WATER-QUALITY ASSESSMENT OF THE RIO GRANDE VALLEY, COLORADO, NEW MEXICO, AND TEXAS--Summary and analysis of water-quality data for the basic-fixed-site network, 1993-95

U.S. Department of the Interior
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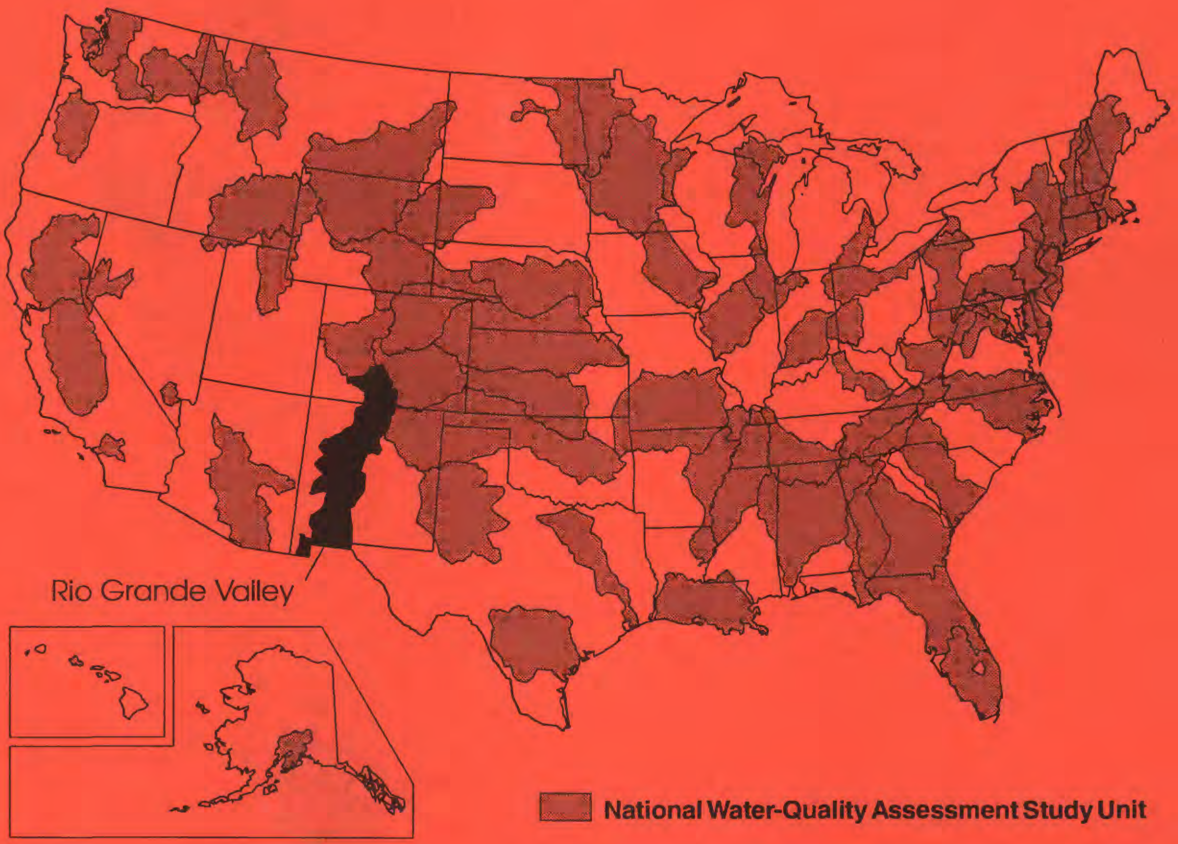
Water-Resources Investigations Report 97-4212



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By Denis F. Healy

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1997

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U.S. DEPARTMENT OF THE INTERIOR
BRUCE BABBITT, Secretary

U.S. GEOLOGICAL SURVEY
Mark Schaefer, Acting Director

For additional information write to:

District Chief
U.S. Geological Survey
Water Resources Division
4501 Indian School Road NE, Suite 200
Albuquerque, NM 87110-3929

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FOREWORD

The mission of the U.S. Geological Survey (USGS) is to assess the quantity and quality of the earth resources of the Nation and to provide information that will assist resource managers and policymakers at Federal, State, and local levels in making sound decisions. Assessment of water-quality conditions and trends is an important part of this overall mission.

One of the greatest challenges faced by water-resources scientists is acquiring reliable information that will guide the use and protection of the Nation's water resources. That challenge is being addressed by Federal, State, interstate, and local water-resource agencies and by many academic institutions. These organizations are collecting water-quality data for a host of purposes that include: compliance with permits and water-supply standards; development of remediation plans for a specific contamination problem; operational decisions on industrial, wastewater, or water-supply facilities; and research on factors that affect water quality. An additional need for water-quality information is to provide a basis on which regional and national-level policy decisions can be based. Wise decisions must be based on sound information. As a society we need to know whether certain types of water-quality problems are isolated or ubiquitous, whether there are significant differences in conditions among regions, whether the conditions are changing over time, and why these conditions change from place to place and over time. The information can be used to help determine the efficacy of existing water-quality policies and to help analysts determine the need for and likely consequences of new policies.

To address these needs, the Congress appropriated funds in 1986 for the USGS to begin a pilot program in seven project areas to develop and refine the National Water-Quality Assessment (NAWQA) Program. In 1991, the USGS began full implementation of the program. The NAWQA Program builds upon an existing base of water-quality studies of the USGS, as well as those of other Federal, State, and local agencies. The objectives of the NAWQA Program are to:

- Describe current water-quality conditions for a large part of the Nation's freshwater streams, rivers, and aquifers.
- Describe how water quality is changing over time.
- Improve understanding of the primary natural and human factors that affect water-quality conditions.

This information will help support the development and evaluation of management, regulatory, and monitoring decisions by other Federal, State, and local agencies to protect, use, and enhance water resources.

The goals of the NAWQA Program are being achieved through ongoing and proposed investigations of 59 of the Nation's most important river basins and aquifer systems, which are referred to as study units. These study units are distributed throughout the Nation and cover a diversity of hydrogeologic settings. More than two-thirds of the Nation's freshwater use occurs within the 59 study units and more than two-thirds of the people served by public water-supply systems live within their boundaries.

National synthesis of data analysis, based on aggregation of comparable information obtained from the study units, is a major component of the program. This effort focuses on selected water-quality topics using nationally consistent information. Comparative studies will explain differences and similarities in observed water-quality conditions among study areas and will identify changes and trends and their causes. The first topics addressed by the national synthesis are pesticides, nutrients, volatile organic compounds, and aquatic biology. Discussions on these and other water-quality topics will be published in periodic summaries of the quality of the Nation's ground and surface water as the information becomes available.

This report is an element of the comprehensive body of information developed as part of the NAWQA Program. The program depends heavily on the advice, cooperation, and information from many Federal, State, interstate, Tribal, and local agencies and the public. The assistance and suggestions of all are greatly appreciated.

Robert M. Hirsch
Chief Hydrologist

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CONVERSION FACTORS AND VERTICAL DATUM

Multiply	By	To obtain
foot (ft)	0.3048	meters (m)
mile (mi)	1.609	kilometers (km)
square mile (mi^2)	259	hectares
gallon (gal)	3.785	liters (L)
ounce (avoirdupois) (oz)	28.35	grams (g)
pound (lb)	0.4536	kilograms (kg)
gallon per minute (gal/min)	0.06309	liters per second (L/sec)
cubic foot per sec (ft^3/s)	28.32	liters per second
ton per day (ton/d)	0.9072	megagrams (metric ton) per day

Milliequivalents per liter (meq/L) are equal to the concentration in milligrams per liter (mg/L) divided by the combining weight, which is the formula weight of that species divided by the charge (Hem, 1985).

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) by the equation:

$$°F = 9/5\,(°C) + 32$$

Sea level: In this report, "sea level" refers to the National Geodetic Vertical Datum of 1929—a geodetic datum derived from a general adjustment of the first-order level nets of the United States and Canada, formerly called Sea Level Datum of 1929.

WATER-QUALITY ASSESSMENT OF THE RIO GRANDE VALLEY, COLORADO, NEW MEXICO, AND TEXAS -- SUMMARY AND ANALYSIS OF WATER-QUALITY DATA FOR THE BASIC-FIXED-SITE NETWORK, 1993-95

By Denis F. Healy

Abstract

The Rio Grande Valley study unit of the U.S. Geological Survey National Water-Quality Assessment Program collected monthly water-quality samples at a network of surface-water sites from April 1993 through September 1995. This basic-fixed-site network consisted of nine main-stem sites on the Rio Grande, five sites on tributaries of the Rio Grande, two sites on streams in the Rio Grande Valley study unit that are not directly tributary to the Rio Grande, and one site on a conveyance channel. During each monthly sampling, field properties were measured and samples were collected for the analysis of dissolved solids, major constituents, nutrients, selected trace elements, and suspended-sediment concentrations. During selected samplings, supplemental samples were collected for the analysis of additional trace elements, organic carbon, and/or pesticides.

Spatial variations of dissolved-solids, major-constituent, and nutrient data were analyzed. The report presents summary statistics for the monthly water-quality data by sampling site and background information on the drainage basin upstream from each site. Regression equations are presented that relate dissolved-solids, major-constituent, and nutrient concentrations to streamflow, selected field properties, and time.

Median instantaneous streamflow at each basic-fixed site ranged from 1.4 to 1,380 cubic feet per second. Median specific conductance at each basic-fixed site ranged from 84 to 1,680 microsiemens per centimeter at 25 degrees Celsius, and median pH values ranged from 7.8 to 8.5. The water sampled at the basic-fixed sites generally was well oxygenated and had a median dissolved-oxygen percent of saturation range from 89 to 108.

With the exception of Rio Grande above mouth of Trinchera Creek, near Lasauses, Colorado, dissolved-solids concentrations in the main stem of the Rio Grande generally increased in a downstream direction. This increase is from natural sources such as ground-water inflow and evapotranspiration and from anthropogenic sources such as irrigation-return flows, urban runoff, and wastewater-treatment plant discharges. The smallest median dissolved-solids concentration detected at a basic-fixed site was 58 milligrams per liter and the largest was 1,240 milligrams per liter.

The spatial distribution of calcium, magnesium, sodium, sulfate, chloride, and fluoride was similar to the spatial distribution of dissolved solids. The spatial distribution of potassium and bicarbonate varied slightly from that of dissolved solids. Median silica concentrations generally decreased in a downstream direction.

Of all cations, calcium and sodium had the largest concentrations at most basic-fixed sites. Bicarbonate and sulfate were the anions having the largest concentrations at most sites. The largest median silica concentration was at Rito de los Frijoles in Bandelier National Monument, New Mexico, where silica composed approximately 50 percent of the dissolved solids.

The largest concentrations and largest median concentrations of dissolved-nutrient analytes were detected at Santa Fe River above Cochiti Lake, New Mexico, and Rio Grande at Isleta, New Mexico. The relatively large dissolved-nutrient concentrations at these sites probably were due to discharges from wastewater-treatment plants and urban runoff.

The largest concentrations and largest median concentrations of total ammonia plus organic nitrogen and total phosphorus were detected at Rio Puerco near Bernardo, New Mexico. The largest concentrations of these nutrients at this site were associated with runoff from summer thunderstorms.

Dissolved-iron concentrations ranged from censored concentrations to 914 micrograms per liter. Median dissolved-iron concentrations ranged from 3 to 160 micrograms per liter. Dissolved-manganese concentrations ranged from censored concentrations to 300 micrograms per liter; median concentrations ranged from 1 to 68 micrograms per liter.

INTRODUCTION

The Rio Grande Valley assessment study (RIOG) began in 1991 as one of the first 20 study unit assessments of the National Water-Quality Assessment (NAWQA) Program of the U.S. Geological Survey (USGS) (Gilliom and others, 1995). RIOG personnel conducted a high-intensity sampling phase from September 1992 through September 1995. This phase included water-column and biological data collection at a network of surface-water sampling sites and surface-water, ground-water, and biological synoptic studies that ranged in size from single land-use studies to study unit assessments.

The surface-water sampling network is referred to as the basic-fixed-site network and was designed to provide an integrated assessment of the spatial and temporal distribution of general water-quality conditions and the transport of major inorganic constituents in streamwater in relation to hydrologic conditions and major sources (Gilliom and others, 1995). The RIOG basic-fixed-site network consists of 17 sites (table 1). Monthly sample collection was planned from April 1993 through September 1995, although the actual sampling schedule varied somewhat. During each monthly sampling streamflow, selected physical properties, and selected constituent concentrations (collectively hereafter referred to as field properties) were measured at the site and samples were collected for analysis of solids residue after evaporation at 180 °C (hereafter referred to as dissolved solids) (DS), major constituents, nutrients, selected trace elements, and suspended sediment (table 2). During selected monthly samplings, supplemental samples also were collected for analysis of additional trace elements (table 3), organic carbon (table 3), and pesticides and metabolites (hereafter referred to as pesticides) (table 4). Supplemental samples include water-column samples collected at some network sites as part of the USGS National Surface-Water-Quality Accounting Network (NASQAN) Program (Ficke and Hawkinson, 1975), USGS New Mexico District cooperative programs (Livingston, 1995; U.S. Geological Survey, 1995), or specific RIOG synoptic studies (Anderholm, 1996; Healy, 1996; Bexfield and Anderholm, 1997; and Carter, 1997).

Purpose and Scope

This report presents summaries and analyses of water-quality data collected at sites in the basic-fixed-site network during the RIOG high-intensity sampling phase, including regression equations relating selected water-quality data to selected field properties and time. The report focuses on the field-property, DS, major-constituent, nutrient, dissolved-iron, and dissolved-manganese data collected at the network sites using NAWQA protocols (Shelton, 1994). Most of these data are for the monthly samples collected as part of the network sampling program. Additional data are for samples collected for NASQAN, New Mexico District cooperative programs, and RIOG synoptic studies. Water-quality data for the monthly samples are summarized and analyzed for the network and then examined for individual sites. This report presents only summaries of the supplemental trace-element, organic-carbon, and pesticide data.

Description of the Rio Grande Valley Study Unit

The RIOG study unit comprises approximately 45,900 mi^2 in Colorado, New Mexico, and Texas, encompassing the surface-water drainage for the Rio Grande upstream from the USGS water-quality monitoring station Rio Grande at El Paso, Texas; the closed surface-water basins between the Rio Grande and the Continental Divide; and the closed-basin part of the San Luis Basin (fig. 1). The study unit covers parts of three physiographic provinces (Fenneman, 1931) and contains four ecological regions (Omernick, 1987). Vegetation zones vary from the alpine tundra

Table 1.--Rio Grande Valley basic-fixed-network sites

[Stream type: MS, main stem; SN, stream in study unit that is not a tributary of the Rio Grande; TR, tributary of the Rio Grande; CC, conveyance channel. Site type: IT, integrator site; IF, indicator site for forest land use; IR, indicator site for an undisturbed forested area to be used as a reference site; IU, indicator site for urban land use. mi^2, square miles; °, degrees; ′, minutes; ″, seconds]

Site number	U.S. Geological Survey Station number	U.S. Geological Survey Station name	Latitude	Longitude	Stream type	Site type	Drainage area (mi^2)	Contributing drainage area (mi^2)
1	08220000	Rio Grande near Del Norte, Colo.	37°41′22″	106°27′38″	MS	IT	1,310	1,310
2	08227000	Saguache Creek near Saguache, Colo.	38°09′48″	106°17′24″	SN	IF	512	512
3	374752105300801	Medano Creek near Mosca, Colo.	37°47′52″	105°30′08″	SN	IR	15	15
4	08240000	Rio Grande above mouth of Trinchera Creek, near Lasauses, Colo.	37°18′58″	105°44 32″	MS	IT	5,680	2,750
5	08249000	Conejos River near Lasauses, Colo.	37°18′01″	105°44′47″	TR	IT	789	789
6	08251500	Rio Grande near Lobatos, Colo.	37°04′42″	105°45′22″	MS	IT	7,520	4,590
7	08276500	Rio Grande below Taos Junction Bridge, near Taos, N. Mex.	36°19′12″	105°45′14″	MS	IT	9,460	6,530
8	08290000	Rio Chama near Chamita, N. Mex.	36°04′26″	106°06′40″	TR	IT	3,140	3,040
9	08313000	Rio Grande at Otowi Bridge, near San Ildefonso, N. Mex.	35°52′29″	106°08′30″	MS	IT	13,960	10,930
10	08313350	Rito de los Frijoles in Bandelier National Monument, N. Mex.	35°47′08″	106°16′50″	TR	IF	18	18
11	08317200	Santa Fe River above Cochiti Lake, N. Mex.	35°32′49″	106°13′41″	TR	IU	228	228
12	08331000	Rio Grande at Isleta, N. Mex.	34°54′21″	106°41′04″	MS	IT	17,570	14,540
13	08353000	Rio Puerco near Bernardo, N. Mex.	34°24′33″	106°51′09″	TR	IT	7,380	6,250
14	08358300	Rio Grande Conveyance Channel at San Marcial, N. Mex.	33°41′07″	106°59′40″	CC	IT	[1]--	[1]--
15	08358400	Rio Grande Floodway at San Marcial, N. Mex.	33°40′50″	106°59′30″	MS	IT	28,900	24,740
16	08363500	Rio Grande below Leasburg Dam, near Leasburg, N. Mex.[2]	32°28′36″	106°55′03″	MS	IT	38,500	29,000
17	08364000	Rio Grande at El Paso, Tex.	31°48′10″	106°32′25″	MS	IT	39,580	30,080

[1] Conveyance channel is an anthropogenic structure that was not assigned a drainage area.

[2] Water-quality data for this site were published under the station name Rio Grande at Leasburg Dam, N. Mex., in annual Water-Data Reports (Cruz and others, 1994; Borland and Ong, 1995; and Ortiz and Lange, 1996).

Table 2.--Streamflow, physical properties, and water-quality analytes sampled monthly

[Property or analyte: dissolved, analytes in a representative water sample passed through a 0.45-micron filter membrane for inorganic analysis or a 0.7-micron glass-fiber filter for organic analysis (Timme, 1995); total, constituents in an unfiltered, representative water-suspended-sediment sample (Timme, 1995). Parameter code, standard five-digit code used by the U.S. Geological Survey Water-Data Storage and Retrieval System (WATSTORE) (U.S.Geological Survey, 1997) and the U.S. Environmental Protection Agency data system (STORET) (U.S. Environmental Protection Agency, 1997) that uniquely identifies a specific analyte. Unit: ft^3/s, cubic feet per second; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mm of Hg, millimeters of mercury; mg/L, milligrams per liter; µg/L, micrograms per liter. Analytical method: mc, measured or calculated from rating curve; m, measured with appropriate instrument; IT, incremental titration; GR, gravimetric analysis; ICP, inductively coupled plasma; AA, atomic absorption; IC, ion-exchange chromatography; ISE, ion selective electrode; CDZ, colorimetric, diazotization; CCDZ, colorimetric, cadmium reduction diazotization; CSH, colorimetric, salicylate-hypochlorate; PPMB, colorimetric, phosphomolybdate; VAP, evaporation]

Property or analyte	Parameter code[1]	Minimum reporting level	Unit	Analytical method[2]
Streamflow, selected physical properties, and selected constituent concentrations (field properties)				
Streamflow, instantaneous	00061	0.01	ft^3/s	mc
Specific conductance	00095	1	µS/cm	m
pH (hydrogen ion activity)	00400	[3]--	pH units	m
Temperature, air	00020	-5.0	degrees Celsius	m
Temperature, water	00010	-5.0	degrees Celsius	m
Barometric pressure	00025	1	mm of Hg	m
Oxygen, dissolved	00300	.05	mg/L	m
Alkalinity, field, dissolved	39086	0	mg/L as $CaCO_3$	IT
Dissolved solids and major ions				
Solids, residue at 180 degrees Celsius (dissolved solids)	70300A	1	mg/L	GR
Calcium	00915D	.02	mg/L as Ca	ICP
Magnesium	00925C	.01	mg/L as Mg	ICP
Sodium	00930C	.2	mg/L as Na	ICP
Potassium	00935B	.1	mg/L as K	AA
Bicarbonate, field, dissolved	00453	0	mg/L as $CaCO_3$	IT
Carbonate, field, dissolved	00452	0	mg/L as $CaCO_3$	IT
Sulfate	00945G	.1	mg/L as SO_4	IC
Chloride	00940J	.1	mg/L as Cl	IC
Fluoride	00950B	.1	mg/L as F	ISE
Silica	00955D	.01	mg/L as SiO_2	ICP
Nutrients				
Nitrogen, nitrite, dissolved	00613F	0.01	mg/L as N	CDZ
Nitrogen, nitrite + nitrate, dissolved	00631E	.05	mg/L as N	CCDZ
Nitrogen, ammonia, dissolved	00608F	.015	mg/L as N	CSH
Nitrogen, ammonia + organic, dissolved	00623D	.2	mg/L as N	CSH
Nitrogen, ammonia + organic, total	00625D	.2	mg/L as N	CSH
Phosphorus, total	00665D	.01	mg/L as P	PPMB
Phosphorus, dissolved	00666D	.01	mg/L as P	PPMB
Phosphorus, orthophosphate, dissolved	00671H	.01	mg/L as P	PPMB
Selected trace elements				
Iron, dissolved	01046D	3	µg/L as Fe	ICP
Manganese, dissolved	01056C	1	µg/L as Mn	ICP
Suspended sediment				
Sediment, suspended	80154	1	mg/L	VAP

[1] Letter code that follows some parameter codes is used by WATSTORE to identify analytical method.

[2] Guy (1969); Fishman and Friedman (1989).

[3] Range of reported pH values can be from 0 to 14 pH units.

Table 3.--Supplemental trace-element and organic-carbon analytes

[Analyte: whole water recoverable, because of incomplete digestion determination represents a value less than the total amount (less than 95 percent) of the analyte present in the dissolved and suspended phases (Timme, 1995); dissolved, analytes in a representative water sample passed through a 0.45-micron filter membrane for inorganic analysis or a 0.7-micron glass-fiber filter for organic analysis (Timme, 1995). Parameter code, standard five-digit code used by the U.S. Geological Survey Water-Data Storage and Retrieval System (WATSTORE) (U.S. Geological Survey, 1997) and the U.S. Environmental Protection Agency data system (STORET) (U.S. Environmental Protection Agency, 1997) that uniquely identifies a specific analyte. Unit: µg/L, micrograms per liter; mg/L, milligrams per liter. Analytical method: DCP, direct-current plasma; ICP/MS, inductively coupled plasma / mass spectrometry; AA, atomic absorption; ICP, inductively coupled plasma; GFAA, graphite furnace atomic absorption; BAASF, barbituric acid, automated-segmented flow, colorimetric; CVAA, cold vapor atomic absorption; WOX, wet oxidation]

Analyte	Parameter code[1]	Minimum reporting level	Unit	Analytical method[2]
Aluminum, whole water recoverable	01105C	10	µg/L as Al	DCP
Aluminum, dissolved	01106G	1	µg/L as Al	ICP/MS
	01106E	10	µg/L as Al	DCP
Antimony, whole water recoverable	01097A	1	µg/L as Sb	AA
Antimony, dissolved	01095G	1	µg/L as Sb	ICP/MS
Arsenic, whole water recoverable	01002B	1	µg/L as As	AA
Arsenic, dissolved	01000B	1	µg/L as As	ICP/MS
Barium, whole water recoverable	01007A	100	µg/L as Ba	AA
Barium, dissolved	01005G	1	µg/L as Ba	ICP/MS
	01005C	2	µg/L as Ba	ICP
Beryllium, whole water recoverable	01012A	10	µg/L as Be	AA
Beryllium, dissolved	01010G	1	µg/L as Be	ICP/MS
Boron, whole water recoverable	01022B	10	µg/L as B	DCP
Boron, dissolved	01020G	10	µg/L as B	DCP
Cadmium, whole water recoverable	01027F	1	µg/L as Cd	GFAA
Cadmium, dissolved	01025F	1	µg/L as Cd	GFAA
	01025G	1	µg/L as Cd	ICP/MS
Chromium, whole water recoverable	01034E	1	µg/L as Cr	GFAA
Chromium, dissolved	01030I	1	µg/L as Cr	GFAA
	01030G	1	µg/L as Cr	ICP/MS
Cobalt, whole water recoverable	01037F	1	µg/L as Co	GFAA
Cobalt, dissolved	01035G	1	µg/L as Co	ICP/MS
	01035C	3	µg/L as Co	ICP
Copper, whole water recoverable	01042F	1	µg/L as Cu	GFAA
Copper, dissolved	01040F	1	µg/L as Cu	GFAA
	01040G	1	µg/L as Cu	ICP/MS
Cyanide, whole water recoverable	00720	10	µg/L as Cn	BAASF
Cyanide, dissolved	00723	10	µg/L as Cn	BAASF
Iron, whole water recoverable	01045B	10	µg/L as Fe	AA
Lead, whole water recoverable	01051F	1	µg/L as Pb	GFAA

Table 3.--Supplemental trace-element and organic-carbon analytes--Concluded

Analyte	Parameter code[1]	Minimum reporting level	Unit	Analytical method[2]
Lead, dissolved	01049F	1	µg/L as Pb	GFAA
	01049G	1	µg/L as Pb	ICP/MS
Lithium, whole water recoverable	01132A	10	µg/L as Li	AA
Lithium, dissolved	01130B	4	µg/L as Li	ICP
Manganese, whole water recoverable	01055A	10	µg/L as Mn	AA
Mercury, whole water recoverable	71900B	.1	µg/L as Hg	CVAA
Mercury, dissolved	71890B	.1	µg/L as Hg	CVAA
Molybdenum, whole water recoverable	01062A	1	µg/L as Mo	GFAA
Molybdenum, dissolved	01060G	1	µg/L as Mo	ICP/MS
	01060A	10	µg/L as Mo	ICP
Nickel, whole water recoverable	01067F	1	µg/L as Ni	GFAA
Nickel, dissolved	01065F	1	µg/L as Ni	GFAA
	01065G	1	µg/L as Ni	ICP/MS
Selenium, whole water recoverable	01147A	1	µg/L as Se	AA, hydride
Selenium, dissolved	01145A	1	µg/L as Se	AA, hydride
Silver, whole water recoverable	01077F	1	µg/L as Ag	GFAA
Silver, dissolved	01075F	1	µg/L as Ag	GFAA
	01075G	1	µg/L as Ag	ICP/MS
Strontium, whole water recoverable	01082A	10	µg/L as Sr	AA
Strontium, dissolved	01080B	.1	µg/L as Sr	ICP
Uranium, dissolved	22703G	1	µg/L as U	ICP/MS
Vanadium, dissolved	01085B	6	µg/L as V	ICP
Zinc, whole water recoverable	01092A	10	µg/L as Zn	AA
Zinc, dissolved	01090G	1	µg/L as Zn	ICP/MS
	01090A	10	µg/L as Zn	AA
Carbon, organic, total	00680A	.1	mg/L as C	WOX
Carbon, organic, dissolved	00681A	.1	mg/L as C	WOX
Carbon, organic, suspended	00689A	.1	mg/L as C	WOX

[1] Letter code that follows some parameter codes is used by WATSTORE to identify analytical method.

[2] Wershaw and others (1987); Fishman and Friedman (1989); Faires (1993).

Table 4.--Supplemental pesticide and metabolite analytes

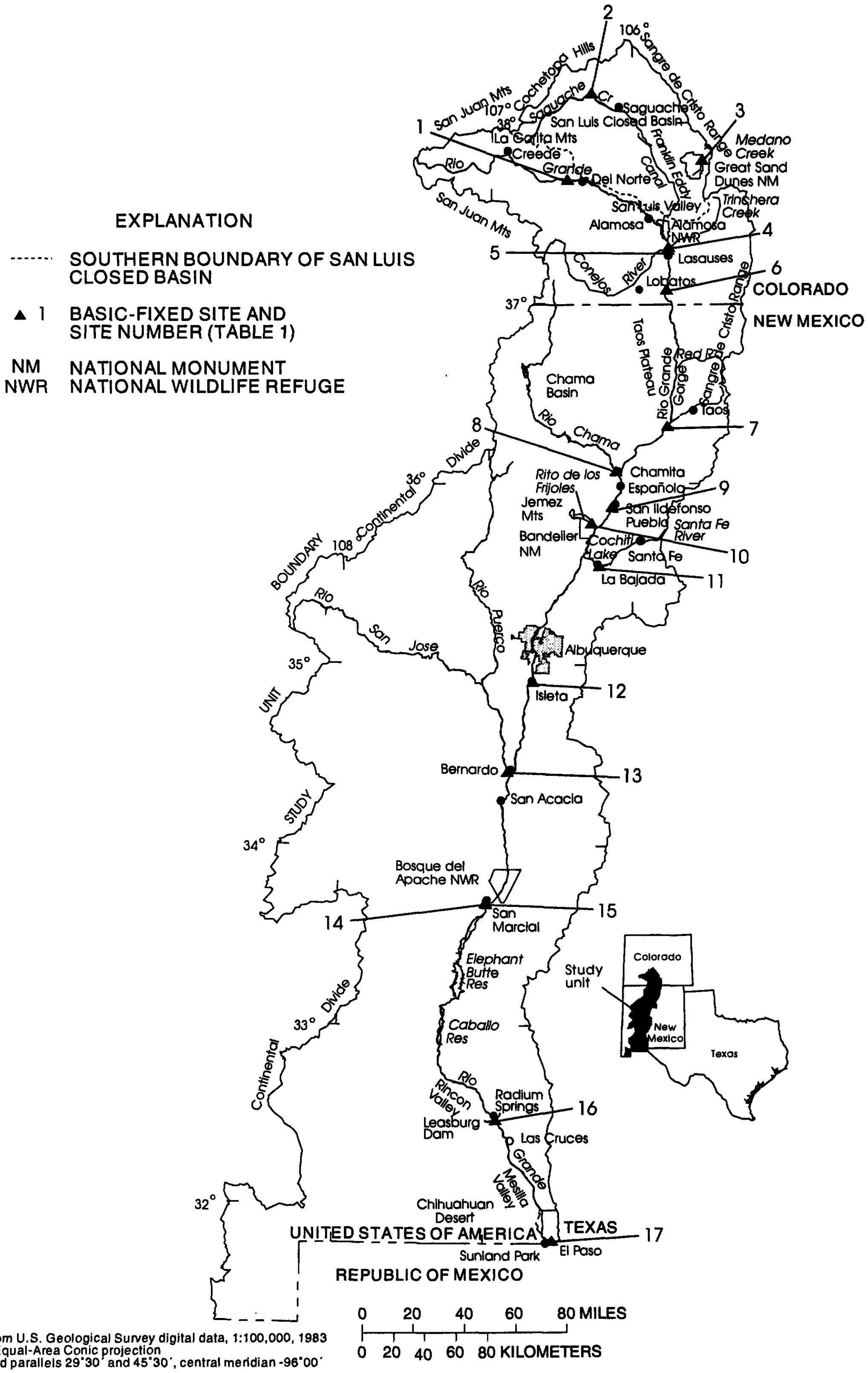
[Parameter code, standard five-digit code used by the U.S. Geological Survey Water-Data Storage and Retrieval System (WATSTORE) (U.S. Geological Survey, 1997) and the U.S. Environmental Protection Agency data system (STORET) (U.S. Environmental Protection Agency, 1997) that uniquely identifies a specific analyte. Pesticides listed in the left columns extracted by C-18 solid-phase extraction cartridge and analyzed by gas chromatography/mass spectrometric detector (Zaugg and others, 1995). Pesticides listed in the right columns extracted by Carbopak-B solid-phase extraction cartridge and analyzed by high-performance liquid chromatography (Werner and others, 1996). Pesticide method detection limits are in micrograms per liter]

Analyte	Parameter code[1]	Method detection limit	Analyte	Parameter code[1]	Method detection limit
Acetochlor	49260A	0.002	Acifluorfen	49315A	0.035
Alachlor	46342D	.002	Aldicarb	49312A	.016
Atrazine	39632D	.001	Aldicarb sulfone	49313A	.016
Benfluralin	82673D	.002	Aldicarb sulfoxide	49314A	.021
Alpha BHC	34253D	.002	Bentazon	38711A	.014
Butylate	04028D	.002	Bromacil	04029A	.035
Carbaryl	82680D	.003	Bromoxynil	49311A	.035
Carbofuran	82674D	.003	Carbaryl	49310A	.008
Chlorpyrifos	38933D	.004	Carbofuran	49309A	.028
Cyanazine	04041D	.004	3-OH-carbofuran	49308A	.014
DCPA	82682D	.002	Chloramben	49307A	.011
p,p'-DDE	34653D	.006	Chlorothalonil	49306A	.035
Deethyl atrazine	04040D	.002	Clopyralid	49305A	.050
Diazinon	39572D	.002	2,4-D	39372B	.035
Dieldrin	39381D	.001	2,4-DB	38746A	.035
2,6 Diethylaniline	82660D	.003	Dacthal, MA	49304A	.017
Disulfoton	82677D	.017	Dicamba	38442A	.035
EPTC	82668D	.002	Dichlobenil	49303A	.020
Ethalfluralin	82663D	.004	Dichlorprop	49302A	.032
Ethoprop	82672D	.003	Dinoseb	49301A	.035
Fonofos	04095D	.003	Diuron	49300A	.020
Lindane (γ-HCH)	39341D	.004	DNOC	49299A	.035
Linuron	82666D	.002	Esfenvalerate	49298A	.019
Malathion	39532D	.005	Fenuron	49297A	.013
Methyl azinphos	82686D	.001	Fluometuron	38811A	.035
Methyl parathion	82667D	.006	Linuron	38478A	.018
Metolachlor	39415D	.002	MCPA	38482A	.050
Metribuzin	82630D	.004	MCPB	38487A	.035
Molinate	82671D	.004	Methiocarb	38501A	.026
Napropamide	82684D	.003	Methomyl	49296A	.017

Table 4.--Supplemental pesticide and metabolite analytes--Concluded

Analyte	Parameter code[1]	Method detection limit	Analyte	Parameter code[1]	Method detection limit
Parathion	39542D	0.004	1-Naphthol	49295A	0.007
Pebulate	82669D	.004	Neburon	49294A	.015
Pendimethalin	82683D	.004	Norflurazon	49293A	.024
Permethrin	82687D	.005	Oryzalin	49292A	.019
Phorate	82664D	.002	Oxamyl	38866A	.018
Prometon	04037D	.018	Picloram	49291A	.050
Pronamide	82676D	.003	Propham	49236A	.035
Propachlor	04024D	.007	Propoxur	38538A	.035
Propanil	82679D	.013	Silvex	39762B	.021
Propargite	82685D	.004	2,4,5-T	39742B	.035
Simazine	04035D	.005	Triclopyr	49235A	.050
Tebuthiuron	82670D	.010			
Terbacil	82665D	.007			
Terbufos	82675D	.013			
Thiobencarb	82681D	.002			
Triallate	82678D	.001			
Trifuralin	82661D	.002			

[1] Letter code that follows some parameter codes is used by WATSTORE to identify analytical method.



Base from U.S. Geological Survey digital data, 1:100,000, 1983
Albers Equal-Area Conic projection
Standard parallels 29°30′ and 45°30′, central meridian -96°00′

Figure 1.--Rio Grande Valley study unit.

regions of the San Juan Mountains in Colorado and Sangre de Cristo Range in Colorado and New Mexico to the Chihuahuan Desert in southern New Mexico and Texas (fig. 1). Land use in the study unit is mainly rangeland (71 percent), forest (22 percent), and agriculture (6 percent) (Anderson and others, 1976; U.S. Geological Survey, 1986). A detailed description of the environmental setting of the Rio Grande Valley study unit is presented in Ellis and others (1993).

Data Collection and Laboratory Analysis Methods

Water-quality samples were collected and processed at basic-fixed sites following protocols described in Shelton (1994). Depth- and width-integrated samples were composited, then split into separate samples for most analytical determinations. Water temperature and dissolved-oxygen (DO) concentrations were measured at one location in the cross section, and organic-carbon samples were dip samples collected from one vertical in the cross section. Streamflow was measured following procedures in Buchanan and Somers (1969) or was calculated from gage height-discharge rating curves (Kilpatrick and Schneider, 1983; Kennedy, 1984).

Most of the samples were analyzed at the USGS National Water Quality Laboratory (NWQL) in Arvada, Colorado. The samples to be analyzed for nutrients, organic carbon, and pesticides were shipped as soon as possible by overnight express. Nutrient samples initially were shipped chilled with mercuric chloride as a preservative; however, after quality-control tests by the NWQL found no statistical difference in nutrient concentrations between samples chilled and preserved with mercuric chloride and samples chilled with no preservative (D.A. Rickert, U.S. Geological Survey, written commun., 1994), the nutrient samples were shipped chilled without preservatives. Samples to be analyzed for DS, major constituents, and trace elements were shipped either with the above samples or at a later date. The methods of analysis for the various different analytes are listed in tables 2, 3, and 4. Descriptions of the analytical methods used for DS, major constituents, nutrients, and dissolved iron and manganese can be found in Fishman and Friedman (1989); for the additional trace elements in Faires (1993); for organic carbon in Wershaw and others (1987); and for pesticides in Zaugg and others (1995), Lindley and others (1996), and Werner and others (1996). Alkalinity, carbonate, and bicarbonate concentrations were analyzed at the sampling site by incremental titration. Suspended-sediment concentrations were measured at the USGS New Mexico District sediment laboratory using methods described in Guy (1969).

Data Summary and Analysis Methods

In this report, major-constituent, nutrient, and trace-element data are reported as censored or uncensored. Censored data are data reported as less than a value, generally the minimum reporting level (MRL). The MRL is defined by the NWQL as the smallest concentration of an analyte that may be reliably reported using a given analytical method (Timme, 1995). Uncensored data are data for which an unqualified numerical value is given.

Mean and standard deviation for data sets with censored data were calculated in one of three ways. For sets that had less than 20 percent censored data, the censored data were assigned a value one-half the MRL, and the mean and standard deviation were calculated in the usual manner. For sets that had between 20 and 80 percent inclusive censored data, the mean and standard deviation were calculated by log-probability regression (Gilliom and Helsel, 1986). If, however, the uncensored data did not contain at least three unique values, there was not sufficient variation to perform log-probability regression. For these sets, a range was calculated for the mean by assigning the censored data a value of zero to calculate the lower end of the range and then assigning the censored data a value equal to the MRL to calculate the upper end of the range. The standard deviation was not reported for these data sets. For sets that had more than 80 percent censored data, a range for the mean was calculated by the above procedure and the standard deviation was not reported.

The mean for pH was calculated by transforming the pH data to hydrogen ion activity values, determining the mean of these values, and then transforming this mean back to pH units. All other statistical values for pH were calculated directly from pH units.

Because un-ionized ammonia is highly toxic to aquatic life, un-ionized ammonia concentrations were calculated and included in tables with the dissolved-ammonia data. Un-ionized ammonia concentrations for data sets that had censored dissolved-ammonia concentrations were calculated by assigning the ammonia MRL value to the censored data. This process is a conservative measure that creates a high bias for these calculated values. None of the un-ionized ammonia concentrations calculated by using the ammonia MRL value exceeded any water-quality standards or criteria.

Pesticide concentrations in this report are reported as censored, uncensored, or estimated data. Censored pesticide data are data reported as less than the method detection limit (MDL), which is defined by the NWQL as the minimum concentration at which a compound can be identified, measured, and reported with 99-percent confidence that the compound concentration is greater than zero (Timme, 1995). Pesticide data reported as censored can result when the compound is not present or, if present, the compound cannot be conclusively identified and measured. Uncensored pesticide data are data for which an unqualified numerical value is given. Estimated pesticide data are data for which a qualified numerical value is given. Estimated values less than the MDL are data for which the compound can be identified and measured, but with less than 99-percent confidence that the compound is actually present. Estimated values at or above the MDL can result from a poor performance record of the analyte with the analytical method used (Zaugg and others, 1995), matrix interference, or small sample volume (J.W. Pritt, National Water Quality Laboratory, written commun., 1994). Estimated concentrations in this report are identified by an E before the value.

Relations among field properties and analytes were examined by using Kendall's tau correlation coefficients, a rank-based procedure that measures the strength of the monotonic relation between two variables (Helsel and Hirsch, 1992). This procedure is resistent to outliers, measures linear and nonlinear monotonic correlations, and can be used with censored data. Kendall's tau correlation coefficients were generated for all data collectively and for each site separately. For this report, coefficients greater than or equal to 0.7 or less than or equal to -0.7 show a strong correlation, coefficients between 0.3 and 0.7 or between -0.3 and -0.7 show a moderate correlation, and coefficients between -0.3 and 0.3 inclusive show no correlation. The strong correlations were graphed to confirm that the correlation was a true indication of the relation.

