<0.2	<0.2	<0.2
39A	9445	Cascade Creek at Highway 550	Animas	Hg.wu	Estimate	13	13	<0.2	<0.2	<0.2	<0.2
41A	DRALP003	Animas at Durango Mall	Animas	Hg.wu	ROS	85	76	<0.1	<1	0.1	0.19
43A	9440	Falls Creek at 0.65 Road	Animas	Hg.wu	Estimate	11	11	<0.2	<0.2	<0.2	<0.2
47A	DRALPLC2	Lightner Creek at mouth at Durango	Animas	Hg.wu	ROS	50	38	<0.05	<1	0.11	0.22
48A	DRALP001	DRALP001	Animas	Hg.wu	Estimate	107	99	<0.06	5.39	<1	<1
49A	DRALP002	Animas River at Durango	Animas	Hg.wu	Estimate	149	137	<0.05	3.5	<1	<1
50A	DRALP209	Animas River behind BMX track at Durango	Animas	Hg.wu	Estimate	21	21	<0.06	<0.2	<0.06	<0.2
54A	9415	Salt Creek at 309A Road	Animas	Hg.wu	Estimate	14	14	<0.2	<0.2	<0.2	<0.2
57A	000066	Animas River near Bondad	Animas	Hg.wu	Estimate	19	19	<0.2	<0.2	<0.2	<0.2
01U	9850	Little Navajo River at Highway 84	Upper San Juan	Hg.wu	Estimate	13	13	<0.2	<0.2	<0.2	<0.2
03U	9860	Rio Blanco at Highway 84	Upper San Juan	Hg.wu	Estimate	14	14	<0.2	<0.2	<0.2	<0.2
10U	9120	McCabe Creek above Pagosa Springs	Upper San Juan	Hg.wu	Estimate	14	14	<0.2	<0.2	<0.2	<0.2
16U	9250	Piedra River at Highway 160	Piedra	Hg.wu	Estimate	21	21	<0.2	<0.2	<0.2	<0.2
17U	9245	Stollsteimer Creek at Highway 151	Piedra	Hg.wu	Estimate	15	15	<0.2	<0.2	<0.2	<0.2
21U	9380	Los Pinos River above Vallecito Reservoir	Upper San Juan	Hg.wu	Estimate	18	18	<0.2	<0.2	<0.2	<0.2
23U	9370	Vallecito Creek near mouth	Upper San Juan	Hg.wu	Estimate	19	19	<0.2	<0.2	<0.2	<0.2
25U	9355	Wallace Gulch at 502 Road north of Bayfield	Upper San Juan	Hg.wu	Estimate	13	13	<0.2	<0.2	<0.2	<0.2
30U	9680	La Plata at Hesperus	Middle San Juan	Hg.wu	Estimate	21	21	<0.2	<0.2	<0.2	<0.2
31U	9610	Spring Creek near Breen	Middle San Juan	Hg.wu	Estimate	12	12	<0.2	<0.2	<0.2	<0.2
32U	9720	East Fork Mancos River at 44 Road	Mancos	Hg.wu	Estimate	11	11	<0.2	<0.2	<0.2	<0.2
34U	9715	Chicken Creek at Mancos	Mancos	Hg.wu	Estimate	14	14	<0.2	<0.2	<0.2	<0.2
01A	A09	North Fork above Cal. Gulch	Animas	Pb.wf	ROS	11	8	<0.8	17	1.98	7
02A	A33	Animas River at Eureka	Animas	Pb.wf	Estimate	24	22	<0.6	150	<30	<30
03A	A39	Eureka below Ben Franklin	Animas	Pb.wf	K-M flipped	24	6	<5	40	9	20
04A	A53	Animas River at Howardsville	Animas	Pb.wf	Estimate	18	16	<0.6	<30	<30	<30
05A	A60	Animas River downstream from Arrastra Gulch	Animas	Pb.wf	Estimate	12	12	<5	<30	<30	<30
07A	A68	Animas River at Silverton	Animas	Pb.wf	Estimate	159	143	<0.2	52	<30	<30
09A	CC18	North Fork Cement Creek upstream from Gold King mine, #7 level (AMLI mine # 103)	Animas	Pb.wf	K-M flipped	95	17	<1	440	10	110
10A	CC32	South Fork Cement Creek downstream from Velocity Lake	Animas	Pb.wf	Estimate	15	14	<0.8	38	<30	<30
11A	CC31	South Fork Cement Creek downstream from Big Colorado mine (AMLI mine # 150)	Animas	Pb.wf	Estimate	14	12	<30	<30	<30	<30
12A	CC23	Prospect Gulch upstream from Red Spring	Animas	Pb.wf	K-M flipped	16	2	<5	160	13.5	40

Table 8. Summary of selected trace element concentrations at sites with 10 or more samples in the Dolores, Upper San Juan, and Lower San Juan River Basins, southwestern Colorado, 1990–2005.—Continued

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Site ID	Database ID	Site name	Subbasin name	Constituent	Method	N	NC	Min	Max	Med	C_{85}
		Upper San Juan River Basin—Continued									
14A	CC14	Minnesota Gulch near mouth	Animas	Pb.wf	ROS	12	9	<5	<30	1.24	5.09
15A	CC20	Porcupine Gulch upstream from mines	Animas	Pb.wf	ROS	121	70	<4	200	3.92	20
16A	CC17	Niagara Gulch near mouth	Animas	Pb.wf	ROS	32	28	<0.8	56	0.98	6.14
19A	CEM48	Cement Creek at USGS gaging station	Animas	Pb.wf	K-M flipped	11	0	5.5	31	15	27
20A	M02	Mineral Creek near headwaters	Animas	Pb.wf	K-M flipped	16	0	41	300	110	238
21A	M02A	Highway 550 drainage ditch above M01 confluence-east side of Highway 550	Animas	Pb.wf	K-M flipped	14	1	<5	270	112	189
22A	M07	Mineral Creek at Chattanooga	Animas	Pb.wf	K-M flipped	16	5	<5	800	48	250
23A	M13	Mineral Creek just below confluence with Browns Gulch	Animas	Pb.wf	ROS	15	10	<30	109	8.23	27
30A	M27	Mineral Creek above confluence with South Fork Mineral Creek	Animas	Pb.wf	ROS	16	9	<1	39	10.5	23
32A	M34	Mineral Creek at Silverton	Animas	Pb.wf	ROS	152	131	<0.2	62	0.48	2.7
33A	09359020	Animas River below Silverton	Animas	Pb.wf	ROS	44	35	<0.04	1	0.09	0.36
35A	A72	Animas River downstream from Silverton	Animas	Pb.wf	Estimate	211	194	<0.2	<40	<40	<40
39A	9445	Cascade Creek at Highway 550	Animas	Pb.wf	Estimate	16	16	<1	<1	<1	<1
41A	DRALP003	Animas at Durango Mall	Animas	Pb.wf	Estimate	60	56	<1	32	<5	<5
43A	9440	Falls Creek at 0.65 Road	Animas	Pb.wf	Estimate	13	13	<1	<1	<1	<1
46A	9420	Animas River at Durango	Animas	Pb.wf	Estimate	30	28	<1	11	<1	<1
47A	DRALPLC2	Lightner Creek at mouth at Durango	Animas	Pb.wf	Estimate	46	44	<0.2	7	<5	<5
48A	DRALP001	DRALP001	Animas	Pb.wf	Estimate	81	79	<1	39	<5	<5
49A	DRALP002	Animas River at Durango	Animas	Pb.wf	Estimate	121	117	<0.2	41	<7.5	<7.5
50A	DRALP209	Animas River behind BMX track at Durango	Animas	Pb.wf	Estimate	21	21	<1	<1	<1	<1
54A	9415	Salt Creek at 309A Road	Animas	Pb.wf	Estimate	15	15	<1	<1	<1	<1
01U	9850	Little Navajo River at Highway 84	Upper San Juan	Pb.wf	Estimate	16	16	<1	<1	<1	<1
03U	9860	Rio Blanco at Highway 84	Upper San Juan	Pb.wf	Estimate	17	16	<1	11	<1	<1
05U	9165	Sand Creek at mouth above East Fork San Juan River	Upper San Juan	Pb.wf	Estimate	12	12	<1	<1	<1	<1
10U	9120	McCabe Creek above Pagosa Springs	Upper San Juan	Pb.wf	Estimate	17	17	<1	<1	<1	<1
15U	9290	East Fork Piedra River below Piedra Falls	Piedra	Pb.wf	Estimate	12	12	<1	<1	<1	<1
16U	9250	Piedra River at Highway 160	Piedra	Pb.wf	Estimate	53	51	<0.1	12	<2	<2
17U	9245	Stollsteimer Creek at Highway 151	Piedra	Pb.wf	Estimate	18	18	<1	<1	<1	<1
20U	09352800	Los Pinos River above Vallecito Reservoir near Bayfield	Upper San Juan	Pb.wf	Estimate	10	10	<0.04	<9.1	<9.1	<9.1
21U	9380	Los Pinos River above Vallecito Reservoir	Upper San Juan	Pb.wf	Estimate	52	51	<0.1	8	<1	<1
22U	09352900	Vallecito Creek near Bayfield	Upper San Juan	Pb.wf	Estimate	20	18	<0.04	<10	<10	<10
23U	9370	Vallecito Creek near mouth	Upper San Juan	Pb.wf	Estimate	52	51	<1	17	<1	<1
24U	372236107344400	Los Pinos River below Vallecito Reservoir near Bayfield	Upper San Juan	Pb.wf	Estimate	14	14	<0.04	<9.1	<9.1	<9.1
25U	9355	Wallace Gulch at 502 Road north of Bayfield	Upper San Juan	Pb.wf	Estimate	16	16	<1	<1	<1	<1

Table 8. Summary of selected trace element concentrations at sites with 10 or more samples in the Dolores, Upper San Juan, and Lower San Juan River Basins, southwestern Colorado, 1990–2005.—Continued

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Site ID	Database ID	Site name	Subbasin name	Constituent	Method	N	NC	Min	Max	Med	C_{85}
		Upper San Juan River Basin—Continued									
30U	9680	La Plata at Hesperus	Middle San Juan	Pb.wf	Estimate	42	42	<0.1	<1	<1	<1
31U	9610	Spring Creek near Breen	Middle San Juan	Pb.wf	Estimate	12	12	<1	<1	<1	<1
32U	9720	East Fork Mancos River at 44 Road	Mancos	Pb.wf	Estimate	22	21	<1	<5	<5	<5
34U	9715	Chicken Creek at Mancos	Mancos	Pb.wf	Estimate	18	18	<1	<2	<2	<2
02A	A33	Animas River at Eureka	Animas	Pb.wu	K-M flipped	10	2	<30	<30	5.71	6.4
07A	A68	Animas River at Silverton	Animas	Pb.wu	K-M flipped	96	31	<1	166	4	30
10A	CC32	South Fork Cement Creek downstream from Velocity Lake	Animas	Pb.wu	Estimate	10	9	<30	<30	<30	<30
15A	CC20	Porcupine Gulch upstream from mines	Animas	Pb.wu	K-M flipped	12	0	12	580	35	200
19A	CEM48	Cement Creek at USGS gaging station	Animas	Pb.wu	K-M flipped	12	0	12	61	15	47
30A	M27	Mineral Creek above confluence with South Fork Mineral Creek	Animas	Pb.wu	K-M flipped	15	6	<30	87	12	23
32A	M34	Mineral Creek at Silverton	Animas	Pb.wu	K-M flipped	115	43	<1	66	7	14
34A	AN72	Animas River at USGS gaging station just above railroad bridge	Animas	Pb.wu	K-M flipped	10	0	5	28	10.5	25
35A	A72	Animas River downstream from Silverton	Animas	Pb.wu	ROS	63	32	<22.5	53	10	22
41A	DRALP003	Animas at Durango Mall	Animas	Pb.wu	ROS	85	49	<1	701	3	8
47A	DRALPLC2	Lightner Creek at mouth at Durango	Animas	Pb.wu	ROS	48	32	<0.2	20	1.85	6
48A	DRALP001	DRALP001	Animas	Pb.wu	ROS	106	63	<1	424	1.21	8
49A	DRALP002	Animas River at Durango	Animas	Pb.wu	ROS	148	90	<1	334	1	8
50A	DRALP209	Animas River behind BMX track at Durango	Animas	Pb.wu	ROS	21	16	<1	2,680	0.007	6.9
01A	A09	North Fork above Cal. Gulch	Animas	Zn.wf	K-M flipped	11	0	320	870	328	790
02A	A33	Animas River at Eureka	Animas	Zn.wf	K-M flipped	24	0	239	573	404	514
03A	A39	Eureka below Ben Franklin	Animas	Zn.wf	K-M flipped	24	0	380	2,730	830	1,480
04A	A53	Animas River at Howardsville	Animas	Zn.wf	K-M flipped	18	0	197	366	270	314
05A	A60	Animas River downstream from Arrastra Gulch	Animas	Zn.wf	K-M flipped	12	0	159	320	249	320
06A	AN68	Animas River at USGS gaging station above 14th Street	Animas	Zn.wf	K-M flipped	12	0	290	450	345	420
07A	A68	Animas River at Silverton	Animas	Zn.wf	K-M flipped	160	0	110	1,900	490	824
09A	CC18	North Fork Cement Creek upstream from Gold King mine, #7 level (AMLI mine # 103)	Animas	Zn.wf	K-M flipped	95	0	64	8,400	3,420	5,640
10A	CC32	South Fork Cement Creek downstream from Velocity Lake	Animas	Zn.wf	K-M flipped	16	1	<20	285	168	215
11A	CC31	South Fork Cement Creek downstream from Big Colorado mine (AMLI mine # 150)	Animas	Zn.wf	K-M flipped	14	0	381	1,753	1,070	1,360
12A	CC23	Prospect Gulch upstream from Red Spring	Animas	Zn.wf	K-M flipped	16	0	358	2,400	384	1,020
14A	CC14	Minnesota Gulch near mouth	Animas	Zn.wf	K-M flipped	13	0	147	1,641	805	1,400
15A	CC20	Porcupine Gulch upstream from mines	Animas	Zn.wf	K-M flipped	124	3	<20	11,500	935	2,090
16A	CC17	Niagara Gulch near mouth	Animas	Zn.wf	K-M flipped	33	0	93	2,020	870	1,250

Table 8. Summary of selected trace element concentrations at sites with 10 or more samples in the Dolores, Upper San Juan, and Lower San Juan River Basins, southwestern Colorado, 1990–2005.—Continued

