



Hydrologic Benchmark Network Stations in the West-Central U.S. 1963-95 (USGS Circular 1173-C)

Abstract and Map Index	List of all HBN Stations	Introduction to Circular	Analytical Methods
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Halfmoon Creek near Malta, Colorado (07083000)

This report details one of the approximately 50 stations in the Hydrologic Benchmark Network (HBN) described in the four-volume U.S. Geological Survey Circular 1173. The suggested citation for the information on this page is:

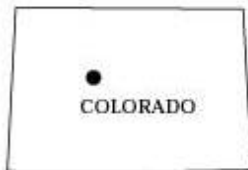
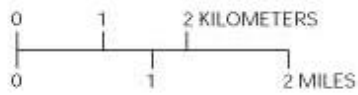
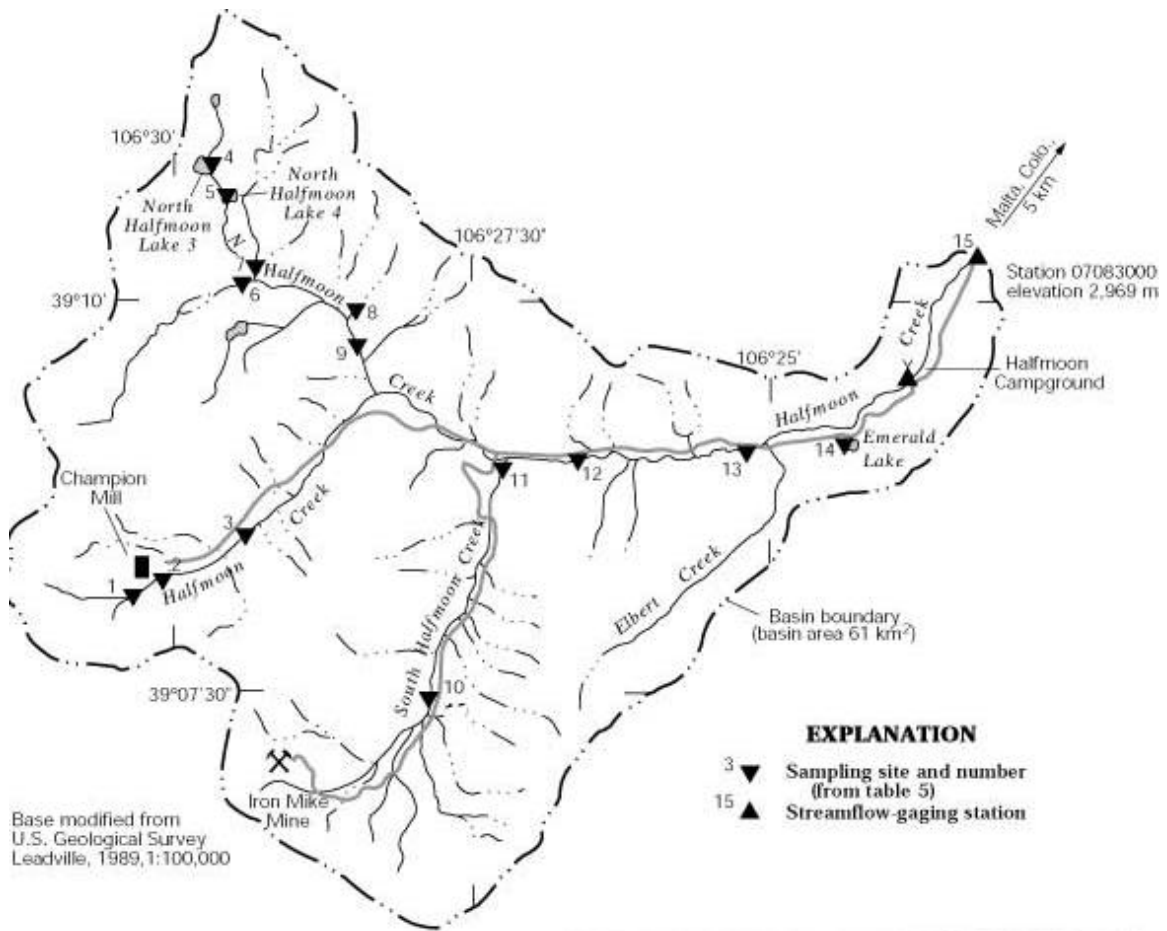
Mast, M.A., and Turk, J.T., 1999, Environmental characteristics and water quality of Hydrologic Benchmark Network stations in the West-Central United States, 1963–95: U.S. Geological Survey Circular 1173–C, 105 p.

All of the tables and figures are numbered as they appear in each circular. Use the navigation bar above to view the abstract, introduction and methods for the entire circular, as well as a map and list of all of the HBN sites. Use the table of contents below to view the information on this particular station.

