Interim Results of Quality-Control Sampling of Surface Water for the Upper Colorado River National Water-Quality Assessment Study Unit, Water Years 1995–96

By Norman E. Spahr and Robert W. Boulger

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Interim Results of Quality-Control Sampling of Surface Water for the Upper Colorado River National Water-Quality Assessment Study Unit, Water Years 1995–96

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Abstract

Quality-control samples provide part of the information needed to estimate the bias and variability that result from sample collection, processing, and analysis. Quality-control samples of surface water collected for the Upper Colorado River National Water-Quality Assessment study unit for water years 1995–96 are presented and analyzed in this report. The types of quality-control samples collected include pre-processing split replicates, concurrent replicates, sequential replicates, post-processing split replicates, and field blanks.

Analysis of the pre-processing split replicates, concurrent replicates, sequential replicates, and post-processing split replicates is based on differences between analytical results of the environmental samples and analytical results of the quality-control samples. Results of these comparisons indicate that variability introduced by sample collection, processing, and handling is low and will not affect interpretation of the environmental data. The differences for most water-quality constituents is on the order of plus or minus 1 or 2 lowest rounding units. A lowest rounding unit is equivalent to the magnitude of the least significant figure reported for analytical results. The use of lowest rounding units avoids some of the difficulty in comparing differences between pairs of samples when concentrations span orders of magnitude and provides a measure of the practical significance of the effect of variability.

Analysis of field-blank quality-control samples indicates that with the exception of chloride and silica, no systematic contamination of samples is apparent. Chloride contamination probably was the result of incomplete rinsing of the dilute cleaning solution from the outlet ports of the decaport sample splitter. Silica contamination seems to have been introduced by the blank water. Sampling and processing procedures for water year 1997 have been modified as a result of these analyses.

INTRODUCTION

The Upper Colorado River study unit (UCOL) is 1 of 59 National Water-Quality Assessment (NAWQA) study units. The long-term goals of the NAWQA program are to (1) describe current water-quality conditions for a large part of the Nation's freshwater streams, rivers, and aquifers; (2) describe how water quality is changing over time; and (3) improve understanding of the primary natural and human factors that affect water-quality conditions (Leahy and others, 1990). Hydrologic and water-quality assessments of the UCOL study unit began in 1994. The UCOL study unit is described by Driver (1994) and Apodaca and others (1996). A network of 14 surface-water-quality sampling stations has been established in the UCOL study unit (Spahr and others, 1996). Sampling for water-quality constituents began at three of these sites in water year 1995, and full implementation of sampling began in water year 1996. Site locations are shown in figure 1. Site names and station numbers are listed in table 1. The NAWQA program requires that quality-control samples be collected at sites within the surface-water network (T.L. Miller, U.S. Geological Survey, written commun., 1996).

Quality-control samples provide part of the information needed to estimate the bias and variability that result from sample collection, processing, and analysis. The results are used to evaluate possible effects of bias and variability on the interpretation of environmental data. Two specific objectives for evaluating bias and variability are to determine the extent to which (1) sampling methods and equipment introduce contaminants (bias) into water-quality samples; and (2) sample processing and handling affect the variability of measured constituent concentrations (T.L. Miller, U.S. Geological Survey, written commun., 1996).

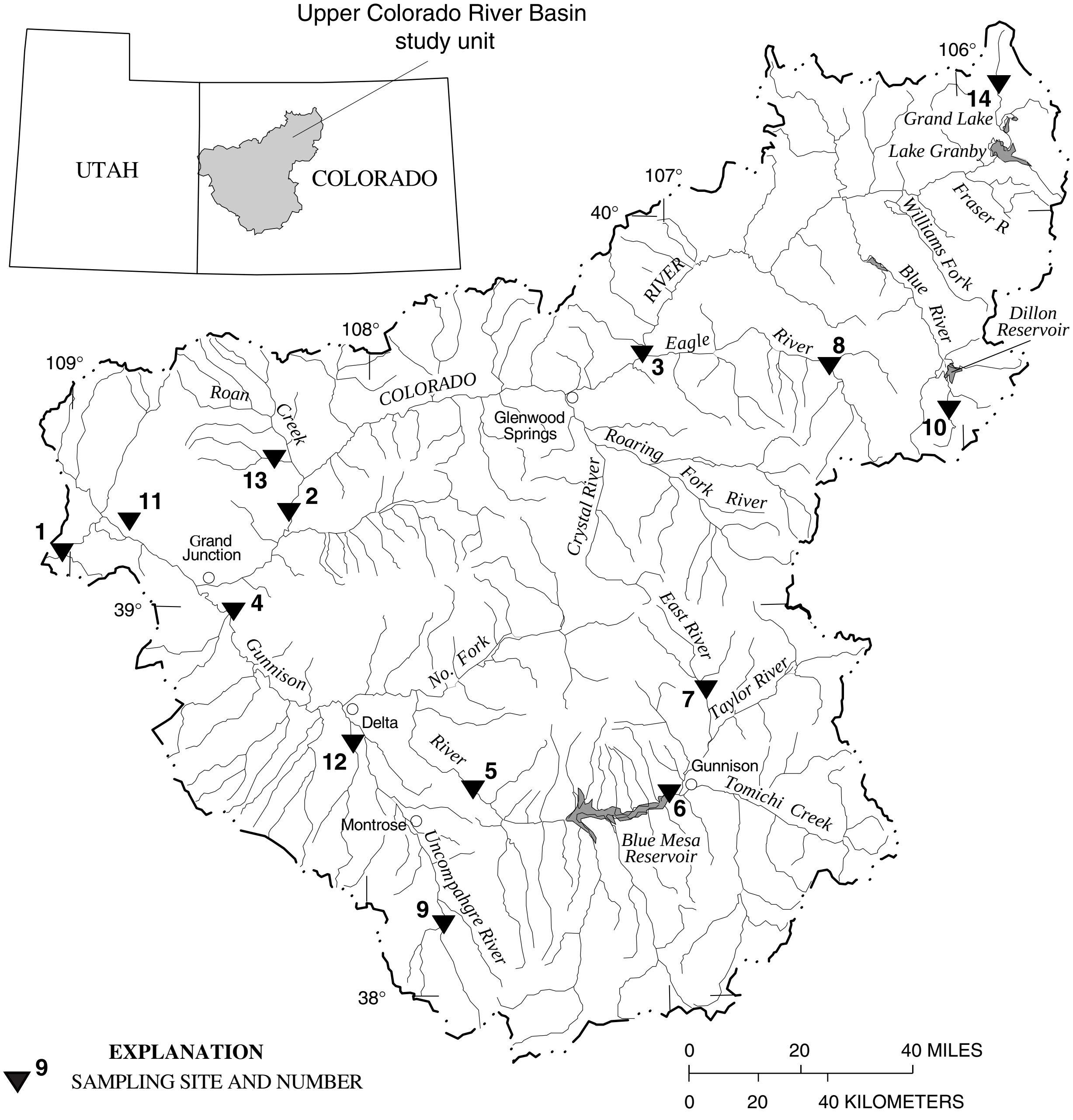

Figure 1. Location of sampling sites (numbers refer to table 1).

Table 1. Water-quality monitoring sites in the Upper Colorado River study unit

Site number in figure 1	Site name	Site name used in this report	USGS station identifier
1	Colorado River near Colorado-Utah State line	State Line	09163500
2	Colorado River near Cameo	Cameo	09095500
3	Colorado River near Dotsero	Dotsero	09070500
4	Gunnison River near Grand Junction	Gunnison near Grand Junction	09152500
5	Gunnison River below Gunnison Tunnel	Gunnison Tunnel	09128000
6	Gunnison River at County Road 32	Gunnison at 32 Road	383103106594200
7	East River below Cement Creek	East	09112200
8	Gore Creek at mouth	Gore	09066510
9	Uncompahgre River near Ridgway	Uncompahgre	09146200
10	French Gulch near Breckenridge	French	09046530
11	Reed Wash near Mack	Reed	09153290
12	Dry Creek at Begonia Road	Dry	09149480
13	Dry Fork at upper station near DeBeque	Dry Fork	09095300
14	Colorado River below Baker Gulch	Baker	09010500

Purpose and Scope

The objectives of this report are to (1) describe what factors were considered in the initial quality-assurance sample design; (2) present and describe quality-control data for water years 1995–96; (3) analyze the quality-control data for systematic problems that can be resolved in water year 1997; and (4) provide insight into operation of the network for the remainder of the data-collection phase of the UCOL study unit.

Several types of quality-control samples were collected during water years 1995–96 and included pre-processing split replicates, concurrent replicates, sequential replicates, post-processing split replicates, and field blanks. Pre-processing split-replicate samples are samples in which twice the normal volume of water is collected and then split into two unique samples before processing. Concurrent-replicate samples are samples that are collected using two sampling teams or two sets of sampling equipment at the same time. Sequential-replicate samples are collected sequentially: first one sample is collected and then a replicate is collected. Post-processing split replicates are samples that are split after all processing has been completed but prior to shipment to the laboratory for analysis. A field blank is a sample prepared using blank water (water that is free of the analytes of interest), which is passed through all of the sampling and processing equipment.

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QUALITY-CONTROL SAMPLING PROGRAM

When surface-water sampling began in the UCOL network, limited information was available to design the quality-control sampling program. In the initial and continuously developing quality-control design, several factors were considered, which included streamflow, expected constituent concentrations, basin characteristics, land use, and whether variability or bias would be important at a site. Variability is the degree of random error in independent measurements of the same quantity. Replicate samples test for variability, which could be important at sites that have high constituent concentrations. Bias is the systematic error inherent in a method. Blank samples test for bias, which could be more important at sites having low constituent concentrations.

The distribution of replicate samples is listed in table 2. The type of replicate sample is based on design considerations. As data collection started, concentration ranges for general chemical constituents, nutrients, organic carbon, and trace elements were determined for each site. Sites within the network were compared and then categorized as low, medium, or high based on measured concentrations. Discharge ranges for each site were defined as low (base flow), medium (flows above base to about 50 percent of the peak), and high (flows greater than about 50 percent of the peak). The distribution of quality-control samples was monitored and adjusted during the data-collection phase of the project, producing a dynamic program design. Additional samples of medium- and high-flow conditions were needed to balance the overall distribution.

The distribution of field-blank samples and information for the site sampled before the blank was processed are listed in table 3. Some field blanks were processed using equipment that had been cleaned in the office laboratory. To test the efficiency of the field cleaning protocol, additional field-blank samples should be collected following field cleaning rather than laboratory cleaning. Results of the quality-control sampling listed in tables 2 and 3 are presented in the following sections of this report.

Replicate Samples

Replicate samples provide an indication of the magnitude and source of variability in sample results. Each type of replicate sample addresses

Table 2. Distribution of replicate samples

[--, no sample]

Site name	Land use	Concentration range[1]					Discharge[2] range for sample	Type of replicate sample
		General chemical constituents	Nutrients	Dissolved organic carbon	Suspended organic carbon	Trace elements		
State Line	Mixed	m	m	m	h	--	l	Concurrent and post-processing split
Cameo	Mixed	m	l	m	m	--	h	Concurrent and post-processing split
Dotsero	Mixed	m	l	m	m	--	l	Sequential
Gunnison near Grand Junction	Mixed	m	m	m	m	--	l	Pre-processing split
Gunnison Tunnel	Mixed reference[3]	l	l	m	l	--	h	Post-processing split
Gunnison at 32 Road	Mixed	l	l	m	m	--	h	Concurrent and post-processing split
East	Rural urban, recreation	l	l	l	l	--	l	Concurrent and post-processing split
						--	h	Concurrent and post-processing split
Gore	Rural urban, recreation	l	m	m	m	--	l	Pre-processing split
						--	l	Concurrent and post-processing split
Uncompahgre	Mining	m	l	l	m	l	l	Pre-processing split
French	Mining	l	l	l	m	h	l	Pre-processing split
Reed	Agriculture	h	h	h	h	--	m	Sequential
Dry	Agriculture	h	h	h	h	--	m	Pre-processing split
Dry Fork	Reference, cp[4]	h	l	h	m	--	l	Pre-processing split
Baker	Reference, srm[4]	l	l	m	l	--	l	Concurrent and post-processing split
						--	l	Sequential
						--	m	Pre-processing split

[1] Concentration ranges with respect to all sites within the surface-water network, l = low, m = medium, h = high.