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Site ID	Database ID	Site name	Subbasin name	Constituent	Method	N	NC	Min	Max	Med	C_{85}
		Upper San Juan River Basin—Continued									
19A	CEM48	Cement Creek at USGS gaging station	Animas	Zn.wf	K-M flipped	12	0	720	1,000	920	**1,000**
20A	M02	Mineral Creek near headwaters	Animas	Zn.wf	K-M flipped	16	0	12,000	230,000	100,500	**180,000**
21A	M02A	Highway 550 drainage ditch above M01 confluence-east side of Highway 550	Animas	Zn.wf	K-M flipped	14	0	7,840	148,000	60,550	**130,000**
22A	M07	Mineral Creek at Chattanooga	Animas	Zn.wf	K-M flipped	16	0	180	8,900	1,645	**5,800**
23A	M13	Mineral Creek just below confluence with Browns Gulch	Animas	Zn.wf	K-M flipped	18	0	211	1,800	720	**1,590**
24A	M12	Browns Gulch above confluence with Mineral Creek	Animas	Zn.wf	K-M flipped	10	0	140	5,600	2,250	**2,800**
29A	M20	Middle Fork Mineral Creek above Bonner Mine	Animas	Zn.wf	K-M flipped	12	0	31	270	115	170
30A	M27	Mineral Creek above confluence with South Fork Mineral Creek	Animas	Zn.wf	K-M flipped	17	0	120	1,500	583	**880**
32A	M34	Mineral Creek at Silverton	Animas	Zn.wf	K-M flipped	168	0	37	750	270	**443**
33A	09359020	Animas River below Silverton	Animas	Zn.wf	K-M flipped	44	0	188	830	442	**589**
34A	AN72	Animas River at USGS gaging station just above railroad bridge	Animas	Zn.wf	K-M flipped	24	0	200	790	370	**670**
35A	A72	Animas River downstream from Silverton	Animas	Zn.wf	K-M flipped	219	0	160	995	470	**670**
39A	9445	Cascade Creek at Highway 550	Animas	Zn.wf	K-M flipped	16	3	<10	27	17	22
41A	DRALP003	Animas at Durango Mall	Animas	Zn.wf	ROS	61	36	<10	70	10	44
42A	89	Trimble Lane Bridge	Animas	Zn.wf	K-M flipped	13	0	10	290	63	127
43A	9440	Falls Creek at 0.65 Road	Animas	Zn.wf	K-M flipped	13	2	<10	54	15	25
44A	135	Animas at 32nd Street Bridge	Animas	Zn.wf	K-M flipped	11	0	10	60	26	41
46A	9420	Animas River at Durango	Animas	Zn.wf	K-M flipped	30	7	<10	120	24.5	49
47A	DRALPLC2	Lightner Creek at mouth at Durango	Animas	Zn.wf	ROS	49	40	<10	28	6.9	11
48A	DRALP001	DRALP001	Animas	Zn.wf	K-M flipped	83	35	<10	160	16	60
49A	DRALP002	Animas River at Durango	Animas	Zn.wf	K-M flipped	124	40	<10	104	27	58
50A	DRALP209	Animas River behind BMX track at Durango	Animas	Zn.wf	K-M flipped	21	4	<10	43	20	36
54A	9415	Salt Creek at 309A Road	Animas	Zn.wf	K-M flipped	15	6	<10	71	13	18
01U	9850	Little Navajo River at Highway 84	Upper San Juan	Zn.wf	K-M flipped	16	6	<10	<50	14	22
03U	9860	Rio Blanco at Highway 84	Upper San Juan	Zn.wf	K-M flipped	17	5	<10	<100	18	45
05U	9165	Sand Creek at mouth above East Fork San Juan River	Upper San Juan	Zn.wf	ROS	12	8	<10	55	5.62	17
10U	9120	McCabe Creek above Pagosa Springs	Upper San Juan	Zn.wf	K-M flipped	17	6	<10	<100	21	77
15U	9290	East Fork Piedra River below Piedra Falls	Piedra	Zn.wf	ROS	12	9	<10	13	9.52	12
16U	9250	Piedra River at Highway 160	Piedra	Zn.wf	ROS	52	31	<10	58	7.94	18
17U	9245	Stollsteimer Creek at Highway 151	Piedra	Zn.wf	K-M flipped	18	8	<10	<100	24	39
20U	09352800	Los Pinos River above Vallecito Reservoir near Bayfield	Upper San Juan	Zn.wf	Estimate	12	11	<0.5	<2	<2	<2
21U	9380	Los Pinos River above Vallecito Reservoir	Upper San Juan	Zn.wf	ROS	52	35	<10	24	8.84	15
22U	09352900	Vallecito Creek near Bayfield	Upper San Juan	Zn.wf	K-M flipped	26	4	<1	24	3	6
23U	9370	Vallecito Creek near mouth	Upper San Juan	Zn.wf	ROS	52	35	<10	<100	7.48	14

Table 8. Summary of selected trace element concentrations at sites with 10 or more samples in the Dolores, Upper San Juan, and Lower San Juan River Basins, southwestern Colorado, 1990–2005.—Continued

[Site ID, site identification number shown on figure 1; Database ID, data repository identification number; <, less than; concentrations are given in micrograms per liter; K-M flipped, Kaplan-Meier method modified for left-censored data used to compute summary statistics; ROS, the robust "regression on order statistics" method used to compute summary statistics; Estimate, summary statistics were reported as less than the maximum reporting limit; N, number of samples; NC, number of samples with concentrations reported as less than the reporting limit; Min, minimum value; Max, maximum value; Med, median; C_{85}, 85th percentile concentration; Al.wf, dissolved aluminum; Al.wu, total recoverable aluminum; Fe.wf, dissolved iron; Fe.wu, total recoverable iron; Hg.wf, dissolved mercury; Hg.wu, total recoverable mercury; Pb.wf, dissolved lead; Pb.wu, total recoverable lead; Se.wf, dissolved selenium; Se.wu, total recoverable selenium; Ur.wf, dissolved uranium; Zn.wf, dissolved zinc; Zn.wu, total recoverable zinc; WWTP, wastewater treatment plant; values shown in blue indicate that chronic State water-quality standards were not met and values shown in red indicate that acute and chronic State water-quality standards were not met]

Site ID	Database ID	Site name	Subbasin name	Constituent	Method	N	NC	Min	Max	Med	C_{85}
		Upper San Juan River Basin—Continued									
24U	372236107344400	Los Pinos River below Vallecito Reservoir near Bayfield	Upper San Juan	Zn.wf	ROS	16	13	<0.5	4.7	0.38	1.41
25U	9355	Wallace Gulch at 502 Road north of Bayfield	Upper San Juan	Zn.wf	K-M flipped	16	6	<10	65	18.5	29
30U	9680	La Plata at Hesperus	Middle San Juan	Zn.wf	ROS	42	27	<1.8	21	4.31	14
31U	9610	Spring Creek near Breen	Middle San Juan	Zn.wf	K-M flipped	12	1	<50	60	23	29
32U	9720	East Fork Mancos River at 44 Road	Mancos	Zn.wf	K-M flipped	22	5	<10	35	14.5	23
34U	9715	Chicken Creek at Mancos	Mancos	Zn.wf	K-M flipped	18	6	<10	170	17	35
01A	A09	North Fork above Cal. Gulch	Animas	Zn.wu	K-M flipped	10	0	255	920	284	780
02A	A33	Animas River at Eureka	Animas	Zn.wu	K-M flipped	13	0	276	594	374	590
06A	AN68	Animas River at USGS gaging station above 14th Street	Animas	Zn.wu	K-M flipped	12	0	270	540	365	420
07A	A68	Animas River at Silverton	Animas	Zn.wu	K-M flipped	108	1	<3	1,800	460	820
10A	CC32	South Fork Cement Creek downstream from Velocity Lake	Animas	Zn.wu	K-M flipped	13	0	158	367	190	266
12A	CC23	Prospect Gulch upstream from Red Spring	Animas	Zn.wu	K-M flipped	14	0	280	2,400	379	960
15A	CC20	Porcupine Gulch upstream from mines	Animas	Zn.wu	K-M flipped	12	0	430	11,300	1,311	8,770
19A	CEM48	Cement Creek at USGS gaging station	Animas	Zn.wu	K-M flipped	12	0	720	1,100	930	1,000
20A	M02	Mineral Creek near headwaters	Animas	Zn.wu	K-M flipped	10	0	11,000	310,000	77,500	230,000
30A	M27	Mineral Creek above confluence with South Fork Mineral Creek	Animas	Zn.wu	K-M flipped	15	0	110	920	340	860
32A	M34	Mineral Creek at Silverton	Animas	Zn.wu	K-M flipped	119	0	73	950	268	454
34A	AN72	Animas River at USGS gaging station just above railroad bridge	Animas	Zn.wu	K-M flipped	12	0	240	800	335	560
35A	A72	Animas River downstream from Silverton	Animas	Zn.wu	K-M flipped	65	0	176	930	423	722
41A	DRALP003	Animas at Durango Mall	Animas	Zn.wu	K-M flipped	86	5	<10	780	60	108
47A	DRALPLC2	Lightner Creek at mouth at Durango	Animas	Zn.wu	K-M flipped	50	24	<10	161	8	25
48A	DRALP001	DRALP001	Animas	Zn.wu	K-M flipped	108	5	<10	437	67	100
49A	DRALP002	Animas River at Durango	Animas	Zn.wu	K-M flipped	149	4	<10	368	67	108
50A	DRALP209	Animas River behind BMX track at Durango	Animas	Zn.wu	K-M flipped	21	1	<10	156	47	76
07A	A68	Animas River at Silverton	Animas	Se.wf	Estimate	32	27	<0.5	<6	<6	<6
09A	CC18	North Fork Cement Creek upstream from Gold King mine, #7 level (AMLI mine # 103)	Animas	Se.wf	Estimate	91	89	<5	14	<5	<5
32A	M34	Mineral Creek at Silverton	Animas	Se.wf	Estimate	30	26	<0.5	<5	<5	<5
33A	09359020	Animas River below Silverton	Animas	Se.wf	Estimate	44	39	<0.2	<2.4	<2.4	<2.4
36A	000082	Animas River near Silverton	Animas	Se.wf	Estimate	36	35	<1	7	<5	<5
39A	9445	Cascade Creek at Highway 550	Animas	Se.wf	Estimate	16	14	<1	1.4	<1	<1
41A	DRALP003	Animas at Durango Mall	Animas	Se.wf	Estimate	62	59	<0.5	9	<2	<2
43A	9440	Falls Creek at 0.65 Road	Animas	Se.wf	Estimate	13	13	<1	<1	<1	<1

Table 8. Summary of selected trace element concentrations at sites with 10 or more samples in the Dolores, Upper San Juan, and Lower San Juan River Basins, southwestern Colorado, 1990–2005.—Continued

[Site ID, site identification number shown on figure 1; Database ID, data repository identification number; <, less than; concentrations are given in micrograms per liter; K-M flipped, Kaplan-Meier method modified for left-censored data used to compute summary statistics; ROS, the robust "regression on order statistics" method used to compute summary statistics; Estimate, summary statistics were reported as less than the maximum reporting limit; N, number of samples; NC, number of samples with concentrations reported as less than the reporting limit; Min, minimum value; Max, maximum value; Med, median; C_{85}, 85th percentile concentration; Al.wf, dissolved aluminum; Al.wu, total recoverable aluminum; Fe.wf, dissolved iron; Fe.wu, total recoverable iron; Hg.wf, dissolved mercury; Hg.wu, total recoverable mercury; Pb.wf, dissolved lead; Pb.wu, total recoverable lead; Se.wf, dissolved selenium; Se.wu, total recoverable selenium; Ur.wf, dissolved uranium; Zn.wf, dissolved zinc; Zn.wu, total recoverable zinc; WWTP, wastewater treatment plant; values shown in blue indicate that chronic State water-quality standards were not met and values shown in red indicate that acute and chronic State water-quality standards were not met]

Site ID	Database ID	Site name	Subbasin name	Constituent	Method	N	NC	Min	Max	Med	C_{85}
		Upper San Juan River Basin—Continued									
46A	9420	Animas River at Durango	Animas	Se.wf	Estimate	30	28	<1	1.3	<1	<1
47A	DRALPLC2	Lightner Creek at mouth at Durango	Animas	Se.wf	ROS	48	37	<0.5	28	0.39	2
48A	DRALP001	DRALP001	Animas	Se.wf	Estimate	83	79	<0.5	9	<2	<2
49A	DRALP002	Animas River at Durango	Animas	Se.wf	Estimate	124	109	<0.5	8	<6	<6
50A	DRALP209	Animas River behind BMX track at Durango	Animas	Se.wf	Estimate	21	21	<1	<1	<1	<1
53A	000138	Florida River below Lemon Reservoir	Animas	Se.wf	Estimate	10	10	<1	<5	<5	<5
54A	9415	Salt Creek at 309A Road	Animas	Se.wf	K-M flipped	15	7	<1	13	1	11
57A	000066	Animas River near Bondad	Animas	Se.wf	Estimate	39	35	<0.4	2	<1	<1
01U	9850	Little Navajo River at Highway 84	Upper San Juan	Se.wf	Estimate	16	16	<1	<1	<1	<1
03U	9860	Rio Blanco at Highway 84	Upper San Juan	Se.wf	ROS	17	13	<1	2.3	0.43	1
05U	9165	Sand Creek at mouth above East Fork San Juan River	Upper San Juan	Se.wf	Estimate	12	12	<1	<1	<1	<1
09U	000137	San Juan River above Pagosa Springs	Upper San Juan	Se.wf	Estimate	24	24	<1	<1	<1	<1
10U	9120	McCabe Creek above Pagosa Springs	Upper San Juan	Se.wf	K-M flipped	17	6	<1	2	1	2
15U	9290	East Fork Piedra River below Piedra Falls	Piedra	Se.wf	Estimate	12	12	<1	<1	<1	<1
16U	9250	Piedra River at Highway 160	Piedra	Se.wf	Estimate	53	53	<1	<2	<2	<2
17U	9245	Stollsteimer Creek at Highway 151	Piedra	Se.wf	K-M flipped	18	6	<1	2	1	1
21U	9380	Los Pinos River above Vallecito Reservoir	Upper San Juan	Se.wf	Estimate	52	52	<1	<1	<1	<1
22U	09352900	Vallecito Creek near Bayfield	Upper San Juan	Se.wf	Estimate	35	35	<1	<2.4	<2.4	<2.4
23U	9370	Vallecito Creek near mouth	Upper San Juan	Se.wf	Estimate	52	52	<1	<1	<1	<1
25U	9355	Wallace Gulch at 502 Road north of Bayfield	Upper San Juan	Se.wf	Estimate	16	16	<1	<1	<1	<1
30U	9680	La Plata at Hesperus	Middle San Juan	Se.wf	Estimate	42	42	<0.4	<1	<1	<1
31U	9610	Spring Creek near Breen	Middle San Juan	Se.wf	Estimate	12	12	<1	<1	<1	<1
32U	9720	East Fork Mancos River at 44 Road	Mancos	Se.wf	Estimate	22	22	<1	<5	<5	<5
34U	9715	Chicken Creek at Mancos	Mancos	Se.wf	ROS	18	13	<1	2	0.64	1
07A	A68	Animas River at Silverton	Animas	Se.wu	ROS	34	27	<0.5	6	0.62	1.56
32A	M34	Mineral Creek at Silverton	Animas	Se.wu	ROS	31	24	<0.5	5	0.52	1.05
41A	DRALP003	Animas at Durango Mall	Animas	Se.wu	ROS	88	50	<0.5	28	0.95	4
47A	DRALPLC2	Lightner Creek at mouth at Durango	Animas	Se.wu	K-M flipped	50	21	<0.5	32	1.8	12
48A	DRALP001	DRALP001	Animas	Se.wu	ROS	108	73	<0.5	34	0.85	4
49A	DRALP002	Animas River at Durango	Animas	Se.wu	ROS	150	99	<0.5	28	0.79	4
50A	DRALP209	Animas River behind BMX track at Durango	Animas	Se.wu	Estimate	21	20	<1	<1	<1	<1
41A	DRALP003	Animas at Durango Mall	Animas	Ur.wf	Estimate	51	49	<3.4	<3.74	<3.74	<3.74
46A	9420	Animas River at Durango	Animas	Ur.wf	ROS	12	6	1	8	0.79	1

Table 8. Summary of selected trace element concentrations at sites with 10 or more samples in the Dolores, Upper San Juan, and Lower San Juan River Basins, southwestern Colorado, 1990–2005.—Continued