Regression equations for estimating DS, major-constituent, nutrient, iron, and manganese concentrations were developed by entering the data into a multiple regression statistical package and picking the "best fit" regression equation by Mallow's Cp (Ott, 1993). The possible independent variables in the equations were limited to instantaneous streamflow, specific conductance, pH, water temperature, DO, and a temporal variable to represent seasonality. For analytes that had between 5 and 20 percent censored data, a Kendall-Theil robust line (Helsel and Hirsch, 1992) was calculated between the analyte and the independent variable with the strongest Kendall's tau correlation. The Kendall-Theil robust line goes through the median of the data. Estimates made from these lines are strongest near the median and become weaker near the extremes (maximum and minimum) of the data. For analytes that had greater than 20 percent censored values, no equation was developed.

The regression equations can be used to estimate the analyte concentrations at each of the sites; however, these regression equations are statistically derived "best fit" and may or may not have any connection with actual physical, chemical, or biological processes. Also, analysis of additional data may result in changes to these equations.

The tables provide the adjusted coefficient of determination (R^2) (Ott, 1993) for each multiple regression. This statistic gives the fraction of the variance in the analyte explained by the equation.

Two-tailed Wilcoxon signed-rank nonparametric statistical tests were used to examine the difference in data among sites. Nonparametric tests use the ranking of the data rather than the data values themselves. Two-tailed tests assume that the difference can be greater or less, whereas a one-tailed test assumes a direction. A description of the Wilcoxon signed-rank test can be found in Ott (1993). If the result of the statistical test was equal to or greater than the 95-percent confidence level, then the data sets were accepted as statistically different. If the result was less than the 95-percent confidence level, the difference between the data sets was assumed to be due to chance and not significant.

Acknowledgments

The author thanks the members of the RIOG Liaison Committee for their assistance in the design of the basic-fixed-site network and the various Federal, State, local, and Indian pueblo government personnel who contributed to the success of the data collection effort by assisting with water-quality sampling, measuring streamflow, or supplying ancillary data. The author also thanks Harriet R. Allen, Todd M. Kelly, and Gary K. Speiran for their reviews and comments in the preparation of this report. Steven F. Richey prepared the map and graphical displays used in this report.

The author particularly wishes to acknowledge the USGS Hydrologic Technicians responsible for collecting most of the data used in this report: Lynn K. Miller, Robert M. Moquino, and Bruce A. Hill. Bruce R. Goddard, Lee W. Lewis, and Stephanie L. Marr (Lundstrom) of the USGS also assisted in the data collection effort at various times.

BASIC-FIXED-SITE NETWORK

The basic-fixed-site network sampling program provides the data needed to assess spatial and temporal water-quality trends. Two site types are in this network: integrator sites and indicator sites. Integrator sites are located downstream from large, complex drainage basins that often contain multiple environmental settings. Indicator sites are located at outlets of drainage basins that have homogeneous land use and physiographic conditions. Gilliom and others (1995) discussed the purpose of the basic-fixed-site network, the logic behind site selection, and the sampling strategy used to choose sampling sites from the NAWQA perspective.

The RIOG basic-fixed-site network consists of 17 sites, of which 13 are integrator sites and 4 are indicator sites. The integrator sites include all nine main-stem sites (sites 1, 4, 6, 7, 9, 12, and 15-17), three tributary sites (sites 5, 8, and 13), and the conveyance channel site (site 14) (table 1). Site 14 is classified as an integrator site although it is on an anthropogenic structure and not assigned a drainage basin area. The indicator sites include two tributary sites (sites 10 and 11) and two sites on streams in the study unit that are not direct tributaries to the Rio Grande (sites 2 and 3) (table 1). Sites 2 and 3 are on streams that discharge into the San Luis Closed Basin, which is defined by a topographic divide that prevents surface water from naturally draining into the Rio Grande (Ellis and others, 1993). The indicator sites can be further classified as an indicator site for urban land use (site 11), indicator sites for forest land (sites 2 and 10), and a reference site for forest land (site 3) (table 1). Reference sites are located downstream from undisturbed drainages that represent the selected physiographic and ecological regions within the study unit and are chosen to represent background conditions (Gilliom and others, 1995).

SUMMARY AND ANALYSIS OF MONTHLY WATER-QUALITY DATA

This section presents summaries and analyses of the field-property and chemical-analyte data for the monthly samples. The monthly data for all sites are examined collectively in separate sections for field properties, DS and major constituents, nutrients, and dissolved iron and dissolved manganese. The monthly samples for individual sites are then examined separately.

Field Properties

Field properties are the determinations measured in the field because these measurements that represent ambient field conditions cannot be made elsewhere (table 2). Because of its influence on and relation to water quality, instantaneous streamflow is included in this report although it is not a water-quality property. Instantaneous streamflow was smallest at the indicator sites on the perennial streams draining small basins and largest at integrator sites 9 and 12 on the main stem. Instantaneous streamflow ranged from 0.26 ft^3/s at site 10 to 7,960 ft^3/s at site 9. At various times during the high-intensity sampling phase, however, there was no streamflow at some basic-fixed sites. The median instantaneous streamflow at each individual site ranged from 1.4 ft^3/s at site 10 to 1,380 ft^3/s at site 9.

Collectively for the basic-fixed sites, instantaneous streamflow showed no correlation with all other field properties and chemical analytes, mainly due to the different instantaneous streamflows among the various sites. For individual sites, however, instantaneous streamflow was strongly correlated with specific field properties and chemical analytes.

At most sites, instantaneous streamflow fluctuated seasonally, and the largest flows were during snowmelt in the spring. However, summer thunderstorms caused the largest flows at site 13, and releases from Caballo Reservoir for irrigation caused the largest flows at sites 16 and 17.

Specific-conductance values also had a wide range at the basic-fixed sites. Specific-conductance values generally were lower at the indicator sites draining small forested basins (sites 2, 3, and 10) and integrator sites 1 and 5. Specific-conductance values generally were greater at integrator sites 13 on an ephemeral tributary, 14 on the conveyance channel, and 16 and 17 on the main stem in the lower part of the study unit. Specific conductance ranged from 42 microsiemens per centimeter at 25 °C (µS/cm) at sites 1 and 3 to 2,960 µS/cm at site 13. Median specific conductance for individual sites ranged from 84 µS/cm at site 3 to 1,680 µS/cm at site 13.

For all sites collectively, specific conductance showed strong positive correlations with DS (correlation coefficient of 0.94) and all major constituents (0.71 to 0.91) except silica (-0.19), no correlation to moderate positive correlations with nutrients (0.09 to 0.45), and a moderate negative correlation with dissolved iron (-0.60). For all sites collectively, specific conductance showed no correlation with instantaneous streamflow (0.11), although for individual sites, the correlation between specific conductance and instantaneous streamflow ranged from no correlation to strongly negative (-0.20 to -0.85).

Specific conductance showed some seasonality especially at the sites where correlations with instantaneous streamflow were moderately to strongly negative. At most of these sites, specific conductance decreased during the late spring as flow increased from snowmelt and increased during the summer as flow decreased. For the other sites, the relation between specific conductance and instantaneous streamflow is altered or controlled by other natural or anthropogenic processes that are discussed in the sections on individual sites.

The pH measured at the basic-fixed sites ranged from 6.9 pH units at site 3 to 9.3 pH units at site 16; the median pH ranged from 7.8 pH units at sites 1, 3, and 10 to 8.5 pH units at site 11. For all data collectively, pH had a moderate positive correlation with specific conductance (0.35) and most major constituents (0.31 to 0.38) except silica (-0.07) and a moderate negative correlation with dissolved iron (-0.32), although the strength of the correlations varied among the individual sites. For the most part, pH did not exhibit seasonality.

The water at the basic-fixed sites was generally well oxygenated. Measured DO concentrations ranged from 3.5 mg/L at site 6 to 14.3 mg/L at site 10; median DO concentrations ranged from 7.7 mg/L at site 12 to 9.3 mg/L at site 8. Because the 100-percent-saturation DO concentration strongly depends on water temperature, there was a moderate negative correlation between DO and water temperature (-0.68) for the collective data and a strong negative correlation for most individual sites. Other properties and analytes showed no correlation with DO for the collective data. DO concentrations were very seasonal because of the relation between DO and water temperature.

Another way to express DO is percent of saturation. The 100-percent-saturation concentration of DO increases with decreasing water temperature and decreases with decreasing barometric pressure. The basic-fixed sites in the Colorado and northern New Mexico parts of the study unit are cooler and higher in altitude than the sites in the Chihuahuan Desert part of the study unit and have larger 100-percent-saturation concentrations of DO. The DO percent of saturation ranged from 49 at site 6 to 163 at site 6; the median DO percent of saturation ranged from 89 at site 12 to 108 at site 6.

Dissolved Solids and Major Constituents

A graphical summary of the magnitudes of DS and major-constituent concentrations detected at the basic-fixed sites is presented in figure 2. The box plots were calculated from base 10 logarithm transformations to accommodate the range of concentrations. The box plot for fluoride in figure 2 was truncated at the MRL by assigning the MRL value to any censored data.

Figure 2 shows that for DS and most major constituents the range of concentrations was greater than an order of magnitude and for some major constituents greater than two orders of magnitude. Of the cations, calcium had the largest median concentration (39 mg/L) and sodium had the largest maximum concentration (460 mg/L). Sodium also had the largest range for base 10 logarithm transformations (2.49 log units) and also for the non-transformed concentrations (458.5 mg/L). Of the anions, bicarbonate had the largest median concentration (120 mg/L) and sulfate had the largest maximum concentration (1,200 mg/L). Chloride had the largest range for base 10 logarithm transformations (3.18 log units) and sulfate had the largest range for non-transformed concentrations (1,198.4 mg/L).

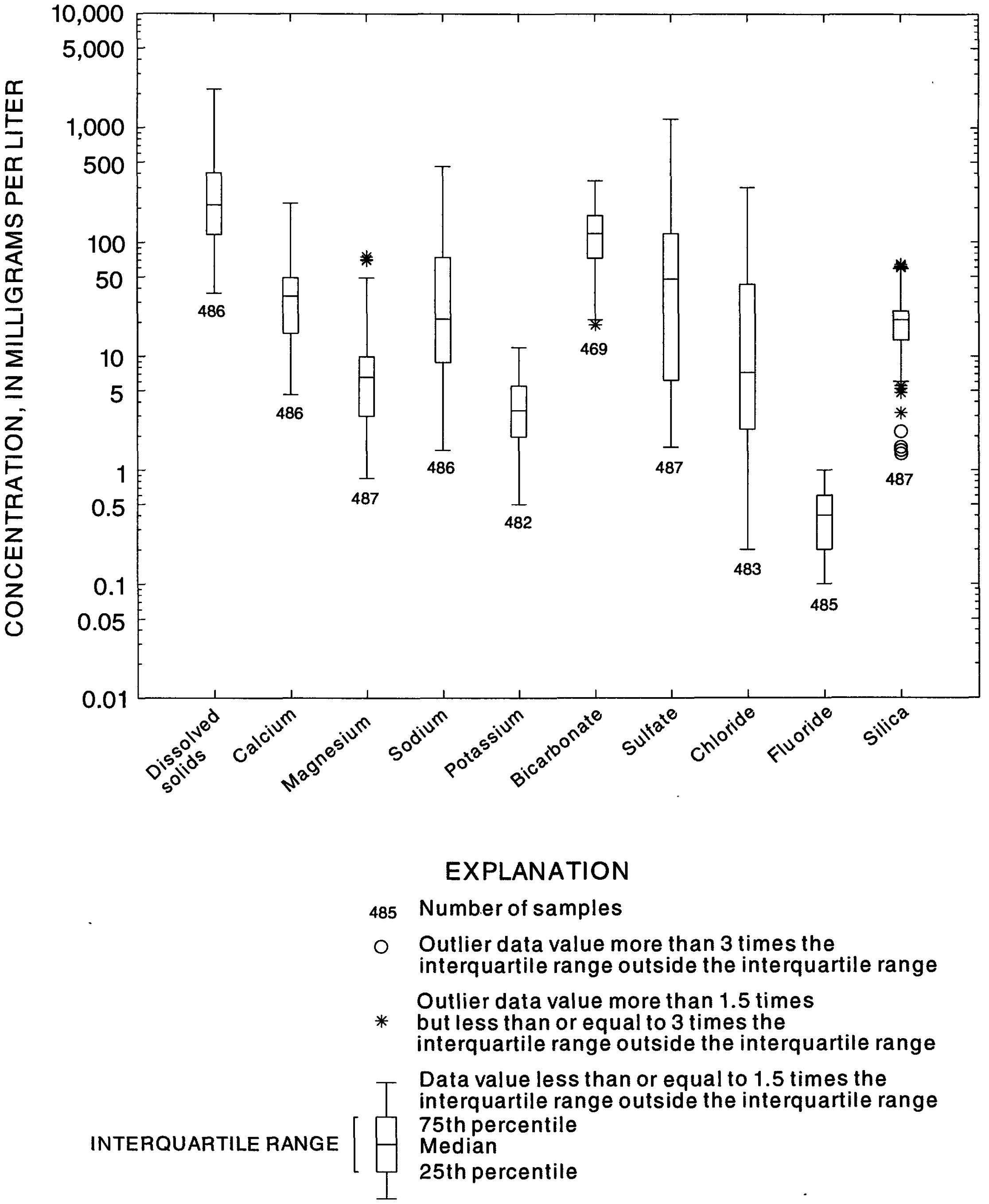


Figure 2.--Dissolved-solids and major-constituent concentrations detected at basic-fixed sites. Box plot for fluoride truncated at minimum reporting level.

The smallest median DS concentration at a basic-fixed site was 58 mg/L at site 3. The largest median DS concentration at a basic-fixed site was 1,240 mg/L at site 13. With the exception of silica, DS had strong positive correlations with all major constituents (0.70 to 0.93) and major constituents had moderate to strong positive correlations among themselves (0.58 to 0.93). Silica showed no correlation with DS (-0.16) and showed no correlation to moderate negative correlations with the other major constituents (-0.03 to -0.32).

The relation among DS and the major constituents can be seen in figure 3. The size of the pie diagrams depicts the median DS concentrations. The upper semicircle of each pie diagram represents 100 percent of total milliequivalents per liter for the median cation concentrations, and the lower semicircle represents 100 percent of total milliequivalents per liter for the median anion concentrations. The sectors in each semicircle indicate the percentage of total cations or anions for that particular ion or pair of ions. The radius of the smaller concentric circle in each pie diagram represents the concentrations of silica relative to DS.

With the exception of site 4, DS concentrations generally increased in the main stem Rio Grande in a downstream direction. DS concentrations at site 1 were the smallest for a main-stem site and of the same magnitude as those at sites 2, 3, 5, and 10. The median DS concentration increased between site 1 and 4 (73 to 298 mg/L); however, there is no direct correlation between concentrations at sites 1 and 4. High flow at site 1 coincides with the irrigation season in the San Luis Valley; most flow at site 1 is diverted before it reaches site 4, and during parts of some years, no flow at site 1 reaches site 4 (Ralph Curtis, Rio Grande Water Conservation District, oral commun., 1996). The increase in DS at site 4 probably was due to a combination of natural and anthropogenic sources downstream from the irrigation diversions and evapotranspiration of the water in the main stem. The median DS concentration in the main stem decreased between sites 4 and 6 (298 to 191 mg/L) because of dilution mainly from the inflow of the Conejos River. Between sites 6 and 7, the median DS concentration increased approximately 2 percent (191 to 194 mg/L), but median instantaneous streamflow increased approximately 73 percent (365 to 633 ft^3/s). This indicates that the median DS concentration of inflows in this reach was similar to the median concentration at site 6. The median DS concentration increased approximately 1 percent between sites 7 and 9 (194 to 196 mg/L), and the median instantaneous streamflow increased approximately 118 percent (633 to 1,380 ft^3/s). This indicates that also in this reach the median DS concentration of the inflow was similar to that at site 7.

Downstream from site 9, the Rio Grande flows through Cochiti Lake; downstream from this reservoir, flow in the river is completely regulated. Downstream from Cochiti Dam, flow is diverted for irrigation, and the Rio Grande receives return flows from agricultural drains and flows past the Albuquerque urban area, from whence it receives urban runoff and discharges from point sources such as wastewater-treatment plants (WWTP's). Between sites 9 and 12, the median DS concentration in the main stem increased approximately 23 percent (196 to 242 mg/L) and the median instantaneous streamflow decreased 8 percent (1,380 to 1,260 ft^3/s).

The median DS concentration at site 15 (299 mg/L) was approximately 24 percent larger than that at site 12 (242 mg/L), but the median instantaneous streamflow was approximately 23 percent smaller (1,260 to 975 ft^3/s). All tributaries in this reach are ephemeral and their contribution to instantaneous streamflow and DS concentration at site 15 is erratic. Most of the time, these tributaries will contribute little or no flow; at certain times, however, especially during the summer months when main-stem flow is low, discharge from one or more of these tributaries dominates DS concentrations at site 15. In addition to inflow from natural tributaries, the Rio Grande receives irrigation-return flows and urban discharges in the upper part of this reach. In the lower part of the reach, most irrigation-return flows discharge to the conveyance channel (Bureau of Reclamation, 1977).

Between sites 15 and 16, the median DS concentration in the Rio Grande increased approximately 50 percent (299 to 448 mg/L) and the median instantaneous streamflow decreased 6 percent (975 to 916 ft^3/s). However, the hydrologic connection between these two sites has been highly altered by humans. The Rio Grande flows through Elephant Butte and Caballo Reservoirs, and streamflow is almost entirely regulated for irrigation downstream from Caballo Reservoir. During the nonirrigation season, no water is released from Caballo Reservoir and streamflow at site 16 is mainly from ground-water inflow. During the irrigation season, most streamflow

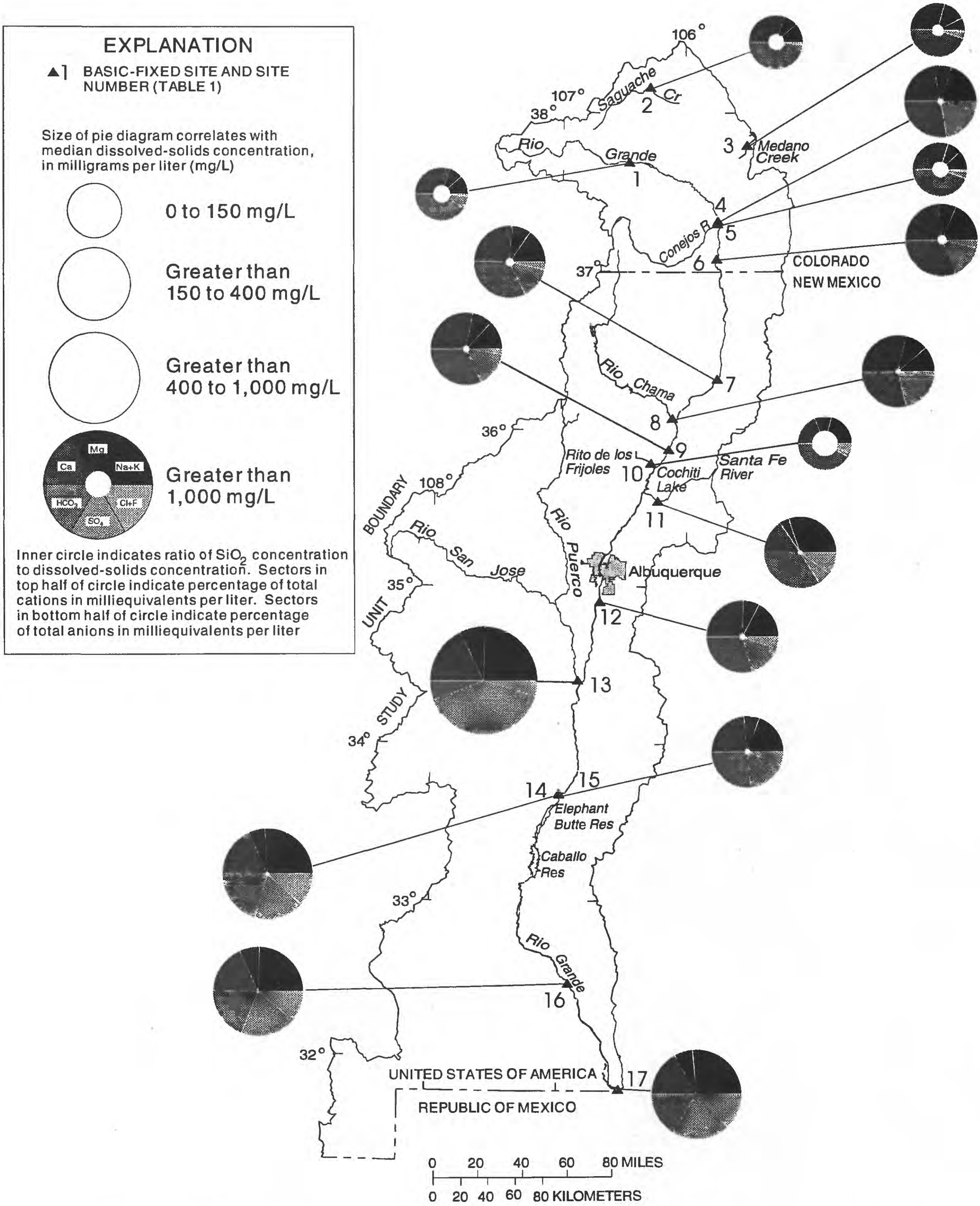


Figure 3.--Median dissolved-solids concentrations and major-constituent ratios at basic-fixed sites.

at site 16 is water released from Caballo Reservoir plus some irrigation-return flow and ground-water inflow.

Between sites 16 and 17, the median DS concentration increased approximately 46 percent (448 to 652 mg/L) and the median instantaneous streamflow decreased approximately 16 percent (916 to 770 ft^3/s). The streamflow regime is similar to that at site 16 except that a larger percentage of the flow is irrigation-return flow. Point discharges and urban runoff may affect water quality in the river in this reach, and site 17 is located near the downstream end of an alluvial basin (Ellis and others, 1993) with the associated upwelling of ground water.

The spatial distribution of median calcium, magnesium, sodium, sulfate, chloride, and fluoride concentrations was similar to the spatial distribution of DS, although the relative differences in concentrations among sites varied for different constituents. For potassium, the major difference in spatial distribution was the decrease in median concentration from site 6 to site 9. For bicarbonate, the largest median concentration was at site 11 (239 mg/L), and the median concentration at site 13 (130 mg/L) was approximately equal to that at site 12 (137 mg/L).

Of all cations, calcium and sodium had the largest concentrations at most basic-fixed sites. When comparing median concentrations in millieqivalents per liter, calcium was the predominant (greater than 50 percent of the total cation milliequivalents per liter) cation at sites 1-3, 5, 7-9, and 12. Sodium was the predominant cation at sites 11 and 17. For the remainder of the sites, neither calcium nor sodium was predominant; however, calcium exceeded sodium in percentage of total cation milliequivalents per liter at sites 4, 6, and 15, they were approximately equal at site 10, and sodium exceeded calcium at sites 13, 14, and 16. Site 3 differed from the other sites in that magnesium exceeded sodium.

Of all anions, bicarbonate and sulfate had the largest concentrations at most basic-fixed sites. Bicarbonate was the predominant anion at all sites except sites 13, 14, 16, and 17. Sulfate was the predominant anion at site 13. Bicarbonate exceeded sulfate in percentage of total anion milliequivalents per liter at site 14, they were approximately equal at site 16, and sulfate exceeded bicarbonate at site 17. Sites 10 and 11 differed from the other sites in that chloride exceeded sulfate.

The median concentration of silica generally decreased at basic-fixed sites in a downstream direction. The spatial distribution of silica also differed from DS in that the median concentration at site 13 was the smallest (7.8 mg/L). The largest silica concentrations were detected at site 10 where the median concentration (57 mg/L) was approximately double the second largest median concentration (29 mg/L at site 2). A noticeable decrease in silica between sites 15 and 16 may be due to biological uptake in Elephant Butte and Caballo Reservoirs.

Silica accounts for approximately 50 percent of the DS at site 10, which is located on a tributary that drains a basin that is predominantly underlain by volcanic tuff. Silica was also a large part of DS at sites 1, 2, and 5 where it accounted for approximately 30 percent of the DS and at site 3 where it accounted for approximately 20 percent of the DS. For the remaining sites, silica concentration as a percentage of DS concentration generally decreased downstream as the concentration of DS increased.

Nutrients

A graphical summary of the magnitudes of nutrient concentrations at the basic-fixed sites is presented in figure 4. The box plots were calculated from base 10 logarithm transformations to accommodate the range of concentrations. All box plots in figure 4 were truncated at the MRL for that analyte by assigning the MRL value to any censored data. The box plot for dissolved nitrite (NO_2) is a straight line at the MRL concentration because more than 75 percent of NO_2 values were censored. The box plot for dissolved ammonia plus organic nitrogen is truncated above the median line because more than 50 percent of dissolved ammonia plus organic nitrogen values were censored.

Figure 4 shows that the range of nutrient concentrations was greater than an order of magnitude and for some nutrients greater than two orders of magnitude. The large number of outliers are due to relatively large concentrations at specific sites.

The largest concentrations and largest median concentrations for the dissolved-nutrient analytes were at sites 11 and 12. Site 11 is a tributary indicator site for urban land use and site 12 is a main-stem integrator site downstream from the Albuquerque area. The relatively large dissolved-nutrient concentrations at these sites probably were due to discharges from WWTP's and

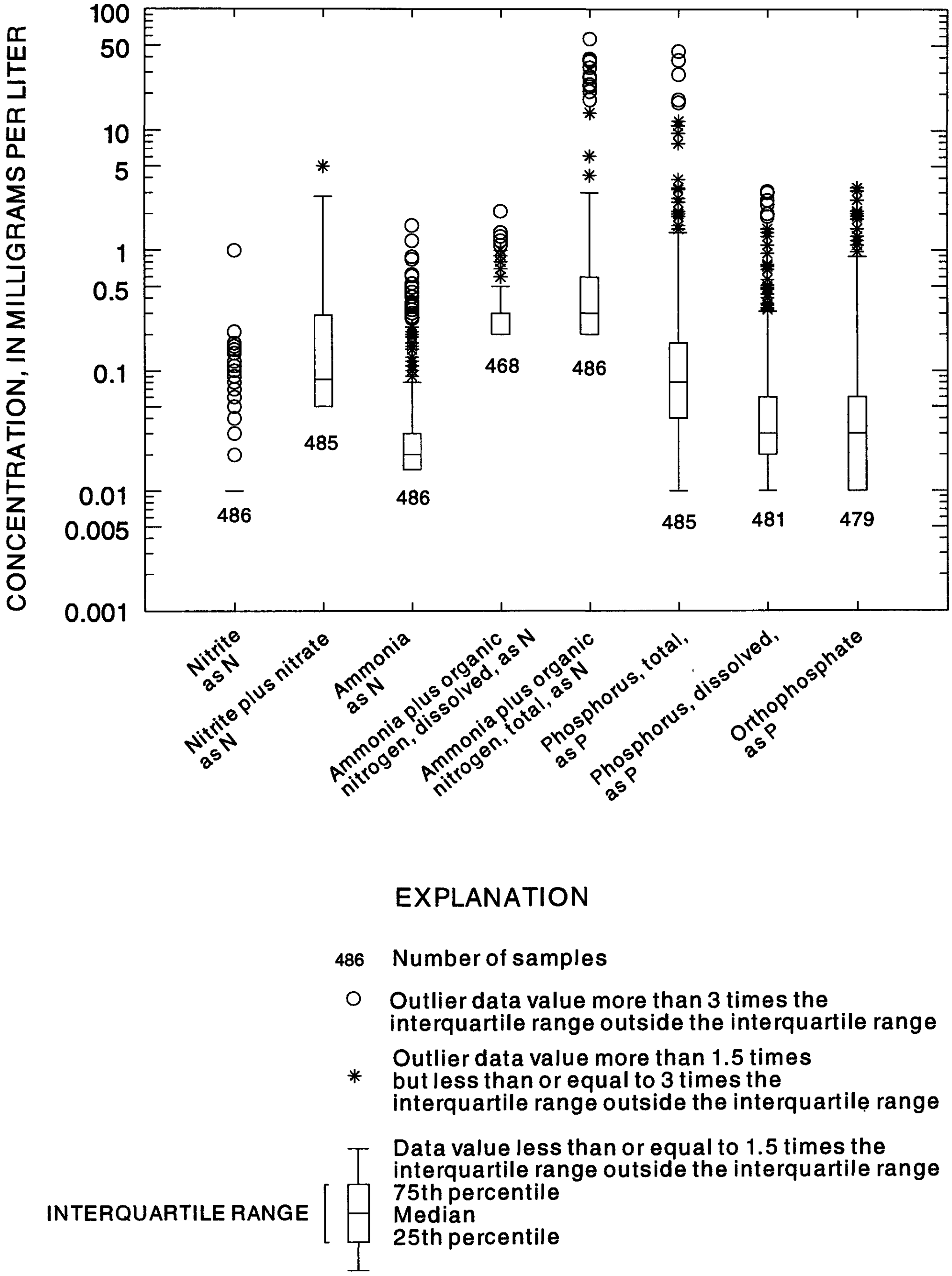


Figure 4.--Nutrient concentrations detected at basic-fixed sites. Box plots for all nutrient analytes truncated at their respective minimum reporting levels.

urban runoff. The second largest median concentration for dissolved nitrite plus nitrate ($NO_2 + NO_3$) was at site 13, an integrator site on an ephemeral tributary. The larger concentrations of $NO_2 + NO_3$ at this site were associated with runoff from summer thunderstorms. The source of this $NO_2 + NO_3$ is probably atmospheric deposition and animal manure on the rangeland upstream from this site (Anderholm and others, 1995).

The largest concentrations and largest median concentrations of total ammonia plus organic nitrogen and total phosphorus were at site 13. As with $NO_2 + NO_3$, the largest concentrations of these nutrients at this site were associated with runoff from summer thunderstorms. Relatively large concentrations of both total nutrient analytes were detected at sites 11 and 15. Most total nutrient analytes at site 11 were in the dissolved phase and associated with WWTP discharges and urban runoff; the largest concentrations of both total nutrients at this site, however, were associated with runoff from snowmelt. The largest concentrations of both total nutrient analytes at site 15 were associated with runoff from ephemeral tributaries.

For all sites collectively, the nutrients showed no correlation to moderate positive correlations with specific conductance (0.09 to 0.45), and the major constituents (-0.02 to 0.48). $NO_2 + NO_3$ showed a moderate negative correlation with dissolved iron (-0.37). Among themselves, most nutrients showed no correlation to moderate positive correlations (0.24 to 0.69), and because most of the dissolved phosphorus is orthophosphate, dissolved phosphorus and orthophosphate showed a strong positive correlation (0.81).

The spatial distribution of $NO_2 + NO_3$ concentrations at the basic-fixed sites is presented in figure 5. The size of the pie diagrams correlates with median $NO_2 + NO_3$ concentrations. The sites that had the smaller median concentrations (sites 1-3, 5, 6, 8, and 10) were all located in Colorado and northern New Mexico. More than 75 percent of the $NO_2 + NO_3$ concentrations at sites 2, 5, 8, and 10 and more than 50 percent of the concentrations at sites 1, 3, and 6 were censored. Site 4 had the largest median concentration (0.06 mg/L) in the Colorado part of the study unit probably due to the anthropogenic discharges upstream from this site. The increase in $NO_2 + NO_3$ concentrations between sites 6 and 7 probably were due to a combination of mineralization/nitrification of organic nitrogen in the main stem, ground-water inflow containing a larger $NO_2 + NO_3$ concentration to the main stem and tributaries, and irrigation-return flow and WWTP discharges to tributaries. The large decrease in $NO_2 + NO_3$ concentration between sites 15 and 16 was probably due to denitrification or uptake by biota in Elephant Butte and Caballo Reservoirs.

Dissolved Iron and Dissolved Manganese

Dissolved-iron concentrations ranged from censored values at sites 13-17 to 914 micrograms per liter (µg/L) at site 13. The range of median concentrations was from 3 µg/L at sites 16 and 17 to 160 µg/L at site 2. Dissolved-manganese concentrations ranged from censored concentrations at sites 13-17 to 300 µg/L at site 4. The range of median concentrations was from 1 µg/L at site 15 to 68 µg/L at site 4.

For all sites collectively, dissolved iron showed a moderate negative correlation with specific conductance (-0.60), pH (-0.32), DS (-0.58), the major constituents (-0.43 to -0.62) except silica (0.26), and $NO_2 + NO_3$ (-0.37) and a moderate positive correlation with dissolved manganese (0.35). Dissolved manganese showed no correlation with all other properties and analytes except dissolved iron and silica (0.34).

Dissolved iron and dissolved manganese differed from DS, major constituents, and nutrients in that the larger median concentrations were detected in Colorado and northern New Mexico. The five sites where the largest median dissolved-iron concentrations were detected (sites 1-3, 5, and 10) are the same sites where the smallest median DS concentrations were detected. Hem (1985) stated that a flowing surface stream that is fully aerated should not contain more than a few micrograms per liter of uncomplexed dissolved iron at equilibrium. The relatively large dissolved-iron concentrations at these five sites may be due to particulates that passed through the 0.45-micron filter (Kennedy and others, 1974). The dissolved-manganese concentrations at sites 4, 5, and 6, as a group, were significantly larger (greater than a 99-percent confidence level) than the concentrations at the other basic-fixed sites.

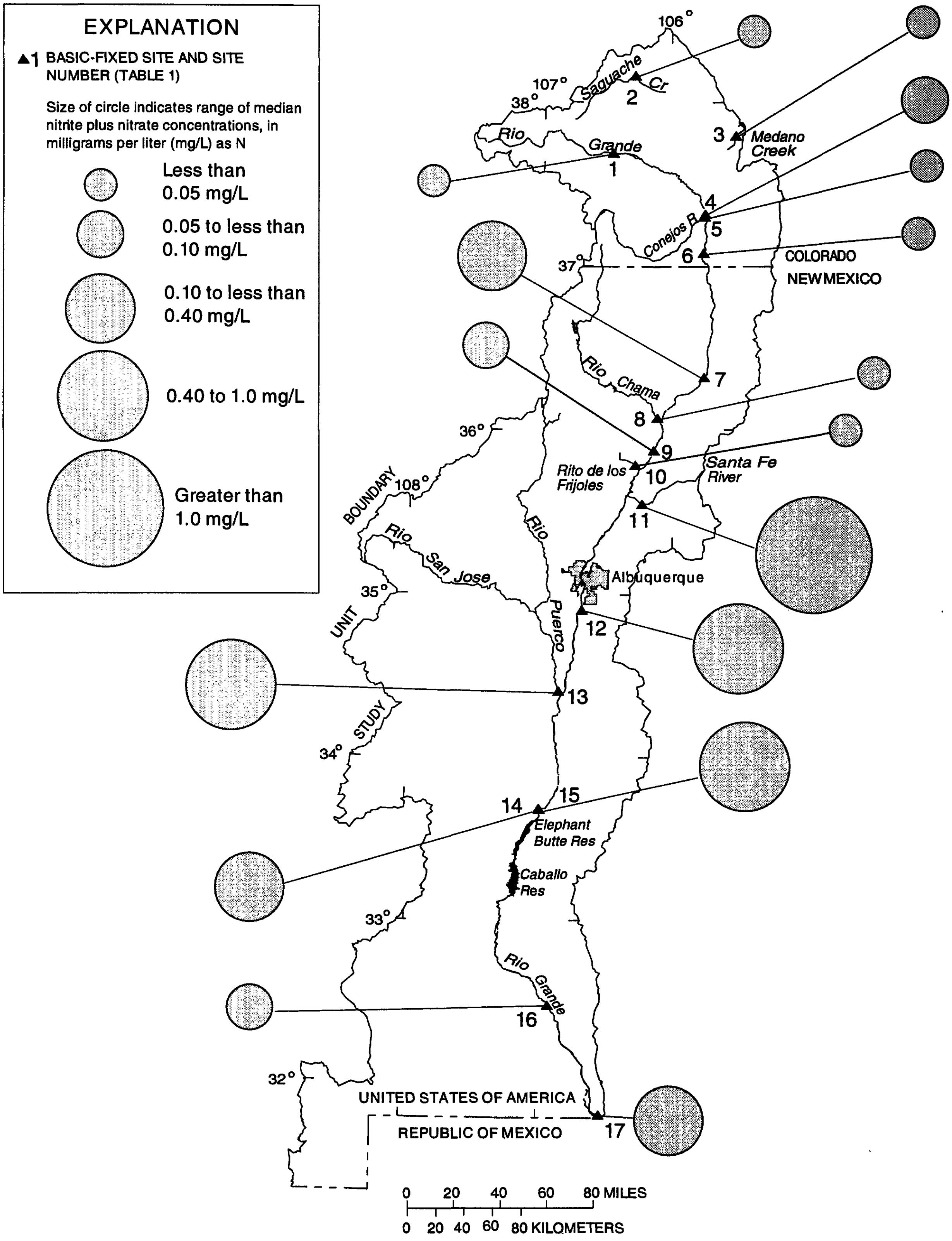


Figure 5.--Median dissolved nitrite plus nitrate concentrations detected at basic-fixed sites.

Summary and Analysis by Basic-Fixed Site

In this section, water-quality data for individual sites are presented in summary statistics tables. The tables are accompanied by a short description of the site location and drainage-basin characteristics upstream from the site and an analysis of the water quality at the site. Each section also contains a table of regression equations relating selected field properties and time to DS and major-constituent and nutrient analytes that have less than 20 percent censored values. In general the discussion follows the sites in a downstream direction in the watershed.

In the discussion on water quality, the median concentrations of individual analytes are grouped into low, middle, and high groups. This grouping system was developed as a reference system for readers who are not familiar with water quality in the upper Rio Grande Valley and wonder how analyte concentrations at individual sites compared with similar concentrations at other basic-fixed sites. For each analyte, the sites were ranked in order from 1 to 17; the site having the smallest median concentration was ranked 1 and the site having the largest median concentration was ranked 17. Sites with the same median concentration were assigned the average rank for those sites--that is, if two sites had the same median concentration and would have been assigned ranks 4 and 5, both sites were assigned rank 4.5. Sites with ranks from 1 to 5 were assigned to the low group, sites with ranks from 6 to 12 were assigned to the middle group, and sites with ranks 13 to 17 were assigned to the high group. Ranks that equaled 5.5 were rounded to 6 and assigned to the middle group; ranks that equaled 12.5 were rounded to 12 and assigned to the middle group. Special consideration was given to median concentrations that were censored data. These median concentrations were assigned values equal to one-half the MDL and used to rank the uncensored median concentrations for that analyte. In the discussion, however, these uncensored median concentrations are not included in any group, but are mentioned as being below the MDL for that analyte.

Site 1 - Rio Grande near Del Norte, Colo.

Site 1, the most upstream integrator site on the main stem of the Rio Grande, is approximately 6 mi west of Del Norte, Colorado. The streamflow-gaging station at this site is operated by the Colorado Division of Water Resources (CDWR) and is located on the right bank about 20 ft downstream from the bridge on county road 17. Low-flow samples were collected by wading downstream from the bridge, and high-flow samples were collected from a cableway located approximately 0.25 mi upstream from the bridge.

Upstream from this site, the Rio Grande drains a 1,310-mi^2 mountainous basin that is mainly forest and rangeland (U.S. Geological Survey, 1986). This basin includes areas of historical mining activity, the largest of which centers around Creede, Colorado, approximately 30 mi upstream from site 1. Major bedrock types in the drainage basin are Tertiary tuff and lava (Tweto, 1979).

Streamflow at this site varies seasonally. High flows, which occur in the late spring and early summer, result mainly from snowmelt in the San Juan Mountains. Late summer and early autumn storms may cause some high flows, but these flows have neither the magnitude nor duration of the high spring flows. Upstream reservoirs regulate flow somewhat, and there are some small diversions for irrigation and some transmountain diversions from the Colorado River Basin to the Rio Grande Basin. The annual mean discharge at site 1 for water years (WY's) 1890 to 1995 was 908 ft^3/s (Crowfoot and others, 1996). The annual mean discharge for WY 1993 was 900 ft^3/s (Ugland and others, 1994); for WY 1994 was 722 ft^3/s (Ugland and others, 1995); and for WY 1995 was 1,164 ft^3/s (Crowfoot and others, 1996). A water year starts October 1 of the previous calendar year and ends September 30 of the calendar year by which it is identified.