[2] Discharge ranges, l = base flow, m = flows above base to about 50 percent of the peak, h = flows greater than about 50 percent of the peak.

[3] Downstream from major reservoir system.

[4] Physiographic province, cp = Colorado Plateau, srm = Southern Rocky Mountain.

Table 3. Distribution of field-blank samples

[--, no sample or not applicable; lab, office laboratory]

Site	Land use	Previous site	Concentration range at previous site[1]				
			General chemical constituents	Nutrients	Dissolved organic carbon	Suspended organic carbon	Trace elements
State Line	Mixed	Reed	h	h	h	h	--
Dotsero	Mixed	Baker	l	l	m	l	--
Gunnison near Grand Junction	Mixed	Gunnison near Grand Junction	m	m	m	m	--
Gunnison Tunnel	Mixed reference[2]	Lab cleaned	--	--	--	--	--
		Lab cleaned	--	--	--	--	--
		Lab cleaned	--	--	--	--	--
East	Rural urban, recreation	Gunnison at 32 Road	l	l	m	m	
Gore	Rural urban, recreation	French	l	l	l	m	h
French	Mining	French	l	l	l	m	h
Dry	Agriculture	Lab cleaned	--	--	--	--	--
Baker	Reference, srm[3]	Lab cleaned	--	--	--	--	--
		Lab cleaned	--	--	--	--	--

[1] Concentration ranges with respect to all sites within the surface-water network, l = low, m = medium, h = high.

[2] Downstream from major reservoir system.

[3] Physiographic province, srm = Southern Rocky Mountain.

different combinations of sources of variability. The pre-processing split replicate, the concurrent and sequential replicate, and the post-processing split-replicate samples collected in surface water of the UCOL study unit for water years 1995–96 are discussed in the following sections.

Data published by the U.S. Geological Survey are rounded. For example, a calcium value of 150 mg/L (milligrams per liter) is reported (rounded) to the nearest 10 mg/L. A calcium value of 6.5 mg/L is rounded to the nearest 0.1 mg/L. Data rounding is incorporated in the assessment of replicate analysis in this report by using a unit called the lowest rounding unit. A lowest rounding unit of 1 would represent 10 mg/L for the 150 mg/L sample and would represent 0.1 mg/L for the 6.5 mg/L sample. A lowest rounding unit is equal to the magnitude of the least significant figure reported by the USGS National Water Quality Laboratory. In this report, the differences between the environmental and replicate values are given in the units of the constituent and in lowest rounding units.

The use of lowest rounding units for comparison avoids skewing comparisons when values of constituents span orders of magnitude. For example, consider the two pairs of magnesium values for the French and Dry sites (table 4). The environmental and split-replicate values for French are 5.5 and 5.6 mg/L, resulting in a difference of –0.1 mg/L. The Dry environmental and split-replicate values are 36 and 37 mg/L, resulting in a difference of –1 mg/L. Both of the differences are –1 unit of the least significant figure or –1 unit of the lowest rounding value. The practical difference between the environmental and replicate values is similar in both of these cases (the only smaller difference available for each pair of samples would be zero). A comparison of the actual magnitude difference between the environmental and split-replicate pairs (–0.1 to –1 mg/L) is of little use. A difference between the environmental and split-replicate sample for the Dry site could not be 0.1 mg/L because the data are reported to the nearest whole milligram per liter.

Percent differences between the environmental and replicate values do not yield practical significance for many of the constituents in this data set. For example, the chloride environmental and replicate values for French have a –0.1 mg/L difference (table 4), which represents a –10 percent difference.

The difference in chloride values for the Gunnison near Grand Junction site also is –0.1 mg/L (table 4), but the percent difference is only −1.4. The lowest rounding unit difference for both pairs of samples is −1. The practical variability (measure of difference between environmental and split-replicate samples due to sample process, handling, shipping, and analysis) is equivalent for both sets of samples.

Pre-Processing Split Replicates

Pre-processing split-replicate sampling for general chemical constituents, nutrients, and trace elements involves the collection of twice the normal volume of water that is needed for a typical water sample. The water is split into two samples—a typical water-quality sample (termed the environmental sample) and a pre-processing split-replicate sample. Pre-processing split-replicate sampling for dissolved and suspended organic carbon involves collecting two separate samples (the environmental and pre-processing split-replicate sample). Each sample is then processed through all the normal steps of a typical water-quality sample. For each step of sample processing, the environmental sample is processed first, and then the pre-processing split-replicate sample is processed. The split-replicate sample is processed using a new filter and clean equipment. Comparison of results between the environmental samples and the split-replicate samples provides an indication of the variability associated with sample processing, handling, shipment, and analysis. During water years 1995–96, seven pairs of environmental and split-replicate samples were collected. The distribution of collection of the split-replicate samples by date and site is shown in figure 2.

Comparison of General Chemical Constituents

Results of comparison of the environmental and the pre-processing split-replicate samples for general chemical constituents are listed in table 4. The differences between the environmental and split-replicate values are given in the units of the constituent and in units termed lowest rounding unit.

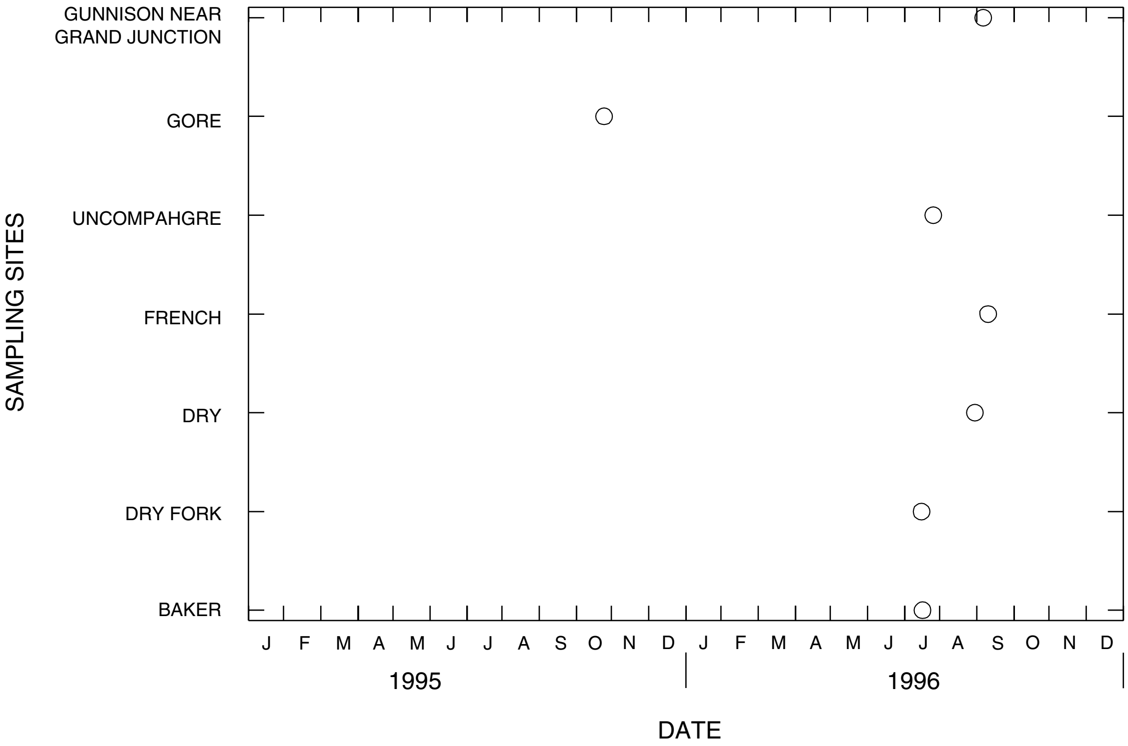

Figure 2. Distribution of collection of pre-processing split-replicate samples, 1995–96.

Table 4. Comparison of environmental and pre-processing split-replicate samples for general chemical constituents

[Env., environmental sample; Split, pre-processing split-replicate sample; Diff. 1, difference in units of constituent; Diff. 2, difference in lowest rounding unit; mg/L, milligrams per liter; µg/L, micrograms per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius; shaded cells represent differences greater than plus or minus 1 lowest rounding unit; lowest rounding unit is equal to the magnitude of the least significant figure]

Station	Date	Calcium				Magnesium				Sodium				Potassium			
		Env. (mg/L)	Split (mg/L)	Diff. 1 (mg/L)	Diff. 2	Env. (mg/L)	Split (mg/L)	Diff. 1 (mg/L)	Diff. 2	Env. (mg/L)	Split (mg/L)	Diff. 1 (mg/L)	Diff. 2	Env. (mg/L)	Split (mg/L)	Diff. 1 (mg/L)	Diff. 2
Gunnison near Grand Junction	090596	120	120	0	0	33	33	0	0	53	53	0	0	3.5	3.5	0	0
Gore	102495	46	47	–1	–1	7.8	7.9	–0.1	–1	5.3	5.3	0	0	1.1	1.1	0	0
Uncompahgre	072596	86	90	–4	–4	10	10	0	0	17	17	0	0	1.8	1.9	–0.1	–1
French	090996	35	34	1	1	5.5	5.6	–0.1	–1	2	2	0	0	1	1.1	–0.1	–1
Dry	082996	170	170	0	0	36	37	–1	–1	47	47	0	0	2.7	2.6	0.1	1
Dry Fork	071596	83	83	0	0	130	130	0	0	300	310	–10	–1	2.7	2.9	–0.2	–2
Baker	071696	6.8	6.8	0	0	1.7	1.7	0	0	1.4	1.4	0	0	0.6	0.7	–0.1	–1
Maximum difference				–4	–4			–1	–1			–10	–1			–0.2	–2
Percent of samples with no difference				57	57			57	57			86	86			29	29
Percent of samples within plus or minus 1 lowest rounding unit					86				100				100				86

Station	Date	Sulfate				Chloride				Fluoride				Laboratory alkalinity			
		Env. (mg/L)	Split (mg/L)	Diff. 1 (mg/L)	Diff. 2	Env. (mg/L)	Split (mg/L)	Diff. 1 (mg/L)	Diff. 2	Env. (mg/L)	Split (mg/L)	Diff. 1 (mg/L)	Diff. 2	Env. (mg/L)	Split (mg/L)	Diff 1. (mg/L)	Diff. 2
Gunnison near Grand Junction	090596	390	390	0	0	7.1	7.2	–0.1	–1	0.5	0.5	0	0	158	158	0	0
Gore	102495	40	40	0	0	8.1	8	0.1	1	0.2	0.2	0	0	109	109	0	0
Uncompahgre	072596	170	170	0	0	3	3	0	0	0.5	0.5	0	0	117	117	0	0
French	090996	81	82	–1	–1	1	1.1	–0.1	–1	0.1	0.1	0	0	36	36	0	0
Dry	082996	450	450	0	0	5.9	6.1	–0.2	–2	0.9	0.9	0	0	222	218	4	4
Dry Fork	071596	950	960	–10	–1	9.4	9.5	–0.1	–1	0.3	0.3	0	0	358	360	–2	–2
Baker	071696	4.1	4.2	–0.1	–1	0.1	0.1	0	0	0.3	0.2	0.1	1	24	24	0	0
Maximum difference				–10	–1			–0.2	–2			0.1	1			4	4
Percent of samples with no difference				57	57			29	29			86	86			71	71
Percent of samples within plus or minus 1 lowest rounding unit					100				86				100				71