[Site ID, site identification number shown on figure 1; Database ID, data repository identification number; <, less than; concentrations are given in micrograms per liter; K-M flipped, Kaplan-Meier method modified for left-censored data used to compute summary statistics; ROS, the robust "regression on order statistics" method used to compute summary statistics; Estimate, summary statistics were reported as less than the maximum reporting limit; N, number of samples; NC, number of samples with concentrations reported as less than the reporting limit; Min, minimum value; Max, maximum value; Med, median; C_{85}, 85th percentile concentration; Al.wf, dissolved aluminum; Al.wu, total recoverable aluminum; Fe.wf, dissolved iron; Fe.wu, total recoverable iron; Hg.wf, dissolved mercury; Hg.wu, total recoverable mercury; Pb.wf, dissolved lead; Pb.wu, total recoverable lead; Se.wf, dissolved selenium; Se.wu, total recoverable selenium; Ur.wf, dissolved uranium; Zn.wf, dissolved zinc; Zn.wu, total recoverable zinc; WWTP, wastewater treatment plant; values shown in blue indicate that chronic State water-quality standards were not met and values shown in red indicate that acute and chronic State water-quality standards were not met]

Site ID	Database ID	Site name	Subbasin name	Constituent	Method	N	NC	Min	Max	Med	C_{85}
		Upper San Juan River Basin—Continued									
48A	DRALP001	DRALP001	Animas	Ur.wf	ROS	83	54	0.4	5.44	1.07	1.77
49A	DRALP002	Animas River at Durango	Animas	Ur.wf	ROS	118	72	0.48	63	1.08	2.18
50A	DRALP209	Animas River behind BMX track at Durango	Animas	Ur.wf	K-M flipped	28	0	0.4	1.6	1.06	1.3
22U	09352900	Vallecito Creek near Bayfield	Upper San Juan	Ur.wf	K-M flipped	22	10	0.31	0.74	0.42	0.49
01L	9887	McElmo Creek above Cortez Sanitation District, Southwest WWTP	McElmo	Al.wf	Estimate	15	14	<30	<500	<500	<500
05L	9871	McElmo Creek above Trail Canyon at gage	McElmo	Al.wf	Estimate	45	44	<30	<2,500	<2,500	<2,500
01L	9887	McElmo Creek above Cortez Sanitation District, Southwest WWTP	McElmo	Fe.wf	ROS	15	12	<100	<100	14	15
05L	9871	McElmo Creek above Trail Canyon at gage	McElmo	Fe.wf	ROS	40	34	<10	<500	5.99	13.2
01L	9887	McElmo Creek above Cortez Sanitation District, Southwest WWTP	McElmo	Fe.wu	K-M flipped	15	1	<100	13,000	890	3,700
05L	9871	McElmo Creek above Trail Canyon at gage	McElmo	Fe.wu	K-M flipped	45	2	<100	34,000	**1,500**	6,900
01L	9887	McElmo Creek above Cortez Sanitation District, Southwest WWTP	McElmo	Hg.wf	Estimate	13	13	<0.1	<0.2	<0.2	<0.2
05L	9871	McElmo Creek above Trail Canyon at gage	McElmo	Hg.wf	Estimate	28	28	<0.1	<0.2	<0.2	<0.2
05L	9871	McElmo Creek above Trail Canyon at gage	McElmo	Hg.wu	Estimate	13	13	<0.2	<0.2	<0.2	<0.2
01L	9887	McElmo Creek above Cortez Sanitation District, Southwest WWTP	McElmo	Pb.wf	Estimate	15	15	<0.1	<5	<5	<5
05L	9871	McElmo Creek above Trail Canyon at gage	McElmo	Pb.wf	Estimate	45	44	<0.1	11	<5	<5
01L	9887	McElmo Creek above Cortez Sanitation District, Southwest WWTP	McElmo	Zn.wf	ROS	15	8	<10	<200	31	110
05L	9871	McElmo Creek above Trail Canyon at gage	McElmo	Zn.wf	ROS	45	31	<10	<500	5.82	31
01L	9887	McElmo Creek above Cortez Sanitation District, Southwest WWTP	McElmo	Se.wf	K-M flipped	15	3	<5	5	2.4	4.1
05L	9871	McElmo Creek above Trail Canyon at gage	McElmo	Se.wf	K-M flipped	45	11	<1	8.4	2	**5**
05L	9871	McElmo Creek above Trail Canyon at gage	McElmo	Ur.wf	K-M flipped	10	2	3	12	4.5	10

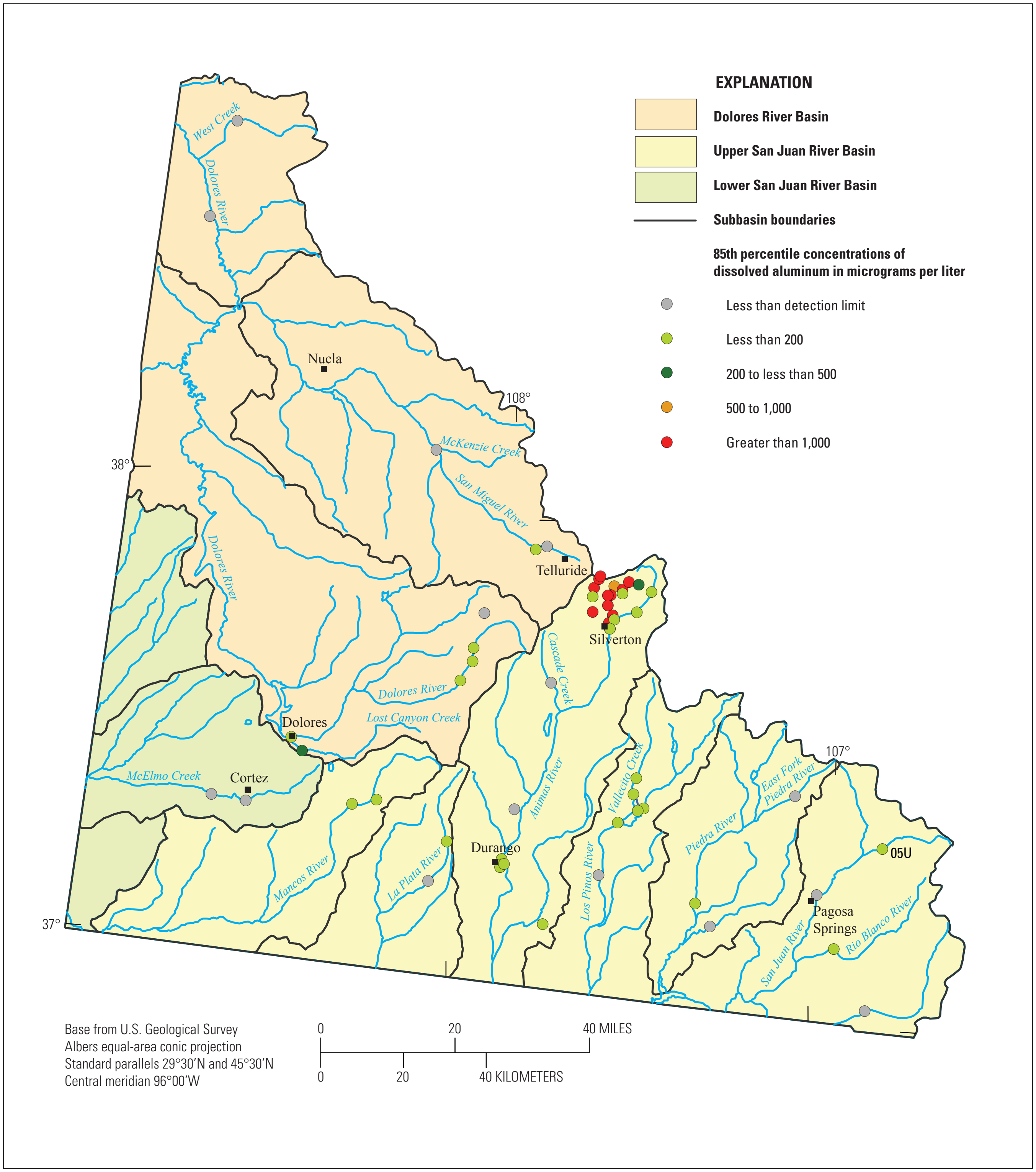

Figure 9. Map showing spatial distribution of 85th percentile concentrations of dissolved aluminum in the Dolores, Upper San Juan, and Lower San Juan River Basins, southwestern Colorado, 1990–2005.

Table 9. Summary of trend analysis results for selected trace metals at sites in the Upper San Juan River Basin, southwestern Colorado, 1991–2004.

[Site ID, site identification number shown on figure 1; p-value, probability value; statistically significant trend at p-value less than or equal to 0.05; nt, no significant trend; µg/L, micrograms per liter; "--", insufficient data or available data did not meet the selection criteria; typical value is the median value for the trend analysis period in µg/L; yr, year]

Site ID	Site name	Aluminum, dissolved					Iron, dissolved					Iron, total recoverable				
		Typical value	Trend	p-value	Trend slope (percent)	Trend slope (µg/L per yr)	Typical value	Trend	p-value	Trend slope (percent)	Trend slope (µg/L per yr)	Typical value	Trend	p-value	Trend slope (percent)	Trend slope (µg/L per yr)
07A	Animas River at Silverton	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt
32A	Mineral Creek at Silverton	--	--	--	--	--	nt	nt	nt	nt	nt	--	--	--	--	--
35A	Animas River downstream from Silverton	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt	--	--	--	--	--

Site ID	Site name	Lead, total recoverable					Zinc, dissolved					Zinc, total recoverable				
		Typical value	Trend	p-value	Trend slope (percent)	Trend slope (µg/L per yr)	Typical value	Trend	p-value	Trend slope (percent)	Trend slope (µg/L per yr)	Typical value	Trend	p-value	Trend slope (percent)	Trend slope (µg/L per yr)
07A	Animas River at Silverton	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt
32A	Mineral Creek at Silverton	7.0	down	0.034	-9.1	-0.6	330	down	0.007	-5.3	-17.4	350	down	0.013	-4.2	-14.7
35A	Animas River downstream from Silverton	--	--	--	--	--	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt

[1] Dissolved zinc at site 35A was the only site and parameter combination that had enough data to analyze using four seasons.

aquatic-life criteria were listed (Colorado Department of Public Health and Environment, 2010a). In addition to the chronic aquatic-life criterion, a domestic water-supply criterion of 300 µg/L was applied to waters used for water supply (Colorado Department of Public Health and Environment, 2010a).

Dolores River Basin.— Total recoverable iron concentrations were analyzed at 17 sites. Median total recoverable iron concentrations ranged from 4.8 to 450 µg/L (table 8 and fig. 10) and were less than 300 µg/L (domestic water-supply criterion) at 16 of the 17 sites analyzed (table 8). Based on available data, all sites in the Dolores River Basin met the State aquatic-life criterion for total recoverable iron. Adequate data were not available to perform trend analyses.

Upper San Juan River Basin.—Total recoverable iron concentrations were analyzed at 35 sites. Median concentrations ranged from 1.6 to 225,000 µg/L (table 8). Median total recoverable iron concentrations equal to or greater than 1,000 µg/L occurred at 10 sites in the Upper SJRB (fig. 10). The highest median total recoverable iron concentrations (greater than 1,000 µg/L) generally occurred in the Cement and Mineral Creek basins and in the Animas River near Silverton (fig. 10). Total recoverable iron concentrations at these sites exceeded the general State water-quality criterion of 1,000 µg/L but may not have exceeded site-specific monthly criteria. Monthly median total recoverable iron concentrations were not calculated. One additional site in the Upper SJRB, McCabe Creek above Pagosa Springs (site 10U), had a median total recoverable iron concentration of 1,000 µg/L (fig. 10). The remaining sites in the Upper SJRB had median total recoverable iron concentrations less than 800 µg/L; and most sites had median concentrations less than 450 µg/L.

Total recoverable iron concentrations in the upper Animas River were affected by inflow from Cement and Mineral Creeks. Median total recoverable iron concentrations were less than 300 µg/L in the Animas River upstream from the confluences with Cement and Mineral Creeks. Immediately downstream from the confluences with Cement and Mineral Creeks, the median total recoverable iron concentration in the Animas River was 2,590 µg/L at the Animas River downstream from Silverton (site 35A). Whereas, further downstream, median total recoverable iron concentrations in the Animas River decreased to less than 300 µg/L in the vicinity of Durango.

Median total recoverable iron concentrations at Animas River downstream from Silverton (site 35A) and Mineral Creek at Silverton (site 32A) were higher during the winter than during the summer; whereas, upstream at Animas River at Silverton (site 07A) and downstream at the Animas River at Durango (site 46A) median total recoverable iron concentrations were similar during the winter and summer (fig. 1). One site on the Animas River was analyzed for trends in total recoverable iron. No significant trends in total recoverable iron concentration data (1991–2004) occurred at the site (table 9).

Lower San Juan River Basin.—Total recoverable iron concentrations were analyzed at McElmo Creek above Cortez Sanitation District, Southwest WWTP and McElmo Creek above Trail Canyon at gage. Median total recoverable iron concentrations in McElmo Creek increased by about 69 percent between McElmo Creek above Cortez Sanitation District, Southwest WWTP and McElmo Creek above Trail Canyon going from 890 to 1,500 µg/L (table 8). This increase in total recoverable iron concentrations may be because of irrigation return flows and inflow from tributaries between the two sites (Richards and Leib, 2011). Total recoverable iron concentrations (at these two sites) in samples from McElmo Creek tended to be higher during the summer (April–October) than during the winter (November–March). Adequate data were not available to perform trend analysis for total recoverable iron at either site.

Mercury

One or more samples were collected and analyzed for total (unfiltered recoverable) mercury at 156 sites. Concentrations of total mercury measured in samples from these sites ranged from less than 0.005 to 12 µg/L. Reporting limits for mercury typically ranged from 0.005 to 1 µg/L. At least 1 measured concentration of total mercury exceeded the chronic aquatic-life criterion of 0.01 µg/L for 32 of the 156 sites sampled (Colorado Department of Public Health and Environment, 2010b). Determining the actual distribution of mercury in surface water throughout the study area was not possible because reporting limits often varied at sites and were usually higher than the aquatic-life criterion.

The most common human exposure to mercury is through consumption of fish or shellfish that are contaminated with methyl mercury (U.S. Environmental Protection Agency, 2011). Elemental mercury can be converted to methyl mercury by microorganisms and then accumulate in fish and shellfish through the aquatic food chain (U.S. Environmental Protection Agency, 2011). A 1990 health risk assessment conducted by the CDPHE indicated that methyl mercury levels of 0.2 part per million (ppm) (one-fifth of the U.S. Food and Drug Administration's (FDA) action level of 1 ppm) in sport-caught fish may pose a health risk to sensitive subpopulations (Colorado Department of Public Health and Environment, 2010b).