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Site Characteristics and Land Use

The Halfmoon Creek HBN Basin is in the Southern Rocky Mountains physiographic province (Fenneman, 1946) in central Colorado ([Figure 2. Map showing study area in Halfmoon Creek Basin and photograph of the landscape of the basin](#)). Halfmoon Creek drains 61 km² of rugged, mountainous terrain of the Sawatch Range. Elevations in the



Map Location



Figure 2. Map showing study area in Halfmoon Creek Basin and photograph of the landscape of the basin

basin range from 2,969 to 4,399 m. The basin drains parts of Mount Elbert and Mount Massive, which are the second and third highest peaks, respectively, in the conterminous United States. The HBN station is about 6.9 km southwest of Malta, Colo., at a latitude of 39°10'20" and a longitude of 106°23'19". The ecoregion of the basin is classified as the Southern Rocky Mountain Steppe- Open Woodland-Coniferous Forest-Alpine Meadow Province (Bailey, 1995). The basin contains forested montane and subalpine zones. The northern slopes of the basin are heavily forested, whereas the south-facing slopes have sparse vegetation (W.A. Swensen, U.S. Geological Survey, written commun., 1997). Timber species in the lower part of the basin include lodgepole pine, Engelmann spruce, and fir. The upper basin (above 3,600 m) is alpine tundra.

Halfmoon Creek is a perennial stream that drains into Lake Fork, which is tributary to the Arkansas River. Several small natural lakes and ponds are located in the basin. The hydrology is largely controlled by melting of the annual snowpack, and mean monthly discharge ranges from about 0.10 m³/s in February to 3.6 m³/s in June (Crowfoot and others, 1996a). Variations in precipitation and temperature occur in the basin primarily because of the range in elevation. Average annual precipitation at the Leadville weather station in Lake County (about 10 km northeast of the HBN station) is about 32 cm. The weather station is at about the same elevation (about 3,000 m) as the HBN station. Annual precipitation at higher elevations in the basin is closer to 100 cm (Cobb and Biesecker, 1971) and is predominantly in the form of snow. Average annual runoff is about 40 cm (Crowfoot and others, 1996a). The climate of the area is characterized by cold winters and mild summers. Mean monthly temperatures at the weather station during the period 1976–95 ranged from -8.9°C in January to 12.2°C in July (National Climatic Data Center, 1996).

The geology of the upper basin is dominated by metamorphic rocks of Precambrian age, including biotite gneiss, schist, and migmatite (Van Loenen, 1985). The biotite gneiss is the most abundant rock type. Schist is next most abundant and contains varying amounts of sillimanite, garnet, hornblende, and muscovite. The remaining rock types, in order of decreasing abundance, are migmatite; quartz-rich, feldspathic gneiss; and calc-silicate gneiss. Small amounts of pegmatite also are present. Small intrusive masses of rhyolitic composition and small dikes of similar composition cut across the gneiss. Mineral deposits occur in brecciated zones of the intrusive rock. Some small vein deposits have high mineral-resource potential for gold, silver, lead, and zinc (Van Loenen and others, 1989). Talus from landslides and avalanche debris accumulate below steep ridges, whereas glacial material is deposited in the lower basin. Glacial deposits contain boulder till and gravel in moraines and outwash. The soil on glacial deposits on the mountains (slopes from 3 to 35 percent) generally is gravelly, sandy loam (U.S. Department of Agriculture, 1975a).

The Halfmoon Creek Basin lies entirely within Lake County and the San Isabel National Forest. The northern part of the basin lies within the Mount Massive Wilderness Area. Access to the lower part of the basin is by way of an improved, light-duty road. Access farther up the main stem of the drainage and some of the main tributaries is by four-wheel-drive roads and trails. Access may be restricted across private property, and mechanized vehicles are not allowed within the Mount Massive Wilderness Area. Access to the HBN station during the winter, as well as to the rest of the basin, is limited to

snowmobiles, skis, or snowshoes. Recreational use in the basin is high, particularly in the summer. Activities include hiking, fishing, and camping. A U.S. Forest Service campground is upstream from the station, and the Mount Massive and Mount Elbert trailheads are both accessible from the basin. Several small, abandoned mines and an inactive mill are in the basin. Historically, small vein deposits of silver, gold, lead, and zinc yielded economic quantities of these metals from Halfmoon Creek Basin. Mining activity in Halfmoon Creek Basin, however, was less than in other drainages in the upper Arkansas River Basin. Other potential influences on water quality in the basin include grazing (U.S. Geological Survey, 1993, p. 200), a few residences, and past forest fires (Cobb and Biesecker, 1971).

Historical Water-Quality Data and Time-Series Trends

The data set analyzed for the Halfmoon Creek HBN station includes 256 water-quality samples that were collected from July 1965 to August 1995. Sampling frequency is described on the basis of water year, which begins on October 1 and ends on September 30. Sampling frequency increased from 2 samples in 1965 to 12 samples in 1967 and remained at 10–12 samples per year from 1967 to 1980. Sampling frequency was variable during the period 1981–90 when between three to nine samples were collected annually. During the early 1990's, sampling frequency generally was bimonthly. Samples were analyzed at USGS district water-quality laboratories until the early 1970's. After 1973, with the creation of the USGS Central Laboratory System, all samples were analyzed at the water-quality laboratory (now called NWQL) in Arvada, Colo. The period of record for discharge is from water year 1946 to current year (2000). Daily water temperature was recorded from May 1967 to September 1982.