Table 4. Comparison of environmental and pre-processing split-replicate samples for general chemical constituents—Continued

[Env., environmental sample; Split, pre-processing split-replicate sample; Diff. 1, difference in units of constituent; Diff. 2, difference in lowest rounding unit; mg/L, milligrams per liter; µg/L, micrograms per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius; shaded cells represent differences greater than plus or minus 1 lowest rounding unit; lowest rounding unit is equal to the magnitude of the least significant figure]

Station	Date	Silica				Iron				Manganese			
		Env. (mg/L)	Split (mg/L)	Diff. 1 (mg/L)	Diff. 2	Env. (µg/L)	Split (µg/L)	Diff. 1 (µg/L)	Diff. 2	Env. (µg/L)	Split (µg/L)	Diff. 1 (µg/L)	Diff. 2
Gunnison near Grand Junction	090596	13	13	0	0	3	3	0	0	15	14	1	1
Gore	102495	5.4	5.4	0	0	3	3	0	0	3	3	0	0
Uncompahgre	072596	10	10	0	0	3	3	0	0	46	50	–4	–4
French	090996	9.5	9.4	0.1	1	11	15	–4	–4	10	10	0	0
Dry	082996	20	19	1	1	3	3	0	0	67	67	0	0
Dry Fork	071596	16	16	0	0	9	9	0	0	4	4	0	0
Baker	071696	6.7	6.6	0.1	1	130	120	10	1	9	9	0	0
Maximum difference				1	1			10	–4			–4	–4
Percent of samples with no difference				57	57			71	71			71	71
Percent of samples within plus or minus 1 lowest rounding unit					100				86				86

Station	Date	Laboratory pH				Laboratory specific conductance				Residue on evaporation			
		Env. (standard units)	Split (standard units)	Diff. 1 (standard units)	Diff. 2	Env. (µS/cm)	Split (µS/cm)	Diff. 1 (µS/cm)	Diff. 2	Env. (mg/L)	Split (mg/L)	Diff. 1 (mg/L)	Diff. 2
Gunnison near Grand Junction	090596	8.0	8.0	0	0	980	978	2	2	749	738	11	11
Gore	102495	8.0	7.9	0.1	1	329	327	2	2	193	191	2	2
Uncompahgre	072596	8.0	8.0	0	0	575	573	2	2	396	391	5	5
French	090996	7.1	7.3	–0.2	–2	255	256	–1	–1	164	164	0	0
Dry	082996	7.9	7.9	0	0	1,200	1,210	–10	–1	916	922	–6	–6
Dry Fork	071596	8.1	8.1	0	0	2,290	2,290	0	0	1,730	1,760	–30	–3
Baker	071696	7.6	7.8	–0.2	–2	59	61	–2	–2	44	40	4	4
Maximum difference				–0.2	–2			–10	2			–30	11
Percent of samples with no difference				57	57			14	14			14	14
Percent of samples within plus or minus 1 lowest rounding unit					71				43				14

A summary of the differences for the constituents listed in table 4 is given in table 5. Except for specific conductance and residue on evaporation, most of the environmental and pre-processing split-replicate samples agree within plus or minus 1 lowest rounding unit. The differences for conductance agree within plus or minus 2 lowest rounding units. These differences would equal plus or minus 2 µS/cm (microsiemens per centimeter at 25 degrees Celsius) for all but the Dry sample (table 4) and probably are well within instrument variation. Differences of 2 µS/cm are not considered excessive. Differences between environmental and split-replicate samples for residue on evaporation are greater than any other of the constituent differences. It appears that differences of a few lowest rounding units for residue on evaporation would be common, and lower differences may be limited by the precision of the laboratory method. Results in table 4 that have differences greater than plus or minus 1 lowest rounding unit have been shaded. By observation of the random position of the shaded cells, it appears that the larger differences for each constituent do not seem to be related to the concentration or the sampling site. Variability associated with sample processing, handling, shipment, and analysis for general chemical constituents is low and will have little effect on interpretation of environmental data.

Comparison of Nutrients and Organic Carbon

Results of comparison of the environmental and pre-processing split-replicate samples for nutrients, dissolved organic carbon, and suspended organic carbon are listed in table 6. To determine the differences between the environmental and pre-processing split-replicate sample concentrations for values less than the laboratory reporting limit (values that have a less-than symbol), a value of one-half of the reporting limit was substituted for the less-than value. A summary of the differences between environmental and pre-processing split-replicate samples for each constituent is listed in table 7. Most of the differences between the environmental and pre-processing split-replicate samples for all constituents are within plus or minus 1 lowest rounding unit. Variability associated with sample processing, handling, shipment, and analysis for nutrients and organic carbon is low and will have little effect on interpretation of environmental data.

Table 5. Summary of differences between environmental and pre-processing split-replicate samples for general chemical constituents

[Lowest rounding unit is equal to the magnitude of the least significant figure]

Constituent	Percent of samples with no difference	Percent of samples within plus or minus 1 lowest rounding unit	Percent of samples within plus or minus 2 lowest rounding units
Calcium	57	86	86
Magnesium	57	100	100
Sodium	86	100	100
Potassium	29	86	100
Sulfate	57	100	100
Chloride	29	86	100
Fluoride	86	100	100
Laboratory alkalinity	71	71	86
Silica	57	100	100
Iron	71	86	86
Manganese	71	86	86
Laboratory pH	57	71	100
Laboratory specific conductance	14	43	100
Residue on evaporation	14	14	28

Table 6. Comparisons of environmental and pre-processing split-replicate samples for nutrients and organic carbon

[Env., environmental sample; Split, pre-processing split-replicate sample; Diff. 1, difference in units of constituent; Diff. 2, difference in lowest rounding unit; mg/L, milligrams per liter; shaded cells represent differences greater than plus or minus 1 lowest rounding unit; lowest rounding unit is equal to magnitude of the least significant figure; <, value is less than the laboratory minimum reporting level]

Station	Date	Ammonia				Dissolved ammonia plus organic				Total ammonia plus organic			
		Env. (mg/L)	Split (mg/L)	Diff. 1 (mg/L)	Diff. 2	Env. (mg/L)	Split (mg/L)	Diff. 1 (mg/L)	Diff. 2	Env. (mg/L)	Split (mg/L)	Diff. 1 (mg/L)	Diff. 2
Gunnison near Grand Junction	090596	0.02	0.02	0	0	0.3	0.2	0.1	1	0.4	0.7	–0.3	–3
Gore	102495	<0.02	<0.02	0	0	<0.2	<0.2	0	0	<0.2	<0.2	0	0
Uncompahgre	072596	0.03	0.03	0	0	<0.2	<0.2	0	0	0.3	0.2	0.1	1
French	090996	<0.02	<0.02	0	0	<0.2	<0.2	0	0	<0.2	<0.2	0	0
Dry	082996	0.05	0.05	0	0	0.4	0.4	0	0	0.8	0.8	0	0
Dry Fork	071596	0.03	0.02	0.01	1	0.3	0.2	0.1	1	0.3	0.2	0.1	1
Baker	071696	0.04	0.02	0.02	2	<0.2	<0.2	0	0	<0.2	<0.2	0	0
Maximum difference				0.02	2			0.1	1			–0.3	–3
Percent of samples with no difference				71	71			71	71			57	57
Percent of samples within plus or minus 1 lowest rounding unit					86				100				86

Station	Date	Nitrite				Nitrite plus nitrate				Dissolved organic carbon				Suspended organic carbon			
		Env. (mg/L)	Split (mg/L)	Diff. 1 (mg/L)	Diff. 2	Env. (mg/L)	Split (mg/L)	Diff. 1 (mg/L)	Diff. 2	Env. (mg/L)	Split (mg/L)	Diff. 1 (mg/L)	Diff. 2	Env. (mg/L)	Split (mg/L)	Diff. 1 (mg/L)	Diff. 2
Gunnison near Grand Junction	090596	0.01	0.02	–0.01	–1	1.5	1.5	0	0	3.5	3.4	0.1	1	0.9	0.8	0.1	1
Gore	102495	<0.01	<0.01	0	0	0.44	0.44	0	0	1.4	1.3	0.1	1	0.1	0.2	–0.1	–1
Uncompahgre	072596	0.01	0.01	0	0	0.14	0.14	0	0	1	0.9	0.1	1	0.3	0.3	0	0
French	090996	<0.01	<0.01	0	0	0.07	0.08	–0.01	–1	0.5	0.4	0.1	1	<0.1	<0.1	0	0
Dry	082996	0.02	0.02	0	0	3.9	3.9	0	0	3.4	3.5	–0.1	–1	2.3	1.9	0.4	4
Dry Fork	071596	0.01	0.01	0	0	0.79	0.8	–0.01	–1	5.2	5.1	0.1	1	0.4	0.5	–0.1	–1
Baker	071696	0.01	0.01	0	0	0.1	0.09	0.01	1	1.9	1.9	0	0	0.2	0.6	–0.4	–4
Maximum difference				–0.01	–1			0.01	1			1	1			0.4	4
Percent of samples with no difference				86	86			57	57			14	14			29	29
Percent of samples within plus or minus 1 lowest rounding unit					100				100				100				71

Table 6. Comparisons of environmental and pre-processing split-replicate samples for nutrients and organic carbon—Continued

[Env., environmental sample; Split, pre-processing split-replicate sample; Diff. 1, difference in units of constituent; Diff. 2, difference in lowest rounding unit; mg/L, milligrams per liter; shaded cells represent differences greater than plus or minus 1 lowest rounding unit; lowest rounding unit is equal to magnitude of the least significant figure; <, value is less than the laboratory minimum reporting level]

Station	Date	Dissolved phosphorus				Total phosphorus				Orthophosphate			
		Env. (mg/L)	Split (mg/L)	Diff. 1 (mg/L)	Diff. 2	Env. (mg/L)	Split (mg/L)	Diff. 1 (mg/L)	Diff. 2	Env. (mg/L)	Split (mg/L)	Diff. 1 (mg/L)	Diff. 2
Gunnison near Grand Junction	090596	0.04	<0.01	0.035	3.5	0.05	0.05	0	0	<0.01	<0.01	0	0
Gore	102495	0.03	0.03	0	0	0.04	0.04	0	0	0.04	0.04	0	0
Uncompahgre	072596	<0.01	<0.01	0	0	<0.01	<0.01	0	0	<0.01	<0.01	0	0
French	090996	<0.01	<0.01	0	0	<0.01	<0.01	0	0	<0.01	<0.01	0	0
Dry	082996	0.02	0.02	0	0	0.18	0.19	–0.01	–1	0.03	0.03	0	0
Dry Fork	071596	<0.01	<0.01	0	0	<0.01	<0.01	0	0	<0.01	0.01	0	0
Baker	071696	<0.01	<0.01	0	0	<0.01	0.03	–0.025	2.5	<0.01	<0.01	0	0
Maximum difference				0.035	3.5			–0.025	–2.5			0	0
Percent of samples with no difference				86	86			71	71			100	100
Percent of samples within plus or minus 1 lowest rounding unit					86				86				100

Table 7. Summary of differences between environmental and pre-processing split-replicate samples for nutrients and organic carbon

[Lowest rounding unit is equal to the magnitude of the least significant figure]

Constituent	Percent of samples with no difference	Percent of samples within plus or minus 1 lowest rounding unit	Percent of samples within plus or minus 2 lowest rounding units
Ammonia	71	86	100
Dissolved ammonia plus organic	71	100	100
Total ammonia plus organic	57	86	86
Nitrite	86	100	100
Nitrite plus nitrate	57	100	100
Dissolved organic carbon	14	100	100
Suspended organic carbon	29	71	71
Dissolved phosphorus	86	86	86
Total phosphorus	71	86	86
Orthophosphate	100	100	100

Comparison of Trace Elements

Trace-element samples are routinely collected at only two of the network sites, therefore only two pre-processing split replicates were collected for trace-element constituents. The environmental and pre-processing split-replicate results for these samples are listed in table 8. Because of the low number of pairs of samples, percentage of samples within ranges of rounding units are not provided. Many of the trace-element concentrations are less than the laboratory reporting limit (indicated by a less-than value). To determine the differences between the environmental and pre-processing split-replicate sample concentrations, a value of one-half of the reporting limit was substituted for the values designated as a “less than.” None of the differences were greater than 1 ug/L (microgram per liter) or 1 lowest rounding unit.