The water sampled at site 1 was a well-oxygenated, calcium bicarbonate type. The median specific-conductance value was 87, the median pH value was 7.8, and the median DO percent of saturation was 98. DS and most major constituents were in the low group; silica was in the middle group. The median magnesium and bicarbonate concentrations were the smallest for any basic-fixed site. The median concentrations of all nitrogen nutrients were below their respective MDL's, whereas the phosphorous nutrients were in the middle group. Dissolved iron was in the high group; dissolved-iron concentrations were larger than expected for well-oxygenated surface waters (Hem, 1985), possibly due to particulates and/or colloids that passed through a 0.45-micron filter (Kennedy and others, 1974). Dissolved manganese was also in the high group. Summary statistics for field-property and chemical-analyte data for site 1 are presented in table 5.

Specific conductance (-0.81) and DS (-0.74) showed strong negative correlations with streamflow; the major constituents showed moderate negative to strong negative correlations with streamflow (-0.43 to -0.85). High flows in late spring and early summer had the lowest concentrations of DS and major constituents. $NO_2 + NO_3$ showed a moderate negative correlation with streamflow (-0.62). For this nitrogen analyte, high-flow concentrations were below the MRL and low-flow concentrations were above the MRL. Dissolved iron showed a moderate positive correlation with streamflow (0.49), whereas dissolved manganese showed a moderate negative correlation (-0.57). Regression equations that relate selected water-quality data to selected field properties and time are presented in table 6.

Site 2 - Saguache Creek near Saguache, Colo.

Site 2 is an indicator site for a small forested basin on a stream that is not a tributary to the Rio Grande. Saguache Creek drains parts of the La Garita Mountains and Cochetopa Hills of the San Juan Mountains and discharges into the San Luis Closed Basin. The streamflow-gaging station at this site is operated by the CDWR and is located on private land approximately 10 mi northwest of Saguache, Colorado. Low-flow samples were collected by wading upstream from the gage, and high-flow samples were collected from a cableway about 25 ft downstream from the gage.

Upstream from site 2, the Saguache Creek Basin has a 512-mi^2 drainage area that is mainly forest and rangeland (U.S. Geological Survey, 1986). Some abandoned mines are in the basin and the site itself is near fields that are sporadically used for grazing livestock. Major bedrock types in the basin are Tertiary tuff and lava (Tweto, 1979).

Streamflow at this site is seasonal; most high flows result from snowmelt in the late spring and early summer. The Tarbell Ditch transmountain diversion discharges into the basin upstream from the gage. Some water is diverted from the creek for irrigation, also upstream from the gage. The annual mean discharge at site 2 for WY's 1910 to 1995 was 68.1 ft^3/s (Crowfoot and others, 1996). The annual mean discharge for WY 1993 was 66.9 ft^3/s (Ugland and others, 1994); for WY 1994 was 45.7 ft^3/s (Ugland and others, 1995); and for WY 1995 was 82.4 ft^3/s (Crowfoot and others, 1996).

The water sampled at site 2 was a well-oxygenated, calcium bicarbonate type. The median specific-conductance value was 126, the median pH value was 8.0, and the median DO percent of saturation was 103. DS and most major constituents were in the low group; silica was in the high group. About 25 percent of the samples contained silica concentrations above the common range for surface waters, 1 to 30 mg/L (Hem, 1985). The larger concentrations of silica were detected during the winter months and were probably the result of a larger percentage of the streamflow that is older ground water from the volcanic tuffs. The median concentrations of all dissolved-nitrogen nutrients were below their respective MDL's. The median concentration of total ammonia plus organic nitrogen was at the MDL, 0.2 mg/L as N, which is in the middle group for the RIOG basic-fixed sites. Total phosphorus was in the middle group; dissolved phosphorus and orthophosphate were in the high group. Dissolved iron was in the high group; dissolved-iron concentrations were larger than expected for well-oxygenated surface waters (Hem, 1985), possibly due to particulates and/or colloids that passed through a 0.45-micron filter (Kennedy and others, 1974). Dissolved manganese was also in the high group. Summary statistics for field-property and chemical-analyte data for site 2 are presented in table 7.

Streamflow did not correlate strongly with any field property or chemical analyte. Samples collected during the two highest streamflows, however, contained the largest concentrations of DS, sodium, magnesium, potassium, dissolved ammonia plus organic nitrogen, total ammonia plus organic nitrogen, iron, and manganese detected at this site. These samples also were among those that had the largest concentrations of calcium, bicarbonate, and sulfate. Regression equations that relate selected water-quality data to selected field properties and time are presented in table 8.

Site 3 - Medano Creek near Mosca, Colo.

Site 3 is an indicator reference site for a small forested basin on Medano Creek, which is not a tributary to the Rio Grande. Medano Creek drains part of the west slope of the Sangre de Cristo Range and discharges into the San Luis Closed Basin along the eastern edge of the dune field in Great Sand Dunes National Monument, Colorado. The site is located approximately 5 mi north of the monument's visitor

Table 5.--Statistical summary of selected water-quality data for site 1 - Rio Grande near Del Norte, Colo.

[Property or analyte: µS/cm, microsiemens per centimeter at 25 degrees Celsius; diss, dissolved, mg/L, milligrams per liter; it, incremental titration; µg/L, micrograms per liter. MRL, minimum reporting level; std dev, standard deviation; C, calculated value; --, not applicable; <, less than]

Property or analyte (unit)	Number of samples	MRL	Percent less than MRL	Mean	Std dev	Minimum	Percentiles 10	Percentiles 25	Percentiles 50 Median	Percentiles 75	Percentiles 90	Maximum
Streamflow, instantaneous (cubic feet per second)	32	0.01	0	1,010	1,270	175	196	238	350	1,110	3,550	4,870
Specific conductance (µS/cm)	33	1.0	0	83	22	42	47	61	87	97	111	114
pH (standard units)	33	.1	0	[1]7.6	.4	7.1	7.3	7.5	7.8	8.0	8.2	8.5
Temperature, water (degrees Celsius)	33	-5.0	0	7.3	6.3	-.5	-.5	.5	7.0	13.0	16.0	18.0
Oxygen, diss (mg/L)	32	.1	0	9.1	1.5	6.0	6.9	7.9	9.2	10.3	10.7	12.4
Oxygen, diss (percent saturation)	32	C	--	97	7	79	87	92	98	102	107	114
Hardness (mg/L as $CaCO_3$)	29	C	--	32	8.2	17	18	24	34	38	41	44
Hardness, noncarbonate (mg/L as $CaCO_3$)	22	C	--	.5	2	0	0	0	0	0	2	7
Alkalinity, it-field (mg/L as $CaCO_3$)	23	1	0	35	8	15	21	30	37	43	45	45
Solids, sum of constituents, diss (mg/L)	29	C	--	66	16	39	41	52	68	78	86	92
Solids, residue at 180 degrees Celsius (mg/L) (diss solids)	29	1	0	70	16	41	44	56	73	86	88	93
Calcium, diss (mg/L as Ca)	29	.02	0	10	2.6	5.4	5.7	7.4	11	12	13	14
Magnesium, diss (mg/L as Mg)	29	.01	0	1.6	.40	.85	.89	1.2	1.7	1.9	2.0	2.2
Sodium, diss (mg/L as Na)	29	.2	0	3.7	1.0	1.9	2.0	2.6	3.7	4.5	4.9	5.3
Sodium percentage	29	C	--	19	.9	18	18	18	19	20	20	21
Sodium adsorption ratio	29	C	--	.3	.05	.2	.2	.2	.3	.3	.3	.4
Potassium, diss (mg/L as K)	29	.1	0	1.5	.3	.9	1.0	1.3	1.6	1.7	1.8	1.9
Bicarbonate, it-field (mg/L as HCO_3)	23	1	0	43	10	19	25	36	44	52	55	55
Carbonate, it-field (mg/L as CO_3)	23	0	0	.04	.2	0	0	0	0	0	0	1
Sulfate, diss (mg/L as SO_4)	29	.1	0	5.8	1.9	2.9	3.0	3.6	6.0	7.5	8.4	8.9
Chloride, diss (mg/L as Cl)	29	.1	0	.8	.3	.3	.3	.4	.7	1.0	1.3	1.6
Fluoride, diss (mg/L as F)	29	.1	45	[2].06-.11	--	<.1	<.1	<.1	.1	.1	.1	.2
Silica, diss (mg/L as SiO_2)	29	.01	0	22	3.9	14	16	19	23	24	27	28
Nitrogen, nitrite, diss (mg/L as N)	29	.01	93	[3].002-.011	--	<.01	<.01	<.01	<.01	<.01	<.01	.05
Nitrogen, nitrite plus nitrate, diss (mg/L as N)	29	.05	66	[4].05	[4].04	<.05	<.05	<.05	<.05	.08	.12	.17
Nitrogen, ammonia, diss (mg/L as N)	29	.015	52	[4].018	[4].011	<.015	<.015	<.015	<.015	.02	.04	.05
Nitrogen, un-ionized ammonia, diss (mg/L as N)	29	[5]C	--	.0002	.0003	<.0001	<.0001	<.0001	.0001	.0003	.0008	.001
Nitrogen, ammonia plus organic, diss (mg/L as N)	29	.2	90	[3].02-.20	--	<.2	<.2	<.2	<.2	<.2	.2	.2
Nitrogen, ammonia plus organic, total (mg/L as N)	29	.2	69	[4].15	[4].11	<.2	<.2	<.2	<.2	.2	.3	.5
Phosphorus, total (mg/L as P)	29	.01	0	.05	.03	.02	.03	.04	.04	.06	.06	.17
Phosphorus, diss (mg/L as P)	29	.01	7	.03	.01	<.01	.01	.02	.03	.03	.05	.05
Phosphorus, orthophosphate (mg/L as P)	27	.01	0	.03	.01	.02	.02	.03	.03	.04	.04	.04
Iron, diss (µg/L as Fe)	29	3	0	81	40	30	34	56	74	100	140	210
Manganese, diss (µg/L as Mn)	29	1	0	12	3	6	7	10	12	14	17	19
Sediment, suspended (mg/L)	29	1	0	41	73	5	7	8	12	44	121	372
Sediment, discharge, suspended (tons/day)	29	C	--	241	562	3.6	4.4	5.8	12	136	696	2,400

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[1] Statistic calculated after transforming pH values to hydrogen-ion concentrations.

[2] Range is given for statistics for data set with more than 20 percent and less than 80 percent censored data and insufficient variation of uncensored data to perform log-probability regression.

[3] Range is given for statistics for data set with 80 percent or more censored data.

[4] Statistics are estimated by log-probability regression for data set with more than 20 percent and less than 80 percent censored data.

[5] The MRL value of 0.015 mg/L was used for censored dissolved-ammonia concentrations in calculating un-ionized ammonia concentrations. All un-ionized ammonia statistics less than 0.0001 mg/L are reported as <0.0001 mg/L.

Table 6.--Regression equations for selected water-quality analytes with selected field properties and time for site 1 - Rio Grande near Del Norte, Colo.

[Analyte: °C, degrees Celsius; diss, dissolved; ortho, orthophosphate. Unit: mg/L, milligrams per liter; µg/L, micrograms per liter. Regression equation: sclog, base 10 logarithm of specific conductance, in microsiemens per centimeter at 25 °C; temp, water temperature, in °C; sea[1], seasonality variable; sc, specific conductance, in microsiemens per centimeter at 25 °C; DOlog, base 10 logarithm of dissolved-oxygen concentration, in mg/L; qlog, base 10 logarithm of streamflow, in cubic feet per second; pH, in standard pH units; DO, dissolved-oxygen concentration, in mg/L; q, streamflow, in cubic feet per second. Adj R^2, adjusted coefficient of determination (Ott, 1993). Method: MLR, multiple linear regression; KTR, Kendall-Theil robust line. --, not applicable]

Analyte	Unit	Regression equation	Adj R^2	Method
Solids, residue at 180 °C (dissolved solids)	mg/L	$10^{(0.218 + 0.855\ \mathrm{sclog} - 0.003\ \mathrm{temp} + 0.025\ \mathrm{sea})}$	0.919	MLR
Calcium	mg/L	$10^{(-0.984 + 1.034\ \mathrm{sclog} + 0.007\ \mathrm{sea})}$	.989	MLR
Magnesium	mg/L	$10^{(-2.234 + 0.070\ \mathrm{qlog} + 1.129\ \mathrm{sclog} + 0.027\ \mathrm{pH} - 0.012\ \mathrm{DO} - 0.004\ \mathrm{temp})}$	.980	MLR
Sodium	mg/L	$10^{(-1.702 + 0.004\ \mathrm{sc} + 0.602\ \mathrm{sclog} + 0.020\ \mathrm{pH} - 0.061\ \mathrm{DO} + 1.257\ \mathrm{DOlog} + + 0.020\ \mathrm{sea})}$	.984	MLR
Potassium	mg/L	$10^{(-1.163 + 0.698\ \mathrm{sclog} + 0.021\ \mathrm{sea})}$	.757	MLR
Bicarbonate, as HCO_3	mg/L	$10^{(-0.377 + 1.033\ \mathrm{sclog})}$	.924	MLR
Sulfate, as SO_4	mg/L	$10^{(-0.123 + 0.006\ \mathrm{sc} + 0.071\ \mathrm{pH} - 0.019\ \mathrm{DO} - 0.007\ \mathrm{temp})}$	.965	MLR
Chloride	mg/L	$10^{(-2.719 + 1.400\ \mathrm{sclog} - 0.021\ \mathrm{temp} + 0.104\ \mathrm{sea})}$	.810	MLR
Silica, as SiO_2	mg/L	$8.220 + 0.0007\ q + 0.207\ \mathrm{sc} - 4.488\ \mathrm{DOlog}$	.955	MLR
Phosphorus, total, as P	mg/L	$-1.232 + 0.00005\ q - 0.088\ \mathrm{qlog} - 0.005\ \mathrm{sc} + 0.999\ \mathrm{sclog}$	.548	MLR
Phosphorus, diss, as P	mg/L	[2]0.03	--	KTR
Phosphorus, ortho, diss, as P	mg/L	$10^{(-4.836 + 0.252\ \mathrm{qlog} + 1.380\ \mathrm{sclog})}$	.379	MLR
Iron, diss	µg/L	$-3{,}352 + 0.022\ q + 124.2\ \mathrm{qlog} - 8.969\ \mathrm{sc} + 2{,}004\ \mathrm{sclog}$	.742	MLR
Manganese, diss	µg/L	$10^{(1.392 - 0.111\ \mathrm{qlog} - 0.046\ \mathrm{sea})}$	.589	MLR

[1] sea = sin(T) + cos(T) where T equals the time, in months, from December 1, 1992, times 0.5236.

[2] The slope coefficient of the Kendall-Theil robust line between dissolved phosphorus and water temperature is equal to zero.

Table 7.--Statistical summary of selected water-quality data for site 2 - Saguache Creek near Saguache, Colo.

[Property or analyte: µS/cm, microsiemens per centimeter at 25 degrees Celsius; diss, dissolved; mg/L, milligrams per liter; it, incremental titration; µg/L, micrograms per liter. MRL, minimum reporting level; std dev, standard deviation; C, calculated value; --, not applicable; <, less than]

Property or analyte (unit)	Number of samples	MRL	Percent less than MRL	Mean	Std dev	Minimum	Percentiles 10	25	50 Median	75	90	Maximum
Streamflow, instantaneous (cubic feet per second)	31	0.01	0	84	83	19	27	34	52	98	201	370
Specific conductance (µS/cm)	31	1.0	0	124	15	91	104	114	126	132	147	158
pH (standard units)	31	.1	0	[1]7.9	.3	7.3	7.5	7.9	8.0	8.2	8.5	8.7
Temperature, water (degrees Celsius)	31	-5.0	0	10.4	7.8	.0	.5	2.0	11.0	17.0	21.0	22.0
Oxygen, diss (mg/L)	31	.1	0	8.8	1.6	6.8	7.0	7.2	8.4	10.6	11.0	11.5
Oxygen, diss (percent saturation)	31	C	--	103	4	92	97	100	103	106	107	113
Hardness (mg/L as $CaCO_3$)	29	C	--	49	5.3	37	42	47	50	54	56	60
Hardness, noncarbonate (mg/L as $CaCO_3$)	26	C	--	0	0	0	0	0	0	0	0	0
Alkalinity, it-field (mg/L as $CaCO_3$)	26	1	0	58	6	42	48	53	59	62	64	68
Solids, sum of constituents, diss (mg/L)	29	C	--	96	9.5	72	84	90	96	103	108	112
Solids, residue at 180 degrees Celsius (mg/L) (diss solids)	29	1	0	99	13	69	80	92	101	108	115	127
Calcium, diss (mg/L as Ca)	29	.02	0	16	1.6	12	13	15	16	17	17	19
Magnesium, diss (mg/L as Mg)	29	.01	0	2.5	.3	1.8	2.0	2.3	2.5	2.7	3.1	3.2
Sodium, diss (mg/L as Na)	29	.2	0	5.6	1.1	3.9	4.6	4.9	5.7	5.9	7.3	9.2
Sodium percentage	29	C	--	19	2	17	17	18	18	20	22	25
Sodium adsorption ratio	29	C	--	.3	.1	.3	.3	.3	.3	.4	.4	.5
Potassium, diss (mg/L as K)	29	.1	0	2.1	.5	1.3	1.6	1.9	2	2.2	2.7	3.5
Bicarbonate, it-field (mg/L as HCO_3)	26	1	0	70	8	52	59	64	72	76	78	83
Carbonate, it-field (mg/L as CO_3)	26	0	0	.1	.3	0	0	0	0	0	0	1
Sulfate, diss (mg/L as SO_4)	29	.1	0	4.2	1.2	2.2	2.7	3.2	4.0	5.0	5.8	6.9
Chloride, diss (mg/L as Cl)	29	.1	0	1.2	.5	.5	.7	.8	1.1	1.7	2.1	2.4
Fluoride, diss (mg/L as F)	29	.1	0	.2	.05	.1	.1	.1	.2	.2	.2	.2
Silica, diss (mg/L as SiO_2)	29	.01	0	29	2.5	24	25	27	29	30	32	34
Nitrogen, nitrite, diss (mg/L as N)	28	.01	93	[2].002-.013	--	<.01	<.01	<.01	<.01	<.01	<.01	.04
Nitrogen, nitrite plus nitrate, diss (mg/L as N)	28	.05	79	[3].04	[3].03	<.05	<.05	<.05	<.05	<.05	.083	.13
Nitrogen, ammonia, diss (mg/L as N)	28	.015	57	[3].017	[3].011	<.015	<.015	<.015	<.015	.02	.04	.04
Nitrogen, un-ionized ammonia, diss (mg/L as N)	28	[4]C	--	.0006	.0001	<.0001	<.0001	<.0001	.0002	.001	.002	.002
Nitrogen, ammonia plus organic, diss (mg/L as N)	28	.2	86	[2].06-.24	--	<.2	<.2	<.2	<.2	<.2	.4	.7
Nitrogen, ammonia plus organic, total (mg/L as N)	28	.2	39	[3].3	[3].2	<.2	<.2	<.2	.2	.3	.6	.9
Phosphorus, total (mg/L as P)	28	.01	0	.10	.04	.06	.06	.07	.09	.12	.17	.20
Phosphorus, diss (mg/L as P)	28	.01	0	.06	.02	.03	.04	.05	.06	.07	.08	.13
Phosphorus, orthophosphate (mg/L as P)	27	.01	0	.06	.02	.03	.04	.05	.06	.07	.09	.12
Iron, diss (µg/L as Fe)	29	3	0	154	59	64	68	110	160	180	230	320
Manganese, diss (µg/L as Mn)	29	1	0	16	9	7	8	11	14	17	29	53
Sediment, suspended (mg/L)	28	1	0	46	39	13	14	23	29	62	105	188
Sediment, discharge, suspended (tons/day)	28	C	--	15	31	1.1	1.7	2.5	4.8	13	38	142

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[1] Statistic calculated after transforming pH values to hydrogen-ion concentrations.

[2] Range is given for statistics for data set with 80 percent or more censored data.

[3] Statistics are estimated by log-probability regression for data set with more than 20 percent and less than 80 percent censored data.

[4] The MRL value of 0.015 mg/L was used for censored dissolved-ammonia concentrations in calculating un-ionized ammonia concentrations. All un-ionized ammonia statistics less than 0.0001 mg/L are reported as <0.0001 mg/L.

Table 8.--Regression equations for selected water-quality analytes with selected field properties and time for site 2 - Saguache Creek near Saguache, Colo.

[Analyte: °C, degrees Celsius; diss, dissolved; ortho, orthophosphate. Unit: mg/L, milligrams per liter; µg/L, micrograms per liter. Regression equation: sc, specific conductance, in microsiemens per centimeter at 25 °C; sclog, base 10 logarithm of specific conductance, in microsiemens per centimeter at 25 °C; qlog, base 10 logarithm of streamflow, in cubic feet per second; DO, dissolved-oxygen concentration, in mg/L; q, streamflow, in cubic feet per second; DOlog, base 10 logarithm of dissolved-oxygen concentration, in mg/L; pH, in standard pH units; sea[1], seasonality variable. Adj R^2, adjusted coefficient of determination (Ott, 1993). Method: MLR, multiple linear regression]

Analyte	Unit	Regression equation	Adj R^2	Method
Solids, residue at 180 °C (dissolved solids)	mg/L	4.649 + 0.753 sc	0.617	MLR
Calcium	mg/L	$10^{(-0.524 + 0.729\ \mathrm{sclog} + 0.024\ \mathrm{pH})}$	.702	MLR
Magnesium	mg/L	-11.13 + 0.257 qlog + 6.278 sclog	.795	MLR
Sodium	mg/L	69.19 + 0.780 qlog + 0.227 sc - 44.940 sclog + 0.092 DO	.890	MLR
Potassium	mg/L	-1.070 + 0.0016 q + 0.024 sc	.674	MLR
Bicarbonate, as HCO_3	mg/L	$10^{(-5.506 + 0.049\ \mathrm{qlog} - 0.012\ \mathrm{sc} + 4.088\ \mathrm{sclog} + 0.172\ \mathrm{DOlog})}$	.701	MLR
Sulfate, as SO_4	mg/L	75.55 - 0.0072 q + 2.336 qlog + 0.278 sc - 58.967 sclog + 13.813 DOlog	.832	MLR
Chloride	mg/L	$10^{(-7.329 + 0.009\ \mathrm{sc} - 0.549\ \mathrm{DO} + 11.880\ \mathrm{DOlog})}$	.623	MLR
Fluoride	mg/L	-1.214 + 0.514 sclog + 0.038 pH	.340	MLR
Silica, as SiO_2	mg/L	$10^{(1.051 + 0.001\ \mathrm{sc} + 0.032\ \mathrm{pH} - 0.028\ \mathrm{sea})}$	.733	MLR
Phosphorus, total, as P	mg/L	-6.29 + 0.002 q - 0.014 sc + 4.045 sclog - 0.039 pH + 0.025 sea	.414	MLR
Phosphorus, diss, as P	mg/L	0.311 + 0.0003 q - 0.064 qlog - 0.167 DOlog	.447	MLR
Phosphorus, ortho, diss, as P	mg/L	0.307 + 0.0003 q - 0.063 qlog - 0.165 DOlog	.540	MLR
Iron, diss	µg/L	$10^{(5.22 + 0.0016\ \mathrm{q} - 0.466\ \mathrm{qlog} - 0.206\ \mathrm{pH} - 0.082\ \mathrm{DO})}$	.516	MLR
Manganese, diss	µg/L	$10^{(1.841 + 0.0006\ \mathrm{q} + 0.007\ \mathrm{sc} - 0.186\ \mathrm{pH} - 0.015\ \mathrm{temp} + 0.129\ \mathrm{sea})}$	.531	MLR

[1] sea = sin(T) + cos(T) where T equals the time, in months, from December 1, 1992, times 0.5236.

center at a streamflow-gaging station and flume operated by the National Park Service (NPS). All samples were collected upstream from the flume.

Land use in the 15-mi^2 drainage basin upstream from site 3 is forest and alpine tundra (U.S. Geological Survey, 1986). A jeep trail that follows the creek, some campsites, and a diversion from the creek to another basin for irrigation are the main anthropogenic effects in this basin. Major bedrock types in this basin are Precambrian granite and gneiss and Pennsylvanian and Permian sedimentary rock (Tweto, 1979).

No long-term streamflow records are available for site 3; however, during the high-intensity sampling phase, streamflow at site 3 was seasonal: high flows occurred in late spring and early summer in conjunction with snowmelt in the Sangre de Cristo Range. The annual mean discharge in WY 1994 was smaller than in WY 1993, and in WY 1995 it was larger than in the 2 previous years.

The water sampled at site 3 was a well-oxygenated, calcium bicarbonate type. The median specific-conductance value was 84, the median pH value was 7.8, and the median DO percent of saturation was 100. DS and the major constituents were in the low group; the median concentrations of DS, chloride, potassium, and sodium were the smallest for any basic-fixed site. The mean chloride concentration of 0.49 mg/L was approximately 5.6 times larger than the weighted monthly mean chloride concentration in precipitation of 0.087 mg/L during the high-intensity sampling phase for this area, and the mean sulfate concentration of 3.1 mg/L was approximately 4.2 times larger than the weighted monthly mean sulfate concentration of 0.736 mg/L (National Atmospheric Deposition Program, 1996). With the exception of total phosphorus, the median concentrations of all nutrients were below their respective MDL's. The median concentration of total phosphorus was at the MDL of 0.01 mg/L; this median concentration was the smallest for any basic-fixed site. Dissolved iron was in the high group; dissolved-iron concentrations were larger than expected for well-oxygenated surface waters (Hem, 1985), possibly due to particulates and/or colloids that passed through a 0.45-micron filter (Kennedy and others, 1974). Dissolved manganese was in the middle group. Summary statistics for field-property and chemical-analyte data for site 3 are presented in table 9.

Specific conductance (-0.85), DS (-0.54), and most major constituents (-0.36 to -0.82) except potassium (-0.19) showed moderate to strong negative correlations with streamflow, whereas nutrients showed no correlation to moderate positive correlations (-0.06 to 0.56). The smallest concentrations of DS and most major constituents and the largest concentrations of total phosphorus and total ammonia plus organic nitrogen were detected during the high flows in late spring and early summer. Dissolved-iron concentrations showed two annual peaks: the first during high flows in late spring and early summer and the second during low flows in late summer and early autumn. This latter peak appears to be associated with the annual die off of vegetation. Regression equations that relate selected water-quality data to selected field properties and time are presented in table 10.

Site 4 - Rio Grande above mouth of Trinchera Creek, near Lasauses, Colo.

Site 4 is an integrator site on the main stem approximately 3.2 mi north of Lasauses, Colorado. The streamflow-gaging station for this site is operated by the CDWR and is located approximately 0.5 mi upstream from a bridge on Z Road. Low-flow samples were collected by wading between the gage and the bridge, and high-flow samples were collected from a cableway about 100 ft downstream from the gage. Because of anthropogenic alterations to the channel of Trinchera Creek, most of its flow enters the Rio Grande upstream from the gaging station (Ugland and others, 1994).

Between sites 1 and 4, the Rio Grande flows through the San Luis Valley skirting the edge of the San Luis Closed Basin. Major land uses in the 1,440-mi^2 contributing drainage basin between the two sites are forest and rangeland along the headwaters of the tributaries that flow from the San Juan Mountains and Sangre de Cristo Range; land use becomes predominantly agricultural in the valley (U.S. Geological Survey, 1986). Upstream from site 4, the WWTP for the city of Alamosa, Colorado, and the Franklin Eddy Canal discharge to the river. The Franklin Eddy Canal is the conveyance channel used by the Bureau of Reclamation (BOR) to deliver water from the unconfined aquifer in the San Luis Closed Basin to the Rio Grande (Elfrink and others, 1989). The Alamosa National Wildlife Refuge is located along this reach of the Rio Grande, and some abandoned mining areas are along the headwaters of tributaries in the San Juan Mountains and Sangre de Cristo Range. Major

Table 9.--Statistical summary of selected water-quality data for site 3 - Medano Creek near Mosca, Colo.

[Property or analyte: µS/cm, microsiemens per centimeter at 25 degrees Celsius; diss, dissolved; mg/L, milligrams per liter; it, incremental titration; µg/L, micrograms per liter. MRL, minimum reporting level; std dev, standard deviation; C, calculated value; --, not applicable; <, less than]

Property or analyte (unit)	Number of samples	MRL	Percent less than MRL	Mean	Std dev	Minimum	Percentiles 10	25	50 Median	75	90	Maximum
Streamflow, instantaneous (cubic feet per second)	31	0.01	0	15	23	1.5	2.0	3.0	4.6	11	59	99
Specific conductance (µS/cm)	32	1.0	0	80	18	42	52	65	84	98	101	102
pH (standard units)	32	.1	0	[1]7.6	.4	6.9	7.3	7.5	7.8	8.1	8.2	8.7
Temperature, water (degrees Celsius)	32	-5.0	0	5.4	5.0	.0	.0	.5	6.0	9.5	12.0	16.0
Oxygen, diss (mg/L)	32	.1	0	9.3	1.1	7.2	7.9	8.4	9.1	10.5	10.7	10.9
Oxygen, diss (percent saturation)	32	C	--	99	3	94	95	98	100	101	102	105
Hardness (mg/L as $CaCO_3$)	30	C	--	34	8	17	20	28	37	41	44	44
Hardness, noncarbonate (mg/L as $CaCO_3$)	29	C	--	.4	1.0	0	0	0	0	0	3	3
Alkalinity, it-field (mg/L as $CaCO_3$)	29	1	0	37	9	17	22	30	39	44	47	49
Solids, sum of constituents, diss (mg/L)	30	C	--	53	10	31	37	47	56	61	64	66
Solids, residue at 180 degrees Celsius (mg/L) (diss solids)	30	1	0	56	10	36	41	48	58	64	71	73
Calcium, diss (mg/L as Ca)	30	.02	0	9.3	2.2	4.6	5.5	7.6	10	11	12	12
Magnesium, diss (mg/L as Mg)	30	.01	0	2.6	.65	1.3	1.6	2.2	2.8	3.2	3.4	3.5
Sodium, diss (mg/L as Na)	30	.2	0	2.5	.5	1.5	1.8	2.2	2.5	3.0	3.1	3.2
Sodium percentage	30	C	--	14	1	12	13	13	13	14	16	17
Sodium adsorption ratio	30	C	--	.2	0	.2	.2	.2	.2	.2	.2	.2
Potassium, diss (mg/L as K)	30	.1	0	.7	.1	.5	.5	.7	.7	.8	.9	.9
Bicarbonate, it-field (mg/L as HCO_3)	29	1	0	45	11	21	27	37	47	54	57	60
Carbonate, it-field (mg/L as CO_3)	29	0	0	0	0	0	0	0	0	0	0	0
Sulfate, diss (mg/L as SO_4)	30	.1	0	3.1	.73	1.9	2.1	2.6	2.8	3.6	4.2	4.4
Chloride, diss (mg/L as Cl)	30	.1	0	.49	.18	.2	.3	.4	.5	.6	.7	1
Fluoride, diss (mg/L as F)	30	.1	0	.19	.03	.1	.1	.2	.2	.2	.2	.2
Silica, diss (mg/L as SiO_2)	30	.01	0	11.7	1.1	9.3	10	11	12	13	13	13
Nitrogen, nitrite, diss (mg/L as N)	30	.01	93	[2].001-.010	--	<.01	<.01	<.01	<.01	<.01	<.01	.01
Nitrogen, nitrite plus nitrate, diss (mg/L as N)	29	.05	72	[3].04	[3].03	<.05	<.05	<.05	<.05	.06	.08	.12
Nitrogen, ammonia, diss (mg/L as N)	30	.015	50	[3].019	[3].014	<.015	<.015	<.015	.015	.02	.05	.05
Nitrogen, un-ionized ammonia, diss (mg/L as N)	30	[4]C	--	.0002	.0003	<.0001	<.0001	<.0001	.0001	.0004	.0007	.001
Nitrogen, ammonia plus organic, diss (mg/L as N)	30	.2	93	[2].02-.21	--	<.2	<.2	<.2	<.2	<.2	<.2	.3
Nitrogen, ammonia plus organic, total (mg/L as N)	30	.2	87	[2].07-.24	--	<.2	<.2	<.2	<.2	<.2	.2	1.1
Phosphorus, total (mg/L as P)	30	.01	40	[3].02	[3].05	<.01	<.01	<.01	.01	.02	.05	.25
Phosphorus, diss (mg/L as P)	30	.01	60	[3].01	[3].008	<.01	<.01	<.01	<.01	.02	.02	.03
Phosphorus, orthophosphate (mg/L as P)	30	.01	73	[5].003-.010	--	<.01	<.01	<.01	<.01	.01	.01	.01
Iron, diss (µg/L as Fe)	30	3	0	140	54	66	76	90	120	160	230	250
Manganese, diss (µg/L as Mn)	30	1	0	10	2.7	5	7	7.8	10	12	13	16
Sediment, suspended (mg/L)	29	1	0	42	115	4	5	8	15	18	88	620
Sediment, discharge, suspended (tons/day)	29	C	--	7.0	31	.04	.06	.07	.13	.48	6.4	165

[1] Statistic calculated after transforming pH values to hydrogen-ion concentrations.

[2] Range is given for statistics for data set with 80 percent or more censored data.

[3] Statistics are estimated by log-probability regression for data set with more than 20 percent and less than 80 percent censored data.

[4] The MRL value of 0.015 mg/L was used for censored dissolved-ammonia concentrations in calculating un-ionized ammonia concentrations. All un-ionized ammonia statistics less than 0.0001 mg/L are reported as <0.0001 mg/L.

[5] Range is given for statistics for data set with more than 20 percent and less than 80 percent censored data and insufficient variation of uncensored data to perform log-probability regression.

Table 10.--Regression equations for selected water-quality analytes with selected field properties and time for site 3 - Medano Creek near Mosca, Colo.

[Analyte: °C, degrees Celsius; diss, dissolved. Unit: mg/L, milligrams per liter; µg/L, micrograms per liter. Regression equation: qlog, base 10 logarithm of streamflow, in cubic feet per second; sc, specific conductance, in microsiemens per centimeter at 25 °C; sea[1], seasonality variable; sclog, base 10 logarithm of specific conductance, in microsiemens per centimeter at 25 °C; pH, in standard pH units; temp, water temperature, in °C; q, streamflow, in cubic feet per second; DOlog, base 10 logarithm of dissolved-oxygen concentration, in mg/L; DO, dissolved-oxygen concentration, in mg/L. Adj R^2, adjusted coefficient of determination (Ott, 1993). Method: MLR, multiple linear regression]

Analyte	Unit	Regression equation	Adj R^2	Method
Solids, residue at 180 °C (dissolved solids)	mg/L	$10^{(-0.648 + 0.0023\ \text{q} + 1.245\ \text{sclog} + 0.035\ \text{sea})}$	0.723	MLR
Calcium	mg/L	$10^{(-0.705 - 0.0008\ \text{q} + 0.885\ \text{sclog})}$	.960	MLR
Magnesium	mg/L	$10^{(-2.323 - 0.003\ \text{sc} + 1.464\ \text{sclog} + 0.024\ \text{pH} - 0.002\ \text{temp})}$	.980	MLR
Sodium	mg/L	$10^{(-1.717 + 0.0010\ \text{q} + 1.117\ \text{sclog} - 0.003\ \text{temp} + 0.028\ \text{sea})}$	.949	MLR
Potassium	mg/L	$10^{(-3.147 + 0.0025\ \text{q} - 0.016\ \text{sc} + 3.326\ \text{sclog} - 2.037\ \text{DOlog} - 0.020\ \text{temp})}$	.470	MLR
Bicarbonate, as HCO_3	mg/L	$10^{(-2.992 + 0.0018\ \text{q} - 0.008\ \text{sc} + 2.771\ \text{sclog})}$	.931	MLR
Sulfate, as SO_4	mg/L	$10^{(-2.588 + 0.002\ \text{q} + 1.089\ \text{sclog} + 0.080\ \text{pH} + 0.036\ \text{DO} + 0.032\ \text{sea})}$	.778	MLR
Chloride	mg/L	$10^{(-3.46 + 0.338\ \text{qlog} + 2.008\ \text{sclog} - 0.111\ \text{pH} - 0.018\ \text{temp})}$	.670	MLR
Fluoride	mg/L	$0.19 - 0.002\ \text{q} + 0.022\ \text{qlog}$	.723	MLR
Silica, as SiO_2	mg/L	$10^{(-2.476 + 0.0022\ \text{q} - 0.010\ \text{sc} + 2.276\ \text{sclog})}$	.683	MLR
Iron, diss	µg/L	$-638.6 + 207.32\ \text{qlog} + 881.59\ \text{sclog} - 103.27\ \text{DO} - 19.29\ \text{temp}$	.670	MLR
Manganese, diss	µg/L	$10^{(-1.079 + 0.302\ \text{qlog} + 1.205\ \text{sclog} - 0.047\ \text{DO} - 0.137\ \text{sea})}$	.658	MLR

[1] sea = sin(T) + cos(T) where T equals the time, in months, from December 1, 1992, times 0.5236.

surficial deposits and bedrock types are unconsolidated gravel, sand, and silt in the San Luis Valley and Tertiary lava and tuff along the headwaters of the tributaries originating in the San Juan Mountains (Tweto, 1979).

The natural streamflow pattern at site 4 has been highly altered by diversions for irrigation between sites 1 and 4. Flows at site 4 are still high during the late spring and early summer, but the magnitude of these flows is much smaller than it would be under natural conditions. Drainage from irrigated land, discharges from the WWTP and Franklin Eddy Canal, and flowing wells that tap the confined aquifer beneath the San Luis Valley augment the streamflow at site 4. Only during the winter months are the flows at site 4 larger than those at site 1. The annual mean discharge at site 4 for WY's 1936 to 1995 was 268 ft^3/s (Crowfoot and others, 1996). The annual mean discharge for WY 1993 was 253 ft^3/s (Ugland and others, 1994); for WY 1994 was 194 ft^3/s (Ugland and others, 1995); and for WY 1995 was 394 ft^3/s (Crowfoot and others, 1996).

The water sampled at site 4 for the most part was a well-oxygenated, calcium sodium bicarbonate type. During high spring flows, sulfate exceeded bicarbonate in percentage of total anion milliequivalents per liter, and in four samples sodium exceeded calcium in percentage of total cation milliequivalents per liter. The median specific-conductance value was 456, the median pH value was 8.2, and the median DO percent of saturation was 100.

Mainly because of anthropogenic influences upstream, DS and most major-constituent concentrations at this site were significantly larger than their comparative concentrations at any other basic-fixed site in the Colorado part of the RIOG study unit. The larger concentrations of DS and most major constituents occurred just prior to and on the falling limb of the high spring flows when nearly all the river is diverted upstream from site 4. These diversions reduce natural flow, allowing anthropogenic discharges to dominate the water quality at site 4. DS and most major constituents were in the high part of the middle group for all RIOG basic-fixed sites; bicarbonate, magnesium, silica, and sulfate were in the high group.

With the exception of NO_2, the nitrogen nutrient concentrations at site 4 also were significantly larger than at any other site in the Colorado part of the RIOG study unit; NO_2 concentrations for the most part were censored. $NO_2 + NO_3$ concentrations were larger in the winter than in the summer when most concentrations were censored, whereas concentrations of dissolved ammonia, dissolved ammonia plus organic nitrogen, and total ammonia plus organic nitrogen were larger in the summer months. The smaller $NO_2 + NO_3$ concentrations during the summer months probably were due to uptake of these nitrogen analytes by aquatic bryophytes and algae. Most nutrients were in the middle group; dissolved ammonia, dissolved ammonia plus organic nitrogen, and dissolved phosphorus were in the high group.

Dissolved iron was in the middle group, whereas dissolved manganese was in the high group. The median dissolved-manganese concentration was the largest for any basic-fixed site; dissolved-manganese concentrations were significantly larger than those at any other basic-fixed site. These concentrations increased with increasing flow but tended to decrease before peak flow was reached. Summary statistics for field-property and chemical-analyte data for site 4 are presented in table 11. Regression equations that relate selected water-quality data to selected field properties and time are presented in table 12.

Site 5 - Conejos River near Lasauses, Colo.

Site 5 is an integrator site on a tributary that originates in the San Juan Mountains and discharges to the Rio Grande approximately 2.1 mi north of Lasauses, Colorado. The streamflow-gaging station for this site is operated by the CDWR and is located about 125 ft downstream from a bridge on 28th Road. Low-flow samples were collected by wading, and high-flow samples were collected from the upstream side of the bridge. When water was flowing in the Conejos River diversion, which flows under 28th Road approximately 1 mi south of Conejos River, a sample from the river and from the diversion was collected and composited for site 5. During August 1993, the main Conejos River channel was straightened upstream from the bridge.