Atmospheric deposition is the primary pathway for mercury to enter aquatic ecosystems (Krabbenhoft and Rickert, 1995); however, point sources may produce higher concentrations in localized areas. The U.S. Environmental Protection Agency (2011) reports that the largest anthropogenic source of airborne mercury in the United States is emissions from coal-burning power plants. In southwestern Colorado, the highest mercury concentrations were measured in the lower Animas River Basin near Durango, in the upper Animas River Basin in the vicinity of Silverton, and in the lower San Miguel River Basin downstream from Nucla. The presence of higher concentrations of mercury in these areas could be because of natural sources of mercury in rocks,

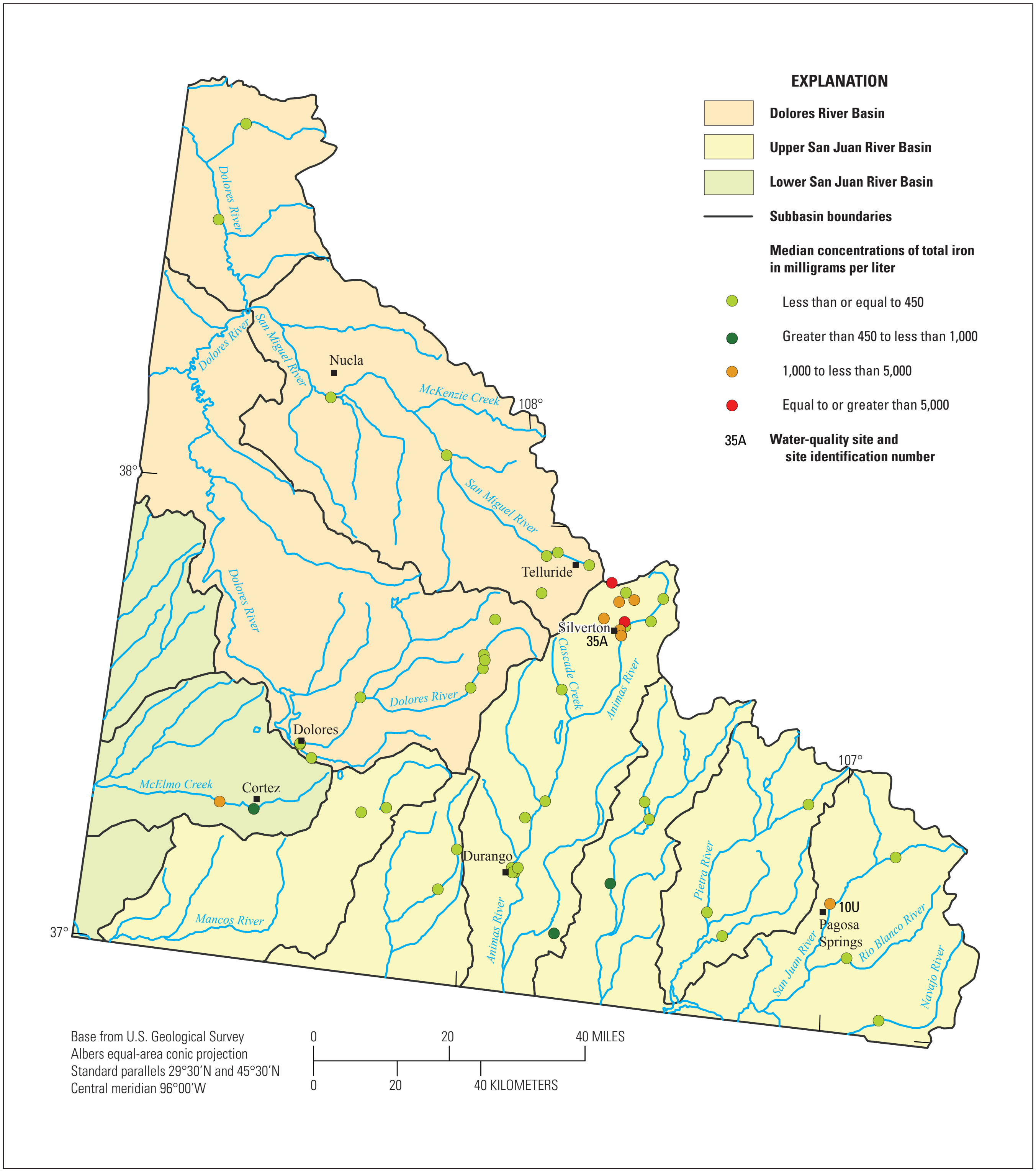

Figure 10. Map showing spatial distribution of median total recoverable iron concentrations in the Dolores, Upper San Juan, and Lower San Juan River Basins, southwestern Colorado, 1990–2005.

waste products of historical smelting processes used to extract metals, and deposition of mercury from regional or local coal combustion and forest fires.

Only 31 of the 156 sites sampled for total mercury had adequate data to calculate summary statistics (table 8). Total mercury was not detected above the individual reporting limits in most samples; 30 of the 31 sites with 10 or more samples had more than 80 percent censored data. Consequently, median total mercury concentrations were all less than the reporting limits and could not be compared to State standards and trend analyses could not be performed.

Lead

Many of the dissolved lead concentrations in samples were censored. Reporting limits for lead varied from 1 to 50 µg/L and were often greater than the calculated chronic criteria. As a result, sample data from some sites could not be compared to criteria. For most stream segments in the study area, the acute and chronic aquatic-life criteria for dissolved lead were based on hardness; however, some segments had fixed site-specific chronic aquatic-life criteria for total recoverable lead, typically equal to 100 µg/L (Colorado Department of Public Health and Environment, 2010a). Hardness-based acute criteria for dissolved lead ranged from about 9 to 281 µg/L. Chronic criteria ranged from about 0.3 to 11 µg/L. Adequate data were not available to analyze trends in dissolved or total-recoverable lead concentrations primarily because of the large amount of censored data.

Dolores River Basin.—Dissolved lead concentrations were analyzed at 17 sites (table 8). Only two sites had 85th percentile concentrations greater than the individual reporting limits for dissolved lead. These sites, Silver Creek at Highway 145 (site 04D) and San Miguel River at Society Turn (site 25D), both had 85th percentile concentrations of dissolved lead equal to 1 µg/L (table 8).

Upper San Juan River Basin.— Dissolved lead concentrations were analyzed at 48 sites. Only 15 sites had 85th percentile concentrations greater than the individual reporting limits. The 85th percentile concentrations for dissolved lead ranged from less than 1 to 250 µg/L (table 8 and fig. 11). The highest dissolved lead concentrations generally occurred in the Mineral and Cement Creek basins. State criteria in these areas were based on total recoverable lead concentrations. Adequate data were not available to analyze trends in dissolved lead concentrations in the Upper SJRB.

Total-recoverable lead data (sites with 10 or more samples) were available for 14 sites in the Animas River Basin. For sites with less than 80 percent censored data, median concentrations of total recoverable lead ranged from 0.007 to 35 µg/L. Based on available data, median total-recoverable lead concentrations in the Animas River Basin did not exceed State standards. Two sites in the Upper SJRB had adequate total-recoverable lead data to analyze for trends. One site, Mineral Creek at Silverton (site 32A), showed a significant downward trend in total-recoverable lead concentrations of 9.1 percent (table 9). The typical total-recoverable lead concentration at this site (1991-2004) was 7 µg/L. The remaining site, Animas River at Silverton (site 07A), showed no trend (table 9).

Lower San Juan River Basin.—Dissolved lead concentrations were analyzed at McElmo Creek above Cortez Sanitation District, Southwest WWTP (site 01L) and McElmo Creek above Trail Canyon (site 05L). One-hundred percent of the dissolved lead concentrations in samples from McElmo Creek above Cortez Sanitation District, Southwest WWTP were censored values; and 97 percent of the dissolved lead concentrations in samples from McElmo Creek above Trail Canyon were censored values. Adequate data were not available to analyze trends in dissolved lead concentrations in the Lower SJRB.

Zinc

The 85th percentile concentrations for dissolved zinc ranged from less than 2 to 180,000 µg/L (table 8). Throughout much of the study area, 85th percentile concentrations of dissolved zinc were less than 200 µg/L (fig. 12). Some sites, particularly those located in the upper Animas River Basin, had higher concentrations. Colorado State aquatic life acute and chronic standards for dissolved zinc were, for the most part, hardness based. Using available data, hardness-based acute criteria for dissolved zinc ranged from 32 to 564 µg/L. Chronic criteria ranged from 24 to 428 µg/L. For several segments in the upper Animas River Basin, the Commission established specific monthly acute and chronic criteria for dissolved zinc (Colorado Department of Public Health and Environment, 2010a); however, monthly 85th percentile dissolved zinc concentrations were not calculated for this report.

Dolores River Basin.—Dissolved zinc concentrations were analyzed at 17 sites. The 85th percentile concentrations of dissolved zinc ranged from less than 10 to 1,300 µg/L (table 8). Four sites had dissolved zinc concentrations that exceeded acute and chronic hardness-based criteria. Two of these sites were located along the upper San Miguel River near Telluride where 85th percentile concentrations of dissolved zinc were between 200 and 500 µg/L (fig. 12). The other two sites [Salt Creek at Highway 141 (site 35D) and Silver Creek at Highway 145 (site 04D)] that exceeded hardness-based criteria had 85th percentile concentrations of dissolved zinc greater than 500 µg/L (fig. 12). Most sites in the Dolores River Basin showed no statistically significant difference between winter and summer concentrations of dissolved zinc or lacked a sufficient distribution of data to determine if seasonal differences in concentrations existed. Adequate data were not available to analyze trends in dissolved zinc concentrations.

Upper San Juan River Basin.—Dissolved zinc concentrations were analyzed at 54 sites. The 85th percentile dissolved zinc concentrations ranged from less than 2 to

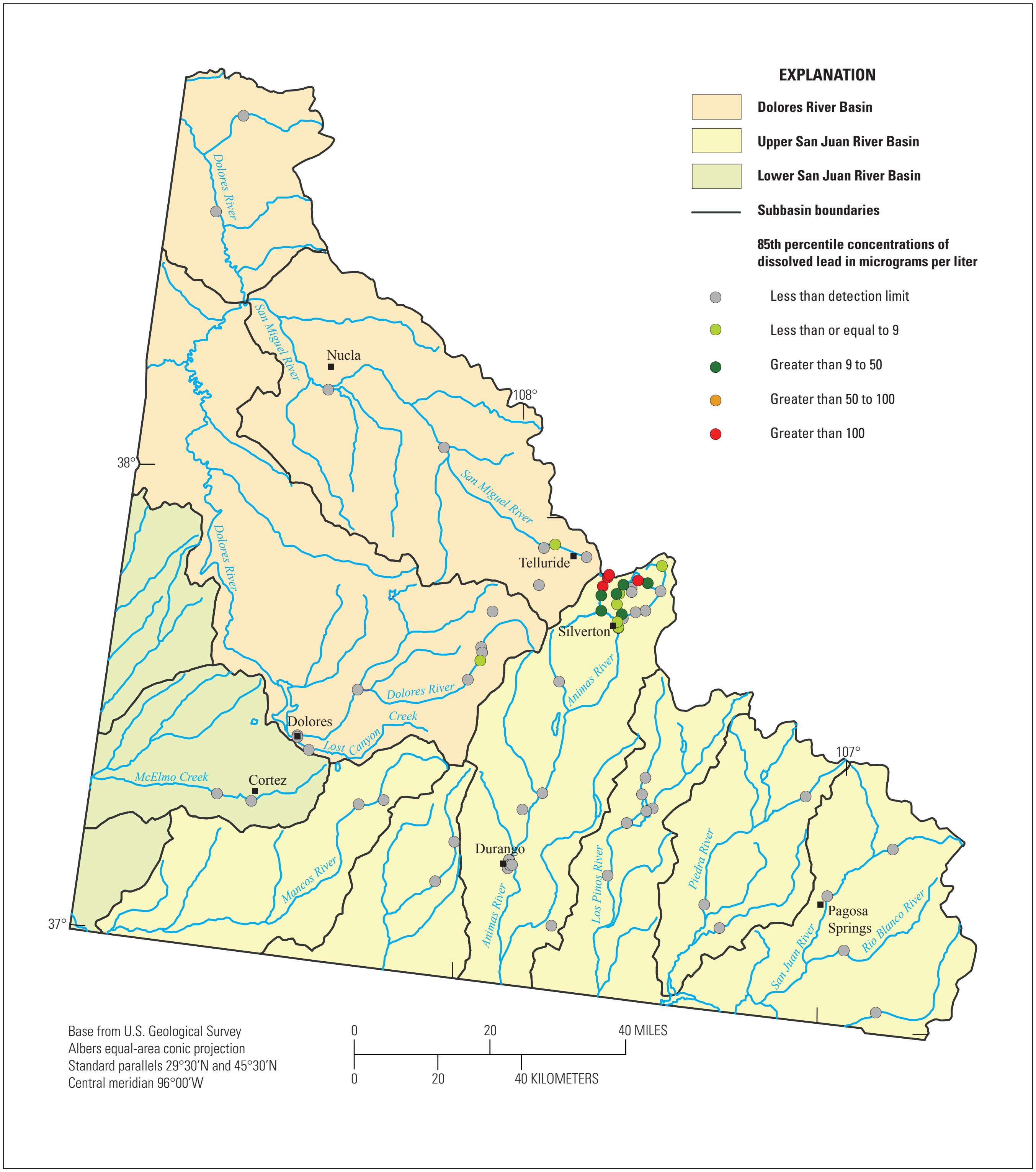

Figure 11. Map showing spatial distribution of 85th percentile concentrations of dissolved lead in the Dolores, Upper San Juan, and Lower San Juan River Basins, southwestern Colorado, 1990–2005.

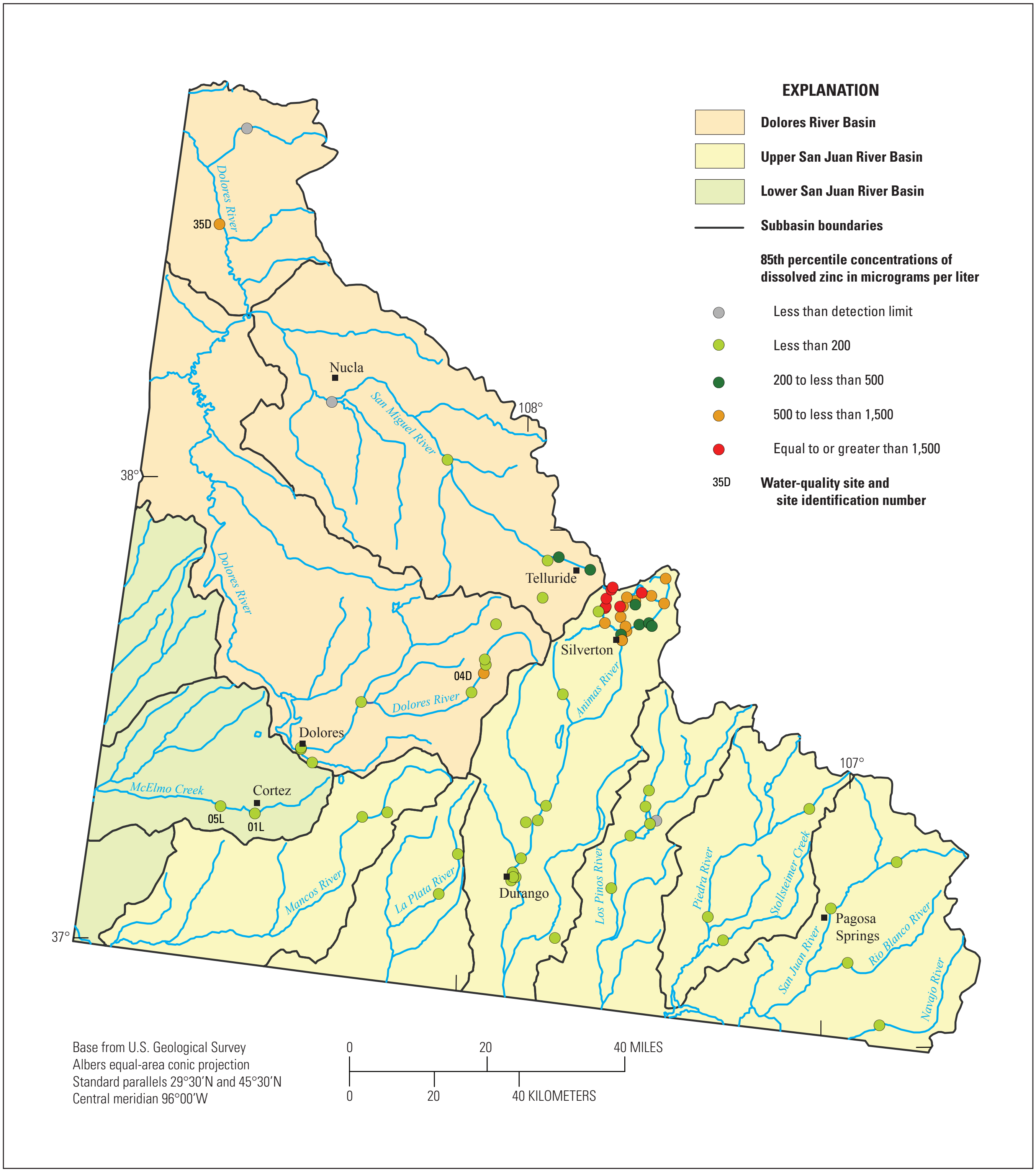

Figure 12. Map showing spatial distribution of 85th percentile concentrations of dissolved zinc in the Dolores, Upper San Juan, and Lower San Juan River Basins, southwestern Colorado, 1990–2005.