Table 8. Comparison of environmental and pre-processing split-replicate samples for trace elements

[Env., environmental sample; Split, pre-processing split-replicate sample; Diff. 1, difference in units of constituent; Diff. 2, difference in lowest rounding unit; lowest rounding unit is equal to the magnitude of the least significant figure; µg/L, micrograms per liter; shaded cells represent differences greater than plus or minus 1 lowest rounding unit; <, value is less than the laboratory minimum reporting level]

Station	Date	Arsenic				Aluminum				Antimony				Barium			
		Env. (µg/L)	Split (µg/L)	Diff. 1 (µg/L)	Diff. 2	Env. (µg/L)	Split (µg/L)	Diff. 1 (µg/L)	Diff. 2	Env. (µg/L)	Split (µg/L)	Diff. 1 (µg/L)	Diff. 2	Env. (µg/L)	Split (µg/L)	Diff. 1 (µg/L)	Diff. 2
Uncompahgre	072596	2	2	0	0	50	50	0	0	<1	<1	0	0	41	41	0	0
French	090996	<1	<1	0	0	5	4	1	1	<1	<1	0	0	23	22	1	1
Maximum difference				0	0			1	1			0	0			1	1
Number of samples with no difference				2	2			1	1			2	2			1	1
Number of samples within plus or minus 1 lowest rounding unit					2				2				2				2

Station	Date	Beryllium				Cadmium				Chromium				Cobalt			
		Env. (µg/L)	Split (µg/L)	Diff. 1 (µg/L)	Diff. 2	Env. (µg/L)	Split (µg/L)	Diff. 1 (µg/L)	Diff. 2	Env. (µg/L)	Split (µg/L)	Diff. 1 (µg/L)	Diff. 2	Env. (µg/L)	Split (µg/L)	Diff. 1 (µg/L)	Diff. 2
Uncompahgre	072596	<1	<1	0	0	1	1	0	0	1	<1	0.5	0.5	<1	<1	0	0
French	090996	<1	<1	0	0	7	7	0	0	<1	<1	0	0	<1	<1	0	0
Maximum difference				0	0			0	0			0.5	0.5			0	0
Number of samples with no difference				2	2			2	2			1	1			2	2
Number of samples within plus or minus 1 lowest rounding unit					2				2				2				2

Table 8. Comparison of environmental and pre-processing split-replicate samples for trace elements—Continued

[Env., environmental sample; Split, pre-processing split-replicate sample; Diff. 1, difference in units of constituent; Diff. 2, difference in lowest rounding unit; lowest rounding unit is equal to the magnitude of the least significant figure; µg/L, micrograms per liter; shaded cells represent differences greater than plus or minus 1 lowest rounding unit; <, value is less than the laboratory minimum reporting level]

Station	Date	Copper				Lead				Molybdenum				Nickel			
		Env. (µg/L)	Split (µg/L)	Diff. 1 (µg/L)	Diff. 2	Env. (µg/L)	Split (µg/L)	Diff. 1 (µg/L)	Diff. 2	Env. (µg/L)	Split (µg/L)	Diff. 1 (µg/L)	Diff. 2	Env. (µg/L)	Split (µg/L)	Diff. 1 (µg/L)	Diff. 2
Uncompahgre	072596	3	4	–1	–1	<1	<1	0	0	2	2	0	0	2	3	–1	–1
French	090996	1	1	0	0	5	4	1	1	<1	<1	0	0	2	2	0	0
Maximum difference				–1	–1			1	1			0	0			–1	–1
Number of samples with no difference				1	1			1	1			2	2			1	1
Number of samples within plus or minus 1 lowest rounding unit					2				2				2				2

Station	Date	Selenium				Silver				Uranium				Zinc			
		Env. (µg/L)	Split (µg/L)	Diff. 1 (µg/L)	Diff. 2	Env. (µg/L)	Split (µg/L)	Diff. 1 (µg/L)	Diff. 2	Env. (µg/L)	Split (µg/L)	Diff. 1 (µg/L)	Diff. 2	Env. (µg/L)	Split (µg/L)	Diff. 1 (µg/L)	Diff. 2
Uncompahgre	072596	<1	<1	0	0	<1	<1	0	0	<1	<1	0	0	14	13	1	1
French	090996	<1	<1	0	0	<1	<1	0	0	<1	<1	0	0	2,400	2,400	0	0
Maximum difference				0	0			0	0			0	0			1	1
Number of samples with no difference				2	2			2	2			2	2			1	1
Number of samples within plus or minus 1 lowest rounding unit					2				2				2				2

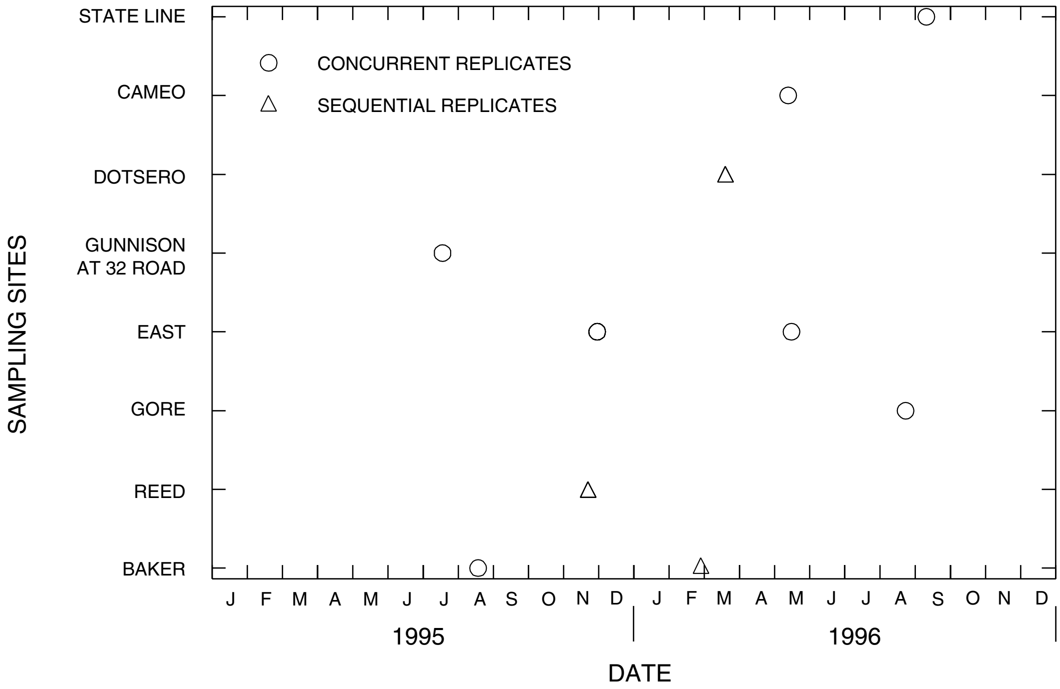

Figure 3. Distribution of collection of concurrent- and sequential-replicate samples, 1995–96.

Concurrent and Sequential Replicates

Concurrent and sequential replicates differ from the split replicates in that two separate samples are collected from the river. In the concurrent replicate, one sample is collected concurrently with the environmental sample using a second collection team or second set of collection equipment. In the sequential replicate, a replicate is collected as close in time as possible to the environmental sample. Each sample is processed through all the normal steps of a typical water-quality sample. For each step of sample processing, the environmental sample is processed first, and then the replicate sample is processed. The replicate samples are processed using a clean filter and equipment. The concurrent and sequential replicates include all the potential sources for variation as with the pre-processing split replicates as well as the variation due to sample-collection technique and short-term environmental variations in the river. The distribution of collection of the concurrent and sequential replicates by site and date is shown in figure 3.

Seven concurrent- and three sequential-replicate samples were collected during water years 1995–96. The comparison of environmental and concurrent-replicate samples and environmental and sequential-replicate samples for general chemical, nutrient, and organic carbon constituents is presented in the following sections. Concurrent- and sequential-replicate data for trace elements are not presented because only one concurrent and no sequential replicates for trace elements were collected.

Comparison of General Chemical Constituents

Results of comparison between environmental and concurrent-replicate samples and between environmental and sequential-replicate samples for general chemical constituents are listed in table 9. A summary of the differences between the environmental and the concurrent-replicate samples for the constituents listed in table 9 is given in table 10. The sequential-replicate comparisons are not summarized because only three samples are available. The majority of the differences agree within plus or minus 1 lowest rounding unit with the exception of laboratory specific conductance and residue on evaporation. The majority of the conductance differences agree within plus or minus 2 lowest rounding units. One-half of the differences for residue on evaporation are within plus or minus 2 lowest rounding units and probably indicate the precision of the laboratory method. Shaded cells in table 9 represent differences greater than plus or minus 1 lowest

Table 9. Comparison of environmental and concurrent- and sequential-replicate samples for general chemical constituents

[Env., environmental sample; Rep., replicate sample; Diff. 1, difference in units of constituent; Diff. 2, difference in lowest rounding unit; mg/L, milligrams per liter; µg/L, micrograms per liter; shaded cells represent differences greater than plus or minus 1 lowest rounding unit; lowest rounding unit is equal to the magnitude of the least significant figure; µS/cm, microsiemens per centimeter at 25 degrees Celsius]

Station	Date	Calcium				Magnesium				Sodium				Potassium			
		Env. (mg/L)	Rep. (mg/L)	Diff. 1 (mg/L)	Diff. 2	Env. (mg/L)	Rep. (mg/L)	Diff. 1 (mg/L)	Diff. 2	Env. (mg/L)	Rep. (mg/L)	Diff. 1 (mg/L)	Diff. 2	Env. (mg/L)	Rep. (mg/L)	Diff. 1 (mg/L)	Diff. 2
Concurrent replicates																	
State Line	091096	120	120	0	0	35	35	0	0	90	92	–2	–2	4.2	4.1	0.1	1
Cameo	051396	34	33	1	1	7.2	7.1	0.1	1	20	20	0	0	1.4	1.5	–0.1	–1
Gunnison at 32 Road	071895	22	22	0	0	4.5	4.5	0	0	2.4	2.4	0	0	0.8	0.7	0.1	1
East	113095	46	47	–1	–1	8.5	8.6	–0.1	–1	4.3	4.3	0	0	0.9	0.9	0	0
East	051696	22	23	–1	–1	3.5	3.7	–0.2	–2	1.4	1.5	–0.1	–1	0.6	0.6	0	0
Gore	082396	42	41	1	1	7.3	7.2	0.1	1	4.7	4.5	0.2	2	1.1	1.1	0	0
Baker	081895	7.4	7.5	–0.1	–1	1.8	1.8	0	0	1.4	1.4	0	0	0.8	0.8	0	0
Maximum difference				1	1			–0.2	2			–2	–2			0.1	1
Percent of samples with no difference				29	29			43	43			57	57			57	57
Percent of samples within plus or minus 1 lowest rounding unit					100				86				71				100
Sequential Replicates																	
Dotsero	032096	39	39	0	0	7.7	7.7	0	0	17	17	0	0	1.8	1.8	0	0
Reed	112295	550	540	10	1	220	210	10	1	300	290	10	1	9.5	9.1	0.4	4
Baker	022796	9.1	9.0	0.1	1	2.4	2.4	0	0	1.9	1.9	0	0	0.9	0.9	0	0
Maximum difference				10	1			10	1			10	1			0.4	4
Number of samples with no difference				1	1			2	2			2	2			2	2
Number of samples within plus or minus 1 lowest rounding unit					3				3				3				2