Land use in the 789-mi^2 Conejos River Basin is predominantly forest in the headwater areas and rangeland and agricultural in the San Luis Valley (U.S. Geological Survey, 1986). The headwater areas also contain a number of historical mining areas. Major bedrock types and surficial deposits in the Conejos River Basin are Tertiary tuff, lava, and conglomerate in the headwater areas and unconsolidated gravel, sand, and silt in the San Luis Basin (Dane and Bachman, 1965; Tweto, 1979).

Streamflow at site 5 is seasonal; high flows occur in the late spring and early summer. A storage

Table 11.--Statistical summary of selected water-quality data for site 4 - Rio Grande above mouth of Trinchera Creek, near Lasauses, Colo.

[Property or analyte: µS/cm, microsiemens per centimeter at 25 degrees Celsius; diss, dissolved; mg/L, milligrams per liter; it, incremental titration; µg/L, micrograms per liter. MRL, minimum reporting level; std dev, standard deviation; C, calculated value; --, not applicable; <, less than]

Property or analyte (unit)	Number of samples	MRL	Percent less than MRL	Mean	Std dev	Minimum	Percentiles					Maximum
							10	25	50 Median	75	90	
Streamflow, instantaneous (cubic feet per second)	30	0.01	0	238	175	36	50	109	190	297	546	748
Specific conductance (µS/cm)	31	1.0	0	451	124	246	266	333	456	551	595	734
pH (standard units)	31	.1	0	[1]8.1	.3	7.3	7.7	8.1	8.2	8.4	8.6	9.1
Temperature, water (degrees Celsius)	31	-5.0	0	11.9	8.6	.0	.0	4.0	13.0	19.5	22.0	27.5
Oxygen, diss (mg/L)	30	.1	0	8.3	1.6	4.5	6.5	7.1	8.2	9.6	10.8	11.0
Oxygen, diss (percent saturation)	30	C	--	98	11	59	86	92	100	104	109	119
Hardness (mg/L as $CaCO_3$)	24	C	--	134	35	74	80	102	130	168	185	190
Hardness, noncarbonate (mg/L as $CaCO_3$)	22	C	--	11	16	0	0	0	2	20	44	46
Alkalinity, it-field (mg/L as $CaCO_3$)	27	1	0	126	30	72	87	98	126	149	168	191
Solids, sum of constituents, diss (mg/L)	22	C	--	285	74	161	171	229	292	344	383	428
Solids, residue at 180 degrees Celsius (mg/L) (diss solids)	24	1	0	297	75	177	182	234	298	358	398	443
Calcium, diss (mg/L as Ca)	24	.02	0	40	9.8	23	24	32	40	50	54	56
Magnesium, diss (mg/L as Mg)	24	.01	0	8.4	2.4	4.0	4.6	6.6	8.4	10	12	12
Sodium, diss (mg/L as Na)	24	.2	0	39	13	18	20	31	39	48	56	67
Sodium percentage	24	C	--	37	4	32	32	34	36	41	42	43
Sodium adsorption ratio	24	C	--	2	.5	.9	1	1	2	2	2	2
Potassium, diss (mg/L as K)	24	.1	0	5.7	1.6	3.3	3.4	4.6	5.4	6.8	8.3	9.5
Bicarbonate, it-field (mg/L as HCO_3)	27	1	0	152	36	82	105	120	152	179	201	233
Carbonate, it-field (mg/L as CO_3)	27	0	0	.7	1	0	0	0	0	2	3	3
Sulfate, diss (mg/L as SO_4)	24	.1	0	80	36	26	28	48	78	107	135	140
Chloride, diss (mg/L as Cl)	22	.1	0	11	2.6	6.0	7.4	8.6	12	13	14	16
Fluoride, diss (mg/L as F)	24	.1	0	.5	.2	.3	.3	.4	.5	.7	.7	.8
Silica, diss (mg/L as SiO_2)	24	.01	0	25	3.0	20	22	23	26	28	30	32
Nitrogen, nitrite, diss (mg/L as N)	23	.01	83	[2].003-.011	--	<.01	<.01	<.01	<.01	<.01	.01	.03
Nitrogen, nitrite plus nitrate, diss (mg/L as N)	23	.05	39	[3].12	[3].10	<.05	<.05	<.05	.06	.22	.29	.30
Nitrogen, ammonia, diss (mg/L as N)	23	.015	26	[3].03	[3].03	<.015	<.015	<.015	.03	.04	.06	.12
Nitrogen, un-ionized ammonia, diss (mg/L as N)	23	[4]C	--	.001	.001	<.0001	.0001	.0003	.0007	.002	.004	.004
Nitrogen, ammonia plus organic, diss (mg/L as N)	23	.2	22	[3].3	[3].2	<.2	<.2	.2	.3	.4	.6	.6
Nitrogen, ammonia plus organic, total (mg/L as N)	23	.2	0	.5	.3	.2	.2	.4	.5	.6	.9	1.2
Phosphorus, total (mg/L as P)	23	.01	0	.12	.08	.05	.06	.08	.10	.15	.19	.46
Phosphorus, diss (mg/L as P)	22	.01	0	.06	.02	.02	.03	.04	.06	.07	.10	.11
Phosphorus, orthophosphate (mg/L as P)	23	.01	0	.05	.02	.02	.03	.04	.05	.07	.09	.11
Iron, diss (µg/L as Fe)	24	3	0	54	30	10	14	31	45	82	95	120
Manganese, diss (µg/L as Mn)	24	1	0	78	62	15	21	37	68	100	145	300
Sediment, suspended (mg/L)	28	1	0	69	81	22	25	33	52	63	106	446
Sediment, discharge, suspended (tons/day)	28	C	--	64	139	2.2	3.0	15	25	47	149	716

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[1] Statistic calculated after transforming pH values to hydrogen-ion concentrations.

[2] Range is given for statistics for data set with 80 percent or more censored data.

[3] Statistics are estimated by log-probability regression for data set with more than 20 percent and less than 80 percent censored data.

[4] The MRL value of 0.015 mg/L was used for censored dissolved-ammonia concentrations in calculating un-ionized ammonia concentrations. All un-ionized ammonia statistics less than 0.0001 mg/L are reported as <0.0001 mg/L.

Table 12.--Regression equations for selected water-quality analytes with selected field properties and time for site 4 - Rio Grande above mouth of Trinchera Creek, near Lasauses, Colo.

[Analyte: °C, degrees Celsius; amm + org, ammonia plus organic; diss, dissolved; ortho, orthophosphate. Unit: mg/L, milligrams per liter; µg/L, micrograms per liter. Regression equation: sc, specific conductance, in microsiemens per centimeter at 25 °C; sclog, base 10 logarithm of specific conductance, in microsiemens per centimeter at 25 °C; qlog, base 10 logarithm of streamflow, in cubic feet per second; DO, dissolved-oxygen concentration, in mg/L; sea[1], seasonality variable; q, streamflow, in cubic feet per second; pH, in standard pH units; temp, water temperature, in °C; DOlog, base 10 logarithm of dissolved-oxygen concentration, in mg/L. Adj R^2, adjusted coefficient of determination (Ott, 1993). Method: MLR, multiple linear regression]

Analyte	Unit	Regression equation	Adj R^2	Method
Solids, residue at 180 °C (dissolved solids)	mg/L	$10^{(1.212 + 0.0006\ \text{sc} + 0.372\ \text{sclog})}$	0.974	MLR
Calcium	mg/L	$10^{(-0.750 + 0.888\ \text{sclog})}$	.922	MLR
Magnesium	mg/L	$10^{(-3.288 + 0.046\ \text{qlog} - 0.0006\ \text{sc} + 1.653\ \text{sclog})}$	.958	MLR
Sodium	mg/L	$10^{(-1.625 + 1.212\ \text{sclog})}$	.944	MLR
Potassium	mg/L	$10^{(0.296 + 0.001\ \text{sc})}$	.911	MLR
Bicarbonate, as HCO_3	mg/L	109.0 + 0.286 sc - 9.541 DO -21.692 sea	.734	MLR
Sulfate, as SO_4	mg/L	$10^{(-3.175 + 0.128\ \text{qlog} + 1.799\ \text{sclog})}$	.940	MLR
Chloride	mg/L	$10^{(-1.787 + 1.072\ \text{sclog} - 0.042\ \text{sea})}$	.817	MLR
Fluoride	mg/L	$10^{(-1.622 - 0.0002\ \text{q} + 0.0008\ \text{sc} - 0.226\ \text{DO} + 3.281\ \text{DOlog} - 0.009\ \text{temp})}$	.812	MLR
Silica, as SiO_2	mg/L	25.82 - 2.302 sea	.611	MLR
Nitrogen, amm + org, total, as N	mg/L	$10^{(-1.180 + 0.986\ \text{sclog} - 0.229\ \text{pH} + 0.010\ \text{temp})}$	.683	MLR
Phosphorus, total, as P	mg/L	$10^{(1.149 - 0.287\ \text{pH} + 0.019\ \text{temp})}$	.449	MLR
Phosphorus, diss, as P	mg/L	0.64 - 0.040 pH + 0.040 DO - 0.688 DOlog + 0.003 temp	.734	MLR
Phosphorus, ortho, diss, as P	mg/L	1.12 + 0.034 qlog + 0.0005 sc - 0.440 sclog - 0.244 DOlog - 0.014 sea	.653	MLR
Iron, diss	µg/L	259.2 + 0.044 q + 88.80 sclog - 54.90 pH	.503	MLR
Manganese, diss	µg/L	$10^{(-9.575 - 0.006\ \text{sc} + 7.273\ \text{sclog} - 0.644\ \text{pH})}$	.478	MLR

[1] sea = sin(T) + cos(T) where T equals the time, in months, from December 1, 1992, times 0.5236.

reservoir in the upper basin and diversions for irrigation alter streamflow at the site. During some years, such as 1994, site 5 may have no streamflow in late summer. The annual mean discharge at site 5 for WY's 1921 to 1995 was 187 ft^3/s (Crowfoot and others, 1996). The annual mean discharge for WY 1993 was 261 ft^3/s (Ugland and others, 1994); for WY 1994 was 184 ft^3/s (Ugland and others, 1995); and for WY 1995 was 313 ft^3/s (Crowfoot and others, 1996).

The water sampled at site 5 was a well-oxygenated, calcium bicarbonate type. The median specific-conductance value was 124, the median pH value was 7.9, and the median DO percent of saturation was 96. DS and most major constituents were in the low group; potassium was in the middle group; and silica was in the high group. About 33 percent of the samples contained silica concentrations above the common range for surface waters, 1 to 30 mg/L (Hem, 1985). These relatively large silica concentrations were detected in late summer when streamflow was lowest and was composed of a larger percentage of ground water from flowing wells or springs (Siebenthal, 1910). Silica concentrations during the remainder of the year probably were the result of weathering of volcanic tuffs in the drainage basin. The median concentrations of the nitrogen nutrients were below their respective MDL's. Total phosphorus was in the low group; dissolved phosphorus and orthophosphate were in the middle group. Dissolved iron and dissolved manganese were in the high group.

Specific conductance (-0.58), DS (-0.57), and most major constituents (-0.34 to 0.67) showed moderate negative correlations to streamflow; silica showed a strong negative correlation to streamflow (-0.71). The smallest concentrations of DS and the major constituents occurred annually during high spring flows. Dissolved-iron concentrations showed a moderate positive correlation with streamflow (0.62); the largest concentrations were detected during high spring flows, possibly due to particulates and/or colloids that passed through a 0.45-micron filter (Kennedy and others, 1974). In contrast, dissolved-manganese concentrations showed a moderate negative correlation with streamflow (-0.39), and the largest concentrations were detected in the late summer of 1994 when streamflow approached zero. Summary statistics for field-property and chemical-analyte data for site 5 are presented in table 13. Regression equations that relate selected water-quality data to selected field properties and time are presented in table 14.

Site 6 - Rio Grande near Lobatos, Colo.

Site 6 is an integrator site on the main stem approximately 11 mi east of Lobatos, Colorado. The streamflow-gaging station for this site is operated by the CDWR and is located just downstream from a bridge on G Road. Low-flow samples were collected by wading upstream from the bridge, and high-flow samples were collected from the upstream side of the bridge.

Between sites 4 and 6, the Rio Grande flows through the lower part of the San Luis Valley, draining an area of approximately 1,830 mi^2. Approximately 43 percent of this area is in the Conejos River Basin. Major land uses in this reach, excluding the Conejos River Basin, are forest in the headwaters of tributaries and rangeland and agricultural in the valley (U.S. Geological Survey, 1986). Major surficial deposits and bedrock types are Tertiary lava, breccia, tuff, and conglomerate and Quaternary unconsolidated gravel and alluvium (Tweto, 1979).

Streamflow at site 6 is seasonal: flow is high in late spring and early summer. These high flows may result from high flows on the main stem (site 4) or on the Conejos River (site 5) or may be a summation of smaller flows on both; very little discharge reaches the river from the basin east of the Rio Grande. During WY 1993, the high spring flow at site 6 was mainly from the Conejos River; during WY 1994, the high spring flow was a summation of main-stem and Conejos River flows; and during WY 1995, the high spring flow was initially from the Conejos River. As this flow started to recede, high flow started on the main stem, and the final WY 1995 peak flow at site 6 was a summation of main-stem and Conejos River flows. Streamflow at other times was composed mainly of main-stem water. The annual mean discharge at site 6 for WY's 1931 to 1995 was 452 ft^3/s (Crowfoot and others, 1996). The annual mean discharge for WY 1993 was 535 ft^3/s (Ugland and others, 1994); for WY 1994 was 399 ft^3/s (Ugland and others, 1995); and for WY 1995 was 742 ft^3/s (Crowfoot and others, 1996).

The water sampled at site 6 for the most part was a well-oxygenated, calcium sodium bicarbonate type. Sodium exceeded calcium in percentage of total cation milliequivalents per liter in three samples collected during late summer and early autumn low flows, and calcium was the predominant cation in three samples

Table 13.--Statistical summary of selected water-quality data for site 5 - Conejos River near Lasauses, Colo.

[Property or analyte: µS/cm, microsiemens per centimeter at 25 degrees Celsius; diss, dissolved; mg/L, milligrams per liter; it, incremental titration; µg/L, micrograms per liter. MRL, minimum reporting level; std dev, standard deviation; C, calculated value; --, not applicable; <, less than]

Property or analyte (unit)	Number of samples	MRL	Percent less than MRL	Mean	Std dev	Minimum	Percentiles					Maximum
							10	25	50 Median	75	90	
Streamflow, instantaneous (cubic feet per second)	30	0.01	0	288	387	1.1	13	51	108	397	887	1,490
Specific conductance (µS/cm)	30	1.0	0	127	36	82	83	91	124	155	171	236
pH (standard units)	30	.1	0	[1]7.8	.3	7.0	7.6	7.8	7.9	8.1	8.3	8.7
Temperature, water (degrees Celsius)	30	-5.0	0	10.4	7.2	-.5	.0	4.0	10.0	17.0	20.0	23.5
Oxygen, diss (mg/L)	29	.1	0	8.3	1.9	4.1	5.8	6.7	8.4	10.0	10.8	12.0
Oxygen, diss (percent saturation)	29	C	--	94	12	51	74	91	96	102	106	112
Hardness (mg/L as $CaCO_3$)	28	C	--	49	14	30	33	37	46	60	64	95
Hardness, noncarbonate (mg/L as $CaCO_3$)	26	C	--	.2	.6	0	0	0	0	0	0	3
Alkalinity, it-field (mg/L as $CaCO_3$)	27	1	0	57	15	35	37	46	55	69	73	105
Solids, sum of constituents, diss (mg/L)	28	C	--	95	26	62	63	69	92	115	130	158
Solids, residue at 180 degrees Celsius (mg/L) (diss solids)	28	1	0	98	26	61	69	77	98	110	132	177
Calcium, diss (mg/L as Ca)	28	.02	0	15	4.4	9.3	10	11	14	19	20	29
Magnesium, diss (mg/L as Mg)	28	.01	0	2.7	.78	1.7	1.9	2.0	2.6	3.2	3.4	5.5
Sodium, diss (mg/L as Na)	28	.2	0	5.8	2.2	3.0	3.5	3.9	5.2	7.2	8.9	12
Sodium percentage	28	C	--	19	2	15	16	18	19	21	22	26
Sodium adsorption ratio	28	C	--	.4	.1	.2	.3	.3	.3	.4	.5	.5
Potassium, diss (mg/L as K)	28	.1	0	2.5	.8	1.5	1.6	1.9	2.2	2.9	3.9	4.3
Bicarbonate, it-field (mg/L as HCO_3)	27	1	0	70	19	42	45	56	68	84	89	129
Carbonate, it-field (mg/L as CO_3)	27	0	0	0	0	0	0	0	0	0	0	0
Sulfate, diss (mg/L as SO_4)	28	.1	0	5.6	2.9	2.0	2.2	3.0	5.3	6.7	11	12
Chloride, diss (mg/L as Cl)	28	.1	0	1.2	.5	.5	.6	.8	1.0	1.4	2.0	2.8
Fluoride, diss (mg/L as F)	28	.1	11	.1	.1	<.1	<.1	.1	.1	.2	.2	.3
Silica, diss (mg/L as SiO_2)	28	.01	0	28	6.5	18	20	22	28	33	38	39
Nitrogen, nitrite, diss (mg/L as N)	29	.01	93	[2].006-.010	--	<.01	<.01	<.01	<.01	<.01	<.01	.02
Nitrogen, nitrite plus nitrate, diss (mg/L as N)	29	.05	93	[2].004-.051	--	<.05	<.05	<.05	<.05	<.05	<.05	.08
Nitrogen, ammonia, diss (mg/L as N)	29	.015	62	[3].016	[3].009	<.015	<.015	<.015	<.015	.02	.03	.04
Nitrogen, un-ionized ammonia, diss (mg/L as N)	29	[4]C	--	.0003	.0004	<.0001	<.0001	<.0001	.0002	.0005	.001	.002
Nitrogen, ammonia plus organic, diss (mg/L as N)	29	.2	83	[2].05-.21	--	<.2	<.2	<.2	<.2	<.2	.3	.4
Nitrogen, ammonia plus organic, total (mg/L as N)	29	.2	52	[3].2	.2	<.2	<.2	<.2	<.2	.2	.4	1.0
Phosphorus, total (mg/L as P)	29	.01	3	.06	.04	<.01	.02	.03	.05	.08	.11	.18
Phosphorus, diss (mg/L as P)	29	.01	17	.03	.02	<.01	<.01	.01	.03	.04	.05	.11
Phosphorus, orthophosphate (mg/L as P)	29	.01	3	.03	.02	<.01	.01	.02	.02	.04	.05	.09
Iron, diss (µg/L as Fe)	28	3	0	120	64	42	48	80	100	150	190	360
Manganese, diss (µg/L as Mn)	28	1	0	33	22	14	17	21	28	35	54	130
Sediment, suspended (mg/L)	27	1	0	48	60	8	14	18	22	63	103	306
Sediment, discharge, suspended (tons/day)	27	C	--	63	110	.05	.37	2.0	4.8	101	306	390

[1] Statistic calculated after transforming pH values to hydrogen-ion concentrations.

[2] Range is given for statistics for data set with 80 percent or more censored data.

[3] Statistics are estimated by log-probability regression for data set with more than 20 percent and less than 80 percent censored data.

[4] The MRL value of 0.015 mg/L was used for censored dissolved-ammonia concentrations in calculating un-ionized ammonia concentrations. All un-ionized ammonia statistics less than 0.0001 mg/L are reported as <0.0001 mg/L.

Table 14.--Regression equations for selected water-quality analytes with selected field properties and time for site 5 - Conejos River near Lasauses, Colo.

[Analyte: °C, degrees Celsius; diss, dissolved; ortho, orthophosphate. Unit: mg/L, milligrams per liter; µg/L, micrograms per liter. Regression equation: q, streamflow, in cubic feet per second; qlog, base 10 logarithm of streamflow, in cubic feet per second; sc, specific conductance, in microsiemens per centimeter at 25 °C; sea[1], seasonality variable; temp, water temperature, in °C; DOlog, base 10 logarithm of dissolved-oxygen concentration, in mg/L; sclog, base 10 logarithm of specific conductance, in microsiemens per centimeter at 25 °C; pH, in standard pH units; DO, dissolved-oxygen concentration, in mg/L. Adj R^2, adjusted coefficient of determination (Ott, 1993). Method: MLR, multiple linear regression; KTR, Kendall-Theil robust line. --, not applicable]

Analyte	Unit	Regression equation	Adj R^2	Method
Solids, residue at 180 °C (dissolved solids)	mg/L	76.1 + 0.029 q - 19.486 qlog + 0.414 sc - 5.186 sea	0.909	MLR
Calcium	mg/L	56.8 - 0.976 qlog + 0.190 sc - 30.669 sclog - 0.710 sea	.951	MLR
Magnesium	mg/L	$10^{(0.174 - 0.024\ \mathrm{qlog} + 0.002\ \mathrm{sc} - 0.003\ \mathrm{temp})}$	.917	MLR
Sodium	mg/L	8.22 + 0.002 q - 1.294 qlog + 0.038 sc - 5.814 DOlog - 0.665 sea	.916	MLR
Potassium	mg/L	$10^{(-0.461 + 0.763\ \mathrm{sclog} - 0.827\ \mathrm{DOlog} - 0.053\ \mathrm{sea})}$	.844	MLR
Bicarbonate, as HCO_3	mg/L	40.66 + 0.494 sc + 6.554 pH + 9.541 DO - 183.26 DOlog	.927	MLR
Sulfate, as SO_4	mg/L	$10^{(-6.460 - 0.082\ \mathrm{qlog} - 0.011\ \mathrm{sc} + 4.424\ \mathrm{sclog} - 0.052\ \mathrm{DO} - 0.104\ \mathrm{sea})}$	.845	MLR
Chloride	mg/L	$10^{(0.614 + 0.003\ \mathrm{sc} - 0.921\ \mathrm{DOlog} - 0.019\ \mathrm{temp})}$	.610	MLR
Fluoride	mg/L	-0.056 + 0.0013 sc	--	KTR
Silica, as SiO_2	mg/L	$10^{(0.924 - 0.045\ \mathrm{qlog} + 0.346\ \mathrm{sclog} - 0.014\ \mathrm{DO} - 0.053\ \mathrm{sea})}$	.923	MLR
Phosphorus, total, as P	mg/L	$10^{(-1.459 + 0.0002\ \mathrm{q} + 0.226\ \mathrm{sea})}$	.644	MLR
Phosphorus, diss, as P	mg/L	0.023 + 0.014 sea	--	KTR
Phosphorus, ortho, diss, as P	mg/L	0.20 + 0.00002 q + 0.018 DO - 0.261 DOlog + 0.005 sea	.767	MLR
Iron, diss	µg/L	484.5 + 0.128 q + 53.72 DO - 940.2 DOlog	.775	MLR
Manganese, diss	µg/L	764.3 + 1.975 sc - 470.7 sclog	.711	MLR

[1] sea = sin(T) + cos(T) where T equals the time, in months, from December 1, 1992, times 0.5236.

collected in the spring of 1995. The median specific-conductance value was 322, the median pH value was 8.3, and the median DO percent of saturation was 108.

DS and most major constituents were in the middle group, calcium and magnesium were in the low group, and silica was in the high group. The DS and major-constituent concentrations at this site reflect the influence of anthropogenic sources upstream from site 4. Because concentrations in the main stem were much larger than those in the Conejos River, the Rio Grande was usually the major contributor of DS and most major constituents at site 6 even when the Conejos River was the major contributor of streamflow. From an analysis of comparative monthly samples, the instantaneous loads of DS at site 5 ranged from 1.5 to 123 percent of the instantaneous load at site 4 and were on average 15 percent. Instantaneous loads are equal to the instantaneous streamflow multiplied by the analyte concentration and are a measure of the total amount of an analyte passing the sampling site. Silica was the exception to this pattern; because silica concentrations in the main stem and Conejos River were about equal, the major source of streamflow was usually the major contributor of silica at site 6.

DS (-0.46) and most major constituents (-0.40 to -0.68) showed moderate negative correlations with streamflow. The smallest concentrations were detected during high spring flows and the largest concentrations were detected during low flow in late summer. Sulfate (-0.27) and silica (-0.21) showed no correlation with streamflow.

Most nutrients were in the middle group; the median concentration of NO_2 and $NO_2 + NO_3$ were below their respective MDL's. With the exception of a few samples, total nitrogen concentrations at site 6 were usually within the range of 0.4 to 0.6 mg/L as N; the relative amounts of the different nitrogen analytes changed during the year, however. $NO_2 + NO_3$ and dissolved-ammonia concentrations were largest during the winter months. At other times of the year, because of dilution or uptake by biota, $NO_2 + NO_3$ concentrations were censored and dissolved-ammonia concentrations were smaller or censored. Concentrations of dissolved ammonia plus organic nitrogen and total ammonia plus organic nitrogen were largest during the high spring flows and in the late summer and were smallest, near or below the MRL, during the winter months. For the latter two nutrients, the increase in organic nitrogen during the spring high flow and in late summer was much larger than the decrease in ammonia.

Dissolved-iron concentrations were larger than expected for well-oxygenated surface waters (Hem, 1985); dissolved iron, however, was in the middle group. Dissolved-iron concentrations showed a moderate negative correlation with streamflow (-0.55), possibly due to particulates and/or colloids that passed through a 0.45-micron filter (Kennedy and others, 1974). Dissolved manganese was in the high group even though dissolved-manganese concentrations were smaller than expected based on the dissolved-manganese concentrations at sites 4 and 5. The smaller dissolved-manganese concentrations probably were due to precipitation or coprecipitation of manganese in the reach upstream from site 6. Summary statistics for field-property and chemical-analyte data for site 6 are presented in table 15. Regression equations that relate selected water-quality data to selected field properties and time are presented in table 16.

Site 7 - Rio Grande below Taos Junction Bridge, near Taos, N. Mex.

Site 7 is an integrator site on the main stem approximately 12 mi southwest of Taos, New Mexico. The USGS streamflow-gaging station for this site is located approximately 1.7 mi downstream from a bridge on State Highway 567. Low-flow samples were collected by wading between the bridge and the gage, and high-flow samples were collected from a cableway at the gage.

For most of the reach between sites 6 and 7, the Rio Grande flows through the Rio Grande Gorge, which is eroded into volcanic rocks in the lower San Luis Valley and Taos Plateau. From the Colorado-New Mexico State line to the NM 567 Bridge, the Rio Grande is designated a Wild and Scenic River. Major land uses in the 1,950-mi^2 drainage area of this reach include forest and rangeland (U.S. Geological Survey, 1986). A large molybdenum mine and tailings pond have been active along the Red River, a tributary to this reach, and active perlite quarries are on the plateau west of the river. Major surficial deposits and bedrock types in this area include Precambrian gneiss and granite; Pennsylvanian sedimentary rocks; and Quaternary lava and unconsolidated gravel, sand, and silt (Dane and Bachman, 1965; Tweto, 1979).

Streamflow at site 7 is seasonal; high flows occur in late spring and early summer. During these high flows, the increase in streamflow between sites 6 and 7

Table 15.--Statistical summary of selected water-quality data for site 6 - Rio Grande near Lobatos, Colo.

[Property or analyte: µS/cm, microsiemens per centimeter at 25 degrees Celsius; diss, dissolved; mg/L, milligrams per liter; it, incremental titration; µg/L, micrograms per liter. MRL, minimum reporting level; std dev, standard deviation; C, calculated value; --, not applicable; <, less than]

Property or analyte (unit)	Number of samples	MRL	Percent less than MRL	Mean	Std dev	Minimum	Percentiles 10	25	50 Median	75	90	Maximum
Streamflow, instantaneous (cubic feet per second)	33	0.01	0	522	529	6.0	45	135	365	530	1,620	1,690
Specific conductance (µS/cm)	33	1.0	0	347	121	187	212	264	322	416	524	673
pH (standard units)	33	.1	0	[1]8.2	.3	7.7	7.9	8.1	8.3	8.6	8.9	9.0
Temperature, water (degrees Celsius)	33	-5.0	0	13.3	8.9	-.5	.0	5.0	14.5	22.0	24.0	25.5
Oxygen, diss (mg/L)	30	.1	0	9.3	2.2	3.5	6.8	8.2	9.2	11.0	12.0	12.3
Oxygen, diss (percent saturation)	30	C	--	111	24	49	91	100	108	125	150	163
Hardness (mg/L as $CaCO_3$)	29	C	--	99	30	54	66	80	92	110	150	180
Hardness, noncarbonate (mg/L as $CaCO_3$)	28	C	--	3	6	0	0	0	0	4	14	22
Alkalinity, it-field (mg/L as $CaCO_3$)	28	1	0	103	31	59	62	84	93	125	148	185
Solids, sum of constituents, diss (mg/L)	29	C	--	210	67	118	128	169	191	246	296	413
Solids, residue at 180 degrees Celsius (mg/L) (diss solids)	29	1	0	219	72	131	140	177	191	247	313	451
Calcium, diss (mg/L as Ca)	29	.02	0	30	8.5	16	20	24	28	32	44	52
Magnesium, diss (mg/L as Mg)	29	.01	0	6.0	1.9	3.4	3.9	4.6	5.5	6.8	9.2	11
Sodium, diss (mg/L as Na)	29	.2	0	27	13	12	14	19	22	34	45	69
Sodium percentage	29	C	--	35	4	28	29	32	35	38	42	45
Sodium adsorption ratio	29	C	--	1	.4	.7	.7	.9	1	1	2	2
Potassium, diss (mg/L as K)	29	.1	0	4.4	1.5	2.5	3.1	3.4	3.8	5.4	6.5	9.0
Bicarbonate, it-field (mg/L as HCO_3)	28	1	0	122	35	72	76	102	112	143	176	220
Carbonate, it-field (mg/L as CO_3)	28	0	0	2	2	0	0	0	0	3	5	8
Sulfate, diss (mg/L as SO_4)	29	.1	0	48	25	19	23	30	45	59	81	120
Chloride, diss (mg/L as Cl)	29	.1	0	7.6	3.0	3.5	3.7	5.9	7.1	9.6	12	17
Fluoride, diss (mg/L as F)	29	.1	0	.4	.2	.2	.2	.3	.3	.5	.7	.8
Silica, diss (mg/L as SiO_2)	29	.01	0	25	3.7	18	21	22	25	28	30	33
Nitrogen, nitrite, diss (mg/L as N)	29	.01	97	[2].001-.011	--	<.01	<.01	<.01	<.01	<.01	<.01	.03
Nitrogen, nitrite plus nitrate, diss (mg/L as N)	29	.05	62	[3].09	[3].08	<.05	<.05	<.05	<.05	.16	.23	.28
Nitrogen, ammonia, diss (mg/L as N)	29	.015	45	[3].02	[3].017	<.015	<.015	<.015	.02	.03	.04	.08
Nitrogen, un-ionized ammonia, diss (mg/L as N)	29	[4]C	--	.001	.002	<.0001	.0001	.0003	.0007	.001	.005	.006
Nitrogen, ammonia plus organic, diss (mg/L as N)	29	.2	38	[3].2	[3].1	<.2	<.2	<.2	.2	.3	.4	.5
Nitrogen, ammonia plus organic, total (mg/L as N)	29	.2	7	.4	.2	<.2	.2	.3	.4	.5	.6	.8
Phosphorus, total (mg/L as P)	29	.01	0	.09	.03	.04	.05	.06	.09	.11	.13	.19
Phosphorus, diss (mg/L as P)	28	.01	4	.04	.02	<.01	.02	.03	.04	.05	.06	.11
Phosphorus, orthophosphate (mg/L as P)	29	.01	0	.04	.01	.02	.02	.03	.04	.04	.05	.09
Iron, diss (µg/L as Fe)	29	3	0	63	49	4	21	27	43	96	150	180
Manganese, diss (µg/L as Mn)	29	1	0	19	10	6	7	12	18	22	31	53
Sediment, suspended (mg/L)	30	1	0	46	24	13	24	28	42	57	88	108
Sediment, discharge, suspended (tons/day)	30	C	--	82	107	.47	4.6	17	32	129	236	478

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[1] Statistic calculated after transforming pH values to hydrogen-ion concentrations.

[2] Range is given for statistics for data set with 80 percent or more censored data.

[3] Statistics are estimated by log-probability regression for data set with more than 20 percent and less than 80 percent censored data.

[4] The MRL value of 0.015 mg/L was used for censored dissolved-ammonia concentrations in calculating un-ionized ammonia concentrations. All un-ionized ammonia statistics less than 0.0001 mg/L are reported as <0.0001 mg/L.

Table 16.--Regression equations for selected water-quality analytes with selected field properties and time for site 6 - Rio Grande near Lobatos, Colo.

[Analyte: °C, degrees Celsius; amm + org, ammonia plus organic; diss, dissolved; ortho, orthophosphate. Unit: mg/L, milligrams per liter; µg/L, micrograms per liter. Regression equation: q, streamflow, in cubic feet per second; sc, specific conductance, in microsiemens per centimeter at 25 °C; sclog, base 10 logarithm of specific conductance, in microsiemens per centimeter at 25 °C; sea[1], seasonality variable; DOlog, base 10 logarithm of dissolved-oxygen concentration, in mg/L; temp, water temperature, in °C; pH, in standard pH units; qlog, base 10 logarithm of streamflow, in cubic feet per second; DO, dissolved-oxygen concentration, in mg/L. Adj R^2, adjusted coefficient of determination (Ott, 1993). Method: MLR, multiple linear regression; KTR, Kendall-Theil robust line. --, not applicable]

Analyte	Unit	Regression equation	Adj R^2	Method
Solids, residue at 180 °C (dissolved solids)	mg/L	$10^{(0.640 + 0.00003\ q + 0.0005\ sc + 0.568\ sclog + 0.021\ pH - 0.085\ DOlog - 0.019\ sea)}$	0.981	MLR
Calcium	mg/L	$-67.70 + 0.040\ sc = 20.886\ sclog + 1.918\ pH + 17.164\ DOlog + 0.123\ temp)$	.954	MLR
Magnesium	mg/L	$-21.67 + 0.008\ sc + 7.138\ sclog + 0.513\ pH + 3.169\ DOlog + 0.360\ sea$	.957	MLR
Sodium	mg/L	$81.51 - 2.308\ qlog + 0.153\ sc - 35.106\ sclog - 2.219\ pH$	.978	MLR
Potassium	mg/L	$-6.78 + 0.013\ sc - 0.931\ DO + 16.385\ DOlog - 0.260\ sea$	.918	MLR
Bicarbonate, as HCO_3	mg/L	$10^{(1.121 - 0.048\ qlog + 0.006\ sc + 0.400\ sclog - 0.007\ DO - 0.005\ temp)}$	.947	MLR
Sulfate, as SO_4	mg/L	$-51.96 + 10.29\ qlog + 0.205\ sc + 0.495\ temp$	.946	MLR
Chloride	mg/L	$-1.356 + 0.030\ sc - 0.085\ temp$	.968	MLR
Fluoride	mg/L	$10^{(-2.578 - 0.00009\ q + 0.881\ sclog)}$	.829	MLR
Silica, as SiO_2	mg/L	$10^{(1.185 + 0.218\ DOlog - 0.040\ sea)}$	.753	MLR
Nitrogen, amm + org, total, as N	mg/L	$0.267 + 0.011\ temp$	--	KTR
Phosphorus, total, as P	mg/L	$1.941 + 0.001\ sc - 0.848\ sclog - 0.007\ DO$	.467	MLR
Phosphorus, diss, as P	mg/L	$0.202 + 0.012\ qlog + 0.0001\ sc - 0.021\ pH - 0.005\ DO$	.452	MLR
Phosphorus, ortho, diss, as P	mg/L	$0.413 + 0.015\ qlog + 0.0003\ sc - 0.212\ sclog$	.558	MLR
Iron, diss	µg/L	$-163.48 + 0.064\ q - 86.971\ sclog - 38.287\ DO + 796.81\ DOlog$	.700	MLR
Manganese, diss	µg/L	$10^{(1.210 + 0.097\ sea)}$	.154	MLR

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[1] sea = sin(T) + cos(T) where T equals the time, in months, from December 1, 1992, times 0.5236.

is due mainly to inputs from tributaries along the east side of the Rio Grande. During low flow, the increase in streamflow due to ground-water inflow may equal or exceed that from the tributaries (Winograd, 1959). The annual mean discharge at this site for WY 1926 to 1995 was 767 ft^3/s (Ortiz and Lange, 1996). The annual mean discharge for WY's 1993 was 950 ft^3/s (Cruz and others, 1994); for WY 1994 was 887 ft^3/s (Borland and Ong, 1995); and for WY 1995 was 1,186 ft^3/s (Ortiz and Lange, 1996).

The water sampled at site 7 was a well-oxygenated type whose chemical composition varied from calcium bicarbonate to calcium sodium bicarbonate. The calcium sodium bicarbonate type was detected mainly during low flow in late summer. The median specific-conductance value was 297, the median pH value was 8.3, and the median DO percent of saturation was 102. DS and the major constituents were in the middle group. For most major constituents, the median concentrations were about equal to or smaller than comparative concentrations at site 6. Streamflow had a moderate to strong negative correlation with specific conductance (-0.59), DS (-0.64), and most major constituents (-0.38 to -0.86) except potassium (-0.16), which showed no correlation to streamflow.

Most nutrients were in the middle group; dissolved phosphorus was in the low group. The median concentrations of NO_2 and dissolved ammonia plus organic nitrogen were below their respective MDL's. Most median nutrient concentrations stayed unchanged or decreased between sites 6 and 7, and these nutrients (0.05 to 0.60) showed no correlation to moderate positive correlation with streamflow. NO_2 + NO_3 concentrations, however, increased significantly, at a 95-percent confidence level, between the sites and showed no correlation with streamflow (-0.27). The increase in NO_2 + NO_3 concentrations probably were due to a combination of mineralization/nitrification of organic nitrogen in the main stem, the inflow of ground water with a larger NO_2 + NO_3 concentration to the main stem and tributaries, and irrigation-return flow and WWTP discharges to tributaries.

Dissolved iron and dissolved manganese were in the middle group. Dissolved iron (0.86) showed a strong positive correlation with streamflow, whereas dissolved manganese (-0.01) showed no correlation with streamflow. Summary statistics for the field-property and chemical-analyte data for site 7 are presented in table 17. Regression equations that relate selected water-quality data to selected field properties and time are presented in table 18.

Site 8 - Rio Chama near Chamita, N. Mex.

Site 8 is an integrator site on the largest tributary to the Rio Grande in the study unit. The USGS streamflow-gaging station for this site is located downstream from the bridge on U.S. Highway 285 approximately 0.5 mi west of Chamita, New Mexico. Low-flow samples were collected by wading upstream from the bridge, and high-flow samples were collected from a cableway about 300 ft downstream from the gage. On September 1, 1994, high water scoured the channel and caused major changes in the cross section.

The 3,040-mi^2 contributing drainage basin for site 8 includes the Chama Basin, the southern San Juan Mountains, and the northern part of the Jemez Mountains. The major land use is forest; rangeland is a distant second use (U.S. Geological Survey, 1986). Some agricultural land is present in lowland areas along the river. Major bedrock types include Precambrian metamorphic rock; Cretaceous sedimentary rock; and Tertiary tuff, lava, and sedimentary rock (Dane and Bachman, 1965; Tweto, 1979).

Streamflow at site 8 is seasonal but regulated by upstream flood-control reservoirs. High flows are in the late spring and early summer and there may be no flow at certain times during some years (Borland and Ong, 1995). Streamflow is affected by transmountain diversions from the San Juan River Basin through the Azotea tunnel and diversions for irrigation. The annual mean discharge at site 8 for WY's 1971 to 1995 was 611 ft^3/s (Ortiz and Lange, 1996). The annual mean discharge for WY 1993 was 819 ft^3/s (Cruz and others, 1994); for WY 1994 was 862 ft^3/s (Borland and Ong, 1995); and for WY 1995 was 881 ft^3/s (Ortiz and Lange, 1996).

The water sampled at site 8 for the most part was a well-oxygenated, calcium bicarbonate type. The median specific-conductance value was 288, the median pH value was 8.2, and the median DO percent of saturation was 101. DS and most major constituents were in the middle group; chloride, fluoride, potassium, and silica were in the low group. The median concentrations of most nutrients were below their respective MDL's. Dissolved ammonia and total ammonia plus organic nitrogen were in the middle group; total phosphorus and dissolved phosphorus were in the low group. Dissolved iron was in the high

Table 17.--Statistical summary of selected water-quality data for site 7 - Rio Grande below Taos Junction Bridge, near Taos, N. Mex.