180,000 µg/L (table 8). Many sites in the upper Animas River Basin had 85th percentile dissolved zinc concentrations greater than 500 µg/L (table 8). Twenty-four sites had 85th percentile concentrations that exceeded acute and chronic hardness-based standards. Sites with concentrations of dissolved zinc that exceeded acute and chronic hardness-based standards may not have exceeded segment-specific monthly standards. Monthly standards were not calculated. For the most part, dissolved zinc concentrations were higher in samples collected during the winter than during the summer in the Upper SJRB.

Data at two sites on the Animas River and one site on Mineral Creek were analyzed for trends in filtered and unfiltered zinc. Downward trends in zinc concentrations, unfiltered and filtered, occurred at the Mineral Creek at Silverton (32A) site (fig. 1 and table 9). No significant trends in filtered or unfiltered zinc concentration data (1991–2004) occurred at Animas River at Silverton (site 07A) or Animas River downstream from Silverton (site 35A).

Lower San Juan River Basin.—Dissolved zinc concentrations were analyzed at two sites along McElmo Creek (table 8). The 85th percentile concentrations of 110 µg/L at McElmo Creek above Cortez Sanitation District, Southwest WWTP (site 01L) and 31 µg/L at McElmo Creek above Trail Canyon at gage (site 05L) were well below the State hardness-based criteria. The cause of the decrease in dissolved zinc concentrations between the two sites is not known. Seasonal and trend analysis could not be performed because more than 50 percent of the data at each site were censored and reporting limits were variable.

Selenium

In total, more than 2,000 samples were analyzed for dissolved selenium, and more than 800 samples were analyzed for total selenium throughout the study area. Dissolved selenium concentrations in samples ranged from less than 0.2 to 170 µg/L. Total selenium concentrations ranged from less than 0.4 to 60.3 µg/L. The discussion in this section of the report focuses on dissolved selenium concentrations at sites where 10 or more samples were collected. In the study area, the State chronic water-quality standard for selenium was 4.6 µg/L; and the acute standard was 18.4 µg/L (Colorado Department of Public Health and Environment, 2010a). Reporting limits for dissolved selenium at some sites were higher than the State chronic and(or) acute selenium standards; as a result, it was not possible to determine if concentrations of selenium exceeded standards at these sites.

Dolores River Basin. —Adequate data were available to calculate summary statistics for dissolved selenium concentrations at 16 sites in the Dolores River Basin. Only five sites had less than 80 percent censored data, 85th percentile dissolved selenium concentrations for these sites ranged from 1.2 to 23 µg/L (table 8). One site in the Dolores River Basin, Salt Creek at Highway 141 (site 35D), had an 85th percentile concentration of dissolved selenium equal to 23 µg/L which exceeded the State chronic (4.6 µg/L) and acute standards (18.4 µg/L). Most sites had 85th percentile concentrations equal to or less than 3 µg/L. A dissolved selenium concentration of 62.1 µg/L was measured in 1 of the 10 samples collected at the Dolores River at Dolores (site 11D). Concentrations in the remaining 9 samples, collected at this site, were reported as less than 40 µg/L; as a result, the 85th percentile concentration was reported as less than 40 µg/L. It is not known if dissolved selenium concentrations exceeded State standards at this site. Adequate data were not available to analyze for trends in dissolved selenium concentrations.

Upper San Juan River Basin. —Adequate data were available to calculate summary statistics for dissolved selenium concentrations at 32 sites in the Upper SJRB. Twenty-six of the sites had more than 80 percent censored data. The 85th percentile dissolved selenium concentrations ranged from less than 1 to 11 µg/L (table 8). Most sites had 85th percentile concentrations less than 3 µg/L. Only one site, Salt Creek at 309A Road (site 54A), had an 85th percentile concentration of dissolved selenium that exceeded the State chronic standard (table 8). Dissolved selenium concentrations greater than the acute water-quality standard (18.4 µg/L) occurred in some samples along Navajo Wash in the southwestern corner of the Upper SJRB (fig. 1). Summary statistics were not calculated for these sites along Navajo Wash because fewer than 10 samples were collected at each site. Adequate data were not available to analyze for trends in dissolved selenium concentrations.

Lower San Juan River Basin. —Adequate data were available to calculate summary statistics for dissolved selenium concentrations at McElmo Creek above Cortez Sanitation District, Southwest WWTP and McElmo Creek above Trail Canyon (table 8). The 85th percentile dissolved selenium concentration at McElmo Creek above Cortez Sanitation District, Southwest WWTP (site 01L) was equal to 4.1 µg/L. At McElmo Creek above Trail Canyon (site 05L), the 85th percentile dissolved selenium concentration was equal to 5 µg/L and exceeded the State chronic standard (fig. 13). Dissolved selenium concentrations greater than the acute water-quality standard (18.4 µg/L) occurred in some samples collected from Mud Creek sites near Cortez; however, summary statistics were not calculated because fewer than 10 samples were analyzed for dissolved selenium at the sites. Adequate data were not available to analyze for trends in dissolved selenium concentrations.

Nutrients

The occurrence and distribution of total ammonia, nitrate and nitrite, and total phosphorus are discussed in the Ammonia, Nitrate and Nitrite, and Phosphorus sections of the report. Median and 85th percentile concentrations were calculated for sites with 10 or more samples; and these concentrations were compared to applicable State aquatic-life water-quality criteria to provide an overview of existing water quality. Concentrations of total ammonia, nitrate, nitrite, and total phosphorus generally were low throughout the study area.

Ammonia

Only four sites had adequate data to compute summary statistics for total ammonia [sum of un-ionized ammonia (NH_3) and ammonium (NH_4^+)]; all concentrations were less than 0.05 mg/L (table 10). The Commission established table-value standards for total ammonia based on pH and water temperature (Colorado Department of Public Health and Environment, 2010a). The mean pH and mean water temperature values shown in table 2 were used to calculate the table-value standards for each site for comparison purposes. The 85th percentile concentrations of total ammonia were less than the calculated chronic and acute table-value standards for total ammonia at the sites analyzed. Adequate data were not available to analyze temporal trends in total ammonia concentrations.

Nitrate and Nitrite

Nitrate and nitrite concentrations generally were low compared to water-quality standards. Concentrations of dissolved nitrate in samples ranged from less than 0.01 to 7.5 mg/L. Dissolved nitrite concentrations ranged from less than 0.001 to 0.16 mg/L, but most dissolved nitrite concentrations were less than 0.01 mg/L. More samples were analyzed for nitrate plus nitrite than nitrate or nitrite alone. Nitrate plus nitrite concentrations (total as nitrogen) ranged from less than 0.05 to 15 mg/L in samples; and 87 percent of samples analyzed had concentrations less than or equal to 0.5 mg/L. Nitrate plus nitrite concentrations generally were higher in samples collected during the winter period than in samples collected during the summer period.

The distribution of nitrate plus nitrite concentrations likely represents the distribution of nitrate concentrations because nitrite concentrations likely contribute a small part of the overall nitrate plus nitrite concentration. For most stream segments in the study area, the State stream water-quality standard for nitrate is 10 mg/L (Colorado Department of Public Health and Environment, 2010a). The national primary drinking-water standard for nitrate also is 10 mg/L (U.S. Environmental Protection Agency, 2010a). The Colorado stream water-quality standard for nitrite is 0.05 mg/L for most stream segments in the study area (Colorado Department of Public Health and Environment, 2010a); whereas, the national primary drinking-water standard for nitrite is 1 mg/L (U.S. Environmental Protection Agency, 2010a).

Dolores River Basin.—Adequate data were available at 21 sites to calculate summary statistics for nitrate plus nitrite concentrations. The 85th percentile nitrate plus nitrite concentrations ranged from less than 0.05 to 0.78 mg/L (table 10). Based on available data, sites in the Dolores River Basin met State water-quality standards for nitrate concentrations.

Upper San Juan River Basin.—Adequate data were available at 35 sites to calculate summary statistics for nitrate plus nitrite concentrations. The 85th percentile nitrate plus nitrite concentrations ranged from 0.06 to 2.4 mg/L (table 10). Only 4 of the 35 sites analyzed had 85th percentile concentrations of nitrate plus nitrite greater than 1 mg/L (fig. 14). These sites were located in the vicinity of Durango mostly on the Animas River. Based on available data, sites in the Upper SJRB met State water-quality standards for nitrate concentrations. The Vallecito Creek near Bayfield (22U) site was the only site in the Upper SJRB that had sufficient data to perform trend analyses for nitrate plus nitrite concentrations. No significant trends in nitrate plus nitrite concentrations occurred at the site (table 7).

Lower San Juan River Basin.—In the Lower SJRB, only the McElmo Creek above Cortez Sanitation District, Southwest WWTP and McElmo Creek above Trail Canyon at gage sites had adequate data to calculate summary statistics for nitrate plus nitrite concentrations. The 85th percentile nitrate plus nitrite concentration at McElmo Creek above Cortez Sanitation District, Southwest WWTP (site 01L) was equal to 1 mg/L (table 10 and fig. 14). Downstream, at McElmo Creek above Trail Canyon at gage (site 05L), the 85th percentile nitrate plus nitrite concentration was equal to 2.7 mg/L (table 10 and fig. 14). Irrigation return flow likely contributes to the higher concentrations of nitrate plus nitrite at the downstream site. Concentrations of nitrate plus nitrate in the Lower SJRB were significantly (p-value < 0.01) higher in samples collected during the winter than in samples collected during the summer. During the winter months, inflow from groundwater which may have higher concentrations of nitrate plus nitrite is likely a larger part of the overall streamflow in the streams. Further study, however, would be required to understand the sources and(or) processes that are affecting nitrate plus nitrite concentrations in water in the Lower SJRB. Adequate data were not available to analyze for temporal trends in nitrate plus nitrite concentrations.

Phosphorus

Total phosphorus concentrations ranged from less than 0.002 to 11 mg/L, though most samples had total phosphorus concentrations less than 0.1 mg/L. Reporting limits for total phosphorus samples used in this report ranged from 0.002 to 0.1 mg/L. No water-quality criteria for total phosphorus were listed for streams in southwestern Colorado (Colorado Department of Public Health and Environment, 2010a). In the study area, 85th percentile total phosphorus concentrations ranged from 0.009 to 1.1 mg/L.

Dolores River Basin.—Adequate data were available for 24 sites to calculate summary statistics for total phosphorus concentrations. The 85th percentile total phosphorus concentrations ranged from less than 0.05 to 1.1 mg/L (table 10).

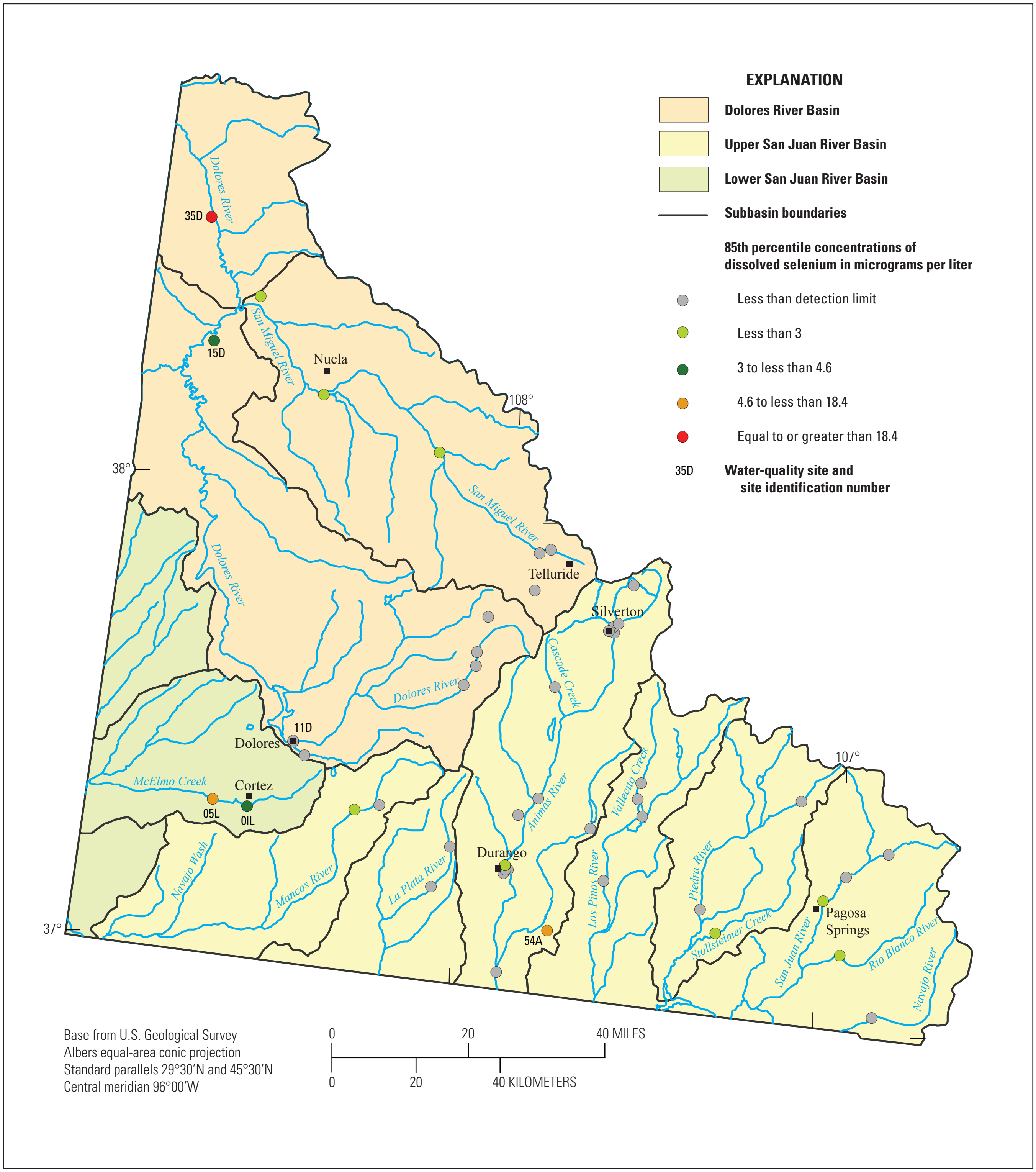

Figure 13. Map showing spatial distribution of 85th percentile concentrations of dissolved selenium in the Dolores, Upper San Juan, and Lower San Juan River Basins, southwestern Colorado, 1990–2005.

