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DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

SURFACE-WATER QUALITY IN THE CAMPBELL CREEK BASIN, ANCHORAGE, ALASKA

By Timothy P. Brabets and Loren A. Wittenberg

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Multiply	by	to obtain
inch (in.)	25.40	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
square mile (mi^2)	2.590	square kilometer (km^2)
foot per mile (ft/mi)	0.1894	meter per kilometer (m/km)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
cubic foot per second per square mile [(ft^3/s)/mi^2]	0.0109	cubic meter per second per square kilometer [(m^3/s)/km^2]
ton (short)	0.09072	megagram (Mg)
degree Fahrenheit (°F)	(°F-32)/1.8	degree Celsius (°C)
micromho per centimeter at 25° Celsius (μmho/cm at 25°C)	1.000	microsiemen per centimeter at 25° Celsius (μS/cm at 25°C)

Other abbreviations in this report are:
μg/L, microgram per liter
mg/L, milligram per liter
mL, milliliter
FC/100 mL, fecal coliform colonies per 100 mL

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ABSTRACT

Four streams in the Campbell Creek basin were sampled during different flow conditions over an 18-month period. North Fork Campbell Creek and South Fork Campbell Creek drain areas virtually undisturbed by man's activities. The other two streams, Little Campbell Creek and the main stem Campbell Creek, drain areas that have been urbanized.

The water from South Fork and North Fork Campbell Creeks is of good quality and does not adversely affect the water quality of the main stem Campbell Creek. Little Campbell Creek, which has been affected by urbanization, impacts the water quality of Campbell Creek during lowland snowmelt periods when discharges from South Fork and North Fork Campbell Creeks are small. High concentrations of suspended sediment in Campbell Creek may be contributed by Little Campbell Creek. Fecal coliform bacteria concentrations are highest at Little Campbell Creek and probably account for most of the high coliform concentrations at Campbell Creek.

INTRODUCTION

The Municipality of Anchorage, Alaska, has grown rapidly in the past decade. According to the 1980 U.S. Census, the population of the Anchorage area increased from about 120,000 people in 1970 to about 173,000 in 1980. With increasing development of Alaska's natural resources such as coal, oil, and natural gas, the population of Alaska, and especially of Anchorage, should continue to increase.

As more of Anchorage becomes developed, the effects of surface-water runoff from urbanized areas need to be evaluated. The effect of runoff (both quantity and quality) is of concern to planners, policymakers, and the general public. Much of this concern has been the result of the areawide planning requirements by section 208 of Public Law 92-500, 1972 Amendments of the Federal Water Pollution Control Act.

Data adequate to describe general flow conditions have been collected on most major streams in the Anchorage area, but comparable water-quality data needed to determine the effect of urbanization on the streams are scarce. Thus, in 1980 the U.S. Geological Survey, in cooperation with the Municipality of Anchorage, began a study of the effects of urban runoff on stream-water quality.

A premise of the study was that urbanization does have an effect on the quality of surface runoff. The primary purpose of the study was to determine differences in water-quality characteristics between streams that drain natural and urban areas in Anchorage. The Campbell Creek basin (fig. 1) was chosen for study because distinct subbasins, either natural or partly urbanized, can be delineated (table 1), and long-term, continuous discharge data are available for three sites in the basin.