Data quality was checked using ion balances and time-series plots. Calculated ion balances for samples with complete major-ion analyses are shown in [Figures 3a](#) and [3b](#). *Temporal variation of discharge, field pH, major dissolved constituents, and ion balance at Halfmoon Creek, Colorado*. About 90 percent of the samples had ion balances within the ± 6 percent range, indicating that the major-ion analytical results were of good quality and that unmeasured constituents, such as organic anions, nutrients, and trace metals, do not contribute substantially to the ionic composition of Halfmoon Creek. Time-series plots of ion concentrations were inspected for evidence of influences that are related to analytical method changes (fig. 3). Calcium, magnesium, potassium, and sodium generally have more scatter in the early part of the record. The scatter for potassium, and to a lesser extent magnesium, coincides with the water-quality laboratory location change around 1973. A decrease in scatter for calcium after 1983 coincides with a change in the analytical method for these analytes from atomic adsorption (AA) spectroscopy to inductively coupled plasma (ICP) spectroscopy (U.S. Geological Survey Office of Water Quality Technical Memorandum No. 82.18, 1982). The reason for the decrease in scatter of sodium could not be isolated because it occurred around 1980, a few years before the method change. The decrease in scatter of sulfate concentrations after 1982 corresponds with the change from a methylthymol blue procedure to a turbidimetric titration method (U.S. Geological Survey Office of Water Quality Technical Memorandum No. 83.07, 1983). The further decrease in the scatter of sulfate concentrations after 1990 corresponds