Table 10. Statistical summary for total ammonia, nitrate plus nitrite, and total phosphorus concentrations for sites with 10 or more samples in the Dolores, Upper San Juan, and Lower San Juan River Basins, southwestern Colorado, 1990–2005.

[SiteID, site identification number; mg/L, milligram per liter; N, number of samples; NC, number of samples with concentrations reported as less than the reporting limit; Min, minimum concentration; Max, maximum concentration; Med, median concentration; C_{85}, 85th percentile concentration; WWTP, wastewater treatment plant; gray shaded column indicates statistic that was used for comparison to State water-quality standards]

Site ID	Site name	Total ammonia, in mg/L as nitrogen					
		N	NC	Min	Max	Med	85th
	Dolores River Basin						
01D	Coal Creek at FR 535 below Lizard Head Wilderness Area	--	--	--	--	--	--
02D	Horse Creek at Highway 145	--	--	--	--	--	--
03D	Dolores River above Horse Creek	--	--	--	--	--	--
04D	Silver Creek at Highway 145	--	--	--	--	--	--
05D	Dolores River below Rico	--	--	--	--	--	--
07D	West Dolores River near Stoner at Highway 145	--	--	--	--	--	--
08D	Lost Canyon Creek near Dolores	--	--	--	--	--	--
12D	Dolores River near town of Dolores	--	--	--	--	--	--
13D	Dolores River at Dolores above Mcphee Reservoir	--	--	--	--	--	--
15D	Dolores River above confluence with San Miguel River						
17D	Lasal Creek at Utah-Colorado State Line	23	23	<0.05	<0.05	<0.05	<0.05
20D	San Miguel River above Marshall Creek	--	--	--	--	--	--
22D	Upstream, SMIG above Bear	--	--	--	--	--	--
24D	Downstream, SMMAHONEY	--	--	--	--	--	--
25D	San Miguel River at Society Turn	--	--	--	--	--	--
26D	South Fork San Miguel River near mouth	--	--	--	--	--	--
27D	Howard Fork San Miguel River at Ophir	--	--	--	--	--	--
29D	San Miguel River near Norwood	--	--	--	--	--	--
30D	McKenzie Creek at mouth above confluence with San Miguel River	--	--	--	--	--	--
32D	Naturita Creek at Naturita	--	--	--	--	--	--
34D	San Miguel River at confluence with Dolores River	--	--	--	--	--	--
35D	Salt Creek at Highway 141	--	--	--	--	--	--
36D	West Creek in Unaweep Canyon	--	--	--	--	--	--
37D	Dolores River at Gateway	--	--	--	--	--	--
	Upper San Juan River Basin						
03A	Eureka below Ben Franklin	--	--	--	--	--	--
09A	North Fork Cement Creek upstream from Gold King mine, #7 level (AMLI mine # 103)	--	--	--	--	--	--
15A	Porcupine Gulch upstream from mines	--	--	--	--	--	--
35A	Animas River downstream from Silverton	--	--	--	--	--	--
36A	Animas River near Silverton	--	--	--	--	--	--
39A	Cascade Creek at Highway 550	--	--	--	--	--	--
40A	Animas River above Durango	--	--	--	--	--	--
41A	Animas at Durango Mall	--	--	--	--	--	--
43A	Falls Creek at 0.65 Road	--	--	--	--	--	--
46A	Animas River at Durango	--	--	--	--	--	--
47A	Lightner Creek at mouth at Durango	--	--	--	--	--	--
48A	DRALP001	--	--	--	--	--	--
49A	Animas River at Durango	--	--	--	--	--	--
50A	Animas River behind BMX track at Durango	--	--	--	--	--	--
53A	Florida River below Lemon Reservoir	--	--	--	--	--	--
54A	Salt Creek at 309A Road	--	--	--	--	--	--
57A	Animas River near Bondad	--	--	--	--	--	--
01U	Little Navajo River at Highway 84	--	--	--	--	--	--
03U	Rito Blanco at Highway 84	--	--	--	--	--	--
05U	Sand Creek at mouth above East Fork San Juan River	--	--	--	--	--	--
09U	San Juan River above Pagosa Springs	--	--	--	--	--	--
10U	McCabe Creek above Pagosa Springs	--	--	--	--	--	--
12U	San Juan River below Pagosa Springs	--	--	--	--	--	--
14U	San Juan River above Navajo Reservoir	--	--	--	--	--	--
15U	East Fork Piedra River below Piedra Falls	--	--	--	--	--	--
16U	Piedra River at Highway 160	--	--	--	--	--	--
17U	Stollsteimer Creek at Highway 151	--	--	--	--	--	--

Table 10. Statistical summary for total ammonia, nitrate plus nitrite, and total phosphorus concentrations for sites with 10 or more samples in the Dolores, Upper San Juan, and Lower San Juan River Basins, southwestern Colorado, 1990–2005.—Continued

[SiteID, site identification number; mg/L, milligram per liter; N, number of samples; NC, number of samples with concentrations reported as less than the reporting limit; Min, minimum concentration; Max, maximum concentration; Med, median concentration; C_{85}, 85th percentile concentration; WWTP, wastewater treatment plant; gray shaded column indicates statistic that was used for comparison to State water-quality standards]

Site ID	Nitrate plus nitrite, in mg/L						Total phosphorus, in mg/L					
	N	NC	Min	Max	Med	85th	N	NC	Min	Max	Med	C_{85}
Dolores River Basin												
01D	10	5	<0.05	0.24	0.08	0.18	10	2	<0.01	0.08	0.02	0.031
02D	12	6	<0.05	0.31	0.07	0.08	12	1	<0.01	0.08	0.0135	0.05
03D	16	16	<0.3	<0.5	<0.5	<0.5	16	13	<0.01	<0.05	<0.05	<0.05
04D	47	34	<0.05	0.9	0.08	0.15	46	30	<0.005	0.06	0.006	0.02
05D	48	39	<0.05	<0.5	<0.5	<0.5	48	31	<0.01	0.13	0.008	0.02
07D	20	19	<0.3	0.8	<0.5	<0.5	20	13	<0.01	0.38	0.012	0.034
08D	14	12	<0.05	<0.3	<0.3	<0.3	14	3	<0.01	0.35	0.01	0.025
12D	12	12	<0.5	<0.5	<0.5	<0.5	11	7	<0.05	0.1	<0.05	0.07
13D	25	23	<0.05	<0.3	<0.3	<0.3	25	17	<0.01	0.07	<0.01	0.022
15D	28	28	<0.3	<0.5	<0.5	<0.5	39	10	<0.01	11	0.08	0.37
17D	--	--	--	--	--	--	19	4	<0.015	0.095	0.037	0.049
20D	11	11	<0.3	<0.5	<0.5	<0.5	11	10	<0.01	<0.05	<0.05	<0.05
22D	--	--	--	--	--	--	10	5	<0.01	0.04	<0.01	0.02
24D	--	--	--	--	--	--	10	4	<0.01	0.06	0.01	0.03
25D	75	51	<0.3	0.5	0.21	0.28	74	35	<0.01	0.30	0.013	0.04
26D	24	18	<0.05	0.32	0.1	0.12	23	11	<0.01	0.08	0.013	0.035
27D	16	16	<0.3	<0.5	<0.5	<0.5	16	12	<0.01	0.05	0.012	0.04
29D	32	24	<0.05	0.495	0.13	0.4	32	13	<0.01	0.25	0.02	0.072
30D	17	13	<0.05	0.22	<0.05	0.05	17	7	<0.01	0.04	0.011	0.02
32D	17	17	<0.3	<0.5	<0.5	<0.5	17	6	<0.05	0.34	0.04	0.17
34D	52	46	<0.05	0.72	<0.5	<0.5	60	23	<0.01	3	0.03	0.14
35D	13	2	<0.05	0.94	0.56	0.78	13	2	<0.01	0.42	0.12	0.16
36D	14	14	<0.3	<0.5	<0.5	<0.5	14	1	<0.01	0.09	0.04	0.05
37D	19	18	<0.3	0.57	<0.5	<0.5	19	3	<0.05	3.3	0.1	1.1
Upper San Juan River Basin												
03A	16	0	0.04	2.64	0.17	0.44	--	--	--	--	--	--
09A	79	0	0.03	1.06	0.18	0.39	19	0	0.01	1.08	0.03	0.16
15A	94	0	0.01	2.94	0.16	0.32	12	0	0.01	0.96	0.025	0.96
35A	--	--	--	--	--	--	13	0	0.02	1.00	0.05	0.11
36A	68	53	<0.05	15.0	0.09	0.16	76	32	<0.01	1.00	0.03	0.05
39A	16	3	<0.3	0.225	0.1	0.14	16	5	<0.01	0.065	0.015	0.03
40A	35	35	<0.5	<0.5	<0.5	<0.5	35	27	<0.02	0.14	0.02	0.06
41A	89	18	<0.05	7.0	0.3	2	--	--	--	--	--	--
43A	13	8	<0.05	0.215	<0.05	0.11	13	3	<0.01	0.05	0.02	0.03
46A	30	26	<0.3	0.23	<0.3	<0.3	30	13	<0.01	0.15	0.01	0.05
47A	46	12	<0.1	7.7	0.6	1.6	--	--	--	--	--	--
48A	86	21	<0.05	7.35	0.2	1.1	18	1	<0.01	0.11	0.02	0.04
49A	113	13	<0.1	7.0	0.6	2.4	19	1	<0.1	0.20	0.05	0.09
50A	--	--	--	--	--	--	18	2	<0.01	0.30	0.04	0.06
53A	25	24	<0.3	0.41	<0.5	<0.5	25	9	<0.01	0.15	0.03	0.08
54A	15	11	<0.05	0.225	<0.05	0.06	15	1	<0.01	0.15	0.05	0.1
57A	59	40	<0.05	0.6	0.14	0.27	59	10	<0.01	0.37	0.04	0.12
01U	16	13	<0.05	0.225	<0.3	<0.3	16	3	<0.01	0.75	0.035	0.04
03U	17	15	<0.05	0.19	<0.3	<0.3	17	4	<0.01	0.48	0.02	0.04
05U	12	11	<0.05	0.175	<0.3	<0.3	12	3	<0.01	0.110	0.021	0.04
09U	32	29	<0.05	0.4	<0.5	<0.5	32	5	<0.01	0.76	0.03	0.07
10U	17	12	<0.05	0.26	<0.05	0.11	17	2	<0.01	0.150	0.04	0.08
12U	10	10	<0.3	<0.4	<0.5	<0.5	10	5	<0.05	0.50	0.04	0.06
14U	20	20	<0.3	<0.4	<0.5	<0.5	20	7	<0.05	0.50	0.06	0.185
15U	12	11	<0.05	0.185	<0.3	<0.3	12	5	<0.01	0.039	0.02	0.03
16U	53	43	<0.05	0.19	<0.3	<0.3	53	11	<0.01	0.180	0.02	0.04
17U	18	11	<0.05	0.63	<0.05	0.4	18	2	<0.01	0.125	0.03	0.08

Table 10. Statistical summary for total ammonia, nitrate plus nitrite, and total phosphorus concentrations for sites with 10 or more samples in the Dolores, Upper San Juan, and Lower San Juan River Basins, southwestern Colorado, 1990–2005.—Continued

[SiteID, site identification number; mg/L, milligram per liter; N, number of samples; NC, number of samples with concentrations reported as less than the reporting limit; Min, minimum concentration; Max, maximum concentration; Med, median concentration; C_{85}, 85th percentile concentration; WWTP, wastewater treatment plant; gray shaded column indicates statistic that was used for comparison to State water-quality standards]

Site ID	Site name	Total ammonia, in mg/L as nitrogen					
		N	NC	Min	Max	Med	85th
	Upper San Juan River Basin—Continued						
19U	Piedra River northeast of Arboles	--	--	--	--	--	--
20U	Los Pinos River above Vallecito Reservoir near Bayfield	22	14	<0.002	0.039	<0.002	0.006
21U	Los Pinos River above Vallecito Reservoir	--	--	--	--	--	--
22U	Vallecito Creek near Bayfield	177	121	<0.002	0.03	0.003	0.006
23U	Vallecito Creek near mouth	--	--	--	--	--	--
24U	Los Pinos River below Vallecito Reservoir near Bayfield	17	3	<0.002	0.017	0.008	0.013
25U	Wallace Gulch at 502 Road north of Bayfield	--	--	--	--	--	--
28U	Los Pinos River near La Boca	--	--	--	--	--	--
30U	La Plata at Hesperus	--	--	--	--	--	--
31U	Spring Creek near Breen	--	--	--	--	--	--
32U	East Fork Mancos River at 44 Road	--	--	--	--	--	--
34U	Chicken Creek at Mancos	--	--	--	--	--	--
	Lower San Juan River Basin						
01L	McElmo Creek above Cortez Sanitation District, Southwest WWTP	--	--	--	--	--	--
05L	McElmo Creek above Trail Canyon at gage	--	--	--	--	--	--

Table 10. Statistical summary for total ammonia, nitrate plus nitrite, and total phosphorus concentrations for sites with 10 or more samples in the Dolores, Upper San Juan, and Lower San Juan River Basins, southwestern Colorado, 1990–2005.—Continued

[SiteID, site identification number; mg/L, milligram per liter; N, number of samples; NC, number of samples with concentrations reported as less than the reporting limit; Min, minimum concentration; Max, maximum concentration; Med, median concentration; C_{85}, 85th percentile concentration; WWTP, wastewater treatment plant; gray shaded column indicates statistic that was used for comparison to State water-quality standards]

Site ID	Nitrate plus nitrite, in mg/L						Total phosphorus, in mg/L					
	N	NC	Min	Max	Med	85th	N	NC	Min	Max	Med	C_{85}
Upper San Juan River Basin—Continued												
19U	16	16	<0.5	<0.5	<0.5	<0.5	16	11	<0.05	0.18	0.03	0.07
20U	--	--	--	--	--	--	17	1	<0.008	0.051	0.01	0.03
21U	52	34	<0.05	0.22	0.06	0.11	52	28	<0.01	0.13	<0.01	0.02
22U	10	0	0.064	0.21	0.115	0.16	47	26	<0.002	0.060	0.004	0.02
23U	52	27	<0.05	0.32	0.16	0.2	52	33	<0.01	0.07	<0.01	0.02
24U	--	--	--	--	--	--	15	1	<0.004	0.015	0.005	0.009
25U	16	10	<0.05	0.215	<0.05	0.1	16	1	<0.01	0.11	0.04	0.09
28U	10	9	<0.5	0.285	<0.5	<0.5	10	4	<0.05	0.20	0.06	0.13
30U	40	30	<0.05	0.305	0.02	0.1	40	28	<0.005	0.17	0.005	0.02
31U	12	9	<0.05	0.09	<0.05	0.07	12	2	<0.01	0.08	0.02	0.03
32U	22	14	<0.05	0.225	0.04	0.08	22	13	<0.01	0.18	<0.01	0.031
34U	18	14	<0.05	0.21	<0.05	0.08	18	1	<0.01	0.08	0.02	0.034
Lower San Juan River Basin												
01L	15	3	<0.3	3.6	0.55	1	15	2	<0.01	0.5	0.05	0.19
05L	45	4	<0.3	4.7	1.1	2.7	45	2	<0.01	1.4	0.12	0.38