Table 9. Comparison of environmental and concurrent- and sequential-replicate samples for general chemical constituents—Continued

[Env., environmental sample; Rep., replicate sample; Diff. 1, difference in units of constituent; Diff. 2, difference in lowest rounding unit; mg/L, milligrams per liter; µg/L, micrograms per liter; shaded cells represent differences greater than plus or minus 1 lowest rounding unit; lowest rounding unit is equal to the magnitude of the least significant figure; µS/cm, microsiemens per centimeter at 25 degrees Celsius]

Station	Date	Sulfate				Chloride				Fluoride				Laboratory alkalinity			
		Env. (mg/L)	Rep. (mg/L)	Diff. 1 (mg/L)	Diff. 2	Env. (mg/L)	Rep. (mg/L)	Diff. 1 (mg/L)	Diff. 2	Env. (mg/L)	Rep. (mg/L)	Diff. 1 (mg/L)	Diff. 2	Env. (mg/L)	Rep. (mg/L)	Diff 1. (mg/L)	Diff. 2
								Concurrent replicates									
State Line	091096	370	370	0	0	80	84	–4	–4	0.4	0.4	0	0	169	181	–12	–12
Cameo	051396	40	40	0	0	22	22	0	0	0.2	0.2	0	0	89	87	2	2
Gunnison at 32 Road	071895	8.3	8.4	–0.1	–1	1	0.6	0.4	4	0.1	0.1	0	0	70	71	–1	–1
East	113095	34	34	0	0	1.2	1.1	0.1	1	0.2	0.1	0.1	1	125	126	–1	–1
East	051696	9.9	10	–0.1	–1	0.4	0.5	–0.1	–1	0.1	0.1	0	0	64	64	0	0
Gore	082396	35	35	0	0	5.7	5.5	0.2	2	0.1	0.1	0	0	103	103	0	0
Baker	081895	4.9	4.9	0	0	0.2	0.1	0.1	1	0.3	0.3	0	0	26	26	0	0
Maximum difference				–0.1	–1			–4	4			0.1	1			–12	–12
Percent of samples with no difference				71	71			14	14			86	86			43	43
Percent of samples within plus or minus 1 lowest rounding unit					100				57				100				71
								Sequential replicates									
Dotsero	032096	65	62	3	3	21	20	1	1	0.3	0.3	0	0	80	78	2	2
Reed	112295	2,200	2,200	0	0	200	200	0	0	0.3	0.1	0.2	2	302	296	6	6
Baker	022796	6.5	6.5	0	0	0.1	0.1	0	0	0.3	0.3	0	0	32	32	0	0
Maximum difference				3	3			1	1			0.2	2			6	6
Number of samples with no difference				2	2			2	2			2	2			1	1
Number of samples within plus or minus 1 lowest rounding unit					2				3				2				1

Table 9. Comparison of environmental and concurrent- and sequential-replicate samples for general chemical constituents—Continued

[Env., environmental sample; Rep., replicate sample; Diff. 1, difference in units of constituent; Diff. 2, difference in lowest rounding unit; mg/L, milligrams per liter; µg/L, micrograms per liter; shaded cells represent differences greater than plus or minus 1 lowest rounding unit; lowest rounding unit is equal to the magnitude of the least significant figure; µS/cm, microsiemens per centimeter at 25 degrees Celsius]

Station	Date	Silica				Iron				Manganese			
		Env. (mg/L)	Rep. (mg/L)	Diff. 1 (mg/L)	Diff. 2	Env. (µg/L)	Rep. (µg/L)	Diff. 1 (µg/L)	Diff. 2	Env. (µg/L)	Rep. (µg/L)	Diff. 1 (µg/L)	Diff. 2
Concurrent replicates													
State Line	091096	12	12	0	0	3	3	0	0	2	1	1	1
Cameo	051396	8.6	8.7	–0.1	–1	24	84	–60	–60	16	17	–1	–1
Gunnison at 32 Road	071895	9.1	9.1	0	0	73	71	2	2	21	21	0	0
East	113095	6.7	6.8	–0.1	–1	3	3	0	0	3	3	0	0
East	051696	5.1	5.4	–0.3	–3	25	25	0	0	10	10	0	0
Gore	082396	5.2	5.1	0.1	1	5	4	1	1	2	2	0	0
Baker	081895	6.9	6.9	0	0	190	200	–10	–1	12	12	0	0
Maximum difference				–0.3	–3			–60	–60			1	1
Percent of samples with no difference				43	43			43	43			71	71
Percent of samples within plus or minus 1 lowest rounding unit					86				71				100
Sequential replicates													
Dotsero	032096	7.8	8	–0.2	–2	13	12	1	1	21	21	0	0
Reed	112295	10	10	0	0	9	11	–2	–2	100	100	0	0
Baker	022796	9.4	9.3	0.1	1	130	150	–20	–2	37	37	0	0
Maximum difference				–0.2	–2			–20	–2			0	0
Number of samples with no difference				1	1			0	0			3	3
Number of samples within plus or minus 1 lowest rounding unit					2				1				3

Table 9. Comparison of environmental and concurrent- and sequential-replicate samples for general chemical constituents—Continued

[Env., environmental sample; Rep., replicate sample; Diff. 1, difference in units of constituent; Diff. 2, difference in lowest rounding unit; mg/L, milligrams per liter; µg/L, micrograms per liter; shaded cells represent differences greater than plus or minus 1 lowest rounding unit; lowest rounding unit is equal to the magnitude of the least significant figure; µS/cm, microsiemens per centimeter at 25 degrees Celsius]

Station	Date	Laboratory pH				Laboratory specific conductance				Residue on evaporation			
		Env. (standard units)	Rep. (standard units)	Diff. 1 (standard units)	Diff. 2	Env. (µS/cm)	Rep. (µS/cm)	Diff. 1 (µS/cm)	Diff. 2	Env. (mg/L)	Rep. (mg/L)	Diff. 1 (mg/L)	Diff. 2
Concurrent replicates													
State Line	091096	8.1	8.1	0	0	1,230	1,230	0	0	852	846	6	6
Cameo	051396	7.8	7.9	–0.1	–1	334	332	2	2	203	210	–7	–7
Gunnison at 32 Road	071895	7.8	7.8	0	0	159	157	2	2	97	94	3	3
East	113095	7.8	7.7	0.1	1	317	316	1	1	180	179	1	1
East	051696	7.8	7.8	0	0	152	153	–1	–1	92	--	--	--
Gore	082396	8.0	8.0	0	0	296	293	3	3	167	169	–2	–2
Baker	081895	7.9	7.2	0.7	7	64	53	11	11	38	38	0	0
Maximum difference				0.7	7			11	11			–7	–7
Percent of samples with no difference				57	57			14	14			17	17
Percent of samples within plus or minus 1 lowest rounding unit					86				43				34
Sequential replicates													
Dotsero	032096	7.7	7.9	–0.2	–2	366	355	11	11	222	213	9	9
Reed	112295	7.5	7.5	0	0	4,300	4,270	30	3	3,960	3,960	0	0
Baker	022796	7.4	7.3	0.1	1	81	81	0	0	48	50	–2	–2
Maximum difference				–0.2	–2			30	11			9	9
Number of samples with no difference				1	1			1	1			1	1
Number of samples within plus or minus 1 lowest rounding unit					2				1				1

Table 10. Summary of differences between environmental and concurrent-replicate samples for general chemical constituents

[Lowest rounding unit is equal to the magnitude of the least significant figure]

Constituent	Percent of samples with no difference	Percent of samples within plus or minus 1 lowest rounding unit	Percent of samples within plus or minus 2 lowest rounding units
Calcium	29	100	100
Magnesium	43	86	100
Sodium	57	71	100
Potassium	57	100	100
Sulfate	71	100	100
Chloride	14	57	71
Fluoride	86	100	100
Laboratory alkalinity	43	71	86
Silica	43	86	86
Iron	43	71	86
Manganese	71	100	100
Lab pH	57	86	86
Laboratory specific conductance	14	43	71
Residue on evaporation	17	34	50

rounding unit. It does not appear that the larger differences are related to sampling site or constituent concentration. Variability associated with sample collection, processing, handling, shipment, and analysis for general chemical constituents is low and will have little effect on interpretation of environmental data.

Comparison of Nutrients and Organic Carbon

Results of comparison between environmental and concurrent replicates and between environmental and sequential replicates for nutrients, dissolved organic carbon, and suspended organic carbon are listed in table 11. Shaded cells in table 11 represent differences greater than plus or minus 1 lowest rounding unit. The pattern of shaded cells indicates that the larger differences are not related to sampling site or constituent concentration. A summary of the differences between the environmental and concurrent-replicate samples for the constituents in table 11 is given in table 12. Sequential-replicate differences are not summarized because of the small number of samples available. The majority of the differences are within plus or minus 1 lowest rounding unit with the exception of suspended organic carbon. The majority of the suspended organic carbon differences are within plus or minus 2 lowest rounding units. Variability associated with sample collection, processing, handling, shipment, and analysis for nutrients and organic carbon is low and will have little effect on interpretation of environmental data.

Table 11. Comparison of environmental and concurrent- and sequential-replicate samples for nutrients and organic carbon

[Env., environmental sample; Rep., replicate sample; Diff. 1, difference in units of constituent; Diff. 2, difference in lowest rounding unit; mg/L, milligrams per liter; <, value is less than the laboratory minimum reporting level; shaded cells represent differences greater than plus or minus 1 lowest rounding unit; lowest rounding unit is equal to the magnitude of the least significant figure]

Station	Date	Ammonia				Dissolved ammonia plus organic				Total ammonia plus organic			
		Env. (mg/L)	Rep. (mg/L)	Diff. 1 (mg/L)	Diff. 2	Env. (mg/L)	Rep. (mg/L)	Diff. 1 (mg/L)	Diff. 2	Env. (mg/L)	Rep. (mg/L)	Diff. 1 (mg/L)	Diff. 2
Concurrent replicates													
State Line	091096	0.07	0.08	–0.01	–1	0.3	0.3	0	0	0.8	0.8	0	0
Cameo	051396	<0.02	<0.02	0	0	<0.2	0.2	–0.1	–1	1.2	1.5	–0.3	–3
Gunnison at 32 Road	071895	0.02	0.02	0	0	<0.2	<0.2	0	0	<0.2	<0.2	0	0
East	113095	<0.02	<0.02	0	0	<0.2	<0.2	0	0	<0.2	<0.2	0	0
East	051696	0.02	0.02	0	0	<0.2	<0.2	0	0	0.3	0.3	0	0
Gore	082396	0.02	0.02	0	0	<0.2	<0.2	0	0	<0.2	<0.2	0	0
Baker	081895	<0.02	<0.02	0	0	<0.2	<0.2	0	0	<0.2	<0.2	0	0
Maximum difference				–0.01	–1			–0.1	–1			–0.3	–3
Percent of samples with no difference				86	86			86	86			86	86
Percent of samples within plus or minus 1 lowest rounding unit					100				100				86
Sequential replicates													
Dotsero	032096	<0.02	<0.02	0	0	<0.2	<0.2	0	0	<0.2	0.3	–0.2	–2
Reed	112295	0.06	0.06	0	0	0.4	0.4	0	0	0.5	0.4	0.1	1
Baker	022796	0.02	<0.02	0.01	1	<0.2	<0.2	0	0	<0.2	<0.2	0	0
Maximum difference				0.01	1			0	0			–0.2	–2
Number of samples with no difference				2	2			3	3			1	1
Number of samples within plus or minus 1 lowest rounding unit					3				3				2

Table 11. Comparison of environmental and concurrent- and sequential-replicate samples for nutrients and organic carbon—Continued

[Env., environmental sample; Rep., replicate sample; Diff. 1, difference in units of constituent; Diff. 2, difference in lowest rounding unit; mg/L, milligrams per liter; <, value is less than the laboratory minimum reporting level; shaded cells represent differences greater than plus or minus 1 lowest rounding unit; lowest rounding unit is equal to the magnitude of the least significant figure]