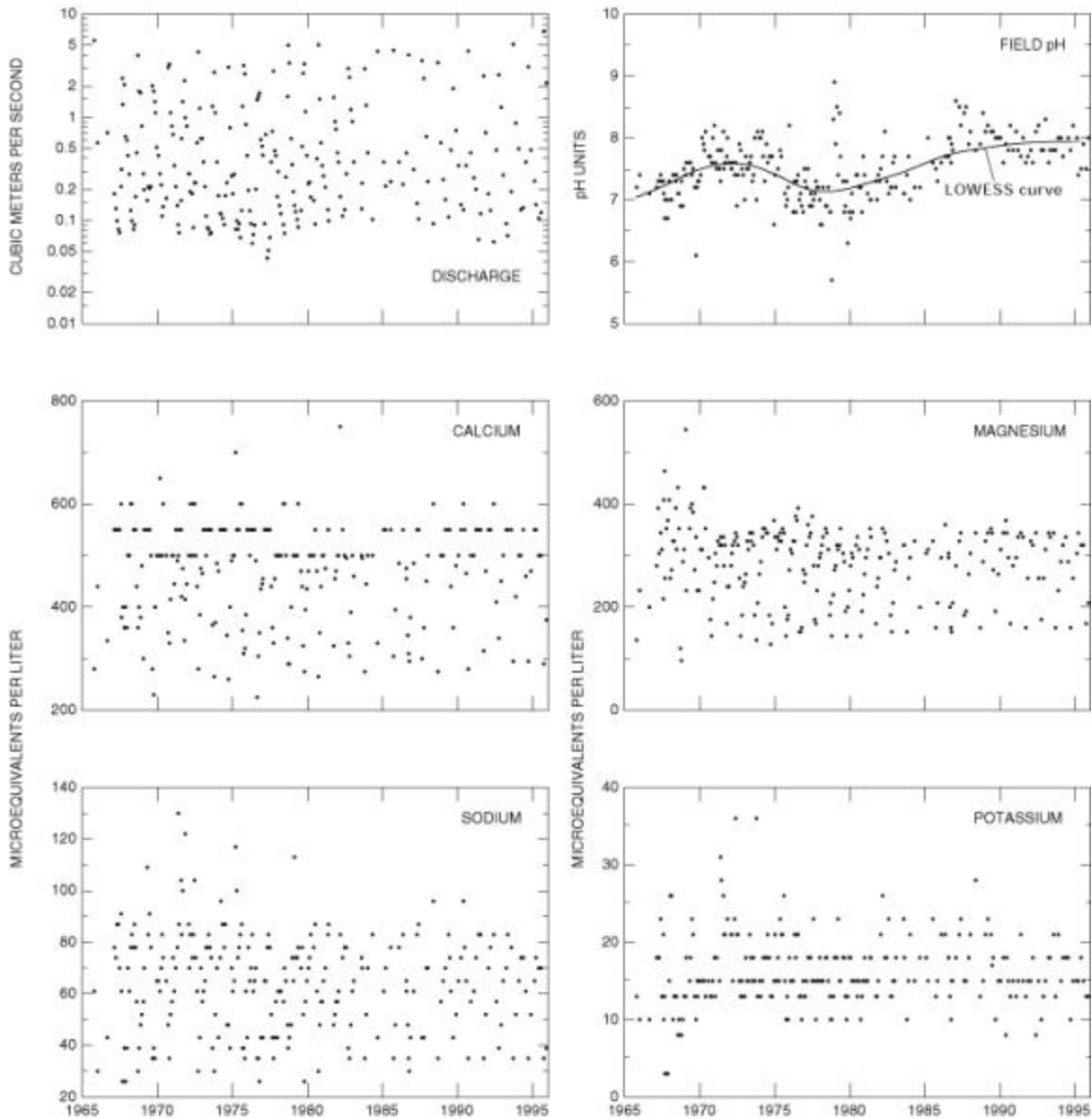


Figure 3a. Temporal variation of discharge, field pH, major dissolved constituents, and ion balance at Halfmoon Creek, Colorado

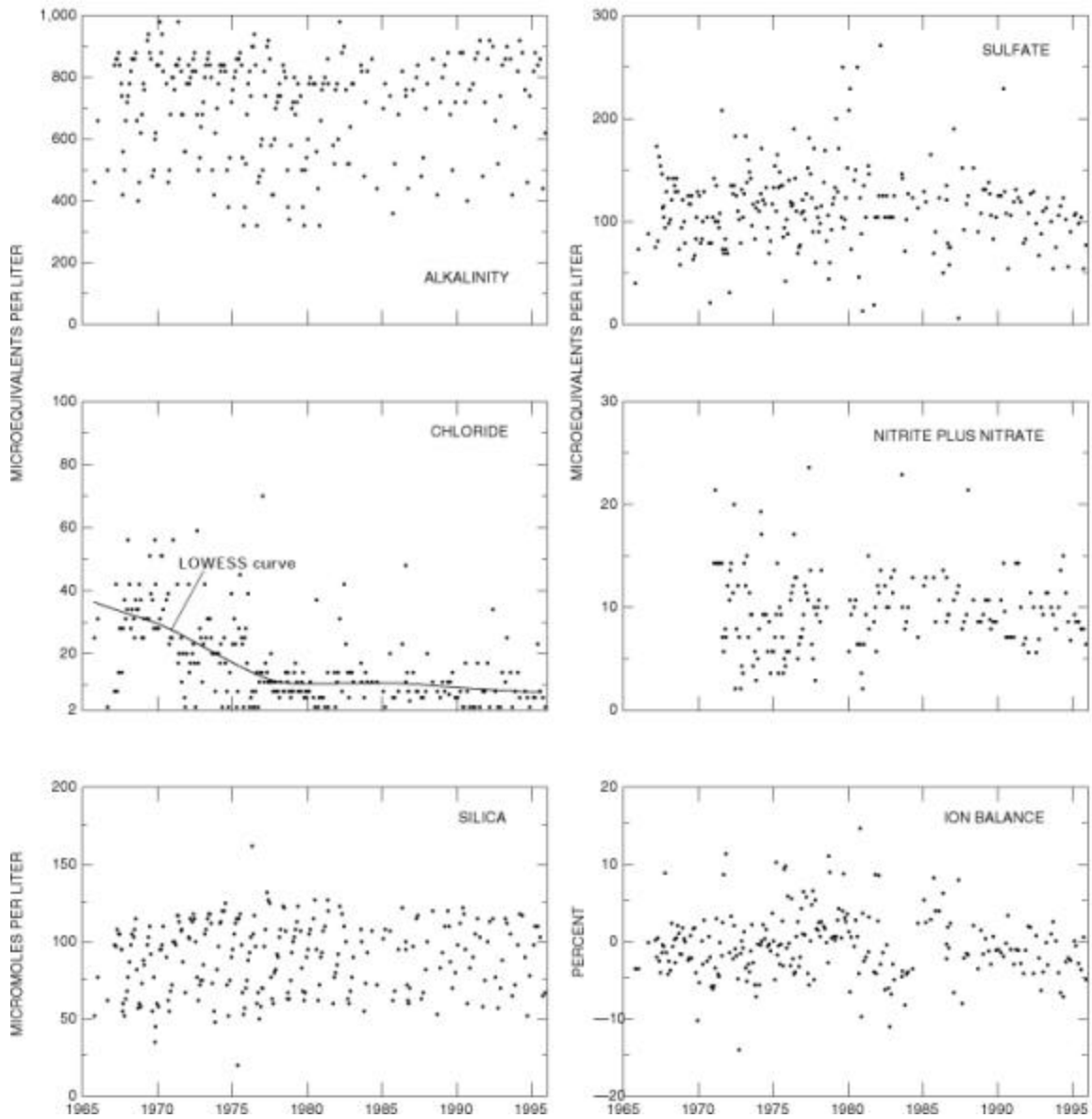


Figure 3b. Temporal variation of discharge, field pH, major dissolved constituents, and ion balance at Halfmoon Creek, Colorado - Continued

with the change from turbidimetric titration to an ion-exchange chromatography analytical method (U.S. Geological Survey Office of Water Quality Technical Memorandum No. 90.04, 1989; U.S. Geological Survey Office of Water Quality Technical Memorandum No. 90.13, 1990). Changes also were made in meters and electrodes used for field pH determinations during the study period. When changes in methods or instrumentation result in improved precision or elimination of measurement bias, time-series data can exhibit less scatter or a directional shift, respectively. The time-series data, therefore, may reflect the method or instrument change rather than an environmental change.