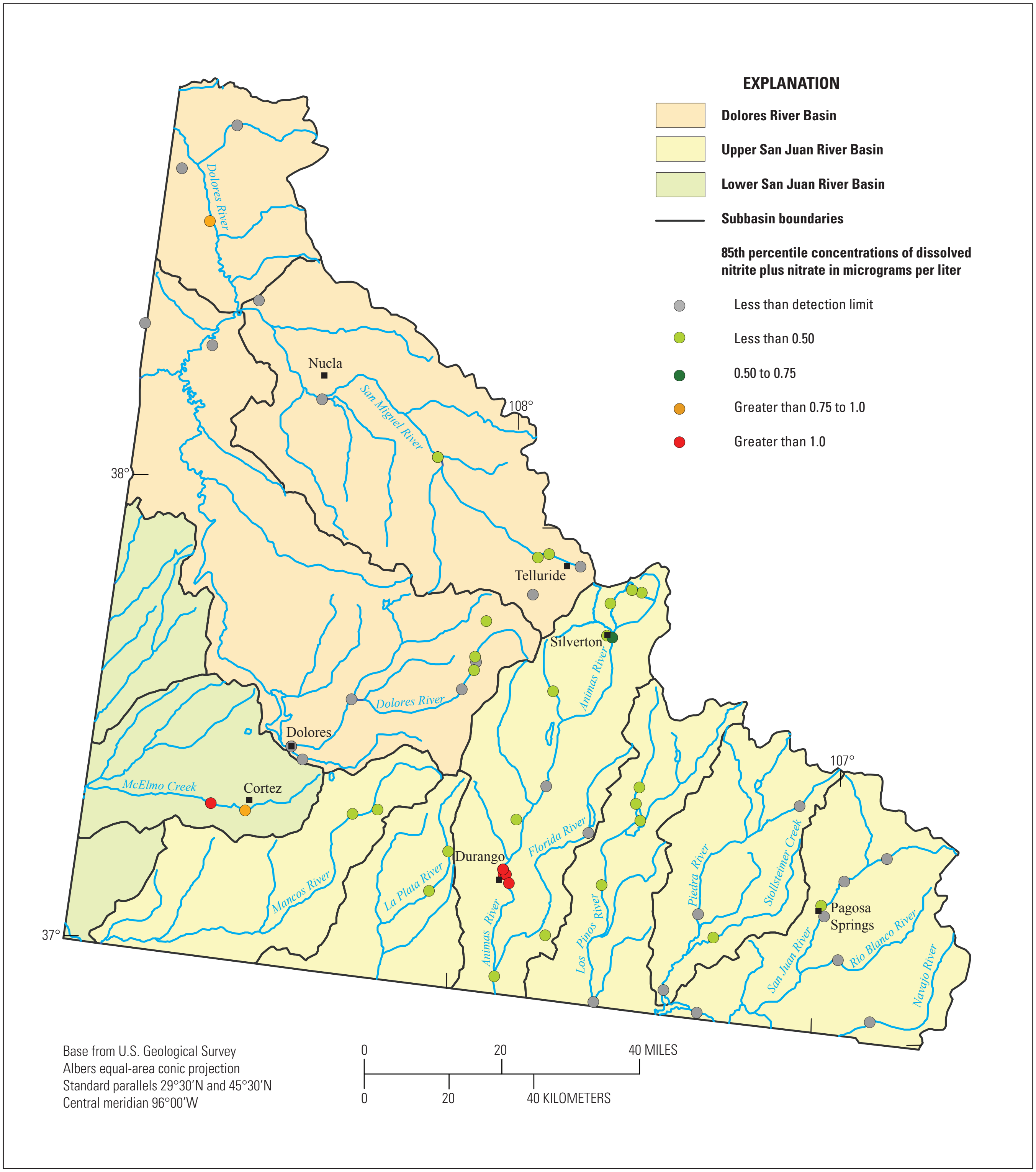

Figure 14. Map showing spatial distribution of 85th percentile concentrations of nitrate plus nitrite in the Dolores, Upper San Juan, and Lower San Juan River Basins, southwestern Colorado, 1990–2005.

The highest 85th percentile total phosphorus concentration occurred at the Dolores River at Gateway (site 37D). Adequate data were not available to analyze temporal trends in total phosphorus concentrations in the Dolores River Basin.

Upper San Juan River Basin.—Adequate data were available for 36 sites to calculate summary statistics for total phosphorus concentrations. The 85th percentile total phosphorus concentrations ranged from 0.009 to 0.96 mg/L (table 10). Total phosphorus concentrations in the Upper SJRB were typically near the reporting limits and were not significantly different seasonally. The highest 85th percentile total phosphorus concentration (0.96 mg/L) occurred at the Porcupine Gulch upstream from mines (site 15A) near Silverton. Adequate data were not available to analyze temporal trends in total phosphorus concentrations in the Upper SJRB.

Lower San Juan River Basin.—Only the McElmo Creek above Cortez Sanitation District, Southwest WWTP and McElmo Creek above Trail Canyon sites had sufficient data to calculate summary statistics for total phosphorus in the Lower SJRB. The 85th percentile total phosphorus concentrations ranged from 0.19 mg/L at McElmo Creek above Cortez Sanitation District, Southwest WWTP to 0.38 mg/L at McElmo Creek above Trail Canyon (table 10). Total phosphorus concentrations were significantly higher in samples collected during the summer period than in samples collected during the winter period. Adequate data were not available to analyze temporal trends in total phosphorus concentrations in the Lower SJRB.

Uranium

Only 10 sites throughout the entire study area had adequate data to calculate summary statistics for dissolved uranium (table 8). The 85th percentile concentrations of dissolved uranium ranged from less than 3 to 10 µg/L, well below the national drinking water water-quality standard of 30 µg/L (U.S. Environmental Protection Agency, 2010a). Dissolved uranium concentrations were generally less than 5 µg/L in most samples from most streams; although concentrations greater than 10 µg/L were measured in some samples at various locations throughout the study area, particularly at sites in the Lower SJRB and along Navajo Wash in the southwestern part of the Upper SJRB (fig. 15). Many of these site locations, where dissolved uranium concentrations were elevated, coincide with areas where the Mancos Shale crops out. Because the solubility of uranium is high, geochemical exploration for uranium is commonly done using water and stream sediments as sampling media to identify areas of abnormally high concentrations (Wenrich-Verbeek, 1980). The highest concentrations of dissolved uranium in the study area were detected at sites along Navajo Wash (fig. 15). Navajo Wash receives irrigation drainage from areas on Mancos Shale (Butler and others, 1997). Pliler and Adams (1962) reported that the average concentration of uranium was 3.7 milligrams per kilogram in samples from the Mancos Shale in Colorado, Utah, Arizona, and New Mexico (Pliler and Adams, 1962). Uranium-vanadium deposits occur in the Salt Wash member of the Morrison Formation in southwestern Colorado (GeoXplor Corp, 2009). Irrigation drainage likely leaches uranium from the Mancos Shale and other deposits containing uranium into groundwater and surface water that enters Navajo Wash.

Summary of Trends in Selected Water-Quality Characteristics

Temporal trends in DO, pH, water temperature, SC, DS, chloride, sulfate, nitrate plus nitrite, and selected trace element values were evaluated at sites with adequate data. Only one site, Vallecito Creek near Bayfield, had sufficient DO data to perform trend analysis. No significant trend in DO concentrations occurred at the site. Small (less than 0.5 percent) statistically significant increases in pH values occurred at the Dolores River at Bedrock, Dolores River near Bedrock, Mud Creek at State Highway 32, near Cortez, and McElmo Creek above Trail Canyon near Cortez sites. These small upward trends in pH values may result from changes in stream water quality resulting from land and(or) water use changes or simply be an artifact of changes in sampling routines. A significant decrease of 2.4 percent in pH values (1993-2003) occurred at the Animas River downstream from Silverton site. No other significant trends in pH values occurred.

Significant upward trends in water temperature occurred at the Los Pinos River at La Boca and the San Juan River at Pagosa Springs sites located in the Upper SJRB. A 3.5 percent increase in water temperature occurred at the Los Pinos River at La Boca site where the typical water temperature for the period of analysis (1993–2003) was 10.9 °C. An increase of 3.9 percent occurred at the San Juan River at Pagosa Springs site where the typical water temperature for the period of analysis was 5.7 °C. Instantaneous streamflow values measured when water-quality samples were collected were generally lower during the last half of the analysis period than during the first half of the analysis period. These upward trends in water temperature may result from changes in groundwater and surface water interactions and(or) changes in stream velocities and depths because of drought conditions during the latter part of the analysis period. No significant trends in water temperature values occurred at sites in the Dolores River Basin or the Lower SJRB.

Significant decreases in SC values and DS and chloride concentrations occurred at the Dolores River near Bedrock site downstream from the Paradox Valley Unit. Specific conductance values decreased by 8.9 percent, DS concentrations decreased by 8.3 percent, and chloride concentrations decreased by 10.5 percent in samples collected from 1993 through 2003. These decreases in SC values and DS and chloride concentrations are likely because of the operation of the Paradox Valley Unit (described in the Geology section of the report) upstream from the site. No significant trends in SC

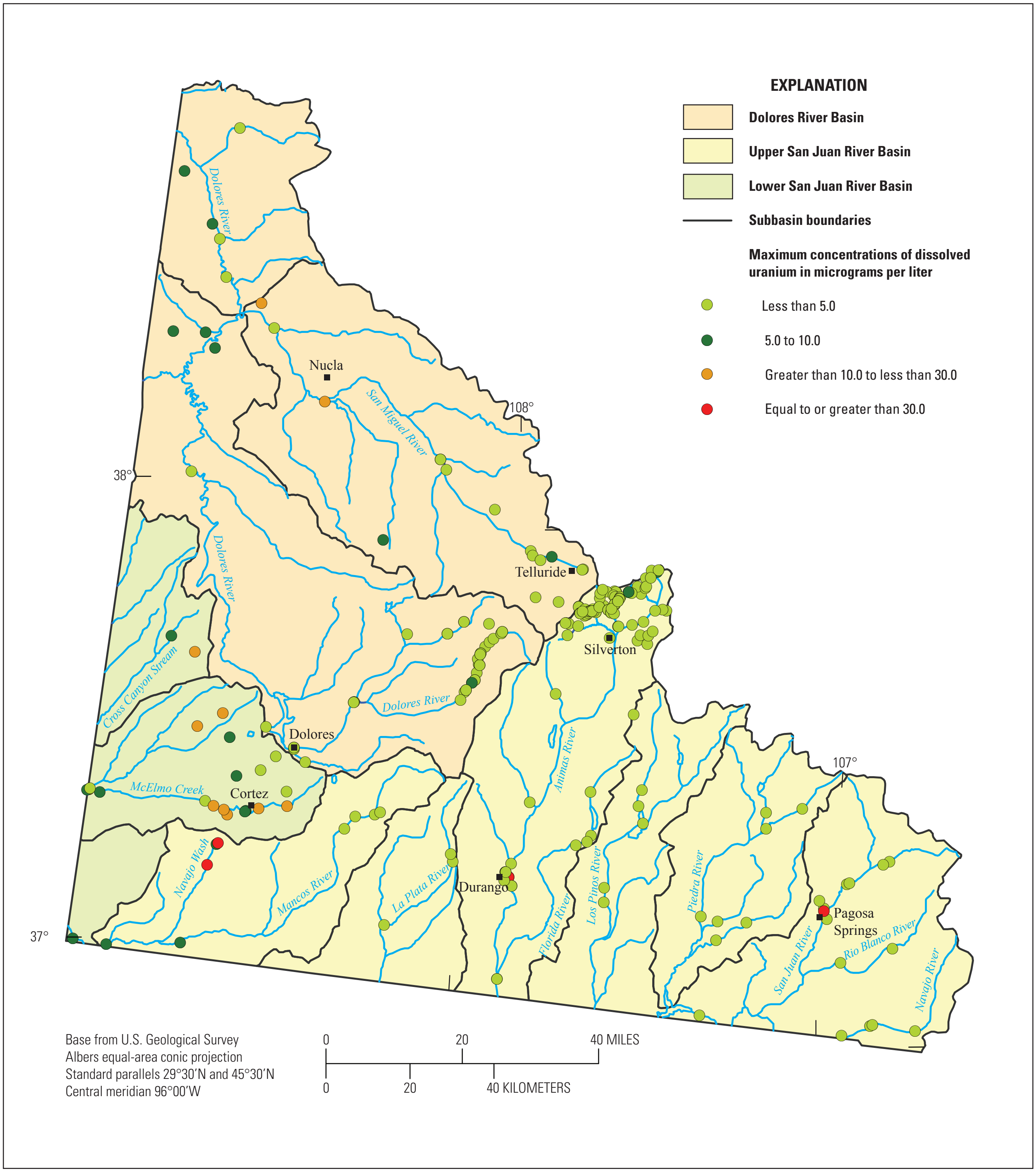

Figure 15. Map showing spatial distribution of maximum uranium concentrations in the Dolores, Upper San Juan, and Lower San Juan River Basins, southwestern Colorado, 1990–2005.

values, DS concentrations, or chloride concentrations occurred at other sites in the Dolores River Basin; no significant trends in sulfate concentrations occurred at any site in the Dolores River Basin.

Significant downward trends in SC values were detected at 4 of the 13 sites analyzed in the Upper SJRB. The largest percent decrease in SC values was detected at Mancos River near Towaoc. This decrease may be the result of salinity control modifications done by the Natural Resources Conservation Service (Environmental Quality Improvement Program) and the Bureau of Reclamation (Colorado River Basin Salinity Control Program) as part of the Mancos Valley Salinity Control Project. Significant downward trends in SC values were also detected at Animas River below Silverton, Spring Creek at La Boca, and Los Pinos River at La Boca. At the Animas River below Silverton site, downward trends in SC and pH values may be because of changes made in the drainage basin to control acid mine drainage. Downward trends in SC values at Spring Creek at La Boca and Los Pinos River at La Boca may result from channel improvements made to decrease sedimentation, changes in irrigation practices, or other changes in water use within the watersheds.

In the Lower SJRB, significant downward trends in SC values and DS and sulfate concentrations occurred at the McElmo Creek above Trail Canyon near Cortez site. Significant downward trends in DS concentrations and sulfate concentrations occurred at the Mud Creek at State Highway 32, near Cortez site. Downstream from these sites, at the McElmo Creek near Colorado-Utah State line site, significant downward trends in SC values and DS, chloride, and sulfate concentrations occurred. These downward trends may be because of irrigation and water-delivery system improvements made by the BOR in the McElmo Creek basin.

The Vallecito Creek near Bayfield site was the only site in the Upper SJRB that had sufficient data to perform trend analyses for DS, chloride, sulfate, and nitrate plus nitrite. No significant trends in DS, chloride, or nitrate plus nitrite concentrations occurred at the site; however, a significant upward trend in sulfate concentrations of 4.0 percent was measured. This trend in sulfate concentrations may be related to the drought conditions during the latter part of the analysis period which may have lowered the water table levels and affected groundwater contributions.

Only the Animas River at Silverton, Animas River downstream from Silverton, and Mineral Creek at Silverton sites had adequate data to analyze for temporal trends (1991–2004) in most selected trace element concentrations. No trends in trace element concentrations occurred at Animas River at Silverton or at Animas River downstream from Silverton. Significant downward trends in total recoverable lead, dissolved zinc, and total recoverable zinc concentrations occurred at Mineral Creek at Silverton.

Overall results from the trend analyses indicate improvement in water-quality conditions as a result of operation of the Paradox Valley Unit in the Dolores River Basin and irrigation and water-delivery system improvements made in the McElmo Creek basin and Mancos River Valley. Other detected trends may be because of precipitation variability during the analysis period. Additional study, however, would be needed to determine the causes of the apparent changes in water-quality characteristic values over time at the sites.