Station	Date	Nitrite				Nitrite plus nitrate				Dissolved organic carbon				Suspended organic carbon			
		Env. (mg/L)	Rep. (mg/L)	Diff. 1 (mg/L)	Diff. 2	Env. (mg/L)	Rep. (mg/L)	Diff. 1 (mg/L)	Diff. 2	Env. (mg/L)	Rep. (mg/L)	Diff. 1 (mg/L)	Diff. 2	Env. (mg/L)	Rep. (mg/L)	Diff. 1 (mg/L)	Diff. 2
Concurrent replicates																	
State Line	091096	0.02	0.02	0	0	1	1	0	0	3.3	3.9	–0.6	–6	3.3	1.7	1.6	16
Cameo	051396	<0.01	<0.01	0	0	0.14	0.14	0	0	4	4	0	0	3.7	4.3	–0.6	–6
Gunnison at 32 Road	071895	<0.01	<0.01	0	0	<0.05	<0.05	0	0	2.5	2.6	–0.1	–1	0.5	0.3	0.2	2
East	113095	<0.01	<0.01	0	0	0.08	0.11	–0.03	–3	0.6	0.8	–0.2	–2	0.1	0.1	0	0
East	051696	<0.01	<0.01	0	0	0.12	0.14	–0.02	–2	2.6	3	–0.4	–4	0.9	1.1	–0.2	–2
Gore	082396	<0.01	<0.01	0	0	0.48	0.48	0	0	1.1	1.1	0	0	0.2	0.2	0	0
Baker	081895	<0.01	<0.01	0	0	<0.05	<0.05	0	0	1.5	1.5	0	0	0.1	0.1	0	0
Maximum difference				0	0			–0.3	–3			–0.6	–6			1.6	16
Percent of samples with no difference				100	100			71	71			43	43			43	43
Percent of samples within plus or minus 1 lowest rounding unit					100				71				57				43
Sequential replicates																	
Dotsero	032096	<0.01	<0.01	0	0	0.13	0.12	0.01	1	2.5	2.2	0.3	3	0.7	0.7	0	0
Reed	112295	0.05	0.05	0	0	8.3	8.3	0	0	4.8	4.7	0.1	1	0.4	0.4	0	0
Baker	022796	<0.01	<0.01	0	0	0.11	0.10	0.01	1	1.0	1.1	–0.1	–1	0.3	0.1	0.2	2
Maximum difference				0	0			0.01	1			0.3	3			0.2	2
Number of samples with no difference				3	3			1	1			0	0			2	2
Number of samples within plus or minus 1 lowest rounding unit					3				3				2				2

Table 11. Comparison of environmental and concurrent- and sequential-replicate samples for nutrients and organic carbon—Continued

[Env., environmental sample; Rep., replicate sample; Diff. 1, difference in units of constituent; Diff. 2, difference in lowest rounding unit; mg/L, milligrams per liter; <, value is less than the laboratory minimum reporting level; shaded cells represent differences greater than plus or minus 1 lowest rounding unit; lowest rounding unit is equal to the magnitude of the least significant figure]

Station	Date	Dissolved phosphorus				Total phosphorus				Orthophosphate			
		Env. (mg/L)	Rep. (mg/L)	Diff. 1 (mg/L)	Diff. 2	Env. (mg/L)	Rep. (mg/L)	Diff. 1 (mg/L)	Diff. 2	Env. (mg/L)	Rep. (mg/L)	Diff. 1 (mg/L)	Diff. 2
Concurrent replicates													
State Line	091096	0.01	0.01	0	0	0.21	0.23	–0.02	–2	0.02	0.02	0	0
Cameo	051396	<0.01	0.03	–0.025	–2.5	0.54	0.44	0.10	10	<0.01	<0.01	0	0
Gunnison at 32 Road	071895	<0.01	<0.01	0	0	0.01	0.02	–0.01	–1	0.01	0.01	0	0
East	113095	0.01	<0.01	0.005	0.5	<0.01	<0.01	0	0	<0.01	<0.01	0	0
East	051696	0.01	0.01	0	0	0.06	0.05	0.01	1	<0.01	<0.01	0	0
Gore	082396	0.04	0.04	0	0	0.08	0.05	0.03	3	0.05	0.05	0	0
Baker	081895	<0.01	<0.01	0	0	<0.01	<0.01	0	0	<0.01	<0.01	0	0
Maximum difference				–0.025	–2.5			0.10	10			0	0
Percent of samples with no difference				71	71			29	29			100	100
Percent of samples within plus or minus 1 lowest rounding unit					86				57				100
Sequential replicates													
Dotsero	032096	<0.01	<0.01	0	0	0.03	0.05	–0.02	–2	0.01	0.01	0	0
Reed	112295	<0.01	<0.01	0	0	0.03	0.01	0.02	2	<0.01	<0.01	0	0
Baker	022796	<0.01	<0.01	0	0	<0.01	<0.01	0	0	<0.01	<0.01	0	0
Maximum difference				0	0			0.02	2			0	0
Number of samples with no difference				3	3			1	1			3	3
Number of samples within plus or minus 1 lowest rounding unit					3				1				3

Table 12. Summary of differences between environmental and concurrent-replicate samples for nutrients and organic carbon

[Lowest rounding unit is equal to the magnitude of the least significant figure]

Constituent	Percent of samples with no difference	Percent of samples within plus or minus 1 lowest rounding unit	Percent of samples within plus or minus 2 lowest rounding units
Ammonia	86	100	100
Dissolved ammonia plus organic	86	100	100
Total ammonia plus organic	86	86	86
Nitrite	100	100	100
Nitrite plus nitrate	71	71	86
Dissolved organic carbon	43	57	71
Suspended organic carbon	43	43	71
Dissolved phosphorus	71	86	86
Total phosphorus	29	57	71
Orthophosphate	100	100	100

Post-Processing Split Replicates

A post-processing split replicate is a processed sample that is poured into identical bottles and thus split into two separate samples (split A and split B). Split A and split B are submitted to the laboratory for analysis as unique samples. These pairs of samples help to evaluate the potential sources of variability resulting from sample shipping and analysis. Variability resulting from sample collection and processing is not evaluated by post-processing split-replicate sampling. The distribution of collection of the post-processing

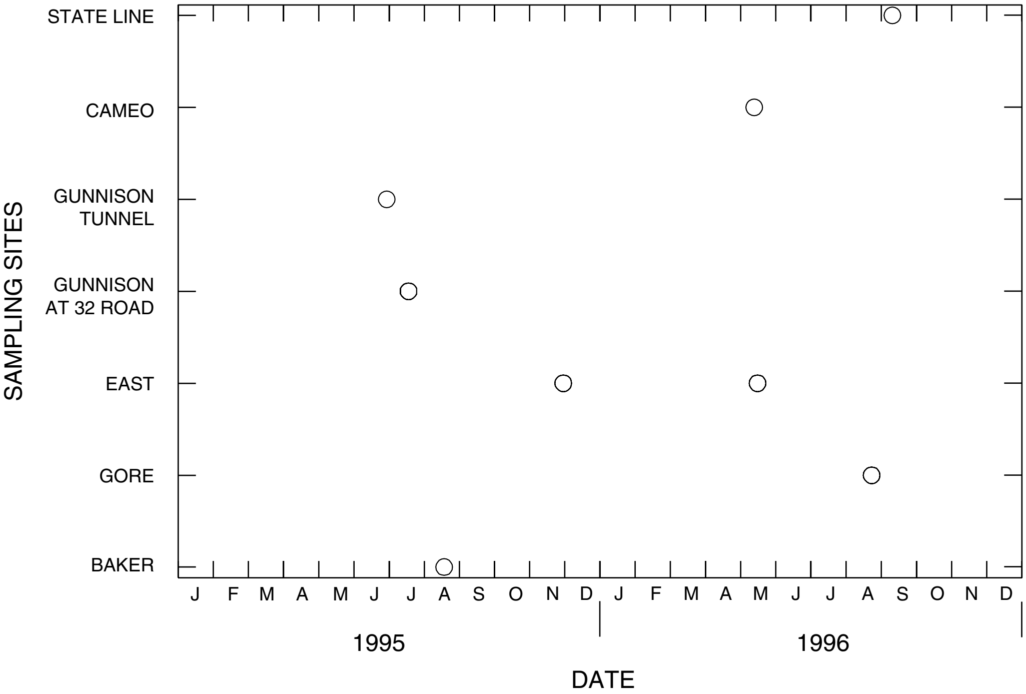

Figure 4. Distribution of collection of post-processing split-replicate samples, 1995–96.

split-replicate samples by site and date is shown in figure 4.

Eight post-processing split-replicate samples were collected during water years 1995–96. Comparisons of split A and split B samples for major chemical, nutrient, and organic carbon constituents are presented in the following sections. Post-processing split-replicate data for trace elements are not presented because only one sample for trace elements was collected.

Comparison of General Chemical Constituents

Results of comparison between post-processing split samples for general chemical constituents are listed in table 13. A summary of the differences between split A and split B samples for the constituents listed in table 13 is given in table 14. Shaded cells in table 13 represent differences greater than plus or minus 1 rounding unit. The majority of the differences agree within plus or minus 1 lowest rounding unit with the exception of residue on evaporation. The differences in residue on evaporation probably reflect the precision of the laboratory method. Variability associated with sample shipment

Table 13. Comparison of post-processing split-replicate samples for general chemical constituents

[Diff. 1, difference in units of constituent; Diff. 2, difference in lowest rounding unit; mg/L, milligrams per liter; µg/L, micrograms per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius; shaded cells represent differences greater than plus or minus 1 lowest rounding unit; lowest rounding unit is equal to the magnitude of the least significant figure]

Station	Date	Calcium				Magnesium				Sodium				Potassium			
		Split A (mg/L)	Split B (mg/L)	Diff. 1 (mg/L)	Diff. 2	Split A (mg/L)	Split B (mg/L)	Diff. 1 (mg/L)	Diff. 2	Split A (mg/L)	Split B (mg/L)	Diff. 1 (mg/L)	Diff. 2	Split A (mg/L)	Split B (mg/L)	Diff. 1 (mg/L)	Diff. 2
State Line	091096	120	120	0	0	35	35	0	0	92	92	0	0	4.1	4.2	–0.1	–1
Cameo	051396	33	33	0	0	7.1	7.2	–0.1	–1	20	20	0	0	1.5	1.5	0	0
Gunnison Tunnel	062995	18	17	1	1	3.7	3.6	0.1	1	3.9	3.8	0.1	1	1.4	1.4	0	0
Gunnison at 32 Road	071895	22	22	0	0	4.5	4.5	0	0	2.4	2.3	0.1	1	0.7	0.7	0	0
East	113095	47	46	1	1	8.6	8.5	0.1	1	4.3	4.3	0	0	0.9	0.9	0	0
East	051696	23	23	0	0	3.7	3.7	0	0	1.5	1.5	0	0	0.6	0.6	0	0
Gore	082396	41	41	0	0	7.2	7.2	0	0	4.5	4.5	0	0	1.1	1.1	0	0
Baker	081895	7.5	7.5	0	0	1.8	1.8	0	0	1.4	1.4	0	0	0.8	0.8	0	0
Maximum difference				1	1			0.1	1			0.1	1			–0.1	–1
Percent of samples with no difference				75	75			62	62			75	75			88	88
Percent of samples within plus or minus 1 lowest rounding unit					100				100				100				100