The median and range of major-ion concentrations in stream water collected at the Halfmoon Creek HBN station and VWM concentrations in wet precipitation measured at the Manitou NADP station are presented in table 2. The NADP station is about 130 km east and south of the HBN station. Precipitation chemistry at the NADP station was dilute and acidic with a VWM pH of 4.9 during the period of record, 1978–95. The dominant cations in precipitation were hydrogen, which contributed 28 percent of the total cation concentration, and calcium and ammonium, which each contributed 26 percent. Sulfate and nitrate were the dominant anions in precipitation, contributing 48 and 46 percent, respectively, of the total anion concentration. A high proportion of nitrate in precipitation in the Rocky Mountains has been attributed to exhaust from cars and other vehicles in urban areas and agricultural activity in the Great Plains States (National Atmospheric Deposition Program/National Trends Network, 1997). Precipitation chemistry at a USGS study site in Halfmoon Creek Basin near the gaging station was slightly more dilute and less acidic with a VWM pH of about 5.1 during the period 1989–94 (A.J. Ranalli, U.S. Geological Survey, written commun., 1997).

Table 2. Minimum, first quartile, median, third quartile, and maximum values of physical properties and major ions measured in water-quality samples from Halfmoon Creek, Colorado, 1965—95, and volume-weighted mean concentrations in wet precipitation collected at the Manitou Station, Colorado, 1978—95

[Parameters in units of microequivalents per liter, except for discharge in cubic meters per second, specific conductance in microsiemens per centimeter at 25 degrees Celsius, pH in standard units, and silica in micromoles per liter; n, number of stream samples; VWM, volume-weighted mean; spec. cond., specific conductance; --, not reported; <, less than]

Parameter	Stream Water						Precipitation VWM
	Minimum	First quartile	Median	Third quartile	Maximum	n	
Discharge	0.04	0.13	0.28	0.88	6.8	247	--
Spec. cond., field	43	65	86	95	107	226	--
pH, field	5.7	7.2	7.5	7.8	8.9	245	4.9 ^a
Calcium	220	400	500	550	750	254	12
Magnesium	96	230	300	340	540	256	3.2
Sodium	26	48	65	78	130	253	4.4
Potassium	3.0	13	15	18	36	251	1.3
Ammonium	<.7	.7	1.4	4.3	16	100	12
Alkalinity, laboratory	320	580	760	840	980	251	--
Sulfate	6.2	90	110	130	270	253	22
Chloride	<2.8	8.5	14	25	70	254	2.9
Nitrite plus nitrate	2.1	7.1	9.3	12	24	183	21 ^b
Silica	20	70	95	110	160	254	--

^a Laboratory pH.

^b Nitrate only.

Stream water in Halfmoon Creek is a calcium bicarbonate type. The sum of ion concentrations ranged from about 830 to about 2,500 meq/L. Alkalinity ranged from 320 to 980 meq/L, and bicarbonate is the primary contributor to alkalinity at this station. Calcium (57 percent) and magnesium (34 percent) accounted for the largest part of the median cation concentration. Bicarbonate accounted for 85 percent of the median anion concentration. The dominance of calcium, magnesium, and bicarbonate reflect the weathering of calc-silicate gneiss, which was formed, in part, by the metamorphism of limestone or dolomite. Streams in basins with high annual runoff and geologic settings that contain metamorphic rocks, particularly schist and gneiss, tend to have low dissolved-solids concentrations (Biesecker and Leifeste, 1975). Specific conductance (43 to 107 mS/cm) is an indicator of the low dissolved solids at this station. Annual precipitation and runoff data indicate that evapotranspiration can account for about a twofold increase in stream-water concentrations compared to precipitation. About 40 percent of the median sulfate and chloride concentrations in the stream water can be accounted for by wet precipitation. This indicates that sulfate and chloride sources may exist in the basin. The precipitation contribution of sulfate is a conservative estimate, however, because dry deposition is not included and it can be an important source. Sulfide minerals typically associated with mineralized rock zones have been mapped in the upper basin, and other minerals in igneous rocks can contribute small amounts of chloride to water (Hem, 1992, p. 118). The pH of the stream water generally remains near neutral to slightly alkaline. Concentrations of ammonium and nitrate were lower in the stream water than in the precipitation, indicating that nitrogen is retained by the biomass in the basin.