[Property or analyte: µS/cm, microsiemens per centimeter at 25 degrees Celsius; diss, dissolved; mg/L, milligrams per liter; it, incremental titration; µg/L, micrograms per liter. MRL, minimum reporting level; std dev, standard deviation; C, calculated value; --, not applicable; <, less than]

Property or analyte (unit)	Number of samples	MRL	Percent less than MRL	Mean	Std dev	Minimum	Percentiles 10	25	50 Median	75	90	Maximum
Streamflow, instantaneous (cubic feet per second)	33	0.01	0	1,130	1,200	270	338	432	633	1,140	3,440	5,330
Specific conductance (µS/cm)	32	1.0	0	298	58	182	205	264	297	345	370	398
pH (standard units)	33	.1	0	[1]8.2	.3	7.6	7.8	8.0	8.3	8.5	8.7	8.8
Temperature, water (degrees Celsius)	33	-5.0	0	12.3	5.9	2.5	3.5	7.0	14.5	18.0	19.0	19.5
Oxygen, diss (mg/L)	33	.1	0	8.9	1.3	6.9	7.5	7.9	8.5	10.4	11.0	11.4
Oxygen, diss (percent saturation)	33	C	--	103	6	91	95	99	102	107	111	114
Hardness (mg/L as $CaCO_3$)	30	C	--	101	18	62	73	90	100	112	129	130
Hardness, noncarbonate (mg/L as $CaCO_3$)	28	C	--	8	6	0	1	3	6	14	16	22
Alkalinity, it-field (mg/L as $CaCO_3$)	28	1	0	95	17	56	63	88	100	107	114	116
Solids, sum of constituents, diss (mg/L)	30	C	--	186	37	113	125	156	192	216	230	242
Solids, residue at 180 degrees Celsius (mg/L) (diss solids)	30	1	0	191	35	128	136	161	194	219	228	257
Calcium, diss (mg/L as Ca)	30	.02	0	30	5.0	19	22	27	30	34	37	38
Magnesium, diss (mg/L as Mg)	30	.01	0	6.4	1.4	3.6	4.2	5.4	6.3	7.6	8.2	8.7
Sodium, diss (mg/L as Na)	30	.2	0	19	5.7	8.5	10	15	19	23	28	30
Sodium percentage	30	C	--	28	3	18	24	26	28	30	32	34
Sodium adsorption ratio	30	C	--	.8	.2	.4	.5	.7	.8	.9	1	1
Potassium, diss (mg/L as K)	30	.1	0	3.1	1.1	1.8	2.1	2.6	2.9	3.4	4.2	8.0
Bicarbonate, it-field (mg/L as HCO_3)	28	1	0	114	20	68	77	98	120	127	136	139
Carbonate, it-field (mg/L as CO_3)	28	0	0	1	3	0	0	0	0	1	3	17
Sulfate, diss (mg/L as SO_4)	30	.1	0	41	13	21	23	33	39	51	62	73
Chloride, diss (mg/L as Cl)	30	.1	0	6.0	1.7	2.6	3.0	4.4	6.4	7.0	7.9	8.5
Fluoride, diss (mg/L as F)	30	.1	0	.5	.2	.2	.3	.4	.5	.6	.8	.8
Silica, diss (mg/L as SiO_2)	30	.01	0	22	4.1	15	17	18	23	25	28	31
Nitrogen, nitrite, diss (mg/L as N)	30	.01	83	[2].002-.010	--	<.01	<.01	<.01	<.01	<.01	.01	.01
Nitrogen, nitrite plus nitrate, diss (mg/L as N)	30	.05	10	.15	.09	<.05	<.05	.07	.12	.23	.31	.34
Nitrogen, ammonia, diss (mg/L as N)	30	.015	40	[3].015-.021	--	<.015	<.015	<.015	.02	.03	.03	.03
Nitrogen, un-ionized ammonia, diss (mg/L as N)	30	[4]C	--	.001	.001	<.0001	<.0001	.0002	.0006	.001	.003	.005
Nitrogen, ammonia plus organic, diss (mg/L as N)	30	.2	77	[3].05-.21	--	<.2	<.2	<.2	<.2	<.2	.2	.3
Nitrogen, ammonia plus organic, total (mg/L as N)	30	.2	40	[5].3	[5].2	<.2	<.2	<.2	.2	.4	.7	1.0
Phosphorus, total (mg/L as P)	30	.01	7	.07	.06	<.01	.01	.03	.06	.08	.20	.25
Phosphorus, diss (mg/L as P)	30	.01	30	[5].02	[5].01	<.01	<.01	<.01	.02	.04	.05	.06
Phosphorus, orthophosphate (mg/L as P)	30	.01	20	[5].02	[5].01	<.01	<.01	.01	.02	.03	.03	.05
Iron, diss (µg/L as Fe)	30	3	0	49	84	3	4	9	21	54	110	440
Manganese, diss (µg/L as Mn)	30	1	0	10	8	4	5	6	9	11	14	51
Sediment, suspended (mg/L)	30	1	0	76	89	10	17	20	36	89	255	325
Sediment, discharge, suspended (tons/day)	30	C	--	434	842	15	19	26	70	336	1,650	3,470

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[1] Statistic calculated after transforming pH values to hydrogen-ion concentrations.

[2] Range is given for statistics for data set with 80 percent or more censored data.

[3] Range is given for statistics for data set with more than 20 percent and less than 80 percent censored data and insufficient variation of uncensored data to perform log-probability regression.

[4] The MRL value of 0.015 mg/L was used for censored dissolved-ammonia concentrations in calculating un-ionized ammonia concentrations. All un-ionized ammonia statistics less than 0.0001 mg/L are reported as <0.0001 mg/L.

[5] Statistics are estimated by log-probability regression for data set with more than 20 percent and less than 80 percent censored data.

Table 18.--Regression equations for selected water-quality analytes with selected field properties and time for site 7 - Rio Grande below Taos Junction Bridge, near Taos, N. Mex.

[Analyte: °C, degrees Celsius; $NO_2 + NO_3$, nitrite plus nitrate; diss, dissolved; ortho, orthophosphate. Unit: mg/L, milligrams per liter; µg/L, micrograms per liter. Regression equation: sclog, base 10 logarithm of specific conductance, in microsiemens per centimeter at 25 °C; qlog, base 10 logarithm of streamflow, in cubic feet per second; sc, specific conductance, in microsiemens per centimeter at 25 °C; temp, water temperature, in °C; q, streamflow, in cubic feet per second; sea[1], seasonality variable; DOlog, base 10 logarithm of dissolved-oxygen concentration, in mg/L; pH, in standard pH units. Adj R^2, adjusted coefficient of determination (Ott, 1993). Method: MLR, multiple linear regression; KTR, Kendall-Theil robust line. --, not applicable]

Analyte	Unit	Regression equation	Adj R^2	Method
Solids, residue at 180 °C (dissolved solids)	mg/L	$10^{(23.748 + 0.572 \text{ sc})}$	0.954	MLR
Calcium	mg/L	$10^{(-2.170 - 0.0014 \text{ sc} + 1.644 \text{ sclog})}$	.940	MLR
Magnesium	mg/L	$10^{(-0.715 - 0.094 \text{ qlog} + 0.717 \text{ sclog} + 0.002 \text{ temp})}$	.957	MLR
Sodium	mg/L	$10^{(-3.193 + 0.00002 \text{ q} + 1.815 \text{ sclog} - 0.003 \text{ temp})}$	.951	MLR
Potassium	mg/L	$10^{(12.877 + 0.010 \text{ sc} - 6.255 \text{ sclog})}$	.247	MLR
Bicarbonate, as HCO_3	mg/L	$10^{(0.709 - 0.064 \text{ qlog} + 0.619 \text{ sclog} - 0.018 \text{ sea})}$	.949	MLR
Sulfate, as SO_4	mg/L	$10^{(-9.024 + 0.00005 \text{ q} - 0.005 \text{ sc} + 4.973 \text{ sclog} - 0.328 \text{ DOlog} + 0.019 \text{ sea})}$	.960	MLR
Chloride	mg/L	$10^{(-3.610 + 1.519 \text{ sclog} + 0.661 \text{ DOlog})}$	.950	MLR
Fluoride	mg/L	$10^{(1.409 - 0.434 \text{ qlog} - 0.495 \text{ DOlog})}$	.897	MLR
Silica, as SiO_2	mg/L	$10^{(9.59 + 0.0001 \text{ q} - 0.272 \text{ qlog} - 0.008 \text{ sc} + 5.728 \text{ sclog} - 0.007 \text{ temp})}$	.778	MLR
Nitrogen, $NO_2 + NO_3$, diss, as N	mg/L	0.162 - 0.74 sea	--	KTR
Phosphorus, total, as P	mg/L	-0.221 + 0.098 qlog	--	KTR
Phosphorus, ortho, diss, as P	mg/L	-0.033 + 0.019 qlog	--	KTR
Iron, diss	µg/L	$10^{(4.192 + 0.913 \text{ qlog} - 0.670 \text{ pH})}$	.677	MLR
Manganese, diss	µg/L	1,214.3 - 0.009 q + 0.703 sc - 569.34 sclog	.161	MLR

[1] sea = sin(T) + cos(T) where T equals the time, in months, from December 1, 1992, times 0.5236.

group; dissolved-iron concentrations were larger than expected for well-oxygenated surface waters (Hem, 1985), possibly due to particulates and/or colloids that passed through a 0.45-micron filter (Kennedy and others, 1974). Dissolved manganese was in the middle group. Summary statistics for field-property and chemical-analyte data for site 8 are presented in table 19.

Streamflow showed moderate negative correlations with specific conductance (-0.44), DS (-0.47), most major constituents (-0.34 to -0.56), and dissolved manganese (-0.42) and moderate positive correlations with total ammonia plus organic nitrogen (0.31) and dissolved iron (0.45). Potassium (0.21) and most nutrients (0 to 0.28) showed no correlation to streamflow. Regression equations that relate selected water-quality data to selected field properties and time are presented in table 20.

Site 9 - Rio Grande at Otowi Bridge, near San Ildefonso, N. Mex.

Site 9 is an integrator site on the main stem approximately 1.8 mi southwest of San Ildefonso, New Mexico. The USGS streamflow-gaging station for this site is located on a former railroad bridge about 400 ft downstream from State Highway 502. Low-flow samples were collected by wading near the gage, and high-flow samples were collected from a cableway about 100 ft upstream from the gage.

The contributing drainage area for the reach between sites 7 and 9 is 4,400 mi^2; approximately 69 percent of the area is in the Rio Chama drainage basin. Major land uses in this area, excluding the Rio Chama drainage basin, are forest and rangeland (U.S. Geological Survey, 1986). Downstream from site 7, the Rio Grande Gorge gradually widens, and land along the main stem and tributaries is used for farming and orchards. Española, New Mexico, is located along the Rio Grande about 10 mi upstream from site 9. Major surficial deposits and bedrock types, excluding the Rio Chama drainage basin, are Precambrian gneiss and granite and Quaternary lava and unconsolidated gravel, sand, and silt (Dane and Bachman, 1965).

Streamflow at site 9 is seasonal; high flows occur in late spring and early summer. High flows at this site may result from high flows on the main stem Rio Grande, on the Rio Chama, or may be the summation of smaller flows on both. During the high-intensity sampling phase, streamflow at site 9 was the summation of flow at sites 7 and 8; the high spring flow at site 7, however, occurred from 1 to 6 weeks later than the high flow at site 8. The annual mean discharge at site 9 for WY's 1910 to 1995 was 1,600 ft^3/s (Ortiz and Lange, 1996). The annual mean discharge for WY 1993 was 1,950 ft^3/s (Cruz and others, 1994); for WY 1994 was 1,902 ft^3/s (Borland and Ong, 1995); and for WY 1995 was 2,234 ft^3/s (Ortiz and Lange, 1996).

The water sampled at site 9 for the most part was a well-oxygenated, calcium bicarbonate type. The median specific-conductance value was 307, the median pH value was 8.1, and the median DO percent of saturation was 95. DS and the major constituents were in the middle group. Because the DS and major-constituent concentrations in the main stem (site 7) and the Rio Chama (site 8) were about the same, the river with the higher streamflow was usually the major contributor to the DS and major-constituent loads at site 9. Streamflow showed moderate negative correlations with specific conductance (-0.49), DS (-0.40), and most major constituents (-0.32 to -0.62). Potassium (-0.19) showed no correlation with streamflow.

$NO_2 + NO_3$, dissolved ammonia, and total phosphorus were in the low group; dissolved phosphorus and orthophosphate were in the middle group. The median concentrations of NO_2 and dissolved ammonia plus organic nitrogen were below their respective MDL's. Most nutrients (0.39 to 0.51) showed a moderate positive correlation to streamflow, whereas NO_2, $NO_2 + NO_3$, and total phosphorus showed no correlation to streamflow. Dissolved-iron and dissolved-manganese concentrations were in the middle group. Dissolved-iron concentrations, however, were larger than expected for well-oxygenated surface waters (Hem, 1985), possibly due to particulates and/or colloids that passed through a 0.45-micron filter (Kennedy and others, 1974). Summary statistics for field-property and chemical-analyte data for site 9 are presented in table 21. Regression equations that relate selected water-quality data to selected field properties and time are presented in table 22.

Site 10 - Rito de los Frijoles in Bandelier National Monument, N. Mex.

Site 10 is an indicator site for a small forested basin on a tributary stream draining an 18-mi^2 basin on the east slope of the Jemez Mountains. The streamflow-gaging station for this site is located in Bandelier National Monument about 800 ft downstream from the monument headquarters. During the high-intensity sampling phase, the gage was operated by the USGS;

Table 19.--Statistical summary of selected water-quality data for site 8 - Rio Chama near Chamita, N. Mex.

[Property or analyte: µS/cm, microsiemens per centimeter at 25 degrees Celsius; diss, dissolved; mg/L, milligrams per liter; it, incremental titration; µg/L, micrograms per liter. MRL, minimum reporting level; std dev, standard deviation; C, calculated value; --, not applicable; <, less than]

Property or analyte (unit)	Number of samples	MRL	Percent less than MRL	Mean	Std dev	Minimum	Percentiles 10	25	50 Median	75	90	Maximum
Streamflow, instantaneous (cubic feet per second)	31	0.01	0	1,010	770	168	238	396	714	1,790	2,340	2,780
Specific conductance (µS/cm)	30	1.0	0	299	45	233	246	266	288	340	370	390
pH (standard units)	31	.1	0	[1]8.1	.2	7.6	7.8	8.0	8.2	8.3	8.4	8.4
Temperature, water (degrees Celsius)	31	-5.0	0	10.2	5.3	.0	3.0	6.0	10.5	14.5	17.0	20.5
Oxygen, diss (mg/L)	31	.1	0	9.4	1.2	7.5	7.9	8.2	9.3	10.6	11.0	11.9
Oxygen, diss (percent saturation)	31	C	--	101	5	93	96	98	101	104	108	117
Hardness (mg/L as $CaCO_3$)	29	C	--	114	16	88	94	100	110	125	140	150
Hardness, noncarbonate (mg/L as $CaCO_3$)	27	C	--	30	5	21	23	25	31	35	36	41
Alkalinity, it-field (mg/L as $CaCO_3$)	27	1	0	84	15	61	69	74	80	96	110	116
Solids, sum of constituents, diss (mg/L)	28	C	--	182	29	138	145	156	174	203	230	242
Solids, residue at 180 degrees Celsius (mg/L) (diss solids)	29	1	0	192	30	152	155	166	187	222	240	252
Calcium, diss (mg/L as Ca)	29	.02	0	34	4.4	26	28	30	34	37	41	43
Magnesium, diss (mg/L as Mg)	29	.01	0	7.0	1.0	5.3	5.9	6.4	7.0	7.6	8.7	9.3
Sodium, diss (mg/L as Na)	29	.2	0	15	4.7	10	11	11	14	18	23	25
Sodium percentage	28	C	--	22	3	18	18	19	21	23	27	28
Sodium adsorption ratio	29	C	--	.6	.1	.4	.5	.5	.6	.8	.9	.9
Potassium, diss (mg/L as K)	28	.1	0	1.8	.3	1.3	1.5	1.6	1.7	2.1	2.2	2.5
Bicarbonate, it-field (mg/L as HCO_3)	27	1	0	102	18	75	84	89	98	117	133	141
Carbonate, it-field (mg/L as CO_3)	27	0	0	0	0	0	0	0	0	0	0	0
Sulfate, diss (mg/L as SO_4)	29	.1	0	57	9.9	41	42	48	56	64	67	82
Chloride, diss (mg/L as Cl)	29	.1	0	3.8	2.2	1.7	2.0	2.3	2.6	4.8	7.8	9.3
Fluoride, diss (mg/L as F)	28	.1	0	.2	.1	.1	.1	.1	.2	.2	.3	.3
Silica, diss (mg/L as SiO_2)	29	.01	0	14	1.1	13	13	13	14	15	16	16
Nitrogen, nitrite, diss (mg/L as N)	29	.01	100	[2].000-.010	--	<.01	<.01	<.01	<.01	<.01	<.01	<.01
Nitrogen, nitrite plus nitrate, diss (mg/L as N)	29	.05	79	[3].06	[3].02	<.05	<.05	<.05	<.05	<.05	.09	.10
Nitrogen, ammonia, diss (mg/L as N)	29	.015	31	[4].016-.021	--	<.015	<.015	<.015	.02	.02	.03	.03
Nitrogen, un-ionized ammonia, diss (mg/L as N)	29	[5]C	--	.0006	.0005	<.0001	.0001	.0002	.0004	.001	.001	.002
Nitrogen, ammonia plus organic, diss (mg/L as N)	29	.2	69	[4].07-.21	--	<.2	<.2	<.2	<.2	.2	.3	.3
Nitrogen, ammonia plus organic, total (mg/L as N)	29	.2	24	[3].3	[4].1	<.2	<.2	<.2	.2	.3	.4	.5
Phosphorus, total (mg/L as P)	29	.01	7	.06	.04	<.01	.01	.02	.05	.07	.14	.17
Phosphorus, diss (mg/L as P)	29	.01	31	[3].02	[3].01	<.01	<.01	<.01	.02	.02	.03	.04
Phosphorus, orthophosphate (mg/L as P)	29	.01	52	[3].01	[3].007	<.01	<.01	<.01	<.01	.01	.02	.03
Iron, diss (µg/L as Fe)	29	3	0	33	29	4	5	10	23	44	67	140
Manganese, diss (µg/L as Mn)	29	1	0	8	8	2	3	3	6	9	16	45
Sediment, suspended (mg/L)	29	1	0	624	1,130	23	39	80	165	788	1,710	5,770
Sediment, discharge, suspended (tons/day)	29	C	--	1,360	1,840	19	53	170	409	2,260	4,770	6,310

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[1] Statistic calculated after transforming pH values to hydrogen-ion concentrations.

[2] Range is given for statistics for data set with 80 percent or more censored data.

[3] Statistics are estimated by log-probability regression for data set with more than 20 percent and less than 80 percent censored data.

[4] Range is given for statistics for data set with more than 20 percent and less than 80 percent censored data and insufficient variation of uncensored data to perform log-probability regression.

[5] The MRL value of 0.015 mg/L was used for censored dissolved-ammonia concentrations in calculating un-ionized ammonia concentrations. All un-ionized ammonia statistics less than 0.0001 mg/L are reported as <0.0001 mg/L.

Table 20.--Regression equations for selected water-quality analytes with selected field properties and time for site 8 - Rio Chama near Chamita, N. Mex.

[Analyte: °C, degrees Celsius; diss, dissolved. Unit: mg/L, milligrams per liter; µg/L, micrograms per liter. Regression equation: q, streamflow, in cubic feet per second; sc, specific conductance, in microsiemens per centimeter at 25 °C; temp, water temperature, in °C; sea[1], seasonality variable; sclog, base 10 logarithm of specific conductance, in microsiemens per centimeter at 25 °C; qlog, base 10 logarithm of streamflow, in cubic feet per second; pH, in standard pH units; DOlog, base 10 logarithm of dissolved-oxygen concentration, in mg/L. Adj R^2, adjusted coefficient of determination (Ott, 1993). Method: MLR, multiple linear regression; KTR, Kendall-Theil robust line. --, not applicable]

Analyte	Unit	Regression equation	Adj R^2	Method
Solids, residue at 180 °C (dissolved solids)	mg/L	-23.61 + 0.009 q + 0.671 sc + 0.726 temp - 6.950 sea	0.949	MLR
Calcium	mg/L	$10^{(-0.284 + 0.726 \text{ sclog} + 0.002 \text{ temp} - 0.015 \text{ sea})}$	.888	MLR
Magnesium	mg/L	-29.48 + 0.0008 q - 1.339 qlog + 14.078 sclog + 0.687 pH	.859	MLR
Sodium	mg/L	279.62 + 0.288 sc - 141 sclog - 0.762 sea	.968	MLR
Potassium	mg/L	0.287 + 0.005 sc	.577	MLR
Bicarbonate, as HCO_3	mg/L	$10^{(0.710 - 0.076 \text{ qlog} + 0.620 \text{ sclog} - 0.002 \text{ temp})}$	.923	MLR
Sulfate, as SO_4	mg/L	$10^{(-8.55 + 0.087 \text{ qlog} - 0.004 \text{ sc} + 4.435 \text{ sclog})}$	.899	MLR
Chloride	mg/L	212.6 - 1.485 qlog + 0.173 sc - 100.48 sclog - 0.868 pH - 0.080 temp	.937	MLR
Fluoride	mg/L	-0.203 + 0.001 sc	.703	MLR
Silica, as SiO_2	mg/L	108.9 + 0.086 sc - 50.720 sclog + 4.847 DOlog	.661	MLR
Phosphorus, total, as P	mg/L	$10^{(1.69 - 3.078 \text{ DOlog})}$	--	KTR
Iron, diss	µg/L	$10^{(6.352 + 0.0003 \text{ q} - 0.649 \text{ pH})}$	.468	MLR
Manganese, diss	µg/L	$10^{(1.257 - 0.422 \text{ qlog} + 0.080 \text{ DO})}$	.370	MLR

[1] sea = sin(T) + cos(T) where T equals the time, in months, from December 1, 1992, times 0.5236.

Table 21.--Statistical summary of selected water-quality data for site 9 - Rio Grande at Otowi Bridge, near San Ildefonso, N. Mex.

[Property or analyte: µS/cm, microsiemens per centimeter at 25 degrees Celsius; diss, dissolved; mg/L, milligrams per liter; it, incremental titration; µg/L, micrograms per liter. MRL, minimum reporting level; std dev, standard deviation; C, calculated value; --, not applicable; <, less than]

Property or analyte (unit)	Number of samples	MRL	Percent less than MRL	Mean	Std dev	Minimum	Percentiles 10	25	50 Median	75	90	Maximum
Streamflow, instantaneous (cubic feet per second)	29	0.01	0	2,420	2,150	725	790	958	1,380	3,560	6,880	7,960
Specific conductance (µS/cm)	28	1.0	0	298	45	204	221	276	307	329	351	377
pH (standard units)	29	.1	0	[1]8.1	.2	7.6	7.8	8.0	8.1	8.3	8.5	8.6
Temperature, water (degrees Celsius)	29	-5.0	0	11.6	5.8	.8	2.0	7.1	13.3	16.8	18.4	20.0
Oxygen, diss (mg/L)	27	.1	0	8.5	1.2	7.1	7.2	7.5	8.2	9.7	10.3	10.7
Oxygen, diss (percent saturation)	27	C	--	95	4	88	90	93	95	97	101	109
Hardness (mg/L as $CaCO_3$)	28	C	--	112	17	75	85	102	115	120	131	140
Hardness, noncarbonate (mg/L as $CaCO_3$)	27	C	--	17	8	0	6	11	16	22	27	37
Alkalinity, it-field (mg/L as $CaCO_3$)	27	1	0	97	18	62	68	83	99	108	119	124
Solids, sum of constituents, diss (mg/L)	28	C	--	186	29	124	135	173	194	209	219	221
Solids, residue at 180 degrees Celsius (mg/L) (diss solids)	28	1	0	192	28	142	144	172	196	216	223	235
Calcium, diss (mg/L as Ca)	28	.02	0	34	5.0	23	26	32	35	37	41	43
Magnesium, diss (mg/L as Mg)	28	.01	0	6.5	.93	4.2	4.9	6.0	6.7	7.2	7.6	7.7
Sodium, diss (mg/L as Na)	28	.2	0	17	4.0	9.6	11	14	17	20	21	25
Sodium percentage	28	C	--	24	3	20	20	21	24	25	28	31
Sodium adsorption ratio	28	C	--	.7	.1	.5	.5	.6	.7	.8	.9	1
Potassium, diss (mg/L as K)	28	.1	0	2.3	.4	1.7	1.8	1.9	2.2	2.6	2.9	3.4
Bicarbonate, it-field (mg/L as HCO_3)	27	1	0	117	21	76	83	101	119	130	146	152
Carbonate, it-field (mg/L as CO_3)	27	0	0	.7	2	0	0	0	0	0	1	12
Sulfate, diss (mg/L as SO_4)	28	.1	0	45	9.3	28	34	38	48	51	56	67
Chloride, diss (mg/L as Cl)	28	.1	0	5.0	1.6	2.6	2.7	3.4	4.7	6.8	7.1	7.7
Fluoride, diss (mg/L as F)	28	.1	0	.3	.1	.2	.2	.2	.3	.4	.5	.5
Silica, diss (mg/L as SiO_2)	28	.01	0	18	3.1	14	15	16	17	20	23	25
Nitrogen, nitrite, diss (mg/L as N)	29	.01	97	[2].000-.010	--	<.01	<.01	<.01	<.01	<.01	<.01	.01
Nitrogen, nitrite plus nitrate, diss (mg/L as N)	29	.05	31	[3].08	[3].06	<.05	<.05	<.05	.06	.12	.17	.28
Nitrogen, ammonia, diss (mg/L as N)	29	.015	45	[4].012-.019	--	<.015	<.015	<.015	.02	.02	.03	.03
Nitrogen, un-ionized ammonia, diss (mg/L as N)	29	[5]C	--	.0006	.0007	<.0001	<.0001	.0002	.0004	.0008	.002	.003
Nitrogen, ammonia plus organic, diss (mg/L as N)	23	.2	65	[4].08-.21	--	<.2	<.2	<.2	<.2	.2	.3	.3
Nitrogen, ammonia plus organic, total (mg/L as N)	29	.2	24	[3].4	[3].4	<.2	<.2	<.2	.3	.4	.9	1.7
Phosphorus, total (mg/L as P)	29	.01	3	.08	.06	<.01	.02	.04	.07	.10	.17	.28
Phosphorus, diss (mg/L as P)	29	.01	28	[3].02	[3].01	<.01	<.01	<.01	.02	.03	.05	.05
Phosphorus, orthophosphate (mg/L as P)	29	.01	34	[3].01	[3].01	<.01	<.01	<.01	.01	.02	.03	.04
Iron, diss (µg/L as Fe)	28	3	0	33	33	5	6	9	19	42	85	140
Manganese, diss (µg/L as Mn)	28	1	0	7	3	3	3	5	6	9	12	15
Sediment, suspended (mg/L)	29	1	0	342	300	40	72	90	332	491	893	1,170
Sediment, discharge, suspended (tons/day)	29	C	--	2,650	3,670	113	181	328	1,140	2,140	10,300	12,700

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[1] Statistic calculated after transforming pH values to hydrogen-ion concentrations.

[2] Range is given for statistics for data set with 80 percent or more censored data.

[3] Statistics are estimated by log-probability regression for data set with more than 20 percent and less than 80 percent censored data.

[4] Range is given for statistics for data set with more than 20 percent and less than 80 percent censored data and insufficient variation of uncensored data to perform log-probability regression.

[5] The MRL value of 0.015 mg/L was used for censored dissolved-ammonia concentrations in calculating un-ionized ammonia concentrations. All un-ionized ammonia statistics less than 0.0001 mg/L are reported as <0.0001 mg/L.

Table 22.--Regression equations for selected water-quality analytes with selected field properties and time for site 9 - Rio Grande at Otowi Bridge, near San Ildefonso, N. Mex.

[Analyte: °C, degrees Celsius; diss, dissolved. Unit: mg/L, milligrams per liter; µg/L, micrograms per liter. Regression equation: sc, specific conductance, in microsiemens per centimeter at 25 °C; DOlog, base 10 logarithm of dissolved-oxygen concentration, in mg/L; qlog, base 10 logarithm of streamflow, in cubic feet per second; sclog, base 10 logarithm of specific conductance, in microsiemens per centimeter at 25 °C; pH, in standard pH units; temp, water temperature, in °C; sea[1], seasonality variable; q, streamflow, in cubic feet per second; DO, dissolved-oxygen concentration, in mg/L. Adj R^2, adjusted coefficient of determination (Ott, 1993). Method: MLR, multiple linear regression]

Analyte	Unit	Regression equation	Adj R^2	Method
Solids, residue at 180 °C (dissolved solids)	mg/L	$28.61 + 0.545 \text{ sc} - 11.16 \text{ pH} + 100.18 \text{ DOlog}$	0.940	MLR
Calcium	mg/L	$10^{(-0.413 - 0.053 \text{ qlog} + 0.683 \text{ sclog} + 0.052 \text{ pH})}$	.891	MLR
Magnesium	mg/L	$10^{(-1.990 + 0.892 \text{ sclog} + 0.073 \text{ pH})}$	.901	MLR
Sodium	mg/L	$10^{(1.343 + 0.002 \text{ sc} - 0.761 \text{ DOlog} - 0.010 \text{ temp})}$	.910	MLR
Potassium	mg/L	$6.532 + 1.025 \text{ qlog} + 0.011 \text{ sc} - 10.275 \text{ DOlog} - 0.102 \text{ temp}$	.275	MLR
Bicarbonate, as HCO_3	mg/L	$10^{(2.042 - 0.085 \text{ qlog} + 0.001 \text{ sc} - 0.024 \text{ sea})}$	.941	MLR
Sulfate, as SO_4	mg/L	$10^{(-14.77 + 0.00003 \text{ q} - 0.009 \text{ sc} + 7.695 \text{ sclog} + 0.042 \text{ sea})}$	.753	MLR
Chloride	mg/L	$10^{(0.627 + 0.003 \text{ sc} - 0.060 \text{ DO} - 0.021 \text{ temp})}$	.828	MLR
Fluoride	mg/L	$10^{(1.979 - 0.302 \text{ qlog} - 0.186 \text{ pH} - 0.049 \text{ sea})}$	.680	MLR
Silica, as SiO_2	mg/L	$10^{(4.332 + 0.0005 \text{ sc} + 0.215 \text{ DO} - 5.252 \text{ DOlog} - 0.017 \text{ temp})}$	.676	MLR
Phosphorus, total, as P	mg/L	$1.06 - 0.0006 \text{ sc} - 0.010 \text{ pH}$	.270	MLR
Iron, diss	µg/L	$1.66 + 0.014 \text{ q}$	.627	MLR
Manganese, diss	µg/L	$10^{(6.16 - 0.985 \text{ sclog} - 0.334 \text{ pH} - 0.018 \text{ temp})}$	.409	MLR

[1] sea = sin(T) + cos(T) where T equals the time, in months, from December 1, 1992, times 0.5236.

for most of the period between 1983 and 1993, however, the gage was operated by the NPS. All samples were collected by wading near the gage.

The basin drained by the Rito de los Frijoles is mainly forested (U.S. Geological Survey, 1986), and Tertiary tuff is the major rock type (Dane and Bachman, 1965). The parking area and picnic grounds for the monument's visitor center are located upstream from the gage.

Streamflow at site 10 is seasonal; high flows usually result from snowmelt in late spring or early summer. However, storms throughout the year may produce flows greater than those produced by snowmelt. Gaging streamflow at this site started in 1963; because of discontinuous records and the effects of the La Mesa forest fire in mid-June 1977 on runoff from the basin, however, the base period used for this site was 1983 to 1995. The annual mean discharge at site 10 for WY's 1983 to 1995 was 2.22 ft^3/s (Ortiz and Lange, 1996). The annual mean discharge for WY 1993 was 1.76 ft^3/s (Cruz and others, 1994); for WY 1994 was 1.37 ft^3/s (Borland and Ong, 1995); and for WY 1995 was 2.24 ft^3/s (Ortiz and Lange, 1996).

The water sampled at site 10 for the most part was a well-oxygenated, sodium calcium magnesium bicarbonate type. The median specific-conductance value was 108, the median pH value was 7.8, and the median DO percent of saturation was 98. DS and most major constituents were in the low group; chloride was in the middle group; and silica was in the high group. The mean sulfate concentration of 2.4 mg/L was approximately 3.5 times larger than the weighted monthly mean sulfate concentration of 0.704 mg/L in precipitation during the high-intensity sampling phase for this area (National Atmospheric Deposition Program, 1996). Silica concentrations were very high, and all measured concentrations were outside the range of what is normally expected in surface waters, 1 to 30 mg/L (Hem, 1985). The minimum silica concentration detected at site 10, 39 mg/L, was equal to the maximum concentration detected at all other basic-fixed sites combined. These large silica concentrations are probably the result of weathering of volcanic tuff in the drainage basin.

The median concentrations of all nitrogen nutrients were below their respective MDL's. Total phosphorus was in the low group; dissolved phosphorus and orthophosphate were in the middle group. Dissolved iron was in the high group; dissolved-iron concentrations were much larger than expected for well-oxygenated surface waters (Hem, 1985), possibly due to particulates and/or colloids that passed through a 0.45-micron filter (Kennedy and others, 1974). Dissolved manganese was in the middle group. Summary statistics for field-property and chemical-analyte data for site 10 are presented in table 23.

Streamflow showed a moderate negative correlation to specific conductance (-0.48), calcium (-0.31), magnesium (-0.35), sodium (-0.61), bicarbonate (-0.69), and fluoride (-0.53), and no correlation to a moderate positive correlation to DS (0.18), sulfate (0.53), chloride (0.37), the nutrients (-0.05 to 0.40), dissolved iron (0.66), and dissolved manganese (0.48). Regression equations that relate selected water-quality data to selected field properties and time are presented in table 24.

Site 11 - Santa Fe River above Cochiti Lake, N. Mex.

Site 11 is an indicator site for an urban watershed on a tributary that originates in the Sangre de Cristo Range, flows through Santa Fe, New Mexico, and drains to an area behind Cochiti Dam. This area may at times be inundated by Cochiti Lake, although this did not occur during the high-intensity sampling phase. The USGS streamflow-gaging station for this site is located approximately 0.8 mi southeast of La Bajada, New Mexico, and 5.0 mi upstream from Cochiti Dam. All samples were collected by wading near the gage.

Major land uses in the 228-mi^2 Santa Fe River Basin are forest and rangeland (U.S. Geological Survey, 1986); a number of abandoned mines are in the basin, including an abandoned uranium mine approximately 1.5 mi upstream from site 11. Because during most of the year a large percentage of the flow at this site is effluent from the Santa Fe WWTP, the site is classified as an urban land-use site. Major surficial deposits and bedrock types in this basin include Precambrian metamorphic rock and granite and Quaternary unconsolidated gravel, sand, and silt and lava (Dane and Bachman, 1965).

Streamflow at site 11 is seasonal; high flows caused by snowmelt usually occur in early to mid-spring. Summer storms also can cause flows as high as spring flows. Streamflow at this site is affected by diversions for municipal supply and irrigation. The annual mean discharge at site 11 for WY's 1970 to 1995 was 11.6 ft^3/s (Ortiz and Lange, 1996). The annual mean discharge for WY 1993 was 16.6 ft^3/s (Cruz and others, 1994); for WY 1994 was 11.6 ft^3/s (Borland and Ong, 1995); and for WY 1995 was 15.3 ft^3/s (Ortiz and Lange, 1996).

Table 23.--Statistical summary of selected water-quality data for site 10 - Rito de los Frijoles in Bandelier National Monument, N. Mex.

[Property or analyte: µS/cm, microsiemens per centimeter at 25 degrees Celsius; diss, dissolved; mg/L, milligrams per liter; it, incremental titration; µg/L, micrograms per liter. MRL, minimum reporting level; std dev, standard deviation; C, calculated value; --, not applicable; <, less than]

Property or analyte (unit)	Number of samples	MRL	Percent less than MRL	Mean	Std dev	Minimum	Percentiles 10	25	50 Median	75	90	Maximum
Streamflow, instantaneous (cubic feet per second)	33	0.01	0	2.0	1.7	0.26	0.75	0.98	1.4	2.3	3.7	8.4
Specific conductance (µS/cm)	32	1.0	0	107	6	96	98	102	108	113	114	115
pH (standard units)	33	.1	0	[1]7.6	.4	7.1	7.2	7.6	7.8	8.0	8.3	8.5
Temperature, water (degrees Celsius)	33	-5.0	0	11.7	7.0	.0	1.0	5.5	11.0	17.0	21.0	25.0
Oxygen, diss (mg/L)	33	.1	0	8.9	1.7	6.8	7.1	7.6	8.2	10.1	11.3	14.3
Oxygen, diss (percent saturation)	32	C	--	100	6	93	94	96	98	101	106	121
Hardness (mg/L as CaCO$_3$)	28	C	--	32	2.2	28	29	30	32	34	35	35
Hardness, noncarbonate (mg/L as CaCO$_3$)	25	C	--	0	0	0	0	0	0	0	0	0
Alkalinity, it-field (mg/L as CaCO$_3$)	28	1	0	45	6	34	34	41	45	49	50	59
Solids, sum of constituents, diss (mg/L)	27	C	--	112	8	96	98	108	113	118	122	126
Solids, residue at 180 degrees Celsius (mg/L) (diss solids)	28	1	0	118	11	98	103	112	118	124	131	149
Calcium, diss (mg/L as Ca)	28	.02	0	8.3	.56	7.3	7.4	7.9	8.4	8.8	8.9	9.4
Magnesium, diss (mg/L as Mg)	29	.01	0	2.7	.18	2.4	2.5	2.6	2.7	2.8	3.0	3.0
Sodium, diss (mg/L as Na)	29	.2	0	9.3	.9	7.3	7.8	8.8	9.5	10	10	11
Sodium percentage	27	C	--	37	2	33	34	36	37	39	40	41
Sodium adsorption ratio	28	C	--	.7	.1	.6	.6	.7	.7	.8	.8	.8
Potassium, diss (mg/L as K)	28	.1	0	1.9	.3	1.3	1.4	1.8	2.0	2.1	2.4	2.7
Bicarbonate, it-field (mg/L as HCO$_3$)	28	1	0	54	7	41	42	50	55	59	61	72
Carbonate, it-field (mg/L as CO$_3$)	28	0	0	0	0	0	0	0	0	0	0	0
Sulfate, diss (mg/L as SO$_4$)	29	.1	0	2.6	.7	1.6	1.8	2.1	2.4	2.8	3.5	4.8
Chloride, diss (mg/L as Cl)	29	.1	0	4.5	1.3	2.6	2.7	3.6	4.5	5.4	6.4	7.6
Fluoride, diss (mg/L as F)	29	.1	3	.2	.1	<.1	.1	.1	.2	.2	.2	.2
Silica, diss (mg/L as SiO$_2$)	29	.01	0	56	5.8	39	46	53	57	60	61	64
Nitrogen, nitrite, diss (mg/L as N)	30	.01	87	[2].003-.012	--	<.01	<.01	<.01	<.01	<.01	.02	.04
Nitrogen, nitrite plus nitrate, diss (mg/L as N)	30	.05	77	[3].04	[3].03	<.05	<.05	<.05	<.05	<.05	.09	.11
Nitrogen, ammonia, diss (mg/L as N)	30	.015	57	[3].017	[3].008	<.015	<.015	<.015	<.015	.02	.03	.04
Nitrogen, un-ionized ammonia, diss (mg/L as N)	30	[4]C	--	.0004	.0005	<.0001	<.0001	<.0001	.0001	.0008	.001	.002
Nitrogen, ammonia plus organic, diss (mg/L as N)	30	.2	87	[2].03-.21	--	<.2	<.2	<.2	<.2	<.2	.2	.3
Nitrogen, ammonia plus organic, total (mg/L as N)	30	.2	73	[3].2	[3].1	<.2	<.2	<.2	<.2	.2	.4	.6
Phosphorus, total (mg/L as P)	30	.01	7	.04	.02	<.01	.02	.03	.04	.05	.07	.12
Phosphorus, diss (mg/L as P)	30	.01	7	.03	.01	<.01	.01	.02	.03	.04	.05	.07
Phosphorus, orthophosphate (mg/L as P)	30	.01	3	.03	.01	<.01	.01	.02	.03	.03	.04	.05
Iron, diss (µg/L as Fe)	29	3	0	190	190	73	84	98	120	200	300	840
Manganese, diss (µg/L as Mn)	29	1	0	9	3	5	5	8	9	10	12	21
Sediment, suspended (mg/L)	29	1	0	18	9	6	8	12	16	22	32	44
Sediment, discharge, suspended (tons/day)	29	C	--	.11	.13	.02	.02	.04	.07	.11	.26	.58

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[1] Statistic calculated after transforming pH values to hydrogen-ion concentrations.