Station	Date	Sulfate				Chloride				Fluoride				Laboratory alkalinity			
		Split A (mg/L)	Split B (mg/L)	Diff. 1 (mg/L)	Diff. 2	Split A (mg/L)	Split B (mg/L)	Diff. 1 (mg/L)	Diff. 2	Split A (mg/L)	Split B (mg/L)	Diff. 1 (mg/L)	Diff. 2	Split A (mg/L)	Split B (mg/L)	Diff 1. (mg/L)	Diff. 2
State Line	091096	370	370	0	0	84	78	6	6	0.4	0.4	0	0	181	181	0	0
Cameo	051396	40	40	0	0	22	22	0	0	0.2	0.2	0	0	87	87	0	0
Gunnison Tunnel	062995	13	13	0	0	0.7	0.7	0	0	0.1	0.1	0	0	56	56	0	0
Gunnison at 32 Road	071895	8.4	8.4	0	0	0.6	0.6	0	0	0.1	0.1	0	0	71	71	0	0
East	113095	34	34	0	0	1.1	1.2	–0.1	–1	0.1	0.2	–0.1	–1	126	126	0	0
East	051696	10	10	0	0	0.5	0.5	0	0	0.1	0.1	0	0	64	64	0	0
Gore	082396	35	35	0	0	5.5	5.5	0	0	0.1	0.1	0	0	103	103	0	0
Baker	081895	4.9	5	–0.1	–1	0.1	0.1	0	0	0.3	0.2	0.1	1	26	26	0	0
Maximum difference				–0.1	–1			6	6			0.1	1			0	0
Percent of samples with no difference				88	88			75	75			75	75			100	100
Percent of samples within plus or minus 1 lowest rounding unit					100				88				100				100

Table 13. Comparison of post-processing split-replicate samples for general chemical constituents—Continued

[Diff. 1, difference in units of constituent; Diff. 2, difference in lowest rounding unit; mg/L, milligrams per liter; µg/L, micrograms per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius; shaded cells represent differences greater than plus or minus 1 lowest rounding unit; lowest rounding unit is equal to the magnitude of the least significant figure]

Station	Date	Silica				Iron				Manganese			
		Split A (mg/L)	Split B (mg/L)	Diff. 1 (mg/L)	Diff. 2	Split A (µg/L)	Split B (µg/L)	Diff. 1 (µg/L)	Diff. 2	Split A (µg/L)	Split B (µg/L)	Diff. 1 (µg/L)	Diff. 2
State Line	091096	12	12	0	0	3	3	0	0	1	1	0	0
Cameo	051396	8.7	8.7	0	0	84	83	1	1	17	17	0	0
Gunnison Tunnel	062995	16	16	0	0	52	49	3	3	3	3	0	0
Gunnison at 32 Road	071895	9.1	9.2	–0.1	–1	71	72	–1	–1	21	21	0	0
East	113095	6.8	6.7	0.1	1	3	3	0	0	3	3	0	0
East	051696	5.4	5.4	0	0	25	23	2	2	10	10	0	0
Gore	082396	5.1	5.1	0	0	4	5	–1	–1	2	2	0	0
Baker	081895	6.9	6.9	0	0	200	190	10	1	12	12	0	0
Maximum difference				0.1	1			10	3			0	0
Percent of samples with no difference				75	75			25	25			100	100
Percent of samples within plus or minus 1 lowest rounding unit					100				75				100

Station	Date	Laboratory pH				Laboratory specific conductance				Residue on evaporation			
		Split A (standard units)	Split B (standard units)	Diff. 1 (standard units)	Diff. 2	Split A µS/cm	Split B µS/cm	Diff. 1 µS/cm	Diff. 2	Split A (mg/L)	Split B (mg/L)	Diff. 1 (mg/L)	Diff. 2
State Line	091096	8.1	8.1	0	0	1,230	1,230	0	0	846	868	–22	–22
Cameo	051396	7.9	7.8	0.1	1	332	332	0	0	210	210	0	0
Gunnison Tunnel	062995	7.1	7.6	–0.5	–5	141	142	–1	–1	90	88	2	2
Gunnison at 32 Road	071895	7.8	7.9	–0.1	–1	157	157	0	0	94	88	6	6
East	113095	7.7	7.6	0.1	1	316	317	–1	–1	179	179	0	0
East	051696	7.8	7.7	0.1	1	153	151	2	2	--	84	--	--
Gore	082396	8.0	8.1	–0.1	–1	293	294	–1	–1	169	165	4	4
Baker	081895	7.2	7.3	–0.1	–1	53	64	–11	–11	38	35	3	3
Maximum difference				–0.5	–5			–11	–11			–22	–22
Percent of samples with no difference				12	12			38	38			29	29
Percent of samples within plus or minus 1 lowest rounding unit					88				75				29

Table 14. Summary of differences between post-processing split-replicate samples for general chemical constituents

[Lowest rounding unit is equal to the magnitude of the least significant figure]

Constituent	Percent of samples with no difference	Percent of samples within plus or minus 1 lowest rounding unit	Percent of samples within plus or minus 2 lowest rounding units
Calcium	75	100	100
Magnesium	62	100	100
Sodium	75	100	100
Potassium	88	100	100
Sulfate	88	100	100
Chloride	75	88	88
Fluoride	75	100	100
Laboratory alkalinity	100	100	100
Silica	75	100	100
Iron	25	75	88
Manganese	100	100	100
Laboratory pH	12	88	88
Laboratory specific conductance	38	75	88
Residue on evaporation	29	29	43

and analysis for general chemical constituents is low and will have little effect on interpretation of environmental data.

Comparison of Nutrients and Organic Carbon

Results of comparison between post-processing split-replicate samples for nutrients and dissolved organic carbon are listed in table 15. Suspended organic carbon is not included. The analysis of suspended organic carbon uses all the sediment on the filter paper. These splits are obtained after processing has been completed, and splitting the filter paper for analysis would not be an acceptable method. A value of one-half the reporting limit was substituted for values less than the reporting limit (values with a less than) to determine the differences between the post-processing split-replicate samples. Shaded cells in table 15 represent differences greater than plus or minus 1 rounding unit. The pattern of shaded cells indicates that the larger differences are not related to sampling site or constituent concentration. A summary of the differences between the post-processing split-replicate samples for the constituents in table 15 is given in table 16. The majority of the differences agree within plus or minus 1 lowest rounding unit.

Table 15. Comparison of post-processing split-replicate samples for nutrients and organic carbon

[Diff. 1, difference in units of constituent; Diff. 2, difference in lowest rounding unit; mg/L, milligrams per liter; <, value is less than the laboratory minimum reporting level; shaded cells represent differences greater than plus or minus 1 lowest rounding unit; lowest rounding unit is equal to magnitude of the least significant figure; --, no data]

Station	Date	Ammonia				Dissolved ammonia plus organic				Total ammonia plus organic			
		Split A (mg/L)	Split B (mg/L)	Diff. 1 (mg/L)	Diff. 2	Split A (mg/L)	Split B (mg/L)	Diff. 1 (mg/L)	Diff. 2	Split A (mg/L)	Split B (mg/L)	Diff. 1 (mg/L)	Diff. 2
State Line	091096	0.08	0.08	0	0	0.3	0.3	0	0	0.8	0.7	0.1	1
Cameo	051396	<0.02	<0.02	0	0	<0.2	<0.2	0	0	1.5	0.8	0.7	7
Gunnison Tunnel	062995	<0.02	<0.02	0	0	<0.2	<0.2	0	0	0.2	<0.2	0.1	0.5
Gunnison at 32 Road	071895	0.02	0.02	0	0	<0.2	<0.2	0	0	<0.2	<0.2	0	0
East	113095	<0.02	<0.02	0	0	<0.2	<0.2	0	0	<0.2	<0.2	0	0
East	051696	0.02	0.02	0	0	<0.2	<0.2	0	0	0.3	0.3	0	0
Gore	082396	0.02	0.02	0	0	<0.2	<0.2	0	0	<0.2	<0.2	0	0
Baker	081895	<0.02	<0.02	0	0	<0.2	<0.2	0	0	<0.2	<0.2	0	0
Maximum difference				0	0			0	0			0.7	7
Percent of samples with no difference				100	100			100	100			62	62
Percent of samples within plus or minus 1 lowest rounding unit					100				100				88

Station	Date	Nitrite				Nitrite plus nitrate				Dissolved organic carbon			
		Split A (mg/L)	Split B (mg/L)	Diff. 1 (mg/L)	Diff. 2	Split A (mg/L)	Split B (mg/L)	Diff. 1 (mg/L)	Diff. 2	Split A (mg/L)	Split B (mg/L)	Diff. 1 (mg/L)	Diff. 2
State Line	091096	0.02	0.02	0	0	1.00	0.97	0.03	3	3.9	3.5	0.4	4
Cameo	051396	<0.01	<0.01	0	0	0.14	0.13	0.01	1	4	4	0	0
Gunnison Tunnel	062995	<0.01	<0.01	0	0	<0.05	<0.05	0	0	3.4	3.2	0.2	2
Gunnison at 32 Road	071895	<0.01	<0.01	0	0	<0.05	<0.05	0	0	2.6	2.5	0.1	1
East	113095	<0.01	<0.01	0	0	0.11	0.08	0.03	3	0.8	0.8	0	0
East	051696	<0.01	<0.01	0	0	0.14	0.12	0.02	2	3	--	--	--
Gore	082396	<0.01	<0.01	0	0	0.48	0.47	0.01	1	1.1	1.2	–0.1	–1
Baker	081895	<0.01	<0.01	0	0	<0.05	<0.05	0	0	1.5	1.5	0	0
Maximum difference				0	0			0.03	3			0.4	4
Percent of samples with no difference				100	100			38	38			43	43
Percent of samples within plus or minus 1 lowest rounding unit					100				62				72

Table 15. Comparison of post-processing split-replicate samples for nutrients and organic carbon—Continued

[Diff. 1, difference in units of constituent; Diff. 2, difference in lowest rounding unit; mg/L, milligrams per liter; <, value is less than the laboratory minimum reporting level; shaded cells represent differences greater than plus or minus 1 lowest rounding unit; lowest rounding unit is equal to magnitude of the least significant figure; --, no data]

Station	Date	Dissolved phosphorus				Total phosphorus				Orthophosphate			
		Split A (mg/L)	Split B (mg/L)	Diff. 1 (mg/L)	Diff. 2	Split A (mg/L)	Split B (mg/L)	Diff. 1 (mg/L)	Diff. 2	Split A (mg/L)	Split B (mg/L)	Diff. 1 (mg/L)	Diff. 2
State Line	091096	0.01	0.01	0	0	0.23	0.20	0.03	3	0.02	0.02	0	0
Cameo	051396	0.03	0.01	0.02	2	0.44	0.31	0.13	13	<0.01	<0.01	0	0
Gunnison Tunnel	062995	<0.01	<0.01	0	0	0.05	0.04	0.01	1	<0.01	<0.01	0	0
Gunnison at 32 Road	071895	<0.01	0.01	–0.005	–0.5	0.02	0.01	0.01	1	0.01	0.01	0	0
East	113095	<0.01	0.01	–0.005	–0.5	<0.01	<0.01	0	0	<0.01	<0.01	0	0
East	051696	0.01	0.01	0	0	0.05	0.04	0.01	1	<0.01	<0.01	0	0
Gore	082396	0.04	0.06	–0.02	–2	0.05	0.07	–0.02	–2	0.05	0.06	–0.01	–1
Baker	081895	<0.01	<0.01	0	0	<0.01	<0.01	0	0	<0.01	<0.01	0	0
Maximum difference				0.02	2			0.13	13			–0.01	–1
Percent of samples with no difference				50	50			25	25			88	88
Percent of samples within plus or minus 1 lowest rounding unit					75				62				100

Table 16. Summary of differences between post-processing split-replicate samples for nutrients and organic carbon

[Lowest rounding unit is equal to magnitude of the lowest significant figure]

Constituent	Percent of samples with no difference	Percent of samples within plus or minus 1 lowest rounding unit	Percent of samples within plus or minus 2 lowest rounding unit
Ammonia	100	100	100
Dissolved ammonia plus organic	100	100	100
Total ammonia plus organic	62	88	88
Nitrite	100	100	100
Nitrite plus nitrate	38	62	75
Dissolved organic carbon	43	72	86
Dissolved phosphorus	50	75	100
Total phosphorus	25	62	75
Orthophosphate	88	100	100

Variability associated with sample shipment and analysis for nutrients and organic carbon is low and will have little effect on interpretation of environmental data.