Correlations among dissolved constituents and discharge were determined for Halfmoon Creek (table 3). Base cations and anions were inversely correlated with discharge. These results are consistent with a hydrologic system where base-flow chemistry that is dominated by ground water is diluted during periods of increased discharge, particularly during annual snowmelt runoff. Ion concentrations in ground water tend to be greater than in surficial sources because the contact time with rocks and minerals is longer. Among the solutes, strong, positive correlations existed among base cations, particularly calcium and magnesium (ρ value = 0.938), calcium and sodium (ρ value = 0.880), and sodium and magnesium (ρ value = 0.924). The relations of calcium, magnesium, and sodium with silica were strong and positively correlated (0.907, 0.949, and 0.941, respectively). Positive correlations among the base cations and alkalinity also were apparent (calcium, ρ value = 0.878; magnesium, ρ value = 0.898; and sodium, ρ value = 0.847). Likewise, a strong correlation between alkalinity and silica was determined (ρ value = 0.859). These relations reflect the weathering of feldspathic and calc-silicate minerals in the metamorphic rocks.

Table 3. Spearman rank correlation coefficients (rho values) showing the relation among discharge, pH, and major ions, Halfmoon Creek, Colorado, 1980 through 1995

[Q, discharge; Ca, calcium; Mg, magnesium; Na, sodium; K, potassium; Alk, alkalinity; SO₄, sulfate; Cl, chloride; SiO₂, silica; --, not applicable]

	Q	pH	Ca	Mg	Na	K	Alk	SO ₄	Cl
pH	0.006	--	--	--	--	--	--	--	--
Ca	-.881	0.082	--	--	--	--	--	--	--
Mg	-.930	.044	0.938	--	--	--	--	--	--
Na	-.927	-.059	.880	0.924	--	--	--	--	--
K	-.523	.015	.536	.591	0.593	--	--	--	--
Alk	-.893	.092	.878	.898	.847	0.487	--	--	--
SO ₄	-.556	-.094	.590	.625	.620	.448	0.461	--	--
Cl	-.236	-.071	.170	.263	.247	.433	.230	0.217	--
SiO ₂	-.940	-.043	.907	.949	.941	.584	.859	.628	0.219

Results of the seasonal Kendall test for trends in discharge and major dissolved constituents for Halfmoon Creek from 1965 through 1995 are presented in table 4. A statistically significant ($\alpha = 0.01$) downward trend for dissolved chloride and a significant upward trend in pH were detected in both unadjusted and flow-adjusted concentrations. A statistically significant upward trend for dissolved silica was detected in the flow-adjusted concentrations. The results of the flow-adjusted tests indicate the changes in hydrogen, chloride, and silica concentrations probably were not driven by changes in stream discharge. The upward trend in pH contrasts with the significant downward trend ($\alpha = 0.01$) in stream-water pH at this station that was observed for the period from the mid-1960's to 1981 (Smith and Alexander, 1983). Likewise, a significant downward trend ($\alpha = 0.01$) in alkalinity determined during the same period is no longer detected. Lewis and Grant (1980) reported decreasing pH and increasing nitrate concentrations in precipitation along the nearby Rocky Mountain Front Range for the period 1975–78. Kling and Grant (1984) correlated decreasing pH and alkalinity with increasing elevation in lakes in the nearby Front Range. The trend of increasing pH, however, is consistent with a more recent study (Lynch and others, 1995), which found increasing pH in precipitation at the Manitou NADP station for the period 1980–92. The downward trend in chloride concentrations is consistent with decreasing chloride concentrations in precipitation at the Manitou station. Some negative bias, however, may have been introduced in the stream-water chloride concentrations from the change in analytical methods for chloride from colorimetric during the 1970's to a ferric thio-cyanate to automated segmented flow method during the 1980's, to ion exchange chromatography

around 1990 (H.D. Ardourel, U.S. Geological Survey, written commun., 1997). The reason for the upward trend in flow-adjusted silica concentrations could not be determined.

Table 4. Results of the seasonal Kendall test for trends in discharge and unadjusted and flow-adjusted pH and major-ion concentrations, Halfmoon Creek, Colorado, 1965 through 1995

[Trends in units of microequivalents per liter per year, except for discharge in cubic meters per second per year, pH in standard units per year, and silica in micromoles per liter per year; p-value, attained significance level; --, not calculated; <, less than]

Parameter	Unadjusted		Flow adjusted	
	Trend	p-value	Trend	p-value
Discharge	0.00	0.956	--	--
pH	.03	<.001	0.03	<0.001
Calcium	<.01	.092	.7	.013
Magnesium	<.01	.599	.4	.201
Sodium	<.01	.574	.05	.609
Potassium	<.01	.650	.02	.489
Alkalinity	.8	.126	.8	.212
Sulfate	<.01	.962	.09	.733
Chloride	-.6	<.001	-.6	<.001
Nitrite plus nitrate	.03	.318	.05	.153
Silica	.3	.013	.3	.004

Synoptic Water-Quality Data

Results of surface-water synoptic sampling conducted during 1988, 1989, and 1990 in the Halfmoon Creek Basin are presented in table 5, and locations of the sampling sites are shown in figure 2. Discharge at the HBN station (site 15) during the four sampling events was 0.63 m³/s (July 1988), 0.17 m³/s (November 1988), 0.19 m³/s (March 1989), and 0.10 m³/s (March 1990) compared to the mean monthly discharge of 2.4, 0.21, and 0.10 m³/s for the months of July, November, and March, respectively (Crowfoot and others, 1996a).