[2] Range is given for statistics for data set with 80 percent or more censored data.

[3] Statistics are estimated by log-probability regression for data set with more than 20 percent and less than 80 percent censored data.

[4] The MRL value of 0.015 mg/L was used for censored dissolved-ammonia concentrations in calculating un-ionized ammonia concentrations. All un-ionized ammonia statistics less than 0.0001 mg/L are reported as <0.0001 mg/L.

Table 24.--Regression equations for selected water-quality analytes with selected field properties and time for site 10 - Rito de Los Frijoles in Bandelier National Monument, N. Mex.

[Analyte: °C, degrees Celsius; diss, dissolved; ortho, orthophosphate. Unit: mg/L, milligrams per liter; µg/L, micrograms per liter. Regression equation: q, streamflow, in cubic feet per second; sclog, base 10 logarithm of specific conductance, in microsiemens per centimeter at 25 °C; pH, in standard pH units; sc, specific conductance, in microsiemens per centimeter at 25 °C; sea[1], seasonality variable; temp, water temperature, in °C; DO, dissolved-oxygen concentration, in mg/L; DOlog, base 10 logarithm of dissolved-oxygen concentration, in mg/L; qlog, base 10 logarithm of streamflow, in cubic feet per second. Adj R^2, adjusted coefficient of determination (Ott, 1993). Method: MLR, multiple linear regression; KTR, Kendall-Theil robust line. --, not applicable]

Analyte	Units	Regression Equation	Adj R^2	Method
Solids, residue at 180 °C (dissolved solids)	mg/L	$-511.83 + 7.928\ q + 352.80\ \text{sclog} - 12.970\ \text{pH}$	0.614	MLR
Calcium	mg/L	$10^{(-1.311 + 0.004\ q + 1.093\ \text{sclog})}$	.682	MLR
Magnesium	mg/L	$10^{(0.078 + 0.0033\ \text{sc})}$	.478	MLR
Sodium	mg/L	$10^{(-24.24 - 0.075\ \text{qlog} - 0.063\ \text{sc} + 15.740\ \text{sclog} - 0.014\ \text{sea})}$	.698	MLR
Potassium	mg/L	$10^{(0.14 + 0.022\ q + 0.008\ \text{temp})}$	.583	MLR
Bicarbonate, as HCO_3	mg/L	$10^{(1.237 - 0.021\ q + 0.003\ \text{sc} + 0.032\ \text{pH} - 0.015\ \text{sea})}$	.829	MLR
Sulfate, as SO_4	mg/L	$1.82 + 0.364\ q$	.750	MLR
Chloride	mg/L	$29.84 + 0.465\ q + 2.692\ \text{DO} - 53.491\ \text{DOlog} + 0.571\ \text{sea}$	.481	MLR
Fluoride	mg/L	$10^{(-0.238 - 0.061\ q - 0.050\ \text{DO} - 0.106\ \text{sea})}$	.667	MLR
Silica, as SiO_2	mg/L	$10^{(1.330 + 0.153\ \text{qlog} - 0.027\ q + 0.004\ \text{sc} - 0.018\ \text{sea})}$	.334	MLR
Phosphorus, total, as P	mg/L	$10^{(-1.443 + 0.120\ \text{sea})}$	--	KTR
Phosphorus, diss, as P	mg/L	$10^{(-1.560 + 0.097\ \text{sea})}$	--	KTR
Phosphorus, ortho, diss, as P	mg/L	$10.18 + 0.004\ q + 0.027\ \text{sc} - 6.364\ \text{sclog} - 0.019\ \text{pH} + 0.003\ \text{sea}$	.467	MLR
Iron, diss	µg/L	$10^{(-8.656 + 0.605\ \text{qlog} - 0.544\ \text{DO} + 15.898\ \text{DOlog} + 0.050\ \text{temp})}$	.693	MLR
Manganese, diss	µg/L	$42.37 + 1.167\ q - 3.824\ \text{pH} - 0.603\ \text{DO} - 1.332\ \text{sea}$	.524	MLR

[1] sea = sin(T) + cos(T) where T equals the time, in months, from December 1, 1992, times 0.5236.

Two different types of water were detected at site 11. During most of the year, the water was a well-oxygenated, sodium bicarbonate type. During high flows, however, calcium became the predominant cation and the water was a calcium to a calcium sodium bicarbonate type. This change in chemical type is due mainly to the percentage of effluent. During high flows, runoff upstream from Santa Fe was the major component of streamflow at site 11, whereas during the remainder of the time, WWTP effluent was the major component of streamflow. The median specific-conductance value was 622, the median pH value was 8.5, and the median DO percent of saturation was 102.

DS and most major constituents were in the high group; calcium, magnesium, silica, and sulfate were in the middle group. The median concentrations of bicarbonate and potassium were the largest for any basic-fixed site. Because of anthropogenic influences, streamflow showed no correlation to moderate negative correlations with DS (-0.31) and the major constituents (-0.18 to -0.61). Chloride (-0.45) and fluoride (-0.61) showed the strongest correlations. During the times that WWTP effluent was a major component of flow, median concentrations of DS and major constituents were 1.7 to 4.4 times larger than those during periods of high flows.

Because of urban influences, median concentrations of most dissolved nutrients were larger at site 11 than at any other basic-fixed site. The median dissolved-ammonia concentration was larger at site 12 (0.20 to 0.06 mg/L). The median concentrations of total ammonia plus organic nitrogen and total phosphorus at site 11 were the second largest median concentrations at any basic-fixed site. The nutrients showed no correlation to moderate negative correlations with streamflow (0.13 to -0.36).

Dissolved iron and dissolved manganese were in the middle group. Dissolved-iron concentrations were larger than expected for well-oxygenated surface waters (Hem, 1985), possibly due to particulates and/or colloids that passed through a 0.45-micron filter (Kennedy and others, 1974). Summary statistics for field-property and chemical-analyte data for site 11 are presented in table 25. Regression equations that relate selected water-quality data to selected field properties and time are presented in table 26.

Site 12 - Rio Grande at Isleta, N. Mex.

Site 12 is an integrator site on the main stem at a bridge on State Highway 47 at Isleta, New Mexico. Although there was no streamflow-gaging station at this site during the high-intensity sampling phase, daily streamflow records can be estimated for this period from records for the USGS streamflow-gaging station Rio Grande at Rio Bravo Bridge near Albuquerque, New Mexico (08330150), approximately 5 mi upstream from site 12, and from inflow data for drains, arroyos, and the WWTP between the Rio Bravo Bridge and Isleta sites. Low-flow samples were collected by wading upstream from the bridge, and high-flow samples were collected from the upstream side of the bridge.

Because this site is located just downstream from Albuquerque, New Mexico, the dominant land use affecting water quality at the site is urban. Other major land uses in the 3,610-mi^2 contributing drainage area between sites 9 and 12 are forest and rangeland (U.S. Geological Survey, 1986). In addition, the Rio Grande flood plain is farmed in the reach between Cochiti Dam, approximately 58 mi upstream from site 12, and the urban area. Major surficial deposits and bedrock types are Quaternary unconsolidated gravel, sand, and silt; tuff; and lava (Dane and Bachman, 1965).

Streamflow at site 12 is almost completely regulated by controlled releases from Cochiti Lake. High flows occur in late spring and early summer; however, storms in the drainage area downstream from Cochiti Lake can cause high flows at other times during the year. Long-term streamflow records are available for the USGS streamflow-gaging station Rio Grande at Albuquerque, New Mexico (08330000), about 10 mi upstream from site 12. At this station, the annual mean discharge for WY's 1974 to 1995 was 1,485 ft^3/s (Ortiz and Lange, 1996). The annual mean discharge for WY 1993 was 1,893 ft^3/s (Cruz and others, 1994); for WY 1994 was 1,717 ft^3/s (Borland and Ong, 1995); and for WY 1995 was 2,149 ft^3/s (Ortiz and Lange, 1996).

The water sampled at site 12 for the most part was a well-oxygenated, calcium to calcium sodium bicarbonate type. The median specific-conductance value was 392, the median pH value was 8.0, and the median DO percent of saturation was 89. Concentrations of DS and most major constituents showed statistically significant increases at the 95-percent confidence interval compared with their corresponding concentrations at site 9. If instantaneous loads at the two sites are compared, however, only sodium, potassium, chloride, and fluoride showed

Table 25.--Statistical summary of selected water-quality data for site 11 - Santa Fe River above Cochiti Lake, N. Mex.

[Property or analyte: µS/cm, microsiemens per centimeter at 25 degrees Celsius; diss, dissolved; mg/L, milligrams per liter; it, incremental titration; µg/L, micrograms per liter. MRL, minimum reporting level; std dev, standard deviation; C, calculated value; --, not applicable; <, less than]

Property or analyte (unit)	Number of samples	MRL	Percent less than MRL	Mean	Std dev	Min-imum	Percentiles 10	25	50 Median	75	90	Max-imum
Streamflow, instantaneous (cubic feet per second)	31	0.01	0	16	14	3.9	5.2	8.3	10	17	41	62
Specific conductance (µS/cm)	31	1.0	0	547	170	192	219	349	622	670	685	713
pH (standard units)	31	.1	0	[1]8.4	.2	7.9	8.0	8.4	8.5	8.6	8.8	8.8
Temperature, water (degrees Celsius)	31	-5.0	0	11.4	6.9	.0	1.5	5.5	11.0	16.5	21.0	22.5
Oxygen, diss (mg/L)	31	.1	0	9.4	1.6	7.0	7.6	8.0	9.1	10.6	12.4	12.8
Oxygen, diss (percent saturation)	31	C	--	103	7	95	96	99	102	106	110	130
Hardness (mg/L as $CaCO_3$)	30	C	--	120	29	60	68	107	120	140	150	170
Hardness, noncarbonate (mg/L as $CaCO_3$)	30	C	--	0	0	0	0	0	0	0	0	0
Alkalinity, it-field (mg/L as $CaCO_3$)	30	1	0	191	65	68	74	142	203	238	257	294
Solids, sum of constituents, diss (mg/L)	29	C	--	343	106	117	124	329	376	414	428	459
Solids, residue at 180 degrees Celsius (mg/L) (diss solids)	30	1	0	340	104	132	141	292	384	408	435	459
Calcium, diss (mg/L as Ca)	30	.02	0	38	9.2	19	22	35	38	46	48	53
Magnesium, diss (mg/L as Mg)	30	.01	0	5.9	1.5	3.0	3.1	5.4	6.4	6.8	7.6	8.3
Sodium, diss (mg/L as Na)	30	.2	0	69	28	14	17	53	80	88	93	97
Sodium percentage	29	C	--	51	9	31	34	51	54	57	59	59
Sodium adsorption ratio	30	C	--	3	1	.8	1	2	3	3	3	4
Potassium, diss (mg/L as K)	29	.1	0	8.4	2.7	2.7	2.8	8.2	9.6	10	10	12
Bicarbonate, it-field (mg/L as HCO_3)	30	1	0	221	75	82	92	153	239	280	297	346
Carbonate, it-field (mg/L as CO_3)	30	0	0	6	5	0	0	0	6	9	.13	18
Sulfate, diss (mg/L as SO_4)	30	.1	0	33	9.2	12	13	30	36	39	40	44
Chloride, diss (mg/L as Cl)	29	.1	0	38	14	8.2	8.9	38	43	46	51	54
Fluoride, diss (mg/L as F)	30	.1	0	.6	.2	.3	.3	.6	.6	.7	.8	.8
Silica, diss (mg/L as SiO_2)	30	.01	0	23	4.9	13	15	18	24	26	28	29
Nitrogen, nitrite, diss (mg/L as N)	30	.01	20	[2].06	[2].06	<.01	<.01	.01	.05	.10	.16	.21
Nitrogen, nitrite plus nitrate, diss (mg/L as N)	30	.05	0	1.3	.98	.12	.14	.56	1.4	1.7	2.2	5.0
Nitrogen, ammonia, diss (mg/L as N)	30	.015	3	.16	.20	<.015	.02	.03	.06	.28	.48	.84
Nitrogen, un-ionized ammonia, diss (mg/L as N)	30	[3]C	--	.009	.018	.0004	.001	.002	.004	.010	.026	.098
Nitrogen, ammonia plus organic, diss (mg/L as N)	30	.2	0	.7	.3	.2	.3	.5	.6	.8	1.0	1.3
Nitrogen, ammonia plus organic, total (mg/L as N)	30	.2	0	.9	.3	.3	.6	.7	.9	1.1	1.4	1.7
Phosphorus, total (mg/L as P)	30	.01	0	1.2	.83	.24	.45	.65	.90	1.7	2.7	3.3
Phosphorus, diss (mg/L as P)	30	.01	0	1.1	.86	.15	.22	.48	.76	1.6	2.6	3.1
Phosphorus, orthophosphate (mg/L as P)	30	.01	0	1.1	.87	.14	.21	.42	.74	1.6	2.6	3.3
Iron, diss (µg/L as Fe)	30	3	0	55	94	9	14	22	28	36	67	430
Manganese, diss (µg/L as Mn)	30	1	0	11	6	3	4	6	8	16	19	22
Sediment, suspended (mg/L)	28	1	0	245	418	6	7	38	66	274	1,030	1,790
Sediment, discharge, suspended (tons/day)	28	C	--	20	48	.11	.17	.87	1.8	8.7	119	197

[1] Statistic calculated after transforming pH values to hydrogen-ion concentrations.

[2] Statistics are estimated by log-probability regression for data set with more than 20 percent and less than 80 percent censored data.

[3] The MRL value of 0.015 mg/L was used for censored dissolved-ammonia concentrations in calculating un-ionized ammonia concentrations. All un-ionized ammonia statistics less than 0.0001 mg/L are reported as <0.0001 mg/L.

Table 26.--Regression equations for selected water-quality analytes with selected field properties and time for site 11 - Santa Fe River above Cochiti Lake, N. Mex.

[Analyte: °C, degrees Celsius; NO_2, nitrite; diss, dissolved; $NO_2 + NO_3$, nitrite plus nitrate; amm, ammonia; amm + org, ammonia plus organic; ortho, orthophosphate. Unit: mg/L, milligrams per liter; µg/L, micrograms per liter. Regression equation: sc, specific conductance, in microsiemens per centimeter at 25 °C; sclog, base 10 logarithm of specific conductance, in microsiemens per centimeter at 25 °C; temp, water temperature, in °C; pH, in standard pH units; sea[1], seasonality variable; qlog, base 10 logarithm of streamflow, in cubic feet per second; DOlog, base 10 logarithm of dissolved-oxygen concentration, in mg/L; DO, dissolved-oxygen concentration in mg/L. Adj R^2, adjusted coefficient of determination (Ott, 1993). Method: MLR, multiple linear regression; KTR, Kendall-Theil robust line. --, not applicable]

Analyte	Unit	Regression equation	Adj R^2	Method
Solids, residue at 180 °C (dissolved solids)	mg/L	$10^{(1.058 + 0.0006\,\text{sc} + 0.415\,\text{sclog})}$	0.987	MLR
Calcium	mg/L	$10^{(-0.033 + 0.610\,\text{sclog} - 0.005\,\text{temp})}$	.956	MLR
Magnesium	mg/L	$10^{(-0.228 + 0.0007\,\text{sc} + 0.081\,\text{pH} - 0.007\,\text{temp} + 0.021\,\text{sea})}$	.959	MLR
Sodium	mg/L	$10^{(-1.953 - 0.069\,\text{qlog} + 1.401\,\text{sclog})}$	.987	MLR
Potassium	mg/L	$10^{(-1.621 - 0.086\,\text{qlog} + 0.991\,\text{sclog} - 0.010\,\text{DO})}$	.963	MLR
Bicarbonate, as HCO_3	mg/L	$10^{(4.907 + 0.001\,\text{sc} + 0.184\,\text{DO} - 4.916\,\text{DOlog} - 0.012\,\text{temp})}$	.978	MLR
Sulfate, as SO_4	mg/L	$10^{(-4.176 - 0.0008\,\text{sc} + 1.701\,\text{sclog} - 0.098\,\text{DO} + 2.496\,\text{DOlog} + 0.025\,\text{sea})}$	.969	MLR
Chloride	mg/L	$10^{(-1.490 - 0.180\,\text{qlog} + 1.176\,\text{sclog})}$	.971	MLR
Fluoride	mg/L	$10^{(-4.486 - 0.155\,\text{qlog} + 0.470\,\text{sclog} - 0.214\,\text{DO} + 5.236\,\text{DOlog} + 0.007\,\text{temp})}$	.903	MLR
Silica, as SiO_2	mg/L	$10^{(3.645 + 0.001\,\text{sc} - 0.736\,\text{sclog} + 0.079\,\text{pH} + 0.138\,\text{DO} - 3.066\,\text{DOlog} - 0.017\,\text{sea})}$	.935	MLR
Nitrogen, NO_2, diss, as N	mg/L	$-2.111 + 0.089\,\text{DO}$	--	KTR
Nitrogen, $NO_2 + NO_3$, diss, as N	mg/L	$10^{(-5.006 + 1.838\,\text{sclog})}$	.652	MLR
Nitrogen, amm, diss, as N	mg/L	$10^{(-1.262 + 1.278\,\text{qlog} - 0.0065\,\text{sc} + 7.559\,\text{sclog} + 1.746\,\text{DO} - 35.698\,\text{DOlog})}$	.495	MLR
Nitrogen, amm + org, diss, as N	mg/L	$10^{(-9.407 - 0.0033\,\text{sc} + 3.761\,\text{sclog} + 0.819\,\text{DOlog})}$	.633	MLR
Nitrogen, amm + org, total, as N	mg/L	$10^{(-12.454 + 0.013\,\text{q} - 0.005\,\text{sc} + 6.325\,\text{sclog} - 0.233\,\text{pH})}$	.267	MLR
Phosphorus, total, as P	mg/L	$5.414 + 1.780\,\text{qlog} + 0.0175\,\text{sc} - 11.028\,\text{sclog} + 12.303\,\text{DOlog} + 0.202\,\text{temp}$	.579	MLR
Phosphorus, diss, as P	mg/L	$10^{(6.145 + 0.008\,\text{sc} - 6.386\,\text{sclog} + 0.536\,\text{pH} + 0.163\,\text{DO} + 0.049\,\text{temp})}$	.647	MLR
Phosphorus, ortho, diss, as P	mg/L	$10^{(6.483 + 0.008\,\text{sc} - 6.498\,\text{sclog} + 0.518\,\text{pH} + 0.166\,\text{DO} + 0.050\,\text{temp})}$	.625	MLR
Iron, diss	µg/L	$6401.4 - 4.157\,\text{q} + 2.232\,\text{sc} - 2{,}769.6\,\text{sclog}$	.629	MLR
Manganese, diss	µg/L	$-23.196 + 3.498\,\text{DO} + 2.602\,\text{sea}$	.531	MLR

[1] sea = sin(T) + cos(T) where T equals the time, in months, from December 1, 1992, times 0.5236.

statistically significant increases. The significant increase in concentrations were due to a combination of increased loads and evapotranspiration of water between the sites. The significant increases in sodium, chloride, and possibly potassium and fluoride loads were the result of anthropogenic activities, such as discharges from WWTP's and irrigation-return flows. DS and all major constituents were in the middle group.

Nutrient concentrations at site 12 also were large as a result of anthropogenic activities; all nutrients were in the high group. The median dissolved-ammonia concentration and the instantaneous loads of dissolved nutrients were the largest detected at any basic-fixed site. Concentrations of all nutrients were smallest during high spring flow and largest during low flow in late summer.

Dissolved iron and dissolved manganese were in the middle group. Summary statistics for field-property and chemical-analyte data for site 12 are presented in table 27. Regression equations that relate selected water-quality data to selected field properties and time are presented in table 28.

Site 13 - Rio Puerco near Bernardo, N. Mex.

Site 13 is an integrator site near the mouth of an ephemeral tributary. The USGS streamflow-gaging station for this site was located on a bridge on former U.S. Highway 25 approximately 1.2 mi southwest of Bernardo, New Mexico. A new gaging station, located about 400 ft upstream from the bridge, was established after the high-intensity sampling phase. Low-flow samples were collected by wading. High-flow samples were collected from a cableway about 300 ft downstream from the old gage or from the upstream side of a bridge on the present U.S. Highway 25 about 0.25 mi downstream from the old gage.

Major land-use types in the 6,250-mi^2 contributing drainage basin include forest in the headwater areas and rangeland in the lower basin (U.S. Geological Survey, 1986). A large uranium mining area is located along the upper reaches of the Rio San Jose, the major tributary to the Rio Puerco (Ellis and others, 1993). Major bedrock types and surficial deposits include Triassic lava and sedimentary rock, Cretaceous sandstone and shale, and Quaternary lava and alluvium (Dane and Bachman, 1965).

Streamflow at site 13 usually results from snowmelt during the spring and storms during the remainder of the year; no flow is present for more than 50 percent of the year. During the high-intensity sampling phase, the highest annual instantaneous flows resulted from summer thunderstorms. The annual mean discharge at this site for WY's 1940 to 1995 was 43.3 ft^3/s (Ortiz and Lange, 1996). The annual mean discharge for WY 1993 was 35.8 ft^3/s (Cruz and others, 1994); for WY 1994 was 23.6 ft^3/s (Borland and Ong, 1995); and for WY 1995 was 20.7 ft^3/s (Ortiz and Lange, 1996).

The water sampled at site 13 varied from a sodium sulfate type to a calcium sulfate type. Generally, the water was well oxygenated and had a median specific-conductance value of 1,680, a median pH value of 8.1, and a median DO percent of saturation of 100. The calcium sulfate-type water was detected in runoff from late summer thunderstorms; however, the runoff from some thunderstorms was a sodium sulfate type. Because of the variation in bedrock and surficial deposits throughout the basin, the location of a storm appears to have had an influence on the predominant cation in storm runoff.

The median concentrations of DS and most major constituents detected at site 13 were the largest detected at any basic-fixed site during the high-intensity sampling phase. Of the other major constituents, potassium and chloride were in the high group; bicarbonate was in the middle group; and the median silica concentration was the smallest detected at any site. The large DS and major-constituent concentrations may be caused by either of two processes. Suspended-sediment concentrations in the Rio Puerco are large and may result from channel bank erosion or overland flow erosion of the river terraces (Allen Gellis, U.S. Geological Survey, written commun., 1996). This erosion continually exposes fresh surfaces containing soluble materials as the fine-grained insoluble detritus is mechanically washed away (Hem, 1985). In addition, in semiarid areas such as the lower part of the RIOG study unit, DS in precipitation and in ground water, brought to the surface by capillary action, are concentrated by evaporation or other mechanisms. These concentrated solids may then be deposited on the surface as a crust to be available for redissolution during the next precipitation event.

The three largest DS concentrations were detected during the winter months and coincided with the three smallest discharges sampled at site 13. The large concentrations in these samples were probably

Table 27.--Statistical summary of selected water-quality data for site 12 - Rio Grande at Isleta, N. Mex.

[Property or analyte: µS/cm, microsiemens per centimeter at 25 degrees Celsius; diss, dissolved; mg/L, milligrams per liter; it, incremental titration; µg/L, micrograms per liter. MRL, minimum reporting level; std dev, standard deviation; C, calculated value; --, not applicable; <, less than]

Property or analyte (unit)	Number of samples	MRL	Percent less than MRL	Mean	Std dev	Minimum	Percentiles 10	Percentiles 25	Percentiles 50 Median	Percentiles 75	Percentiles 90	Maximum
Streamflow, instantaneous (cubic feet per second)	30	0.01	0	2,200	1,810	531	563	746	1,260	4,020	5,070	6,110
Specific conductance (µS/cm)	31	1.0	0	382	62	237	280	350	392	430	452	475
pH (standard units)	32	.1	0	[1]8.0	.2	7.7	7.7	8.0	8.0	8.1	8.2	8.3
Temperature, water (degrees Celsius)	32	-5.0	0	14.8	6.4	4.0	5.0	9.5	15.0	20.0	23.0	26.5
Oxygen, diss (mg/L)	32	.1	0	7.6	1.4	5.4	5.8	6.4	7.7	8.6	9.5	11.4
Oxygen, diss (percent saturation)	31	C	--	88	7	75	75	83	89	92	97	104
Hardness (mg/L as $CaCO_3$)	30	C	--	120	19	84	90	110	130	140	140	150
Hardness, noncarbonate (mg/L as $CaCO_3$)	27	C	--	14	8	0	1	8	15	19	24	31
Alkalinity, it-field (mg/L as $CaCO_3$)	28	1	0	110	19	74	77	98	112	123	132	149
Solids, sum of constituents, diss (mg/L)	29	C	--	234	42	142	169	202	245	262	281	297
Solids, residue at 180 degrees Celsius (mg/L) (diss solids)	30	1	0	238	39	158	171	221	242	266	293	295
Calcium, diss (mg/L as Ca)	30	.02	0	38	6.0	26	28	33	40	42	45	46
Magnesium, diss (mg/L as Mg)	30	.01	0	6.6	.84	4.6	5.2	6.2	6.8	7.2	7.6	7.7
Sodium, diss (mg/L as Na)	30	.2	0	27	7.0	12	16	23	29	33	34	41
Sodium percentage	30	C	--	31	4	23	25	30	32	33	36	38
Sodium adsorption ratio	30	C	--	.9	.1	.6	.7	1	1	1	1	1
Potassium, diss (mg/L as K)	30	.1	0	3.7	1.0	2.0	2.2	2.9	3.8	4.3	4.8	6.6
Bicarbonate, it-field (mg/L as HCO_3)	28	1	0	134	23	90	94	118	137	150	162	175
Carbonate, it-field (mg/L as CO_3)	28	0	0	.1	.6	0	0	0	0	0	0	3
Sulfate, diss (mg/L as SO_4)	30	.1	0	54	9.0	30	43	51	55	61	66	70
Chloride, diss (mg/L as Cl)	29	.1	0	13	4.6	5.2	6.0	9.7	14	16	19	21
Fluoride, diss (mg/L as F)	30	.1	0	.4	.1	.2	.3	.3	.5	.5	.6	.6
Silica, diss (mg/L as SiO_2)	30	.01	0	20	2.6	15	16	18	21	22	23	25
Nitrogen, nitrite, diss (mg/L as N)	29	.01	14	.05	.05	<.01	<.01	.01	.04	.10	.12	.17
Nitrogen, nitrite plus nitrate, diss (mg/L as N)	29	.05	0	.79	.50	.20	.23	.30	.66	1.2	1.4	2.0
Nitrogen, ammonia, diss (mg/L as N)	29	.015	0	.32	.37	.02	.04	.08	.20	.39	.88	1.6
Nitrogen, un-ionized ammonia, diss (mg/L as N)	29	[2]C	--	.010	.018	.0006	.0009	.002	.004	.009	.017	.10
Nitrogen, ammonia plus organic, diss (mg/L as N)	28	.2	4	.5	.4	<.2	.2	.3	.4	.6	1.1	2.1
Nitrogen, ammonia plus organic, total (mg/L as N)	29	.2	3	.7	.5	<.2	.3	.4	.6	1.0	1.3	2.3
Phosphorus, total (mg/L as P)	28	.01	0	.32	.19	.07	.09	.15	.32	.43	.51	.84
Phosphorus, diss (mg/L as P)	27	.01	0	.24	.16	.05	.07	.09	.22	.33	.47	.69
Phosphorus, orthophosphate (mg/L as P)	29	.01	0	.23	.15	.02	.06	.09	.22	.30	.47	.62
Iron, diss (µg/L as Fe)	30	3	0	30	33	4	6	12	18	32	79	160
Manganese, diss (µg/L as Mn)	30	1	0	13	10	3	3	6	10	20	28	44
Sediment, suspended (mg/L)	30	1	0	649	1,080	57	86	125	272	778	1,260	5,830
Sediment, discharge, suspended (tons/day)	30	C	--	5,710	13,000	115	177	344	1,380	3,540	16,900	67,900

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[1] Statistic calculated after transforming pH values to hydrogen-ion concentrations.

[2] The MRL value of 0.015 mg/L was used for censored dissolved-ammonia concentrations in calculating un-ionized ammonia concentrations. All un-ionized ammonia statistics less than 0.0001 mg/L are reported as <0.0001 mg/L.

Table 28.--Regression equations for selected water-quality analytes with selected field properties and time for site 12 - Rio Grande at Isleta, N. Mex.

[Analyte: °C, degrees Celsius; NO_2, nitrite; diss, dissolved; $NO_2 + NO_3$, nitrite plus nitrate; amm, ammonia; amm + org, ammonia plus organic; ortho, orthophosphate. Unit: mg/L, milligrams per liter; µg/L, micrograms per liter. Regression equation: sc, specific conductance, in microsiemens per centimeter at 25 °C; temp, water temperature, in °C; sclog, base 10 logarithm of specific conductance, in microsiemens per centimeter at 25 °C; DOlog, base 10 logarithm of dissolved-oxygen concentration, in mg/L; sea[1], seasonality variable; pH, in standard pH units; qlog, base 10 logarithm of streamflow, in cubic feet per second; q, streamflow, in cubic feet per second; DO, dissolved-oxygen concentration, in mg/L. Adj R^2, adjusted coefficient of determination (Ott, 1993). Method: MLR, multiple linear regression; KTR, Kendall-Theil robust line. --, not applicable]

Analyte	Unit	Regression equation	Adj R^2	Method
Solids, residue at 180 °C (dissolved solids)	mg/L	$32.47 + 0.572 \text{ sc} - 0.808 \text{ temp}$	0.924	MLR
Calcium	mg/L	$-85.68 + 53.412 \text{ sclog} - 14.776 \text{ DOlog} - 2.279 \text{ sea}$	.896	MLR
Magnesium	mg/L	$10^{(-3.879 - 0.0017 \text{ sc} + 1.924 \text{ sclog} + 0.048 \text{ pH} - 0.014 \text{ sea})}$	.865	MLR
Sodium	mg/L	$10^{(-2.763 + 1.625 \text{ sclog})}$	.926	MLR
Potassium	mg/L	$10^{(-2.132 + 1.045 \text{ sclog})}$	.481	MLR
Bicarbonate, as HCO_3	mg/L	$10^{(0.658 + 0.613 \text{ sclog} - 0.125 \text{ DOlog} - 0.040 \text{ sea})}$	.936	MLR
Sulfate, as SO_4	mg/L	$10^{(-2.380 + 0.074 \text{ qlog} + 1.236 \text{ sclog} + 0.086 \text{ pH})}$	.875	MLR
Chloride	mg/L	$10^{(0.002 + 0.003 \text{ sc} - 0.010 \text{ temp} + 0.078 \text{ sea})}$	.901	MLR
Fluoride	mg/L	$10^{(0.654 - 0.00003 \text{ q} + 0.001 \text{ sc} - 0.167 \text{ pH})}$	.756	MLR
Silica, as SiO_2	mg/L	$10^{(0.907 - 0.00001 \text{ q} + 0.363 \text{ sclog} - 0.063 \text{ pH})}$	.776	MLR
Nitrogen, NO_2, diss, as N	mg/L	$10^{(-1.900 - 1.055 \text{ qlog})}$	--	KTR
Nitrogen, $NO_2 + NO_3$, diss, as N	mg/L	$10^{(-3.502 - 0.0001 \text{ q} + 1.368 \text{ sclog})}$	.782	MLR
Nitrogen, amm, diss, as N	mg/L	$10^{(-27.329 + 0.0002 \text{ q} - 1.961 \text{ qlog} - 0.0227 \text{ sc} + 18.04 \text{ sclog} - 4.966 \text{ DOlog} - 0.073 \text{ temp})}$	.755	MLR
Nitrogen, amm + org, diss, as N	mg/L	$10^{(-15.836 + 0.0002 \text{ q} - 1.837 \text{ qlog} - 0.015 \text{ sc} + 10.091 \text{ sclog} + 0.595 \text{ pH} - 4.008 \text{ DOlog} - 0.055 \text{ temp})}$	.712	MLR
Nitrogen, amm + org, total, as N	mg/L	$17.565 + 0.0002 \text{ q} - 1.687 \text{ qlog} + 0.810 \text{ DO} -19.754 \text{ DOlog} - 0.059 \text{ temp}$	.643	MLR
Phosphorus, total, as P	mg/L	$10^{(1.777 - 0.740 \text{ qlog})}$	.804	MLR
Phosphorus, diss, as P	mg/L	$10^{(2.424 - 0.821 \text{ qlog} - 0.606 \text{ DOlog})}$	.898	MLR
Phosphorus, ortho, diss, as P	mg/L	$10^{(-21.364 - 0.357 \text{ qlog} - 0.012 \text{ sc} + 11.194 \text{ sclog} - 0.368 \text{ pH} + 0.025 \text{ temp} - 0.132 \text{ sea})}$	.885	MLR
Iron, diss	µg/L	$10^{(0.035 + 0.0003 \text{ q} - 1.783 \text{ qlog} - 2.431 \text{ sclog} - 1.433 \text{ DO} + 26.815 \text{ DOlog})}$	.560	MLR
Manganese, diss	µg/L	$10^{(2.883 - 0.461 \text{ qlog} - 0.028 \text{ temp})}$	.631	MLR

[1] sea = sin(T) + cos(T) where T equals the time, in months, from December 1, 1992, times 0.5236.

caused by the redissolution of the solids concentrated by freezing. The sample with the fourth largest DS concentration was runoff from a summer storm.

The median concentrations of total ammonia plus organic nitrogen and total phosphorus at site 13 were the largest and the median concentration of $NO_2 + NO_3$ was the second largest detected at any basic-fixed site. These three nutrients showed no correlation to moderate positive correlation to streamflow (0.27 to 0.58). The large difference in median concentrations between total (14 mg/L) and dissolved ammonia plus organic nitrogen (0.3 mg/L) and between total (2.7 mg/L) and dissolved phosphorus (0.02 mg/L) indicates that most of the nitrogen and phosphorus are in the particulate phase. The larger concentrations of total ammonia plus organic nitrogen and total phosphorus showed a dual relation to suspended-sediment concentration. Most samples had a linear relation between the concentrations; about one-third of the samples, however, appear to have no relation. Most of these samples were collected in the spring of 1993 and the summer of 1995. The reason for these different relations could not be explained from the available data.

The larger $NO_2 + NO_3$ concentrations were detected in samples of runoff from summer storms. These larger concentrations are probably the result of dissolution of nitrates deposited in the basin by atmospheric deposition and animal manure (Anderholm and others, 1995). Most dissolved-nitrogen nutrients were in the high group; dissolved phosphorus was in the low group. The median concentrations of NO_2 and orthophosphate were below their respective MDL's.

Dissolved iron and dissolved manganese were in the low group. Summary statistics for field-property and chemical-analyte data for site 13 are presented in table 29. Regression equations that relate selected water-quality data to selected field properties and time are presented in table 30.

Site 14 - Rio Grande Conveyance Channel at San Marcial, N. Mex.

Site 14 is at the USGS streamflow-gaging station on the Rio Grande Conveyance Channel about 1 mi downstream from the former site of San Marcial, New Mexico. Low-flow samples were collected by wading near the gage, and high-flow samples were collected from a cableway downstream from the gage.

Because of the anthropogenic origins of the conveyance channel, site 14 is not considered to have a drainage basin. However, the conveyance channel discharges water to and receives water from the system of irrigation canals and drains that serve the agricultural fields and Bosque del Apache National Wildlife Refuge between San Acacia, New Mexico, and Elephant Butte Reservoir.

The conveyance channel was designed to carry the entire flow of the Rio Grande when river streamflow is below 2,000 ft^3/s (Bureau of Reclamation, 1977). Because of sedimentation problems in the lowest reaches of the channel due to high flows, however, diversions to the conveyance channel from the Rio Grande were suspended in March 1985 (Bureau of Reclamation, 1997). During the high-intensity sampling phase, all flow in the conveyance channel was from ground-water inflow or return flows from irrigation canals and drains. High flows were in late spring and early summer and coincided with the largest diversions from the Rio Grande to the irrigation-canal system. From November through February, during each winter of the high-intensity sampling phase, water was not diverted for irrigation, and streamflow at site 14 was mostly ground-water inflow to the conveyance channel or irrigation drains. All irrigation canals and drains west of the Rio Grande in this reach eventually discharge to the conveyance channel south of the wildlife refuge, upstream from site 14. The annual mean discharge at site 14 for WY's 1986 to 1995 was 313 ft^3/s. The annual mean discharge for WY 1993 was 329 ft^3/s (Cruz and others, 1994); for WY 1994 was 345 ft^3/s (Borland and Ong, 1995); and for WY 1995 was 354 ft^3/s (Ortiz and Lange, 1996).

The water sampled at site 14 for the most part was a well-oxygenated, sodium to sodium calcium bicarbonate sulfate chloride type. The median specific-conductance value was 867, the median pH value was 8.1 and the median DO percent of saturation was 93. DS and most major constituents were in the high group; fluoride and silica were in the middle group. Specific conductance (-0.45), DS (-0.41), and most major constituents (-0.38 to -0.60) showed moderate negative correlations with streamflow; chloride (0.27) and fluoride (-0.21) showed no correlation to streamflow. The largest concentrations of DS and most major constituents were detected during low flow in the winter months, and the smallest concentrations were detected during mid- to late summer.

Table 29.--Statistical summary of selected water-quality data for site 13 - Rio Puerco near Bernardo, N. Mex.

[Property or analyte: µS/cm, microsiemens per centimeter at 25 degrees Celsius; diss, dissolved; mg/L, milligrams per liter; it, incremental titration; µg/L, micrograms per liter. MRL, minimum reporting level; std dev, standard deviation; C, calculated value; --, not applicable; <, less than]

Property or analyte (unit)	Number of samples	MRL	Percent less than MRL	Mean	Std dev	Minimum	Percentiles 10	25	50 Median	75	90	Maximum
Streamflow, instantaneous (cubic feet per second)	22	0.01	0	212	505	1.2	5.0	11	53	126	599	2,350
Specific conductance (µS/cm)	21	1.0	0	1,840	627	487	1,230	1,420	1,680	2,380	2,930	2,960
pH (standard units)	22	.1	0	[1]8.0	.3	7.6	7.8	7.9	8.1	8.3	8.5	8.6
Temperature, water (degrees Celsius)	22	-5.0	0	15.8	6.3	1.1	5.5	11.0	18.0	19.5	23.0	25.0
Oxygen, diss (mg/L)	22	.1	0	8.2	1.9	4.6	5.6	6.9	8.0	9.5	11.2	12.0
Oxygen, diss (percent saturation)	22	C	--	97	13	61	72	92	100	104	112	116
Hardness (mg/L as $CaCO_3$)	22	C	--	480	170	77	300	350	460	620	700	750
Hardness, noncarbonate (mg/L as $CaCO_3$)	21	C	--	360	160	24	180	240	340	480	610	650
Alkalinity, it-field (mg/L as $CaCO_3$)	21	1	0	114	46	52	58	84	106	127	199	220
Solids, sum of constituents, diss (mg/L)	22	C	--	1,320	482	274	820	983	1,180	1,750	2,030	2,110
Solids, residue at 180 degrees Celsius (mg/L) (diss solids)	22	1	0	1,380	510	310	809	1,040	1,240	1,820	2,140	2,190
Calcium, diss (mg/L as Ca)	22	.02	0	131	45	24	89	98	130	150	210	220
Magnesium, diss (mg/L as Mg)	22	.01	0	36	18	4.1	18	23	32	46	71	75
Sodium, diss (mg/L as Na)	22	.2	0	230	110	52	120	160	200	310	410	460
Sodium percentage	22	C	--	50	8	31	35	47	52	57	58	60
Sodium adsorption ratio	22	C	--	5	2	2	2	4	4	6	7	8
Potassium, diss (mg/L as K)	22	.1	0	6.7	2.3	3.4	4.0	4.8	6.3	8.1	11	12
Bicarbonate, it-field (mg/L as HCO_3)	21	1	0	137	54	62	71	102	130	155	243	251
Carbonate, it-field (mg/L as CO_3)	21	0	0	1	2	0	0	0	0	1	6	8
Sulfate, diss (mg/L as SO_4)	22	.1	0	740	260	120	430	570	700	970	1,100	1,200
Chloride, diss (mg/L as Cl)	22	.1	0	94	88	22	25	38	57	120	290	300
Fluoride, diss (mg/L as F)	21	.1	5	.7	.3	<.1	.2	.7	.8	.9	1.0	1.0
Silica, diss (mg/L as SiO_2)	22	.01	0	9.6	4.3	6.2	6.8	7.2	7.8	9.5	18	22
Nitrogen, nitrite, diss (mg/L as N)	21	.01	71	[2].01	[2].01	<.01	<.01	<.01	<.01	.02	.03	.05
Nitrogen, nitrite plus nitrate, diss (mg/L as N)	21	.05	5	.81	.56	<.05	.10	.28	.78	1.3	1.7	1.7
Nitrogen, ammonia, diss (mg/L as N)	21	.015	29	[2].03	[2].012	<.015	<.015	<.015	.03	.04	.05	.05
Nitrogen, un-ionized ammonia, diss (mg/L as N)	21	[3]C	--	.001	.0009	.0002	.0002	.0005	.0009	.001	.003	.004
Nitrogen, ammonia plus organic, diss (mg/L as N)	21	.2	10	.31	.17	<.2	<.2	.2	.3	.4	.6	.8
Nitrogen, ammonia plus organic, total (mg/L as N)	21	.2	10	16	17	<.2	<.2	.3	14	30	39	57
Phosphorus, total (mg/L as P)	21	.01	0	9.8	13	.01	.02	.04	2.7	17	36	45
Phosphorus, diss (mg/L as P)	21	.01	48	[2].02	[2].01	<.01	<.01	<.01	.01	.02	.03	.07
Phosphorus, orthophosphate (mg/L as P)	21	.01	57	[2].009	[2].009	<.01	<.01	<.01	<.01	.01	.02	.04
Iron, diss (µg/L as Fe)	22	9	55	[2]72	[2]198	<9	<9	<9	<9	43	230	914
Manganese, diss (µg/L as Mn)	22	1	64	[2]6	[2]11	<3	<3	<3	<3	6	13	50
Sediment, suspended (mg/L)	22	1	0	58,900	48,100	409	630	20,400	46,200	83,300	139,500	184,900
Sediment, discharge, suspended (tons/day)	22	C	--	34,100	73,900	1.3	8.6	1,040	12,900	19,800	168,500	294,000

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[1] Statistic calculated after transforming pH values to hydrogen-ion concentrations.