Field Blanks

A field blank is a sample prepared using water that is free of the analytes of interest. The blank water is passed through all sampling equipment and then processed as a typical water-quality sample. Results of analysis of field blanks are used to test for bias that could result from the contamination of environmental samples as a result of sample collection, processing, handling, shipping, and analysis. Specifically, field blanks demonstrate that equipment has been properly cleaned to remove contamination from other samples, that sample collection and processing do not contaminate samples, and that sample handling, transport, and analysis have not contaminated the sample. Twelve field-blank samples were collected during water years 1995–96. The distribution of collection of field-blank samples by site and date is shown in figure 5.

General Chemical Constituents

Analytical results of field blanks for water years 1995–96 for general chemical constituents are listed in table 17. Any concentration that was greater than twice the laboratory reporting limit is shown in a shaded cell. Silica and, to some extent, chloride indicate some systematic contamination. The silica contamination can for the most part be explained as the result of the use of contaminated blank water. Independent analyses of the lots of blank water used at French, East, and State Line sites showed silica concentrations of 0.11 mg/L. Analyses of the lots of blank water suspected of being used at Gore and Dotsero showed a silica concentration of 0.30 mg/L (lot numbers were not recorded for these

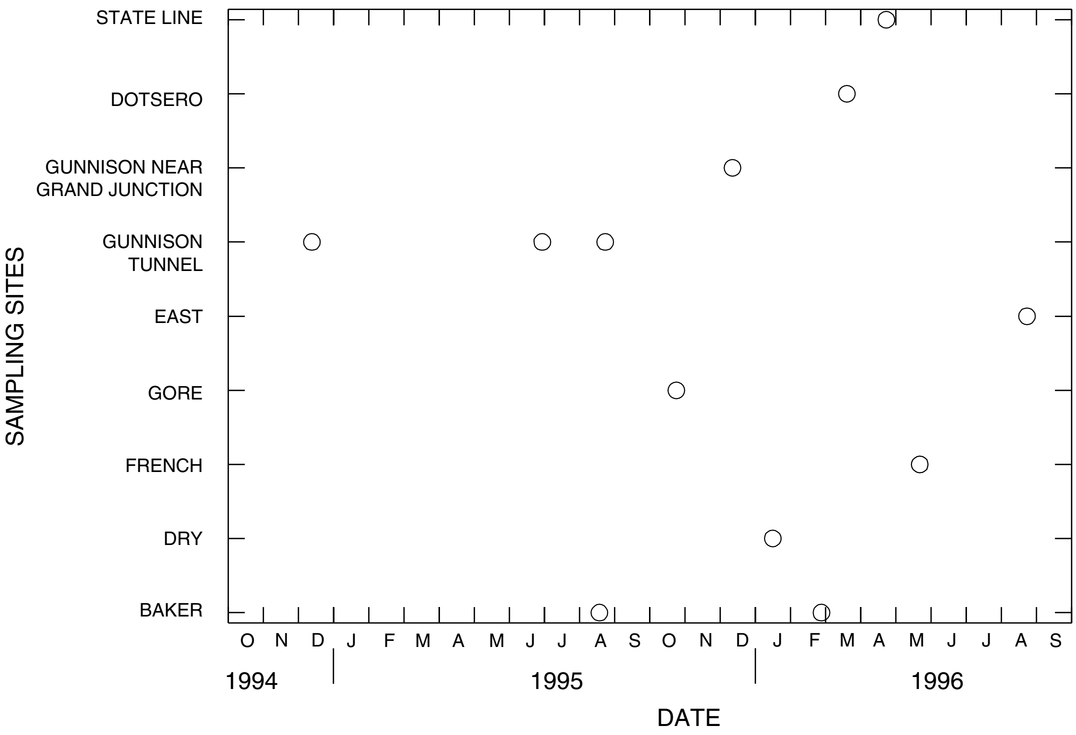

Figure 5. Distribution of collection of field blanks, 1995–96.

samples). Interpretation of the silica data collected at network sites should not be affected by the silica blank results because the contamination was introduced by the blank water.

The systematic chloride contamination source might be due to incomplete flushing of the dilute hydrochloric acid cleaning solution from the cone-splitter outlet ports. Except for the one high value at the State Line site, the contamination is on the order of a few tenths of a milligram per liter (table 17). Chloride concentrations for the environmental samples within the study unit range from 0.1 to 240 mg/L (U.S. Geological Survey, 1996, 1997). The interpretation of the environmental data for sites with low chloride concentrations, collected during the period of contamination, will need to be qualified. For future processing, the cone-splitter ports were fully disassembled for rinsing, and further chloride contamination has not been observed. All of the other constituents appear to have little or no contamination.

Nutrients and Organic Carbon

Analytical results of field blanks for water years 1995–96 for nutrients, dissolved organic carbon, and suspended organic carbon are listed in table 18. Constituents listed in table 18 show little or no contamination. Any concentration that was greater than twice the laboratory reporting limit is shown in a shaded cell. Results of the dissolved organic carbon blanks show concentrations in the 0.1 to 0.3 mg/L range. The South Platte NAWQA study unit also had dissolved organic carbon blanks with similar detections (Robert Kimbrough and Dennis Smits, U.S. Geological Survey, oral commun., 1997). Increasing the amount of blank water used to leach the suspended organic filter prior to processing

Table 17. Field blanks for general chemical constituents

[Shaded cells represent concentrations greater than twice the laboratory reporting limit; mg/L, milligrams per liter; µg/L, micrograms per liter; <, concentration less than the laboratory reporting limit]

Site	Date	Calcium (mg/L)	Magnesium (mg/L)	Sodium (mg/L)	Potassium (mg/L)	Sulfate (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Silica (mg/L)	Iron (µg/L)	Manganese (µg/L)	Residue on evaporation (mg/L)
State Line	042396	0.03	<0.01	<0.2	<0.1	<0.1	3.9	<0.1	0.09	<3	<1	5
Dotsero	032096	<0.02	<0.01	<0.2	<0.1	<0.1	<0.1	<0.1	0.33	<3	<1	<1
Gunnison near Grand Junction	121295	<0.02	<0.01	<0.2	<0.1	<0.1	0.3	<0.1	<0.01	<3	<1	<1
Gunnison Tunnel	121394	<0.02	<0.01	<0.2	0.2	<0.1	<0.1	<0.1	<0.01	<3	<1	<1
Gunnison Tunnel	062995	<0.02	<0.01	<0.2	<0.1	<0.1	<0.1	<0.1	<0.01	<3	<1	<1
Gunnison Tunnel	082395	<0.02	<0.01	<0.2	<0.1	<0.1	0.3	<0.1	0.01	<3	<1	<1
East	082396	0.03	<0.01	<0.2	<0.1	<0.1	<0.1	<0.1	0.15	<3	<1	<1
Gore	102495	<0.02	<0.01	<0.2	<0.1	<0.1	<0.1	<0.1	0.38	<3	<1	<1
French	052296	<0.02	<0.01	<0.2	<0.1	<0.1	<0.1	<0.1	0.09	<3	<1	9
Dry	011696	0.06	0.02	0.2	0.1	0.3	0.8	<0.1	0.01	<3	<1	<1
Baker	081895	<0.02	<0.01	<0.2	<0.1	<0.1	<0.1	<0.1	<0.01	5	<1	<1
Baker	022796	<0.02	<0.01	<0.2	<0.1	<0.1	<0.1	<0.1	0.22	<3	<1	<1
Number of samples with concentrations greater than twice the lab reporting limit		1	0	0	0	1	4	0	6	1	0	2

Table 18. Field blanks for nutrients and organic carbon

[Shaded cells represent concentrations greater than twice the laboratory reporting limit; mg/L, milligrams per liter; <, concentration less than the laboratory reporting limit; --, no data]

Site	Date	Ammonia (mg/L)	Ammonia plus organic (mg/L)	Total ammonia plus organic (mg/L)	Nitrite (mg/L)	Nitrite plus nitrate (mg/L)	Dissolved organic carbon (mg/L)	Suspended Organic Carbon (mg/L)	Phosphorus (mg/L)	Total phosphorus (mg/L)	Orthophosphate (mg/L)
State Line	042396	<0.02	<0.2	<0.2	<0.01	<0.05	--	--	<0.01	<0.01	<0.01
Dotsero	032096	<0.02	<0.2	<0.2	<0.01	<0.05	0.2	0.1	<0.01	<0.01	<0.01
Gunnison near Grand Junction	121295	<0.02	<0.2	<0.2	<0.01	<0.05	0.3	0.1	<0.01	<0.01	<0.01
Gunnison Tunnel	121394	<0.02	<0.2	<0.2	<0.01	<0.05	0.2	0.1	<0.01	<0.01	<0.01
Gunnison Tunnel	062995	<0.02	<0.2	<0.2	<0.01	<0.05	0.1	0.1	0.01	<0.01	<0.01
Gunnison Tunnel	082395	<0.02	<0.2	<0.2	<0.01	<0.05	0.1	--	<0.01	<0.01	<0.01
East	082396	<0.02	<0.2	<0.2	<0.01	<0.05	--	--	0.01	<0.01	<0.01
Gore	102495	<0.02	<0.2	<0.2	<0.01	<0.05	0.1	0.1	<0.01	0.02	<0.01
French	052296	0.02	<0.2	<0.2	<0.01	<0.05	0.1	<0.1	<0.01	<0.01	<0.01
Dry	011696	<0.02	<0.2	<0.2	<0.01	<0.05	0.2	0.1	<0.01	<0.01	<0.01
Baker	081895	<0.02	<0.2	<0.2	<0.01	<0.05	0.2	0.1	<0.01	<0.01	<0.01
Baker	022796	<0.02	<0.2	<0.2	<0.01	<0.05	0.3	0.1	<0.01	<0.01	<0.01
Number of samples with concentrations greater than twice the lab reporting limit		0	0	0	0	0	2	0	0	0	0

the sample may reduce the concentrations measured in these blanks. Future processing methods will include a 100 ml (milliliter) blank-water rinse.

CONCLUSIONS

Quality-control samples provide part of the information needed to estimate the bias and variability that result from sample collection, processing, and analysis. This report discusses the quality-control samples of surface water collected during water years 1995–96 in the UCOL study unit. Initial design of the quality-control plan incorporated the expected and measured constituent concentrations, streamflow conditions, and land use to distribute samples within the network. Results of the analysis of pre-processing split-replicate, concurrent-replicate, sequential-replicate, and post-processing split-replicate quality-control samples indicate that variability resulting from sample collection, processing, handling, shipping, and analysis generally is low and will have no practical effect on environmental data interpretation. No large systematic increase in variability resulting from sample collection or processing is evident in the results of the analysis. Analysis of field-blank samples indicated that, with the exception of chloride and silica, no systematic contamination of samples is apparent. Interpretation of the chloride environmental data will need to be qualified by reference to the chloride blank contamination. The silica contamination was the result of silica in the blank water and will not affect interpretation of environmental data.

Data analysis presented in this report has resulted in the following procedural changes for sampling within the UCOL surface-water network: (1) Fully disassemble the fittings and tubing of the outlet ports of the decaport sample splitter during field cleaning and rinsing; (2) implement recording and tracking of lot numbers and certificate of analyses for water used as blank water; (3) leach dissolved organic carbon filters with at least 100 ml of organic blank water prior to processing the sample (smaller volumes were previously used); (4) process additional field blanks and replicates for trace-element constituents (few samples available to date); and (5) test the efficiency of the field cleaning protocol by processing blanks after field-cleaning equipment rather than using laboratory-cleaned equipment. These changes were implemented in water year 1997.

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