The water type of samples from all sites in the basin was calcium bicarbonate. The sum of ions in tributary streams ranged from about 660 (site 7, July 1988) to about 2,400 meq/L (site 2, March 1989). The sum of ions at the HBN station (site 15) ranged from about 1,500 (July 1988) to about 2,000 meq/L (March 1990). Concentrations of most dissolved constituents measured during synoptic sampling of the tributaries were within the range of dissolved-constituent concentrations measured at the HBN station for the record period 1965–95 (table 2). Concentrations of dissolved sulfate at sites 1, 2, and 3 exceeded the historical maximums for the HBN station. Ion concentrations were generally more dilute in the three lake sites: North Halfmoon Lake No. 3 (site 4), North Halfmoon Lake No. 4 (site 5), and Emerald Lake (site 14); ion concentrations in the lakes ranged from 500 (site 5) to 680 meq/L (site 14). Several constituents measured in the lake samples were less than the minimum concentration detected at the HBN station during 1965–95.

Concentrations of most major ions (including calcium, magnesium, sodium, bicarbonate, and sulfate) were lower in stream water of North Halfmoon Creek and its tributaries (sites 6–9) compared to Halfmoon Creek and South Halfmoon Creek. The elevated sulfate concentrations in samples that were collected from the upper Halfmoon Creek drainage (sites 1, 2, and 3) coincide with the mineralized zone identified as having high mineral-resource potential. Placer mining for low-grade gold has occurred along upper Halfmoon Creek (Van Loenen and others, 1989). Increased sulfate concentrations are associated with the oxidation of iron-sulfide minerals, particularly pyrite, which commonly are associated with precious metal deposits (Deer and others, 1966, p. 448). Mining operations expose sulfide minerals to air and water, increasing the potential for oxidation (Hem, 1992, p. 111). The sulfate concentration at site 10 (98 meq/L), below a historical mine site on South Halfmoon Creek, however, was less than the median sulfate at the HBN station. The South Halfmoon Creek drainage is outside the high mineral-resource potential zone. In all drainages, the stream waters were near neutral to moderately alkaline (pH = 7.2 to 8.2) during the synoptic study.

Table 5. Physical properties and major-ion concentrations in surface-water samples collected at sites in the Halfmoon Creek Basin, Colorado, 1988 through 1990

[Site locations shown in fig. 2; Q, discharge in cubic meters per second; SC, specific conductance in microsiemens per centimeter at 25 degrees Celsius; pH in standard units; Ca, calcium; Mg, magnesium; Na, sodium; K, potassium; Alk, alkalinity; SO₄, sulfate; Cl, chloride; NO₃, nitrate; SiO₂, silica; concentrations in microequivalents per liter, except silica is in micromoles per liter; --, not measured; <, less than; criteria used in selection of sampling sites:BG = bedrock geology, TRIB = major tributary, LU = land use]

Site	Identification number	Sample date	Q	SC	pH	Ca	Mg	Na	K	Alk	SO ₄	Cl	NO ₃	SiO ₂	Criteria
1	390806106302200	07/26/88	0.034	76	7.2	430	240	42	7.4	520	190	1.4	4.4	57	LU
		10/31/88	--	98	--	600	270	48	8.5	490	380	3.7	16	58	
2	390816106295700	10/31/88	--	104	7.8	560	360	50	10	670	270	3.9	13	62	LU
		03/22/89	<.001	127	8.0	750	380	74	12	710	440	8.5	14	72	
3	390830106292400	07/26/88	.10	75	7.5	430	250	40	9	570	130	2	4.5	55	LU
		10/31/88	--	94	7.9	550	310	52	10	640	220	5.1	13	62	
		03/22/89	.005	113	8.0	650	340	74	12	760	140	5.6	15	68	
		03/20/90	.004	116	7.6	700	380	78	14	830	290	2.8	21	73	
4	391050106294300	07/25/88	.003	28	--	160	72	23	3.8	220	29	2.5	--	32	BG
5	391039106293400	07/25/88	.001	27	--	160	70	22	3.3	220	27	1.7	--	28	BG
6	391010106292200	07/25/88	.099	38	--	220	120	26	5.4	310	46	2	3.9	42	TRIB
7	391011106291900	07/25/88	.085	35	--	220	80	29	6.7	280	38	2.8	6.9	42	TRIB
8	390955106283200	07/25/88	.003	53	--	300	160	65	11	420	63	4.8	18	82	TRIB
9	390945106282800	07/25/88	.24	40	--	240	110	29	6.4	330	44	2.3	4.6	45	BG
		11/01/88	--	58	7.7	360	180	43	9	440	73	5.9	16	62	
		03/23/89	.012	59	7.9	320	180	48	8.7	440	77	4.8	15	65	
		03/21/90	.033	58	7.7	340	180	48	9.5	460	73	<.3	18	68	
10	390724106275100	07/26/88	.097	79	7.6	490	220	52	14	660	98	3.9	5.9	67	LU
11	390901106271200	07/26/88	.17	93	7.9	550	300	57	15	790	100	3.4	8.6	75	TRIB
		11/01/88	--	108	8.0	650	370	61	18	910	130	6.2	14	78	
		03/22/89	.01	113	8.2	700	390	70	18	960	150	5.6	16	82	
		03/21/90	.025	116	8.1	700	380	70	18	990	140	<.3	21	85	
12	390901106263600	07/26/88	.50	70	7.8	400	220	41	10	580	77	2.8	6.8	62	BG
		11/01/88	--	91	7.9	500	310	57	15	740	110	6.2	14	73	
		03/22/89	.054	96	8.1	550	330	61	15	780	120	5.6	16	77	
		03/21/90	.052	97	7.9	550	330	61	16	820	130	5.1	18	82	