[2] Statistics are estimated by log-probability regression for data set with more than 20 percent and less than 80 percent censored data.

[3] The MRL value of 0.015 mg/L was used for censored dissolved-ammonia concentrations in calculating un-ionized ammonia concentrations. All un-ionized ammonia statistics less than 0.0001 mg/L are reported as <0.0001 mg/L.

Table 30.--Regression equations for selected water-quality analytes with selected field properties and time for site 13 - Rio Puerco near Bernardo, N. Mex.

[Analyte: °C, degrees Celsius; NO_2 + NO_3, nitrite plus nitrate; diss, dissolved; amm + org, ammonia plus organic. Unit: mg/L, milligrams per liter. Regression equation: sclog, base 10 logarithm of specific conductance, in microsiemens per centimeter as 25 °C; sc, specific conductance, in microsiemens per centimeter at 25 °C; pH, in standard pH units; DO, dissolved-oxygen concentration, in mg/L; DOlog, base 10 logarithm of dissolved-oxygen concentration, in mg/L; sea[1], seasonality variable; q, streamflow, in cubic feet per second; temp, water temperature, in °C; qlog, base 10 logarithm of streamflow, in cubic feet per second. Adj R^2, adjusted coefficient of determination (Ott, 1993). Method: MLR, multiple linear regression; KTR, Kendall-Theil robust line. --, not applicable]

Analyte	Unit	Regression equation	Adj R^2	Method
Solids, residue at 180 °C (dissolved solids)	mg/L	$10^{(-0.564 + 1.132\ \text{sclog})}$	0.978	MLR
Calcium	mg/L	$10^{(-1.924 + 1.215\ \text{sclog} - 0.223\ \text{pH} - 0.247\ \text{DO} + 4.332\ \text{DOlog})}$	.921	MLR
Magnesium	mg/L	$10^{(-3.745 + 1.510\ \text{sclog} - 0.360\ \text{DOlog} + 0.046\ \text{sea})}$	.960	MLR
Sodium	mg/L	$-17.64 + 0.132\ \text{sc} + 63.725\ \text{pH} + 71.916\ \text{DO} - 1{,}223.86\ \text{DOlog}$	.914	MLR
Potassium	mg/L	$10^{(2.138 + 0.00016\ \text{sc} - 0.2004\ \text{pH})}$	.414	MLR
Bicarbonate, as HCO_3	mg/L	$110.4 + 100.47\ \text{sclog} + 42.494\ \text{pH} + 98.34\ \text{DO} - 1{,}607.17\ \text{DOlog})$	.856	MLR
Sulfate, as SO_4	mg/L	$10^{(-3.457 + 0.00005\ q + 1.444\ \text{sclog} - 0.229\ \text{DO} + 3.843\ \text{DOlog})}$	.973	MLR
Chloride	mg/L	$1{,}744.18 - 0.0657\ q + 242.78\ \text{DO} - 4{,}021.52\ \text{DOlog}$	.852	MLR
Fluoride	mg/L	$10^{(-12.259 - 0.0004\ q - 0.001\ \text{sc} + 4.332\ \text{sclog} - 0.007\ \text{temp})}$	.944	MLR
Silica, as SiO_2	mg/L	$10^{(1.122 - 0.103\ \text{qlog})}$	.226	MLR
Nitrogen, NO_2 + NO_3, diss as N	mg/L	$-0.189 + 0.565\ \text{qlog}$	--	KTR
Nitrogen, amm + org, diss, as N	mg/L	$10^{(-0.689 + 0.097\ \text{qlog})}$	--	KTR
Nitrogen, amm + org, total, as N	mg/L	$10^{(0.301 + 0.492\ \text{qlog})}$	--	KTR
Phosphorus, total, as P	mg/L	$10^{(24.074 - 2.932\ \text{pH})}$	.302	MLR

[1] sea = sin(T) + cos(T) where T equals the time, in months, from December 1, 1992, times 0.5236.

Most nitrogen nutrients and total phosphorus were in the middle group; dissolved phosphorus and orthophosphate were in the high group. The median concentrations of NO_2 and dissolved ammonia plus organic nitrogen were below their respective MDL's. Dissolved nutrients (0 to 0.15) showed no correlation to streamflow, whereas total nutrients (0.31 and 0.37) showed moderate positive correlations.

Dissolved iron and dissolved manganese were in the low group. Summary statistics for the field-property and chemical-analyte data for site 14 are presented in table 31. Regression equations that relate selected water-quality data to selected field properties and time are presented in table 32.

Site 15 - Rio Grande Floodway at San Marcial, N. Mex.

Site 15 is an integrator site on the main stem approximately 1.1 mi downstream from the former site of San Marcial, New Mexico. The USGS streamflow-gaging station for this site is located on a pier of the railroad bridge crossing the river at this location. Low-flow samples were collected by wading in the vicinity of the gage, and high-flow samples were collected from a cableway about 400 ft upstream from the gage.

The contributing drainage area between sites 12 and 15 is 10,200 mi^2, of which approximately 61 percent is in the Rio Puerco Basin. Major land use in this area, excluding the Rio Puerco Basin, is rangeland (U.S. Geological Survey, 1986). In the Rio Grande flood plain, however, agricultural land use is predominant, and some small areas of urban land use are along the river in the upper part of this reach. Major surficial deposits and bedrock types in this area excluding the Rio Puerco drainage basin are Quaternary unconsolidated gravel, sand, and silt and lava (Dane and Bachman, 1965).

Streamflow at site 15 is controlled by releases from reservoirs and diversions for irrigation upstream except during high flow on ephemeral tributaries. The Rio Grande Floodway is the stabilized natural river channel designed to carry only the portion of streamflow that exceeds the 2,000-ft^3/s capacity of the conveyance channel; since March 1985, however, the floodway carries most of the streamflow that is not diverted for irrigation (Bureau of Reclamation, 1997). Sustained high flows were in late spring and early summer, whereas there was no flow at this site during part of July 1994 and August 1995. The annual mean discharge at this site for WY's 1986 to 1995 was 1,099 ft^3/s. The annual mean discharge for WY 1993 was 1,404 ft^3/s (Cruz and others, 1994); for WY 1994 was 1,279 ft^3/s (Borland and Ong, 1995); and for WY 1995 was 1,560 ft^3/s (Ortiz and Lange, 1996). The annual mean discharge for the sum of streamflows in the conveyance channel and floodway for WY's 1986 to 1995 was 1,412 ft^3/s. The annual mean discharge for WY 1993 was 1,733 ft^3/s (Cruz and others, 1994); for WY 1994 was 1,624 ft^3/s (Borland and Ong, 1995); and for WY 1995 was 1,914 ft^3/s (Ortiz and Lange, 1996).

The water sampled at site 15 was well oxygenated and mainly a calcium sodium bicarbonate type; the composition, however, ranged from a calcium bicarbonate to a calcium sodium sulfate type. The calcium bicarbonate water occurred during high spring flows, whereas the calcium sodium sulfate water was associated with storms on tributaries during the late summer. The median specific-conductance value was 482, the median pH value was 8.2, and the median DO percent of saturation was 98.

DS and most major constituents were in the middle group; calcium was in the high group. The largest concentrations of DS and most major constituents were detected in samples associated with storms on tributaries. These samples also contained the largest instantaneous loads, although most of the annual DS load originated in the main stem upstream from site 12. Specific conductance (-0.52), DS (-0.48), and the major constituents (-0.30 to -0.59) showed moderate negative correlations with streamflow.

Most nutrients were in the high group; dissolved ammonia was in the middle group. The median concentrations of NO_2 and dissolved ammonia plus organic nitrogen were below their respective MDL's. Most nutrients showed no correlation with streamflow, whereas $NO_2 + NO_3$ (-0.33) and orthophosphate (-0.30) showed moderate negative correlations to streamflow. $NO_2 + NO_3$ concentrations were largest during low flow, whereas the largest concentrations of total ammonia plus organic nitrogen, 23 mg/L, and total phosphorus, 9.5 mg/L, resulted from a storm in the Rio Puerco drainage basin.

Dissolved iron and dissolved manganese were in the low group. The median dissolved-manganese concentration was the smallest for any basic-fixed site. Summary statistics for the field-property and chemical-analyte data for site 15 are presented in table 33. Regression equations that relate selected water-quality data to selected field properties and time are presented in table 34.

Table 31.--Statistical summary of selected water-quality data for site 14 - Rio Grande Conveyance Channel at San Marcial, N. Mex.

[Property or analyte: µS/cm, microsiemens per centimeter at 25 degrees Celsius; diss, dissolved; mg/L, milligrams per liter; it, incremental titration; µg/L, micrograms per liter. MRL, minimum reporting level; std dev, standard deviation; C, calculated value; --, not applicable; <, less than]

Property or analyte (unit)	Number of samples	MRL	Percent less than MRL	Mean	Std dev	Minimum	Percentiles 10	25	50 Median	75	90	Maximum
Streamflow, instantaneous (cubic feet per second)	29	0.01	0	352	79	247	269	276	348	410	468	518
Specific conductance (µS/cm)	29	1.0	0	881	58	777	812	842	867	936	952	999
pH (standard units)	29	1	0	[1]8.1	.2	7.8	7.9	8.0	8.1	8.2	8.3	8.4
Temperature, water (degrees Celsius)	29	-5.0	0	15.5	4.1	7.5	10.5	11.5	16.5	19.0	21.0	21.5
Oxygen, diss (mg/L)	29	.1	0	8.0	1.0	6.2	6.8	7.2	7.9	8.5	9.6	10.6
Oxygen, diss (percent saturation)	29	C	--	94	6	80	85	90	93	98	103	106
Hardness (mg/L as $CaCO_3$)	29	C	--	210	18	160	190	200	210	230	230	240
Hardness, noncarbonate (mg/L as $CaCO_3$)	29	C	--	30	11	0	14	26	30	38	45	47
Alkalinity, it-field (mg/L as $CaCO_3$)	29	1	0	179	14	145	166	168	176	190	194	212
Solids, sum of constituents, diss (mg/L)	28	C	--	537	47	452	477	503	528	582	604	634
Solids, residue at 180 degrees Celsius (mg/L) (diss solids)	29	1	0	547	47	465	487	512	543	589	616	641
Calcium, diss (mg/L as Ca)	29	.02	0	64	5.2	49	57	60	63	68	70	73
Magnesium, diss (mg/L as Mg)	29	.01	0	12	1.2	9.3	11	12	12	13	14	14
Sodium, diss (mg/L as Na)	28	.2	0	99	11	80	85	90	98	110	120	120
Sodium percentage	28	C	--	50	2	47	48	49	50	51	53	53
Sodium adsorption ratio	28	C	--	3	0	3	3	3	3	3	3	3
Potassium, diss (mg/L as K)	29	.1	0	5.4	.5	4.3	4.7	5.0	5.5	5.8	6.2	6.5
Bicarbonate, it-field (mg/L as HCO_3)	29	1	0	218	17	177	202	206	215	233	236	259
Carbonate, it-field (mg/L as CO_3)	29	0	0	0	0	0	0	0	0	0	0	0
Sulfate, diss (mg/L as SO_4)	29	.1	0	150	15	120	130	140	150	160	170	180
Chloride, diss (mg/L as Cl)	29	.1	0	72	11	55	57	64	72	84	87	94
Fluoride, diss (mg/L as F)	29	.1	0	.5	.05	.4	.5	.5	.5	.5	.6	.6
Silica, diss (mg/L as SiO_2)	29	.01	0	23	1.3	20	22	22	23	24	25	26
Nitrogen, nitrite, diss (mg/L as N)	29	.01	76	[2].004-.011	--	<.01	<.01	<.01	<.01	<.01	.02	.02
Nitrogen, nitrite plus nitrate, diss (mg/L as N)	29	.05	3	.20	.10	<.05	.10	.12	.18	.27	.38	.41
Nitrogen, ammonia, diss (mg/L as N)	29	.015	28	[3].03	[3].014	<.015	<.015	<.015	.02	.04	.04	.07
Nitrogen, un-ionized ammonia, diss (mg/L as N)	29	[4]C	--	.001	.001	.0001	.0002	.0004	.0007	.001	.003	.005
Nitrogen, ammonia plus organic, diss (mg/L as N)	29	.2	90	[5].02-.20	--	<.2	<.2	<.2	<.2	<.2	.2	.3
Nitrogen, ammonia plus organic, total (mg/L as N)	29	.2	31	[3].3	[3].2	<.2	<.2	<.2	.3	.4	.7	1.1
Phosphorus, total (mg/L as P)	29	.01	0	.16	.13	.04	.06	.08	.11	.20	.38	.64
Phosphorus, diss (mg/L as P)	29	.01	0	.06	.02	.04	.04	.05	.06	.08	.10	.10
Phosphorus, orthophosphate (mg/L as P)	27	.01	0	.07	.02	.04	.05	.06	.06	.08	.09	.10
Iron, diss (µg/L as Fe)	29	3	34	[3]5	[3]4	<3	<3	<3	4	6	10	21
Manganese, diss (µg/L as Mn)	29	1	10	8	9	<1	<1	2	5	10	20	38
Sediment, suspended (mg/L)	29	1	0	501	994	36	50	132	233	421	1,160	5,340
Sediment, discharge, suspended (tons/day)	29	C	--	480	866	24	38	94	235	406	1,360	4,570

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[1] Statistic calculated after transforming pH values to hydrogen-ion concentrations.

[2] Range is given for statistics for data set with more than 20 percent and less than 80 percent censored data and insufficient variation of uncensored data to perform log-probability regression.

[3] Statistics are estimated by log-probability regression for data set with more than 20 percent and less than 80 percent censored data.

[4] The MRL value of 0.015 mg/L was used for censored dissolved-ammonia concentrations in calculating un-ionized ammonia concentrations All un-ionized ammonia statistics less than 0.0001 mg/L are reported as <0.0001 mg/L.

[5] Range is given for statistics for data set with 80 percent or more censored data.

Table 32.--Regression equations for selected water-quality analytes with selected field properties and time for site 14 - Rio Grande Conveyance Channel at San Marcial, N. Mex.

[Analyte: °C, degrees Celsius; $NO_2 + NO_3$, nitrite plus nitrate; diss, dissolved; ortho, orthophosphate. Unit: mg/L, milligrams per liter; µg/L, micrograms per liter. Regression equation: sc, specific conductance, in microsiemens per centimeter at 25 °C; q, streamflow, in cubic feet per second; sclog, base 10 logarithm of specific conductance, in microsiemens per centimeter at 25 °C; pH, in standard pH units; sea[1], seasonality variable; temp, water temperature, in °C; qlog, base 10 logarithm of streamflow, in cubic feet per second; DO, dissolved-oxygen concentration, in mg/L; DOlog, base 10 logarithm of dissolved-oxygen concentration, in mg/L. Adj R^2, adjusted coefficient of determination (Ott, 1993). Method: MLR, multiple linear regression; KTR, Kendall-Theil robust line. --, not applicable]

Analyte	Unit	Regression equation	Adj R^2	Method
Solids, residue at 180 °C (dissolved solids)	mg/L	-29.12 + 0.654 sc	0.645	MLR
Calcium	mg/L	-2,858.6 - 0.023 q - 0.502 sc + 1,117.8 sclog + 10.05 pH	.713	MLR
Magnesium	mg/L	61.74 + 20.476 sclog + 1.691 pH - 0.531 sea	.781	MLR
Sodium	mg/L	136.87 + 0.1076 sc + 19.514 pH + 27.60 DO - 546.01 DOlog - 1.328 temp	.827	MLR
Potassium	mg/L	-9.543 - 2.869 qlog + 5.18 sclog + 0.736 pH	.617	MLR
Bicarbonate, as HCO_3	mg/L	6,340.8 - 0.0445 q + 1.357 sc - 2,583.71 sclog + 37.629 pH - 6.447 sea	.859	MLR
Sulfate, as SO_4	mg/L	-661.0 + 296.10 sclog - 7.254 DO - 11.27 sea	.741	MLR
Chloride	mg/L	-21.966 + 0.135 sc - 1.619 temp + 4.448 sea	.802	MLR
Fluoride	mg/L	0.513 - 0.0177 sea	.104	MLR
Silica, as SiO_2	mg/L	-1,123.22 - 0.0057 q - 0.215 sc + 446.73 sclog + 2.797 pH	.349	MLR
Nitrogen, $NO_2 + NO_3$, diss, as N	mg/L	-160.68 - 0.0041 q + 3.836 qlog - 0.029 sc + 60.489 sclog + 0.019 temp - 0.073 sea	.473	MLR
Phosphorus, total, as P	mg/L	$10^{(-207.67 + 1.542\ \text{qlog} - 0.040\ \text{sc} + 83.0\ \text{sclog} - 0.864\ \text{pH} + 0.052\ \text{temp} - 0.073\ \text{sea})}$	.518	MLR
Phosphorus, diss, as P	mg/L	$10^{(-175.5 + 6.579\ \text{qlog} - 0.008\ \text{q} - 0.030\ \text{sc} + 61.590\ \text{sclog} - 0.472\ \text{DO} + 9.943\ \text{DOlog} + 0.032\ \text{temp} - 0.072\ \text{sea})}$	.631	MLR
Phosphorus, ortho, diss, as P	mg/L	$10^{(-113.20 + 5.135\ \text{qlog} - 0.005\ \text{q} - 0.020\ \text{sc} + 40.074\ \text{sclog} + 0.018\ \text{sclog} - 0.077\ \text{sea})}$	.496	MLR
Manganese, diss	µg/L	26.75 - 1.318 temp	--	KTR

[1] sea = sin(T) + cos(T) where T equals the time, in months, from December 1, 1992, times 0.5236.

Table 33.--Statistical summary of selected water-quality data for site 15 - Rio Grande Floodway at San Marcial, N. Mex.

[Property or analyte: µS/cm, microsiemens per centimeter at 25 degrees Celsius; diss, dissolved; mg/L, milligrams per liter; it, incremental titration; µg/L, micrograms per liter. MRL, minimum reporting level; std dev, standard deviation; C, calculated value, --, not applicable; <, less than]

Property or analyte (unit)	Number of samples	MRL	Percent less than MRL	Mean	Std dev	Minimum	Percentiles 10	25	50 Median	75	90	Maximum
Streamflow, instantaneous (cubic feet per second)	27	0.01	0	1,690	1,480	105	173	569	975	3,030	4,250	4,710
Specific conductance (µS/cm)	27	1.0	0	510	193	279	332	395	482	530	804	1,150
pH (standard units)	27	.1	0	[1]8.1	.3	7.7	7.9	8.0	8.2	8.4	8.5	8.8
Temperature, water (degrees Celsius)	27	-5.0	0	14.1	7.8	.0	1.5	8.0	16.0	22.0	23.0	24.0
Oxygen, diss (mg/L)	27	.1	0	8.6	1.9	5.8	6.0	7.2	8.1	9.8	11.6	12.2
Oxygen, diss (percent saturation)	27	C	--	96	9	77	81	89	98	101	106	110
Hardness (mg/L as $CaCO_3$)	27	C	--	160	53	98	110	120	150	160	250	340
Hardness, noncarbonate (mg/L as $CaCO_3$)	27	C	--	38	53	0	10	16	21	27	120	240
Alkalinity, it-field (mg/L as $CaCO_3$)	27	1	0	119	23	81	87	99	120	139	151	166
Solids, sum of constituents, diss (mg/L)	27	C	--	319	129	169	201	224	298	331	519	751
Solids, residue at 180 degrees Celsius (mg/L) (diss solids)	27	1	0	327	141	190	216	229	299	341	533	816
Calcium, diss (mg/L as Ca)	27	.02	0	48	16.9	30	33	36	47	50	76	110
Magnesium, diss (mg/L as Mg)	27	.01	0	8.6	2.7	5.5	6.2	6.6	8.3	9.1	14	17
Sodium, diss (mg/L as Na)	27	.2	0	43	20	17	22	27	42	47	77	100
Sodium percentage	27	C	--	36	4	27	29	32	37	38	41	43
Sodium adsorption ratio	27	C	--	2	.5	.7	.9	1	2	2	2	2
Potassium, diss (mg/L as K)	27	.1	0	3.9	.8	2.7	3.0	3.5	3.8	4.3	5.1	6.5
Bicarbonate, it-field (mg/L as HCO_3)	27	1	0	144	28	91	106	121	146	162	178	203
Carbonate, it-field (mg/L as CO_3)	27	0	0	.8	3	0	0	0	0	0	3	12
Sulfate, diss (mg/L as SO_4)	27	.1	0	100	81	40	51	65	75	87	230	380
Chloride, diss (mg/L as Cl)	27	.1	0	20	9.3	6.9	9.2	14	19	24	26	56
Fluoride, diss (mg/L as F)	27	.1	0	.5	.1	.3	.3	.3	.5	.6	.6	.7
Silica, diss (mg/L as SiO_2)	27	.01	0	19	2.9	13	16	17	19	22	23	24
Nitrogen, nitrite, diss (mg/L as N)	27	.01	70	[2].009	[2].008	<.01	<.01	<.01	<.01	.01	.02	.03
Nitrogen, nitrite plus nitrate, diss (mg/L as N)	27	.05	4	.77	.43	<.05	.23	.33	.71	1.1	1.3	1.5
Nitrogen, ammonia, diss (mg/L as N)	27	.015	48	[2].02	[2].011	<.015	<.015	<.015	.02	.03	.04	.04
Nitrogen, un-ionized ammonia, diss (mg/L as N)	27	[3]C	--	.001	.001	<.0001	.0001	.0003	.0006	.001	.003	.005
Nitrogen, ammonia plus organic, diss (mg/L as N)	21	.2	76	[4].06-.21	--	<.2	<.2	<.2	<.2	<.2	.3	.3
Nitrogen, ammonia plus organic, total (mg/L as N)	27	.2	11	1.7	4.4	<.2	<.2	.3	.6	1.0	3.2	23
Phosphorus, total (mg/L as P)	27	.01	0	.87	1.8	.07	.09	.24	.43	.84	1.6	9.5
Phosphorus, diss (mg/L as P)	27	.01	4	.13	.09	<.01	.04	.07	.11	.17	.25	.43
Phosphorus, orthophosphate (mg/L as P)	25	.01	4	.13	.07	<.01	.03	.08	.13	.18	.23	.27
Iron, diss (µg/L as Fe)	27	3	15	15	15	<3	<3	5	10	19	34	72
Manganese, diss (µg/L as Mn)	27	1	44	[2]1	[2]1	<1	<1	<1	1	2	3	5
Sediment, suspended (mg/L)	27	1	0	4,680	8,510	274	479	1,060	1,610	2,300	20,800	35,000
Sediment, discharge, suspended (tons/day)	27	C	--	18,900	46,400	109	559	1,980	7,580	15,000	30,900	241,000

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[1] Statistic calculated after transforming pH values to hydrogen-ion concentrations.

[2] Statistics are estimated by log-probability regression for data set with more than 20 percent and less than 80 percent censored data.

[3] The MRL value of 0.015 mg/L was used for censored dissolved-ammonia concentrations in calculating un-ionized ammonia concentrations. All un-ionized ammonia statistics less than 0.0001 mg/L are reported as <0.0001 mg/L.

[4] Range is given for statistics for data set with more than 20 percent and less than 80 percent censored data and insufficient variation of uncensored data to perform log-probability regression.

Table 34.--Regression equations for selected water-quality analytes with selected field properties and time for site 15 - Rio Grande Floodway at San Marcial, N. Mex.

[Analyte: °C, degrees Celsius; $NO_2 + NO_3$, nitrite plus nitrate; diss, dissolved; amm + org, ammonia plus organic; ortho, orthophosphate. Unit: mg/L, milligrams per liter; µg/L, micrograms per liter. Regression equation: qlog, base 10 logarithm of streamflow, in cubic feet per second; sc, specific conductance, in microsiemens per centimeter at 25 °C; pH, in standard pH units; sea[1], seasonality variable; sclog, base 10 logarithm of specific conductance, in microsiemens per centimeter at 25 °C; q, streamflow, in cubic feet per second; temp, water temperature, in °C; DOlog, base 10 logarithm of dissolved-oxygen concentration, in mg/L; DO, dissolved-oxygen concentration, in mg/L. Adj R^2, adjusted coefficient of determination (Ott, 1993). Method: MLR, multiple linear regression; KTR, Kendall-Theil robust line. --, not applicable]

Analyte	Unit	Regression equation	Adj R^2	Method
Solids, residue at 180 °C (dissolved solids)	mg/L	$419.34 - 14.592\ \text{qlog} + 0.733\ \text{sc} - 51.598\ \text{pH} + 9.575\ \text{sea}$	0.994	MLR
Calcium	mg/L	$44.5 + 0.0870\ \text{sc} - 4.950\ \text{pH}$	.965	MLR
Magnesium	mg/L	$10^{(-1.116 + 0.859\ \text{sclog} - 0.033\ \text{pH})}$	.985	MLR
Sodium	mg/L	$-2.62 - 0.0019\ \text{q} + 0.095\ \text{sc}$	.988	MLR
Potassium	mg/L	$2.23 - 0.00008\ \text{q} + 0.0036\ \text{sc}$	.876	MLR
Bicarbonate, as HCO_3	mg/L	$10^{(-1.050 - 0.0008\ \text{sc} + 1.372\ \text{sclog} - 0.005\ \text{temp})}$	.752	MLR
Sulfate, as SO_4	mg/L	$774.97 + 0.627\ \text{sc} - 334.97\ \text{sclog} - 103.41\ \text{DOlog}$	.988	MLR
Chloride	mg/L	$10^{(-1.684 - 0.083\ \text{qlog} + 1.265\ \text{sclog} - 0.015\ \text{temp} + 0.066\ \text{sea})}$	.873	MLR
Fluoride	mg/L	$10^{(-3.731 - 0.00003\ \text{q} - 0.0007\ \text{sc} + 1.421\ \text{sclog})}$	.724	MLR
Silica, as SiO_2	mg/L	$10^{(-0.606 - 0.0006\ \text{sc} + 0.766\ \text{sclog} + 0.018\ \text{DO})}$	.707	MLR
Nitrogen, $NO_2 + NO_3$, diss, as N	mg/L	$-4.725 + 0.217\ \text{qlog} + 1.814\ \text{sclog} - 0.281\ \text{sea}$	.841	MLR
Nitrogen, amm + org, total, as N	mg/L	$-1.328 + 0.004\ \text{sc}$	--	KTR
Phosphorus, total, as P	mg/L	$10^{(-6.389 + 2.237\ \text{sclog})}$	.382	MLR
Phosphorus, diss, as P	mg/L	$10^{(-8.080 + 0.00009\ \text{q} - 0.518\ \text{DO} + 12.333\ \text{DOlog} - 0.190\ \text{sea})}$	.685	MLR
Phosphorus, ortho, diss, as P	mg/L	$-0.454 + 0.628\ \text{DOlog}$	.727	MLR
Iron, diss	µg/L	$10^{(7.676 - 2.488\ \text{sclog})}$	--	KTR

[1] sea = sin(T) + cos(T) where T equals the time, in months, from December 1, 1992, times 0.5236.

Site 16 - Rio Grande below Leasburg Dam, near Las Cruces, N. Mex.

Site 16 is an integrator site on the main stem approximately 1.5 mi southeast of Radium Springs, New Mexico. The streamflow-gaging station for this site is operated by the Elephant Butte Irrigation District. The gage is located approximately 1.5 mi downstream from Leasburg Dam, a low head diversion dam used to divert water from the Rio Grande to irrigation-supply canals for the Mesilla Valley. Low-flow samples were collected by wading, and high-flow samples were collected from a cableway at the gaging station.

Major land use in the 4,260-mi^2 contributing drainage basin between sites 15 and 16 is rangeland (U.S. Geological Survey, 1986); however, water quality at site 16 probably is more affected by Elephant Butte and Caballo Reservoirs, which store irrigation water between sites 15 and 16, and the small area of intense agricultural activity in the Rincon Valley upstream from this site (Scott Anderholm, U.S. Geological Survey, written commun., 1996). Major surficial deposits and bedrock types are Tertiary volcanic rock and Quaternary unconsolidated gravel, sand, and silt (Dane and Bachman, 1965).

The streamflow at this station is almost completely controlled by releases from Caballo Reservoir. Releases begin in January or February and end in September or October. High flows are in late spring and early summer. During the period when water is not released from Caballo Reservoir, streamflow at site 16 is mainly ground-water inflow to the main stem. The annual mean discharge at site 16 for WY's 1938 to 1995 was 693 ft^3/s. The annual mean discharge for WY 1993 was 859 ft^3/s (Cruz and others, 1994); for WY 1994 was 883 ft^3/s (Borland and Ong, 1995); and for WY 1995 was 1,163 ft^3/s (Ortiz and Lange, 1996).

The water sampled at site 16 for the most part was a well-oxygenated, calcium sodium sulfate bicarbonate chloride type. Of the anions, sulfate had the largest percentage of total anion milliequivalents per liter during low flow and bicarbonate had the largest during high flows. The median specific-conductance value was 740, the median pH value was 8.3, and the median DO percent of saturation was 98. DS and most major constituents were in the high group; silica was in the low group. Silica appeared to have been effectively removed from the water in the two reservoirs, probably due to biological activity. Streamflow showed moderate negative correlations with specific conductance (-0.62), DS (-0.58), and most major constituents (-0.32 to -0.69); chloride (-0.70) showed a strong negative correlation with streamflow; and silica (-0.18) showed no correlation with streamflow. The largest concentrations of DS and most major constituents were during low flow.

Most nutrients were in the middle group; dissolved phosphorus was in the low group. The median concentrations of NO_2 and orthophosphate were below their respective MDL's. The two reservoirs appear to have effectively removed most of the nutrient load from the Rio Grande through sediment trapping and biological activities. During high flow, ground-water inflow and irrigation-drain discharges in the Rincon Valley did not measurably affect nutrient concentrations in the main stem Rio Grande. During low flow, because of the difference in magnitude of flows in the main stem and irrigation drains, ground-water inflow to the main stem, derived from the irrigated fields, appears to be the major source of nutrients in the main stem at site 16 (Scott Anderholm, U.S. Geological Survey, oral commun., 1996).

Dissolved iron and dissolved manganese were in the low group. Site 16 was one of two sites that had the smallest median dissolved-iron concentration. Summary statistics for the field-property and chemical-analyte data for site 16 are presented in table 35. Regression equations that relate selected water-quality data to selected field properties and time are presented in table 36.

Site 17 - Rio Grande at El Paso, Tex.

Site 17 is an integrator site on the main stem approximately 1 mi southeast of Sunland Park, New Mexico. The streamflow-gaging station for this site is operated by the International Boundary and Water Commission and is located at the Courchesne Bridge on Texas State Highway 273. Low-flow samples were collected by wading upstream from the bridge, and high-flow samples were collected on the upstream side of the bridge or by boat.

The major land-use type in the 1,080-mi^2 contributing drainage area between sites 16 and 17 is rangeland (U.S. Geological Survey, 1986); water quality at site 17, however, is more affected by the areas of agricultural and urban land use in the Mesilla Valley just upstream from this site (Healy, 1996). Major surficial deposits in this drainage area are Quaternary unconsolidated gravel, sand, and silt (Dane and Bachman, 1965).

Table 35.--Statistical summary of selected water-quality data for site 16 - Rio Grande below Leasburg Dam, near Las Cruces, N. Mex.

[Property or analyte: µS/cm, microsiemens per centimeter at 25 degrees Celsius; diss, dissolved; mg/L, milligrams per liter; it, incremental titration; µg/L, micrograms per liter. MRL, minimum reporting level; std dev, standard deviation; C, calculated value; --, not applicable; <, less than]

Property or analyte (unit)	Number of samples	MRL	Percent less than MRL	Mean	Std dev	Minimum	Percentiles 10	25	50 Median	75	90	Maximum
Streamflow, instantaneous (cubic feet per second)	32	0.01	0	1,050	808	58	93	406	916	1,640	2,390	3,280
Specific conductance (µS/cm)	32	1.0	0	859	281	628	646	674	740	835	1,400	1,450
pH (standard units)	31	.1	0	[1]8.3	.2	7.8	8.2	8.2	8.3	8.4	8.5	8.7
Temperature, water (degrees Celsius)	32	-5.0	0	16.6	6.7	2.0	6.0	12.5	17.0	22.0	26.0	27.0
Oxygen, diss (mg/L)	32	.1	0	8.5	1.5	6.3	6.8	7.3	8.2	9.6	10.8	12.1
Oxygen, diss (percent saturation)	32	C	--	98	6	83	91	95	98	102	107	116
Hardness (mg/L as $CaCO_3$)	32	C	--	220	75	140	150	170	190	200	360	390
Hardness, noncarbonate (mg/L as $CaCO_3$)	32	C	--	63	46	24	26	36	44	72	150	170
Alkalinity, it-field (mg/L as $CaCO_3$)	32	1	0	151	33	113	117	126	143	156	210	220
Solids, sum of constituents, diss (mg/L)	32	C	--	515	195	353	371	396	430	489	896	929
Solids, residue at 180 degrees Celsius (mg/L) (diss solids)	32	1	0	530	197	376	384	408	448	510	920	955
Calcium, diss (mg/L as Ca)	32	.02	0	62	23	39	43	48	54	57	110	120
Magnesium, diss (mg/L as Mg)	32	.01	0	14	4.5	9.5	11	11	13	14	23	24
Sodium, diss (mg/L as Na)	32	.2	0	92	33	60	63	69	80	92	160	160
Sodium percentage	32	C	--	47	2	44	44	46	47	48	50	52
Sodium adsorption ratio	32	C	--	3	.8	2	2	2	3	3	4	4
Potassium, diss (mg/L as K)	32	.1	0	6.1	.9	4.9	5.1	5.3	5.8	6.6	7.7	8.1
Bicarbonate, it-field (mg/L as HCO_3)	32	1	0	180	40	135	142	153	168	181	257	268
Carbonate, it-field (mg/L as CO_3)	32	0	0	2	3	0	0	0	0	4	8	11
Sulfate, diss (mg/L as SO_4)	32	.1	0	170	82	110	110	120	140	150	340	350
Chloride, diss (mg/L as Cl)	32	.1	0	69	31	40	44	46	56	84	130	140
Fluoride, diss (mg/L as F)	32	.1	0	.6	.05	.5	.5	.5	.6	.6	.6	.7
Silica, diss (mg/L as SiO_2)	32	.01	0	8.3	4.3	1.4	1.5	5.7	8.1	11	15	16
Nitrogen, nitrite, diss (mg/L as N)	32	.01	72	[2].004-.012	--	<.01	<.01	<.01	<.01	.01	.02	.02
Nitrogen, nitrite plus nitrate, diss (mg/L as N)	32	.05	31	[3].11	[3].09	<.05	<.05	<.05	.08	.16	.25	.37
Nitrogen, ammonia, diss (mg/L as N)	32	.015	31	[3].02	[3].012	<.015	<.015	<.015	.02	.03	.03	.07
Nitrogen, un-ionized ammonia, diss (mg/L as N)	32	[4]C	--	.001	.001	.0002	.0003	.0005	.001	.002	.003	.004
Nitrogen, ammonia plus organic, diss (mg/L as N)	32	.2	31	[3].2	[3].08	<.2	<.2	<.2	.2	.3	.3	.4
Nitrogen, ammonia plus organic, total (mg/L as N)	32	.2	12	.4	.2	<.2	<.2	.3	.4	.5	.7	.8
Phosphorus, total (mg/L as P)	32	.01	3	.08	.08	<.01	.01	.03	.06	.09	.19	.36
Phosphorus, diss (mg/L as P)	31	.01	48	[3].02	[3].02	<.01	<.01	<.01	.01	.03	.04	.11
Phosphorus, orthophosphate (mg/L as P)	32	.01	56	[3].01	[3].01	<.01	<.01	<.01	<.01	.01	.03	.05
Iron, diss (µg/L as Fe)	32	3	34	[3]4	[3]2.9	<3	<3	<3	3	5	10	13
Manganese, diss (µg/L as Mn)	32	1	3	7	10	<1	2	2	3	5	29	40
Sediment, suspended (mg/L)	32	1	0	622	1,800	19	34	84	141	248	821	8,920
Sediment, discharge, suspended (tons/day)	32	C	--	3,350	10,300	3.3	9.1	143	333	836	6,970	43,600

[1] Statistic calculated after transforming pH values to hydrogen-ion concentrations.

[2] Range is given for statistics for data set with more than 20 percent and less than 80 percent censored data and insufficient variation of uncensored data to perform log-probability regression.

[3] Statistics are estimated by log-probability regression for data set with more than 20 percent and less than 80 percent censored data

[4] The MRL value of 0.015 mg/L was used for censored dissolved-ammonia concentrations in calculating un-ionized ammonia concentrations. All un-ionized ammonia statistics less than 0.0001 mg/L are reported as <0.0001 mg/L.

Table 36.--Regression equations for selected water-quality analytes with selected field properties and time for site 16 - Rio Grande below Leasburg Dam, near Las Cruces, N. Mex.