Summary

In 2004, the U.S. Geological Survey (USGS) in cooperation with Bureau of Land Management (BLM), Bureau of Reclamation (BOR), Southwestern Water Conservation District (WCD), San Miguel County, and Telluride Power/Water began a surface-water and groundwater assessment of the Dolores River and San Juan River Basins in southwestern Colorado. As part of this assessment, historical water-quality data collected in the Dolores and San Juan River Basins (Southwest Study Area) by various local, State, Tribal, and Federal agencies were compiled into a single electronic database. Selected surface-water quality data from this database (1990–2005) were analyzed to determine the spatial and temporal distribution of physical and chemical water-quality characteristics. Results from this analysis and previous studies done by others were used to describe environmental and land-use factors which affect surface-water-quality conditions in southwestern Colorado.

Minimum, maximum, median, and other selected percentile values were calculated using available surface-water-quality data for sites with 10 or more samples. These values were compared to State and(or) Federal water-quality standards to assess existing water quality in southwestern Colorado. Trend analyses for dissolved oxygen (DO), pH, water temperature, specific conductance (SC), dissolved solids (DS), chloride, and sulfate data were done for the period January 1993 through December 2003 and for selected trace metals data for the period January 1991 through December 2004. The spatial and temporal distribution of DO, pH, water temperature, DS, major ions, selected trace elements, nutrients, and uranium data were described spatially by location within the Dolores, Upper San Juan, and Lower San Juan River Basins.

Overall, streams throughout the study area were well oxygenated. Median DO concentrations generally ranged from 8 to 10 milligrams per liter (mg/L). The 15th percentile DO concentrations ranged from 5.0 to 8.9 mg/L in the Dolores River Basin, from 0.1 to 9.7 mg/L in the Upper San Juan River Basin (SJRB), and from 7.2 to 7.6 mg/L in the Lower SJRB.

Values of pH in surface water generally were near neutral to slightly alkaline throughout most of the study area with the exception of the upper Animas River Basin (within the Upper SJRB) near Silverton where acidic conditions existed at some sites because of hydrothermal alteration and(or) historical mining. In the Upper SJRB, 15th percentile values for pH ranged from 1.6 to 7.9, and 85th percentile pH values ranged from 2.6 to 8.7 standard units. One site in the Mineral Creek basin and two sites in the Cement Creek basin had

15th percentile values for pH less than 3.7, the lowest designated State surface-water-quality standard value for pH in the study area.

Mean water temperatures in the study area ranged from 5.3 to 14.1 °C. Instantaneous water temperatures varied from less than 0 to 31.5 °C. Sites located in the headwaters of the Dolores River Basin and the Upper SJRB typically had mean water temperatures less than 10 °C. Lower elevation sites throughout the study area generally had mean water temperatures between 9 and 13 °C.

Median DS concentrations ranged from 8 to 42,600 mg/L. The highest DS concentrations typically occurred in samples collected from December through March when streamflows were lowest and groundwater inflow was the dominant source of flow. The lowest DS concentrations typically occurred in samples collected from May through July when streamflows were highest and snowmelt was the dominant source of the flow. Seasonal differences in DS concentrations were more apparent in samples from the Upper SJRB and the Lower SJRB than the Dolores River Basin. In the Dolores River Basin, 14 of the 22 sites analyzed had median DS concentrations less than 500 mg/L. Thirty-one of the 32 sites analyzed in the Upper SJRB had median DS concentrations less than 500 mg/L; and many sites had median DS concentrations less than 250 mg/L. Median DS concentrations ranged from 1,340 to 3,385 mg/L at sites analyzed in the Lower SJRB.

Eighty-fifth percentile concentrations for dissolved aluminum ranged from less than 50 to 67,000 µg/L; and median total recoverable aluminum concentrations ranged from 57 to 2,000 µg/L. In the Upper SJRB, two sites had 85th percentile concentrations of dissolved aluminum (used as surrogate for total recoverable aluminum) that exceeded the acute hardness-based criteria, and 11 sites had 85th percentile concentrations of dissolved aluminum that exceeded the chronic hardness-based criteria. All of the sites that exceeded the acute criteria and all but one site that exceeded the chronic criteria were located in the Cement and Mineral Creek basins north and west of Silverton.

Median total recoverable iron concentrations ranged from 1.6 to 225,000 µg/L. It was common for total recoverable iron concentrations to vary over several orders of magnitude at a given site. The highest median total recoverable iron concentrations in the study area generally occurred at sites in the Cement Creek and Mineral Creek Basins in the Upper SJRB north and west of Silverton. In the Dolores River Basin, median total recoverable iron concentrations ranged from 4.8 to 450 µg/L and were less than 300 µg/L at 16 of the 17 sites analyzed. Median total recoverable iron concentrations equal to or greater than 1,000 µg/L occurred at 10 sites in the Upper SJRB. The remaining sites in the Upper SJRB had median total recoverable iron concentrations less than 800 µg/L; and most sites had median concentrations less than 450 µg/L. In the Lower SJRB, median total recoverable iron concentrations in McElmo Creek were 890 µg/L at McElmo Creek above Cortez Sanitation District, Southwest WWTP and 1,500 µg/L at McElmo Creek above Trail Canyon.

One or more samples were collected and analyzed for total (unfiltered recoverable) mercury at 156 sites. Concentrations of total mercury measured in samples from these sites ranged from less than 0.005 to 12 µg/L. Reporting limits for mercury typically ranged from 0.005 to 1 µg/L. At least one measured concentration of total mercury exceeded the State chronic aquatic-life criterion of 0.01 µg/L for 32 of the 156 sites sampled. Determining the actual distribution of mercury in surface water throughout the study area was not possible because reporting limits often varied at sites and were usually higher than the aquatic-life criterion.

Many of the dissolved lead concentrations in samples were censored. Reporting limits for lead varied from 1 to 50 µg/L and were often greater than the calculated chronic criteria. In the Dolores River Basin, only two sites had 85th percentile concentrations of dissolved lead greater than the individual reporting limits. Both sites had 85th percentile concentrations of dissolved lead equal to 1 µg/L. The 85th percentile concentrations for dissolved lead ranged from less than 1 to 250 µg/L at sites in the Upper SJRB. The highest dissolved lead concentrations in the Upper SJRB generally occurred in the Mineral and Cement Creek basins. State criteria in these areas were based on total recoverable lead concentrations, and median concentrations of total recoverable lead did not exceed criteria. In the Lower SJRB, almost all dissolved lead concentrations were censored.

The 85th percentile concentrations for dissolved zinc ranged from less than 2 to 180,000 µg/L; although, most sites in the study area generally had 85th percentile concentrations less than 200 µg/L. Four sites in the Dolores River Basin had dissolved zinc concentrations that exceeded State acute and chronic hardness-based criteria. Twenty-four sites in the Upper SJRB had 85th percentile concentrations that exceeded acute and chronic hardness-based standards. Sites with concentrations of dissolved zinc that exceeded State acute and chronic hardness-based standards in the Upper SJRB may not have exceeded segment-specific monthly standards; but monthly concentrations were not calculated. In the Lower SJRB, 85th percentile concentrations of dissolved zinc were well below the State hardness-based criteria.

Dissolved selenium concentrations in samples ranged from less than 0.2 to 170 µg/L in the study area. One site in the Dolores River Basin, Salt Creek at Highway 141 (site 35D), had an 85th percentile concentration of dissolved selenium equal to 23 µg/L which exceeded the State chronic (4.6 µg/L) and acute standards (18.4 µg/L). Most sites in the Dolores River Basin had 85th percentile concentrations equal to or less than 3 µg/L. In the Upper SJRB, 85th percentile dissolved selenium concentrations ranged from less than 1 to 11 µg/L. Most sites in the Upper SJRB had 85th percentile dissolved selenium concentrations less than 3 µg/L. One site, Salt Creek at 309A Road, in the Upper SJRB had an 85th percentile concentration of dissolved selenium that exceeded the State chronic standard. Dissolved selenium concentrations greater than the acute water-quality standard occurred in some samples along Navajo Wash in the southwestern corner of the Upper SJRB, but insufficient data were available to compute summary statistics. In the Lower SJRB, at McElmo Creek above Trail Canyon, the 85th percentile dissolved selenium concentration was equal to 5 µg/L and exceeded the State chronic standard. Dissolved selenium concentrations greater than the acute water-quality standard occurred in some samples collected from Mud Creek sites near Cortez, but insufficient data were available to compute summary statistics.

Concentrations of total ammonia, nitrate, nitrite, and total phosphorus generally were low throughout the study area. The 85th percentile concentrations of total ammonia were less than the calculated chronic and acute State table-value standards for total ammonia. Nitrate plus nitrite concentrations ranged from less than 0.05 to 15 mg/L in samples; and 87 percent of samples analyzed had concentrations less than or equal to 0.5 mg/L. In the Dolores River Basin, 85th percentile nitrate plus nitrite concentrations at the 21 sites analyzed ranged from less than 0.05 to 0.78 mg/L. In the Upper SJRB, 85th percentile nitrate plus nitrite concentrations at the 35 sites analyzed ranged from less than 0.06 to 2.4 mg/L. Only 4 sites in the Upper SJRB had 85th percentile concentrations of nitrate plus nitrite that exceeded 1 mg/L. These sites were located in the vicinity of Durango mostly on the Animas River. In the Lower SJRB, the 85th percentile nitrate plus nitrite concentration was equal to 1 mg/L at the McElmo Creek above Cortez Sanitation District, Southwest WWTP site and 2.7 mg/L downstream at the McElmo Creek above Trail Canyon at gage site. Concentrations of nitrate plus nitrate in the Lower SJRB were significantly (p-value < 0.01) higher in samples collected during the winter than in samples collected during the summer. Total phosphorus concentrations ranged from less than 0.002 to 11 mg/L, though concentrations in most samples were less than 0.1 mg/L.

Only 10 sites throughout the entire study area had adequate data to calculate summary statistics for dissolved uranium. The 85th percentile concentrations of dissolved uranium ranged from less than 3 to 10 µg/L, well below the national drinking water water-quality standard of 30 µg/L. Although dissolved uranium concentrations in most samples from most streams were less than 5 µg/L, concentrations of dissolved uranium greater than 10 µg/L were measured in some samples at various locations throughout the study area, particularly at sites in the Lower SJRB and along Navajo Wash in the Upper SJRB. Many of these site locations, where dissolved uranium concentrations were elevated, coincide with areas where the Mancos Shale crops out.

In the Dolores River Basin, significant downward trends in SC values and DS and chloride concentrations were detected at the Dolores River near Bedrock site downstream from the Paradox Valley Unit. Significant downward trends in SC values were detected at 4 of the 13 sites analyzed in the Upper SJRB. In the Lower SJRB, significant downward trends were detected in SC values and DS and sulfate concentrations at the McElmo Creek above Trail Canyon near Cortez site and in DS and sulfate concentrations at the Mud Creek at State Highway 32, near Cortez site. Downstream from these sites, at the McElmo Creek near Colorado-Utah State line site, significant downward trends in SC values and DS, chloride, and sulfate concentrations were observed. Trend tests for trace elements were limited to three sites in the Silverton area, of which one (Mineral Creek at Silverton) showed significant downward trends in total recoverable lead, dissolved zinc, and total zinc concentrations.

Overall results from the trend analyses indicate improvement in water-quality conditions as a result of operation of the Paradox Valley Unit in the Dolores River Basin and irrigation and water-delivery system improvements made in the McElmo Creek Basin and Mancos River Valley. Other detected trends period. Additional study, however, would be needed to determine the causes of the apparent changes in water-quality characteristic values over time at the sites.

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Appendix

Appendix 1. U.S. Environmental Protection Agency typical range of values for selected water-quality parameters (U.S. Environmental Protection Agency, 1977).

[U.S. Environmental Protection Agency, USEPA; Minimum sample value, minimum value from the data repository (http://rmgsc.cr.usgs.gov/cwqdr/Southwest/index.shtml) used in the analysis; Maximum sample value, maximum value from the data repository used in the analysis; °C, degrees Celsius; µS/cm, microseimen per centimeter; mg/L, milligram per liter; N, nitrogen; P, phosphorus; $CaCO_3$, calcium carbonate; NO_3, nitrate; µg/L, microgram per liter; OK, measured values were within USEPA's typical range of values for the selected water-quality parameter; 9999, one or more measured values were outside of USEPA's typical range of values for the selected water-quality parameter but were used in the analysis because the value(s) were considered reasonable for the study area]

Parameter code	Parameter code name	USEPA low value	Minimum sample value	USEPA high value	Maximum sample value	Value check
P00010	Water temperature (°C)	-2.0	-2.9	37	32	9,999
P00094	Specific conductance (µS/cm)	1.0	0.09	60,000	83,500	9,999
P00095	Specific conductance (µS/cm)	1.0	1.6	60,000	20,767	
P00300	Oxygen, dissolved (mg/L)	0.0	0	30	23	
P00400	pH (standard units)	0.9	1.5	12	10	
P00610	Ammonia, total (mg/L as N)	0.0	0.000	20	0	
P00615	Nitrite, total (mg/L as N)	0.0	0.001	5	0	
P00630	Nitrite plus nitrate, total (mg/L as N)	0.0	0	55	15	
P00665	Phosphorus, total (mg/L as P)	0.0	0	10	11	9,999
P00900	Hardness, total (mg/L as $CaCO_3$)	0.0	1.99	5,000	4,040	
P00915	Calcium, dissolved (mg/L)	0.0	0.62	1,000	600	
P00925	Magnesium, dissolved (mg/L)	0.0	0.09	1,000	752	
P00930	Sodium, dissolved (mg/L)	0.0	0.059	5,000	4,312	
P00935	Potassium, dissolved (mg/L)	0.0	0	1,000	243	
P00940	Chloride, dissolved (mg/L)	0.0	0.015	22,000	6,844	
P00945	Sulfate, total (mg/L)	0.0	0.97	2,500	6,681	9,999
P00950	Fluoride, dissolved (mg/L)	0.0	0.000	15	101	9,999
P01000	Arsenic, dissolved (µg/L)	0.0	0.001	5,000	4,700	
P01002	Arsenic, total (µg/L)	0.0	0.2	5,000	4,900	
P01045	Iron, total (µg/L)	0.0	6	56,000	887,000	9,999
P01046	Iron, dissolved (µg/L)	0.0	3	56,000	683,000	9,999
P01049	Lead, dissolved (µg/L)	0.0	0.04	1,000	800	
P01051	Lead, total (µg/L)	0.0	0.03	1,000	6,580	9,999
P01090	Zinc, dissolved (µg/L)	0.0	0.5	25,000	230,000	9,999
P01092	Zinc, total (µg/L)	0.0	1	25,000	310,000	9,999
P01105	Aluminum, total (µg/L)	0.0	21.177	20,000	230,000	9,999
P01106	Aluminum, dissolved (µg/L)	0.0	0.062	20,000	85,000	9,999
P01145	Selenium, dissolved (µg/L)	0.0	0.2	100	97	
P22703	Uranium, natural, dissolved (µg/L)	0.0	0.02	500	16	
P70300	Residue, total filtrable, dried at 180°C (mg/L)	0.0	22	4,000	59,200	9,999
P71850	Nitrate nitrogen, total (mg/L as NO_3)	0.0	0.05	65	216	9,999
P71890	Mercury, dissolved (µg/L)	0.0	0	10	260	9,999
P71900	Mercury, total (µg/L)	0.0	0.005	10	10	

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