13	390905106250700	07/26/88	.58	72	7.8	410	240	43	11	600	81	3.1	7.1	65	BG
		11/01/88	--	96	7.8	550	350	61	16	790	120	5.9	10	85	
		03/23/89	.067	99	8.1	550	350	74	16	850	130	6.5	11	110	
		03/21/90	.063	102	7.7	550	350	74	17	880	120	2.8	14	93	
14	390906106242000	06/26/88	--	35	--	180	110	48	10	300	30	4.2	1.5	72	BG
15	07083000	07/26/88	.63	79	8.0	420	260	52	12	620	82	4.2	6.2	24	
		11/01/88	.17	95	7.9	500	340	65	16	810	120	7.6	8.2	30	
		03/22/89	.19	99	8.1	550	350	78	17	800	120	7.1	9.2	35	
		03/21/90	.10	100	7.8	550	350	78	18	840	130	.3	9.6	37	

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Appendix A. List of Map References

- a. U.S. Geological Survey topographic maps:
 - Lake County, Colorado (1:50,000), 1975
 - Mount Elbert, Colorado (1:24,000), 1979
 - Mount Massive, Colorado (1:24,000), 1967, streamflow-gaging station
 - Mt. Champion, Colorado (1:24,000), 1960

- b. Geologic maps:
 - Tweto, Ogden, and Reed, J.C., Jr., 1973, Reconnaissance geologic map of the Mount Elbert 15-minute quadrangle, Lake, Chaffee, and Pitkin Counties, Colorado: U.S. Geological Survey Open-File Report 72-287.
 - Van Loenen, R.E., 1985, Geologic map of the Mount Massive Wilderness, Lake County, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map 1792-A, 1 pl., scale 1:50,000.
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- c. Soil surveys:
 - U.S. Department of Agriculture, 1975, Soil survey of Chaffee-Lake area, Colorado: U.S. Department of Agriculture, Soil Conservation Service, 78 p.

- d. Other maps:
 - Leadville, Colorado, 30' x 60' quadrangle, Bureau of Land Management, 1983, scale 1:100,000.

Appendix B. NWIS Site-Identification Numbers

Table B-1. NWIS site-identification numbers and site names for water-quality sampling sites.

Site	Identification Number	Site Name
1	390806106302200	HALFMOON CREEK ABOVE CHAMPION MILL
2	390816106295700	HALFMOON CREEK BELOW CHAMPION MILL
3	390830106292400	HALFMOON CREEK NEAR PROSPECT MINE
4	391050106294300	NORTH HALFMOON LAKE NUMBER 3
5	391039106293400	NORTH HALFMOON LAKE NUMBER 4
6	391010106292200	NORTH HALFMOON CREEK ABOVE NORTH BRANCH OF CREEK
7	391011106291900	NORTH BRANCH OF NORTH HALFMOON CREEK BELOW HALFMOON LAKES
8	390955106283200	THIRD UNNAMED TRIBUTARY TO NORTH HALFMOON CREEK AT MOUTH
9	390945106282800	NORTH HALFMOON CREEK 0.42 MILE ABOVE HALFMOON CREEK
10	390724106275100	SOUTH HALFMOON CREEK NEAR IRON MIKE MINE
11	390901106271200	SOUTH HALFMOON CREEK ABOVE HALFMOON CREEK
12	390901106263600	HALFMOON CREEK ABOVE BOG
13	390905106250700	HALFMOON CREEK ABOVE ELBERT CREEK
14	390906106242000	EMERALD LAKE
15	07083000	HALFMOON CREEK NEAR MALTA, COLORADO