[Analyte: °C, degrees Celsius; amm + org, ammonia plus organic; diss, dissolved. Unit: mg/L, milligrams per liter; µg/L, micrograms per liter. Regression equation: sc, specific conductance, in microsiemens per centimeter at 25 °C; q, streamflow, in cubic feet per second; qlog, base 10 logarithm of streamflow, in cubic feet per second; sclog, base 10 logarithm of specific conductance, in microsiemens per centimeter at 25 °C; sea[1], seasonality variable; temp, water temperature, in °C; pH, in standard pH units; DO, dissolved-oxygen concentration, in mg/L; DOlog, base 10 logarithm of dissolved-oxygen concentration, in mg/L. Adj R^2, adjusted coefficient of determination (Ott, 1993). Method: MLR, multiple linear regression; KTR, Kendall-Theil robust line. --, not applicable]

Analyte	Unit	Regression equation	Adj R^2	Method
Solids, residue at 180 °C (dissolved solids)	mg/L	3,241.7 + 1.288 sc - 1,430.26 sclog + 339.4 DOlog + 2.319 temp	0.988	MLR
Calcium	mg/L	-258.33 + 0.008 q - 32.389 qlog + 138.24 sclog + 4.887 sea	.977	MLR
Magnesium	mg/L	-66.50 + 0.0007 q - 3.222 qlog + 30.314 sclog + 0.057 temp	.984	MLR
Sodium	mg/L	-449.13 + 0.004 q - 22.969 qlog + 206.414 sclog	.990	MLR
Potassium	mg/L	-16.946 + 7.794 sclog + 0.019 temp	.852	MLR
Bicarbonate, as HCO_3	mg/L	44.274 + 0.157 sc + 7.555 sea	.902	MLR
Sulfate, as SO_4	mg/L	2,024.6 - 24.20 qlog + 0.611 sc - 828.22 sclog + 8.136 DO	.986	MLR
Chloride	mg/L	-600.3878 + 20.5163 qlog + 233.1403 sclog - 13.0577 pH + 4.933 DO - 7.1014 sea	.977	MLR
Fluoride	mg/L	$10^{(-2.395 - 0.191 \text{ DO} + 4.086 \text{ DOlog})}$	.551	MLR
Silica, as SiO_2	mg/L	-7.99 + 0.0028 q + 0.016 sc + 0.241 temp - 2.880 sea	.627	MLR
Nitrogen, amm + org, total, as N	mg/L	$10^{(-0.026 - 0.0006 \text{ sc})}$	--	KTR
Phosphorus, total, as P	mg/L	$10^{(14.056 - 2.474 \text{ sclog} - 7.636 \text{ DOlog} - 0.062 \text{ temp} - 0.235 \text{ sea})}$	.532	MLR
Manganese, diss	µg/L	$10^{(16.03 + 0.004 \text{ sc} - 6.513 \text{ sclog} - 0.298 \text{ pH} + 2.766 \text{ DOlog} + 0.106 \text{ sea})}$	.879	MLR

[1] sea = sin(T) + cos(T) where T equals the time, in months, from December 1, 1992, times 0.5236.

Streamflow at site 17 is controlled by releases from Caballo Reservoir and has the same general pattern of low flows and high flows as site 16. During low flows, however, streamflow at site 17 generally is higher than that at site 16, whereas during high flows streamflow at site 17 generally is lower than that at site 16. Because site 17 is located near the discharge point for an alluvial basin, the gain in streamflow during low flow is probably the result of ground water discharging to the Rio Grande (Ellis and others, 1993). At other times, the loss of water to evapotranspiration and to seepage of irrigation water to the ground-water system exceeds this gain. The annual mean discharge at site 17 for WY's 1938 to 1995 was 557 ft^3/s. The annual mean discharge for WY 1993 was 714 ft^3/s (Cruz and others, 1994); for WY 1994 was 670 ft^3/s (Borland and Ong, 1995); and for WY 1995 was 974 ft^3/s (Ortiz and Lange, 1996).

The water sampled at site 17 for the most part was a well-oxygenated, sodium sulfate bicarbonate chloride type. The larger concentrations of DS and major constituents were detected during low flow. Of the anions, sulfate had the largest percentage of total milliequivalents per liter and bicarbonate had the second largest. During low flow, however, chloride exceeded bicarbonate as the anion with the second largest percentage of total anion milliequivalents per liter. This may be due to the larger percentage of ground water and WWTP effluent in the streamflow during this period. The median specific-conductance value was 1,070, the median pH value was 8.3, and the median DO percent of saturation was 95. DS and most major constituents were in the high group; silica was in the low group. The median chloride concentration was the largest detected at any basic-fixed site. Streamflow showed strong negative correlations with specific conductance (-0.80) and DS (-0.77) and moderate to strong negative correlations with the major constituents (-0.56 to -0.86) except silica (-0.27), which showed no correlation to streamflow.

Most nutrients were in the high group; total ammonia plus organic nitrogen, dissolved phosphorus, and orthophosphate were in the middle group. All median nutrient concentrations increased between sites 16 and 17 due mainly to a combination of agricultural and urban discharges in the Mesilla Valley (Healy, 1996).

Dissolved iron and dissolved manganese were in the low group. Site 17 was one of two sites that had the smallest median dissolved-iron concentration. Summary statistics for the field-property and chemical-analyte data for site 17 are presented in table 37. Regression equations that relate selected water-quality data to selected field properties and time are presented in table 38.

WATER-QUALITY DATA FOR SUPPLEMENTAL SAMPLES

The supplemental trace-element (table 3) and pesticide (table 4) data analyzed in this section were collected mainly during monthly sampling in addition to collection of the regular monthly samples. Dissolved organic carbon (DOC) (table 3) and suspended organic carbon (table 3) also were collected as part of monthly sampling during WY 1993; however, they were collected at basic-fixed sites as additions to regular sampling or as part of a synoptic study during WY's 1994 and 1995. Total organic carbon (TOC) (table 3) samples were collected at the sites in conjunction with total recoverable trace-element sampling or as part of a cooperative program.

Trace Elements and Organic Carbon

Trace elements were collected as part of basic-fixed-site sampling during only the spring and summer of 1995. A single sample for total recoverable trace elements and a single sample for dissolved trace elements were collected at each site. In addition, trace elements were collected at basic-fixed sites as part of NASQAN, cooperative programs, and RIOG synoptic studies.

Table 39 summarizes trace-element data for these four sources. Data in this table are only for samples collected using NAWQA protocols and analyzed at the NWQL. Table 39 presents for each trace element the number of samples; minimum, median, and maximum concentrations; the site at which the maximum concentration was detected; the MRL; and the number of samples with censored data for their respective MRL's. Some trace elements have multiple MRL's because of different analytical procedures used for NAWQA samples and NASQAN and cooperator samples or because of quality-assurance testing at the time of analysis. Only the MRL's at which data were censored are presented in table 39.

Table 37.--Statistical summary of selected water-quality data for site 17 - Rio Grande at El Paso, Tex.

[Property or analyte: µS/cm, microsiemens per centimeter at 25 degrees Celsius; diss, dissolved; mg/L, milligrams per liter; it, incremental titration; µg/L, micrograms per liter. MRL, minimum reporting level; std dev, standard deviation; C, calculated value; --, not applicable; <, less than]

Property or analyte (unit)	Number of samples	MRL	Percent less than MRL	Mean	Std dev	Minimum	Percentiles 10	25	50 Median	75	90	Maximum
Streamflow, instantaneous (cubic feet per second)	32	0.01	0	804	559	96	184	328	770	1,050	1,380	2,520
Specific conductance (µS/cm)	31	1.0	0	1,190	343	835	861	989	1,070	1,430	1,790	2,080
pH (standard units)	32	.1	0	[1]8.2	2	7.4	8.1	8.2	8.3	8.4	8.5	8.7
Temperature, water (degrees Celsius)	32	-5.0	0	16.6	6.1	6.0	7.5	11.5	16.0	23.0	24.5	26.0
Oxygen, diss (mg/L)	32	.1	0	8.2	1.3	6.2	6.4	6.9	8.4	9.2	10.1	10.9
Oxygen, diss (percent saturation)	31	C	--	95	7	79	88	91	95	99	107	117
Hardness (mg/L as $CaCO_3$)	32	C	--	262	67	180	200	220	240	300	380	450
Hardness, noncarbonate (mg/L as $CaCO_3$)	32	C	--	76	35	36	42	52	66	95	130	190
Alkalinity, it-field (mg/L as $CaCO_3$)	32	1	0	187	33	145	151	165	176	193	248	267
Solids, sum of constituents, diss (mg/L)	30	C	--	698	217	472	506	552	634	744	1,100	1,350
Solids, residue at 180 degrees Celsius (mg/L) (diss solids)	32	1	0	742	239	496	517	588	652	892	1,180	1,390
Calcium, diss (mg/L as Ca)	32	.02	0	76	19	54	59	63	70	88	110	130
Magnesium, diss (mg/L as Mg)	32	.01	0	17	4.5	12	13	14	16	20	25	29
Sodium, diss (mg/L as Na)	32	.2	0	143	53	86	93	110	120	170	230	290
Sodium percentage	30	C	--	52	3	48	49	51	52	54	56	59
Sodium adsorption ratio	32	C	--	4	.9	3	3	3	3	4	5	6
Potassium, diss (mg/L as K)	30	.1	0	7.6	1.4	5.4	6.3	6.7	7.5	8.0	11	11
Bicarbonate, it-field (mg/L as HCO_3)	32	1	0	222	38	176	180	195	213	228	292	326
Carbonate, it-field (mg/L as CO_3)	32	0	0	3	4	0	0	0	0	5	9	16
Sulfate, diss (mg/L as SO_4)	32	.1	0	240	85	150	150	180	210	290	390	460
Chloride, diss (mg/L as Cl)	32	.1	0	110	46	62	67	81	97	140	200	240
Fluoride, diss (mg/L as F)	32	.1	0	.6	.1	.2	.6	.6	.6	.7	.7	.8
Silica, diss (mg/L as SiO_2)	32	.01	0	13.0	5.9	5.5	6.4	8.6	11	18	22	29
Nitrogen, nitrite, diss (mg/L as N)	32	.01	44	[2].02	[2].02	<.01	<.01	<.01	.01	.03	.05	.08
Nitrogen, nitrite plus nitrate, diss (mg/L as N)	32	.05	0	.42	.28	.09	.13	.22	.31	.73	.92	.97
Nitrogen, ammonia, diss (mg/L as N)	32	.015	16	.07	.08	<.015	<.015	.02	.04	.08	.20	.30
Nitrogen, un-ionized ammonia, diss (mg/L as N)	32	[3]C	--	.003	.003	.0004	.0007	.001	.002	.004	.008	.013
Nitrogen, ammonia plus organic, diss (mg/L as N)	27	.2	18	.3	.1	<.2	<.2	.2	.3	.3	.4	.5
Nitrogen, ammonia plus organic, total (mg/L as N)	32	.2	0	.6	.3	.3	.3	.4	.5	.8	.9	1.5
Phosphorus, total (mg/L as P)	32	.01	0	.14	.09	.03	.05	.09	.12	.20	.26	.47
Phosphorus, diss (mg/L as P)	32	.01	9	.03	.03	<.01	<.01	.02	.03	.05	.08	.10
Phosphorus, orthophosphate (mg/L as P)	32	.01	12	.03	.02	<.01	<.01	.02	.02	.04	.07	.07
Iron, diss (µg/L as Fe)	31	3	52	[2]5	[2]8	<3	<3	<3	3	5	18	38
Manganese, diss (µg/L as Mn)	31	1	16	7	11	<1	<1	1	2	7	26	50
Sediment, suspended (mg/L)	32	1	0	372	370	38	65	168	219	544	750	1,900
Sediment, discharge, suspended (tons/day)	32	C	--	1,110	1,570	13	36	121	440	1,600	3,280	6,280

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[1] Statistic calculated after transforming pH values to hydrogen-ion concentrations.

[2] Statistics are estimated by log-probability regression for data set with more than 20 percent and less than 80 percent censored data.

[3] The MRL value of 0.015 mg/L was used for censored dissolved-ammonia concentrations in calculating un-ionized ammonia concentrations. All un-ionized ammonia statistics less than 0.0001 mg/L are reported as <0.0001 mg/L.

Table 38.--Regression equations for selected water-quality analytes with selected field properties and time for site 17 - Rio Grande at El Paso, Tex.

[Analyte: °C, degrees Celsius; NO_2+NO_3, nitrite plus nitrate; diss, dissolved; amm, ammonia; amm + org, ammonia plus organic; ortho, orthophosphate. Unit: mg/L, milligrams per liter; µg/L, micrograms per liter. Regression equation: sc, specific conductance, in microsiemens per centimeter at 25 °C; sclog, base 10 logarithm of specific conductance, in microsiemens per centimeter at 25 °C; temp, water temperature, in °C; qlog, base 10 logarithm of streamflow, in cubic feet per second; DOlog, base 10 logarithm of dissolved-oxygen concentration, in mg/L; DO, dissolved-oxygen concentration, in mg/L; sea[1], seasonality variable; q, streamflow, in cubic feet per second. Adj R^2, adjusted coefficient of determination (Ott, 1993). Method: MLR, multiple linear regression; KTR, Kendall-Theil robust line. --, not applicable]

Analyte	Unit	Regression equation	Adj R^2	Method
Solids, residue at 180 °C (dissolved solids)	mg/L	-80.2 + 0.695 sc	0.980	MLR
Calcium	mg/L	3.72 + 0.059 sc + 0.221 temp	.971	MLR
Magnesium	mg/L	-43.19 + 0.00077 sc + 16.879 sclog	.972	MLR
Sodium	mg/L	832.06 - 42.028 qlog + 0.202 sc - 248.22 sclog - 57.23 DOlog	.989	MLR
Potassium	mg/L	2.91 + 0.0041 sc	.864	MLR
Bicarbonate, as HCO_3	mg/L	$10^{(-0.664 + 0.781 \text{ sclog} - 0.086 \text{ DO} + 1.451 \text{ DOlog} + 0.014 \text{ sea})}$	.887	MLR
Sulfate, as SO_4	mg/L	-55.6 + 0.249 sc	.981	MLR
Chloride	mg/L	-24.557 + 0.117 sc - 6.438 sea	.970	MLR
Fluoride	mg/L	-0.568 + 0.398 sclog	.420	MLR
Silica	mg/L	133.23 + 6.775 qlog + 0.036 sc - 61.262 sclog + 0.396 temp - 4.315 sea	.913	MLR
Nitrogen, NO_2 + NO_3, diss, as N	mg/L	2.378 - 0.751 qlog + 0.0002 q - 0.096 sea	.856	MLR
Nitrogen, amm, diss, as N	mg/L	0.396 - 0.123 qlog	--	KTR
Nitrogen, amm + org, diss, as N	mg/L	-1.501 + 0.594 sclog	--	KTR
Nitrogen, amm + org, total, as N	mg/L	33.629 - 0.976 qlog + 0.002 sc - 10.783 sclog - 0.132 sea	.294	MLR
Phosphorus, total, as P	mg/L	$10^{(47.64 - 1.325 \text{ qlog} + 0.003 \text{ sc} - 14.527 \text{ sclog} - 4.364 \text{ DOlog} - 0.034 \text{ temp})}$	.360	MLR
Phosphorus, diss, as P	mg/L	-0.229 + 0.085 sclog	--	KTR
Phosphorus, ortho, diss, as P	mg/L	-0.104 + 0.041 sclog	--	KTR
Manganese, diss	µg/L	-13.588 + 0.015 sc	--	KTR

[1] sea = sin(T) + cos(T) where T equals the time, in months, from December 1, 1992, times 0.5236.

Table 39.--Summary statistics for supplemental trace-element analytes

[Some analytes have multiple minimum reporting levels (MRL's) because of different analytical procedures used or because of quality-assurance testing at the time of analysis. Only the MRL's at which data were censored are presented in this table. Analyte: ww rec, whole water recoverable--because of incomplete digestion, determination represents a value less than the total amount (less than 95 percent) of the analyte present in the dissolved and suspended phases (Timme, 1995); dissolved, analytes in a representative water sample passed through a 0.45-micron filter membrane for inorganic analysis or a 0.7-micron glass-fiber filter for organic analysis (Timme, 1995). µg/L, micrograms per liter; --, not applicable; <, less than]

Analyte	Number of samples	Concentration			Site(s) of maximum concentration (table 1)	Censored data	
		Minimum (µg/L)	Median (µg/L)	Maximum (µg/L)		MRL (µg/L)	Number less than MRL
Aluminum, ww rec	18	190	1,850	210,000	13	--	--
Aluminum, dissolved	50	<1	11.5	430	15	1	1
						10	17
Antimony, ww rec	17	<1	<1	12	13	1	15
Antimony, dissolved	19	<1	<1	<1	--	1	19
Arsenic, ww rec	37	<1	2	6	12, 14	1	4
Arsenic, dissolved	41	<1	2	5	11, 12	1	6
Barium, ww rec	17	<100	<100	1,900	13	100	10
Barium, dissolved	49	14	56	101	16	--	--
Beryllium, ww rec	17	<10	<10	30	13	10	16
Beryllium, dissolved	19	<1	<1	<1	--	1	19
Boron, ww rec	17	<10	40	200	13	10	5
Boron, dissolved	46	<10	50	450	12	10	8
Cadmium, ww rec	36	<1	<1	8	13	1	32
Cadmium, dissolved	41	<1	<1	<1	--	1	41
Chromium, ww rec	36	<1	1.6	160	13	1	12
Chromium, dissolved	41	<1	<1	7	17	1	35
Cobalt, ww rec	17	<1	1	270	13	1	6
Cobalt, dissolved	51	<1	<3	3	12	1	19
						3	31
Copper, ww rec	36	<1	3.5	880	13	1	5
Copper, dissolved	41	<1	2	6	11	1	10
Cyanide, ww rec	23	<10	<10	40	9	10	22
Cyanide, dissolved	2	<10	--	<10	--	10	2
Iron, ww rec	17	220	1,900	220,000	13	--	--
Lead, ww rec	36	<1	3	500	13	1	6
Lead, dissolved	41	<1	<1	3	11	1	37
Lithium, ww rec	17	<10	20	800	13	10	6
Lithium, dissolved	45	<4	35	220	17	4	4
Manganese, ww rec	17	10	120	13,000	13	--	--
Mercury, ww rec	35	<.1	<.1	3.3	13	.1	31
Mercury, dissolved	37	<.1	<.1	<.1	--	.1	37
Molybdenum, ww rec	17	<1	1.8	6.7	17	1	8
Molybdenum, dissolved	59	<1	10	20	15, 17	1	4
						10	17

Table 39.--Summary statistics for supplemental trace-element analytes--Concluded

Analyte	Number of samples	Concentration			Site(s) of maximum concentration (table 1)	Censored data	
		Minimum (µg/L)	Median (µg/L)	Maximum (µg/L)		MRL (µg/L)	Number less than MRL
Nickel, ww rec	17	<1	3	380	13	1	5
Nickel, dissolved	50	<1	1	9	13	1	23
Selenium, ww rec	36	<1	<1	38	13	1	31
						25	1
Selenium, dissolved	70	<1	<1	3	13	1	61
						2	3
Silver, ww rec	18	<1	<1	5	13	1	17
Silver, dissolved	51	<1	<1	<1	--	1	51
Strontium, ww rec	17	40	250	7,500	13	--	--
Strontium, dissolved	60	43	320	2,100	13	--	--
Uranium, dissolved	38	<1	2.4	13	13	1	8
Vanadium, dissolved	46	<6	<6	9	5, 7	6	40
Zinc, ww rec	36	<10	15	1,300	13	10	9
Zinc, dissolved	41	<1	<10	51	11	1	1
						10	19

Because of the small number of samples, a detailed examination of the spatial variation of trace elements at the basic-fixed sites is not warranted. However, some general observations can be made. The maximum concentrations of most total recoverable trace elements were detected at site 13. This was due to the large suspended-sediment concentrations at this site; trace-element concentrations on a gram-to-gram basis in the suspended sediment at this site are similar to comparative concentrations at other basic-fixed sites. Concentrations of dissolved antimony, beryllium, cadmium, mercury, and silver were smaller than their respective MRL's in all samples. Concentrations of dissolved chromium, cobalt, lead, selenium, and vanadium were smaller than their respective MRL's in more than 80 percent of the samples; concentrations of these trace elements detected in the remaining samples were within the range of natural waters (Hem, 1985). Concentrations of dissolved arsenic, copper, and nickel were near or smaller than their respective MRL's in more than 50 percent of the samples. Concentrations of dissolved barium, boron, lithium, molybdenum, strontium, and uranium increased in a downstream direction, although the largest concentrations of boron, strontium, and uranium were detected at site 13. The two relatively large dissolved-aluminum concentrations at sites 9 and 15 probably were due to particulate or colloids that were less than 0.45 micron, whereas the relatively large dissolved-zinc concentrations at sites 1 and 11 may have had anthropogenic sources.

Table 40 summarizes organic carbon sampling at the basic-fixed sites. The maximum TOC concentration was detected at site 13. The maximum DOC concentrations at sites 7, 8, 9, 12, and 15 are significantly larger than the maximum DOC concentrations detected at the other basic-fixed sites or any other DOC concentration from those five sites; all are from the June 1993 sampling.

Pesticides

A total of 58 samples from nine basic-fixed sites were analyzed for dissolved-pesticide concentrations. Forty-four of the samples were collected during monthly sampling in the spring and summer of 1995, 13 samples were collected during the Mesilla Valley synoptic study, and 1 sample was collected as part of the survey sample at site 12 in August 1994. All 58 samples were analyzed by the C-18 solid-phase extraction method (Zaugg and others, 1995). The 13 samples collected during the Mesilla Valley synoptic and the single survey sample also were analyzed by the Carbopak-B solid-phase extraction method (Werner and others, 1996). Table 41 lists the sampling sites, number of samples, time period of samples, and the study for which the samples were collected.

There was a total of 152 detections of 17 pesticides from 3,278 analyses of 88 pesticide analytes (table 3). Simazine was detected in the most samples, 31 of 58, and at the most sampling sites, eight of nine. Prometon was detected in 29 of 58 samples; all prometon detections were at sites 11 to 17. The diazinon concentration of 0.21 µg/L at site 11 in September 1995 was the largest concentration of any pesticide detected at a basic-fixed site. The second largest concentration was an estimated 0.068 µg/L of carbofuran detected at site 15 in April 1995. Of the 152 detections, 91 were uncensored values at or above their corresponding MDL's, 47 were estimated values below their corresponding MDL's, and the 9 carbofuran and 5 carbaryl detections were estimated values because of the poor performance record of these two pesticides analyzed with the C-18 method (Zaugg and others, 1995). Table 42 gives summary statistics for the pesticide analytes detected.

On an individual site basis, pesticides were detected at all nine basic-fixed sites that were sampled. The number of detections ranged from 1 detection out of 188 analyses at site 3 to 39 detections out of 797 analyses at site 17. The number of analytes detected ranged from 1 at site 3 to 10 at sites 16 and 17. In comparing the samples collected during the summer of 1995, the number of analytes detected increased from the upper part of the basin, one at site 3, to the lower part of the basin, eight at site 16. The number of detections also generally increased from the upper to the lower part of the basin except at site 11, which had the second highest number of detections during this time period. Table 43 summarizes pesticide analyses and detections at the nine sites sampled, and table 44 lists the uncensored and estimated concentrations for all detections at these sites.

Table 40. --Summary statistics for organic carbon analytes

[All concentrations are in milligrams per liter. Num, number of samples; min, minimum; med, median; max, maximum. --, not applicable]

Site number (table 1)	Total				Dissolved				Suspended			
	Num	Min	Med	Max	Num	Min	Med	Max	Num	Min	Med	Max
1	1	--	4.4	--	7	1.8	2.4	4.8	6	0.3	0.45	3.5
2	1	--	4.5	--	6	2.2	2.95	13	6	.5	1.3	2.1
3	1	--	5.9	--	6	1.9	2.5	5.2	6	.2	.6	1.2
4	1	--	8.0	--	6	3.2	4.75	9.0	6	.7	.7	2.3
5	1	--	6.3	--	6	1.4	2.0	9.7	7	.4	.6	1.8
6	1	--	9.8	--	7	3.0	5.5	8.0	6	.4	1.0	2.7
7	10	2.2	4.4	11	6	1.8	2.85	20	6	.3	1.1	3.0
8	1	--	7.4	--	6	3.8	4.65	22	6	.5	.6	.7
9	1	--	8.1	--	6	2.8	4.45	20	6	.5	.8	1.1
10	1	--	4.9	--	6	2.2	2.95	7.9	5	.4	.5	1.5
11	2	7.2	--	12	8	5.6	6.65	9.4	6	.3	.65	5.0
12	11	4.4	6.5	25	7	3.3	4.1	25	6	1.0	1.5	5.5
13	1	--	260	--	2	6.6	--	7.5	0	--	--	--
14	1	--	9.7	--	6	3.1	3.35	6.2	4	1.2	2.3	4.1
15	2	6.5	--	11	3	4.7	5.3	26	2	3.6	4.2	4.8
16	2	4.1	--	7.4	12	3.1	4.2	7.5	11	.2	.9	1.5
17	2	5.0	--	7.3	11	3.2	3.8	5.7	11	.7	1.7	2.9

Table 41.--Basic-fixed sites at which pesticide samples were collected

Site number (table 1)	Number of samples	Time period	Study[1]
3	4	June-September 1995	Network sampling
6	6	May-September 1995	Network sampling
9	5	April-August 1995	Network sampling
11	4	June-September 1995	Network sampling
12	1	August 1994	Survey sample
	6	April-September 1995	Network sampling
14	5	April-August 1995	Network sampling
15	5	April-August 1995	Network sampling
16	6	April-May 1994 January 1995	Mesilla Valley synoptic
	5	April-August 1995	Network sampling
17	7	April-May 1994 January 1995	Mesilla Valley synoptic
	4	April-August 1995	Network sampling

[1] All samples were analyzed by the C-18 solid-phase extraction method. The survey sample at site 12 and Mesilla Valley synoptic samples also were analyzed by the Carbopak-B solid-phase extraction method.

Table 42.--Summary of pesticide analytes detected at basic-fixed sites

[U.S. Geological Survey's Water-Data Storage and Retrieval System (WATSTORE) parameter code: D, C-18 solid-phase extraction method; A, Carbopak-B solid-phase extraction method. All concentrations are in micrograms per liter. E, estimated value; --, not applicable]

Analyte	Parameter code	Method detection limit	Number of analyses	Number of detections[1]		Number of sites	Concentration		
				Uncensored	Estimated		Minimum	Median	Maximum
Atrazine	39632D	0.001	58	5	0	3	0.003	0.004	0.006
Carbaryl[2]	82680D	.003	58	0	5	3	E.002	E.026	E.044
Carbofuran[2]	82674D	.003	58	0	9	4	E.006	E.016	E.068
Chlorpyrifos	38933D	.004	58	5	0	2	.005	.006	.008
DCPA	82682D	.002	58	13	4	3	E.001	.005	.021
p,p'DDE	34653D	.006	58	0	3	3	E.001	E.002	E.002
Diazinon	39572D	.002	58	14	0	6	.003	.0085	.21
Diuron	49300A	.020	14	0	1	1	--	E.001	--
EPTC	82668D	.002	58	2	1	2	E.001	.004	.010
Lindane	39341D	.004	58	3	0	1	.009	.011	.040
Malathion	39532D	.005	58	2	1	3	E.003	.007	.009
Metolachlor	39415D	.002	58	13	0	4	.002	.003	.008
Prometon	04037D	.018	58	2	27	6	E.003	E.007	.039
Propargite	82685D	.004	58	1	0	1	--	.055	--
Simazine	04035D	.005	58	28	3	8	E.002	.009	.059
Tebuthiuron	82670D	.010	58	2	7	6	E.004	E.007	.018
Trifluralin	82661D	.002	58	1	0	1	--	.010	--

[1] Uncensored detections are data to which an unqualified value can be assigned. Estimated detections are of two types. Estimated concentrations below the method detection limit lack the statistical confidence that they are not equal to zero. Estimated concentrations at or above the method detection limit result from matrix interference with the analytical procedure or a poor or variable performance record of the analyte with the analytical procedure used.

[2] The five carbaryl detections and nine carbofuran detections are estimated values because of poor performance records of these analytes with the C-18 solid-phase extraction method.

Table 43.--Summary of pesticide detections at basic-fixed sites

[SPE, solid-phase extraction; --, not applicable]

Site number (table 1)	C-18 SPE method				Carbopak-B SPE method			
	Number of samples	Number of analyses	Number of detections	Number of analytes detected	Number of samples	Number of analyses	Number of detections	Number of analytes detected
3	4	188	1	1	0	--	--	--
6	6	282	5	4	0	--	--	--
9	5	235	5	5	0	--	--	--
11	4	188	15	5	0	--	--	--
12	7	328	18	7	1	41	0	0
14	5	235	14	7	0	--	--	--
15	5	235	19	8	0	--	--	--
16	11	512	36	10	6	237	1	1
17	11	511	39	10	7	286	0	0
All sites	58	2,714	152	17	14	564	1	1

Table 44.--Pesticide detections at basic-fixed sites

[All concentrations in micrograms per liter. C, censored data; E, estimated data[1]]

Site number (table 1)	Date	Atra-zine	Car-baryl	Carbo-furan	Chlor-pyrifos	DCPA	p,p'DDE	Dia-zinon	Diuron
3	09/06/95	C	C	C	C	C	E0.001	C	C
6	06/13/95	C	C	C	C	C	C	C	C
	07/19/95	C	C	C	C	C	C	C	C
	09/05/95	C	C	C	C	C	C	0.008	C
9	04/18/95	C	C	C	C	C	C	C	C
	05/16/95	C	C	C	C	C	C	.008	C
	06/21/95	C	C	C	C	C	C	C	C
	07/26/95	C	C	C	C	C	C	C	C
11	06/07/95	C	C	C	C	C	C	.009	C
	07/06/95	C	E0.026	C	C	C	C	.023	C
	08/02/95	C	E.036	C	C	C	C	.022	C
	09/06/95	C	C	C	C	C	C	.21	C
12	08/31/94	C	E.044	C	0.006	C	C	.025	C
	04/27/95	C	C	C	C	C	C	C	C
	05/31/95	C	C	C	C	C	C	.003	C
	06/23/95	C	C	C	C	C	C	C	C
	07/12/95	C	E.002	C	C	C	C	C	C
	09/05/95	C	C	C	.006	C	C	.025	C
14	04/20/95	C	C	E0.031	C	C	C	C	C
	05/24/95	C	C	C	C	C	C	C	C
	06/28/95	C	E.012	C	C	C	C	C	C
	07/26/95	C	C	C	C	C	C	C	C
	08/30/95	C	C	C	C	C	C	.004	C
15	04/19/95	0.004	C	E.068	C	C	C	.005	C
	05/24/95	C	C	C	C	C	C	.003	C
	06/28/95	C	C	C	C	C	C	.004	C
	07/26/95	C	C	C	C	C	C	C	C
	08/30/95	C	C	C	C	E0.001	C	.009	C
16	04/13/94	C	C	E.016	C	.005	C	C	C
	04/18/94	C	C	C	C	.004	E.002	C	C
	04/26/94	C	C	E.006	C	C	C	C	C
	05/04/94	C	C	C	C	.003	C	C	C
	05/10/94	C	C	C	C	C	C	C	C
	01/04/95	C	C	C	C	.003	C	C	E0.001
	04/18/95	C	C	E.029	C	.006	C	C	C
	05/22/95	C	C	C	C	.012	C	C	C
	06/26/95	.004	C	E.010	C	.008	C	C	C
	07/25/95	C	C	C	C	C	C	C	C
	08/29/95	C	C	C	C	E.001	C	C	C
17	04/06/94	.006	C	C	.008	.012	C	C	C
	04/12/94	C	C	E.013	C	.006	C	C	C
	04/19/94	.004	C	C	C	.005	C	C	C
	04/28/94	C	C	E.022	C	C	C	C	C
	05/03/94	C	C	C	C	C	C	C	C
	05/11/94	C	C	C	C	C	C	C	C
	01/07/95	C	C	C	C	.021	E.002	C	C
	04/18/95	C	C	E.011	C	.009	C	C	C
	05/23/95	C	C	C	.005	.008	C	C	C
	06/27/95	.003	C	C	C	E.001	C	C	C
	08/29/95	C	C	C	.008	E.001	C	C	C

Table 44.--Pesticide detections at basic-fixed sites--Concluded

Site number (table 1)	Date	EPTC	Lindane	Mala- thion	Meto- lachlor	Pro- meton	Propar- gite	Sima- zine	Tebu- thiuron	Triflu- ralin
3	09/06/95	C	C	C	C	C	C	C	C	C
6	06/13/95	0.010	C	C	C	C	C	C	C	C
	07/19/95	E.001	C	0.009	C	C	C	E0.002	C	C
	09/05/95	C	C	C	C	C	C	C	C	C
9	04/18/95	C	C	C	C	C	C	C	0.010	C
	05/16/95	C	C	C	C	C	C	C	C	C
	06/21/95	.004	C	C	C	C	C	C	C	C
	07/26/95	C	C	.007	C	C	C	E.003	C	C
11	06/07/95	C	0.009	C	C	E0.005	C	C	C	C
	07/06/95	C	C	C	C	.039	C	C	C	C
	08/02/95	C	.011	C	C	E.009	C	.006	C	C
	09/06/95	C	.040	C	C	E.012	C	.006	C	C
12	08/31/94	C	C	C	C	0.031	C	.059	C	C
	04/27/95	C	C	C	C	E.005	C	.009	E.007	C
	05/31/95	C	C	C	C	E.004	C	C	C	C
	06/23/95	C	C	C	C	C	C	.016	C	C
	07/12/95	C	C	E.003	C	C	C	.016	C	C
	09/05/95	C	C	C	C	E.005	C	.022	C	C
14	04/20/95	C	C	C	C	E.004	C	.009	E.004	C
	05/24/95	C	C	C	C	C	C	.022	C	C
	06/28/95	C	C	C	0.002	E.004	C	.009	C	C
	07/26/95	C	C	C	C	C	C	.007	C	C
	08/30/95	C	C	C	C	E.005	C	.005	E.008	C
15	04/19/95	C	C	C	C	E.004	C	.018	E.006	C
	05/24/95	C	C	C	C	C	C	.056	E.005	C
	06/28/95	C	C	C	.002	E.003	C	.022	C	C
	07/26/95	C	C	C	C	C	C	.022	C	C
	08/30/95	CC	C	C	C	E.005	C	E.004	.018	C
16	04/13/94	C	C	C	.008	C	C	C	C	C
	04/18/94	C	C	C	C	E.009	C	.007	C	C
	04/26/94	C	C	C	C	E.008	C	C	C	C
	05/04/94	C	C	C	C	E.009	C	C	C	C
	05/10/94	C	C	C	C	C	C	C	C	C
	01/04/95	C	C	C	.008	C	C	C	C	C
	04/18/95	C	C	C	.002	E.009	C	.010	C	C
	05/22/95	C	C	C	C	E.007	C	.010	C	C
	06/26/95	C	C	C	.005	E.009	0.055	.009	C	C
	07/25/95	C	C	C	C	E.007	C	.013	C	C
	08/29/95	C	C	C	.005	E.007	C	.011	E.008	C
17	04/06/94	C	C	C	.003	C	C	.008	C	C
	04/12/94	C	C	C	C	C	C	C	C	C
	04/19/94	C	C	C	C	E.007	C	.006	C	C
	04/28/94	C	C	C	C	E.009	C	C	C	C
	05/03/94	C	C	C	C	E.008	C	C	C	C
	05/11/94	C	C	C	C	C	C	C	C	C
	01/07/95	C	C	C	.007	C	C	C	C	0.010
	04/18/95	C	C	C	.002	E.007	C	.009	C	C
	05/23/95	C	C	C	.002	E.005	C	.007	C	C
	06/27/95	C	C	C	.003	E.008	C	.010	C	C
	08/29/95	C	C	C	.004	E.007	C	.008	E.006	C

SUMMARY

As part of the RIOG NAWQA program, water-column samples were collected monthly at a network of 17 basic-fixed sites from April 1993 through September 1995 for the analyses of DS, major constituents, nutrients, selected trace elements, and suspended-sediment concentrations. During selected sampling events, samples also were collected for analysis of additional trace elements, organic carbon, and pesticides.

Instantaneous streamflow was smallest at the indicator sites on the perennial streams draining small basins and was largest at integrator sites 9 and 12 on the main stem. The median instantaneous streamflow at each individual site ranged from 1.4 ft^3/s at site 10 to 1,380 ft^3/s at site 9. Median specific conductance for each site ranged from 84 μS/cm at site 3 to 1,680 μS/cm at site 13, and the median pH values ranged from 7.8 at sites 1, 3, and 10 to 8.5 at site 11. The water sampled at the basic-fixed sites was generally well oxygenated and had a median DO percent of saturation ranging from 89 at site 12 to 108 at site 6.

With the exception of site 4, DS concentrations generally increased in the main stem of the Rio Grande in a downstream direction. This increase is from natural sources, such as ground-water inflow and evapotranspiration, and from anthropogenic sources, such as irrigation-return flows, urban runoff, and WWTP discharges. The smallest median DS concentration was 58 mg/L at site 3, and the largest median DS concentration was 1,240 mg/L at site 13.

The spatial distribution of calcium, magnesium, sodium, sulfate, chloride, and fluoride was similar to the spatial distribution of DS, although the differences in concentrations among sites varied for different constituents. For potassium, the major difference in spatial distribution was the decrease in median concentration from site 6 to site 9. For bicarbonate, the largest median concentration was at site 11, and the median concentration at site 13 was approximately equal to that at site 12.

Of all cations, calcium and sodium had the largest concentrations at most sites. Calcium was the predominant cation at sites 1-3, 5, 7-9, and 12. Sodium was the predominant cation at sites 11 and 17. For the remainder of the sites, neither calcium nor sodium was predominant; however, calcium exceeded sodium in percentage of total cation milliequivalents per liter at sites 4, 6, and 15, they were approximately equal at site 10, and sodium exceeded calcium at sites 13, 14, and 16. Site 3 differed from the other basic-fixed sites in that magnesium exceeded sodium.

Of all anions, bicarbonate and sulfate had the largest concentrations at most sites. Bicarbonate was the predominant anion at all sites except 13, 14, 16, and 17. Sulfate was the predominant anion at site 13. Bicarbonate exceeded sulfate in percentage of total anion milliequivalents per liter at site 14; they were approximately equal at site 16; and sulfate exceeded bicarbonate at site 17. Sites 10 and 11 differed from the other basic-fixed sites in that chloride exceeded sulfate.

Silica had the largest concentration at site 10, where silica accounted for approximately 50 percent of the DS. Silica also was important at sites 1, 2, and 5, where it accounted for approximately 30 percent of the DS, and at site 3, where it accounted for approximately 20 percent of the DS. For the remaining sites, silica concentration as a percentage of DS concentration generally decreased downstream as the concentration of DS increased.

The largest concentrations and largest median concentrations for the dissolved-nutrient analytes were detected at sites 11 and 12. The relatively large dissolved-nutrient concentrations at these sites probably were due to discharges from WWTP's and urban runoff. The second largest median concentration for $NO_2 + NO_3$ was at site 13; the larger concentrations of $NO_2 + NO_3$ at this site were associated with runoff from summer thunderstorms.

The largest concentrations and largest median concentrations of total ammonia plus organic nitrogen and total phosphorus were detected at site 13. As with $NO_2 + NO_3$, the largest concentrations of these nutrients at this site were associated with runoff from summer thunderstorms.

Dissolved-iron concentrations ranged from censored values at sites 13-17 to 914 μg/L at site 13. Median concentrations ranged from 3 μg/L at sites 16 and 17 to 160 μg/L at site 2. Dissolved-manganese concentrations ranged from censored concentrations at sites 13-17 to 300 μg/L at site 4. Median concentrations ranged from 1 μg/L at site 15 to 68 μg/L at site 4.

The maximum concentrations of most total recoverable trace elements were detected at site 13, due to the large suspended-sediment concentrations at this site. Concentrations of dissolved antimony, beryllium, cadmium, mercury, and silver were smaller than their respective MRL's in all samples. Concentrations of dissolved chromium, cobalt, lead, selenium, and vanadium were smaller than their respective MRL's in more than 80 percent of the samples. Concentrations of dissolved arsenic, copper, and nickel were near or smaller than their respective MRL's in more than 50 percent of the samples. Concentrations of dissolved barium, boron, lithium, molybdenum, strontium, and uranium increased in a downstream direction, although the largest concentrations of boron, strontium, and uranium were detected at site 13.

There was a total of 152 detections of 17 pesticides from 3,278 analyses of 88 pesticide analytes. Simazine was detected in the most samples, 31 of 58, and at the most sampling sites, eight of nine. Prometon was detected in 29 of 58 samples, all at sites 11-17. The diazinon concentration of 0.21 µg/L at site 11 in September 1995 was the largest concentration of any pesticide detected at a basic-fixed site. The second largest concentration was an estimated 0.068 µg/L of carbofuran detected at site 15 in April 1995. Of the 152 detections, 91 were uncensored values at or above their respective MDL's, 47 were estimated values below their respective MDL's, and the 9 carbofuran and 5 carbaryl detections were estimated values because of the poor performance record of these two pesticides analyzed with the C-18 method.

On a individual site basis, pesticides were detected at all nine sites that were sampled. The number of detections ranged from 1 detection out of 188 analyses at site 3 to 39 detections out of 797 analyses at site 17. The number of analytes detected ranged from 1 at site 3 to 10 at sites 16 and 17. In comparing the samples collected during the summer of 1995, the number of analytes detected increased from the upper part of the basin, one at site 3, to the lower part of the basin, eight at site 16.

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☆U.S. GOVERNMENT PRINTING OFFICE:1997-673-691/85004