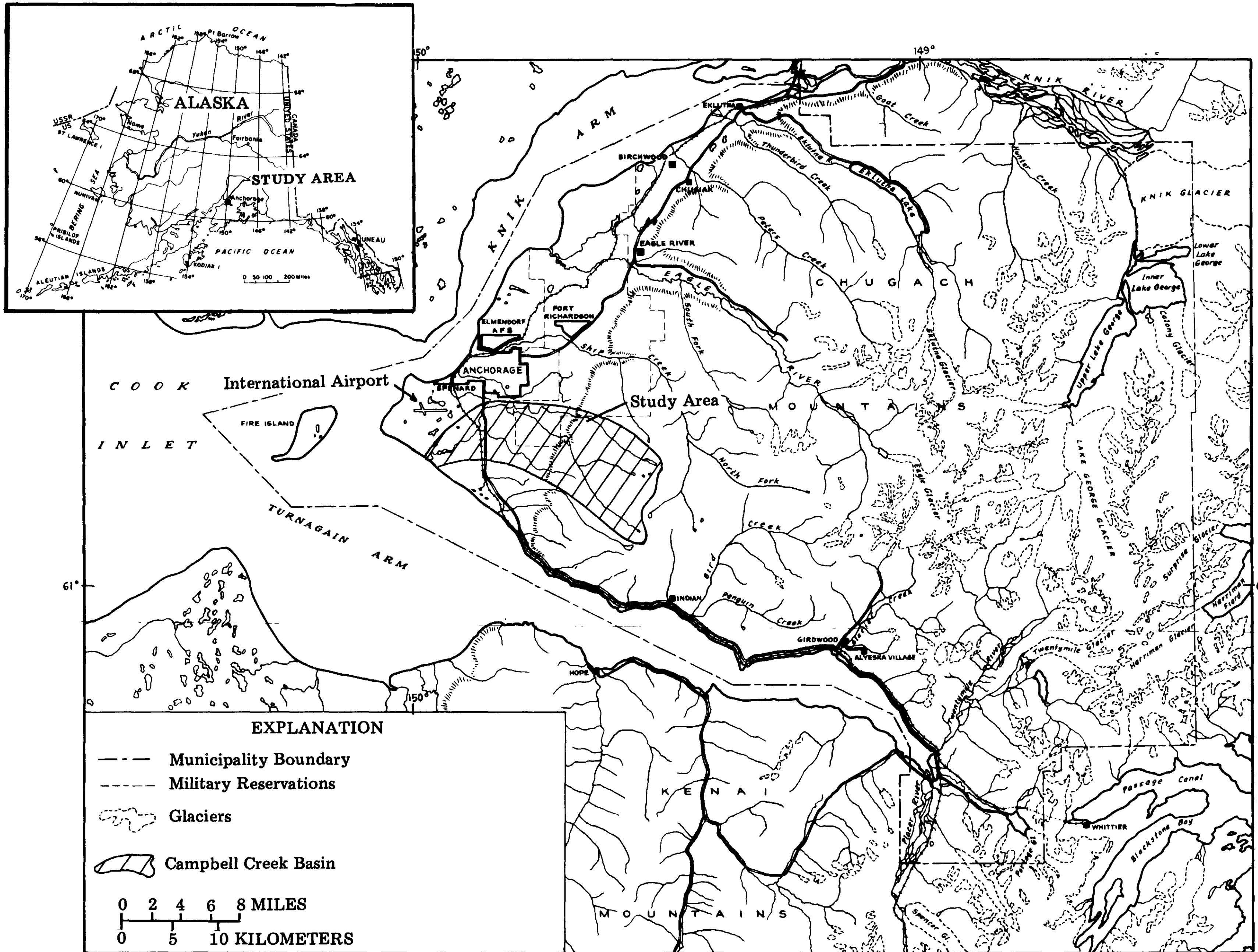

Figure 1.--Location of Municipality of Anchorage and Campbell Creek basin.

Four stream sites representing the subbasins were chosen for monitoring water quality and flow characteristics: South Fork Campbell Creek at canyon mouth near Anchorage (U.S. Geological Survey station no. 15273900), North Fork Campbell Creek near Anchorage (15274300), Little Campbell Creek at Nathan Drive (15274550), and Campbell Creek near Spenard (15274600) (fig. 2).

Table 1.--Types of land use in Campbell Creek basin

[Data in percentages, except as indicated. Source: modified from Municipality of Anchorage (1978, table A-2)]

Subbasin name	Drainage area (mi^2)	Commercial	Industrial	Residential			Natural
				Multifamily[1]	High density[2] single-family	Low density[3] single-family	
South Fork	25.2	0	0	0	0	0	100
North Fork	13.4	0	0	0	0	0	100
Little Campbell	15.1	1	6	2	2	17	72
Campbell Creek	16.0	1.2	9.7	2.8	14.2	3.6	68.5

[1] Greater than 10 dwelling units per acre.
[2] Between 1 and 10 dwelling units per acre.
[3] Less than 1 dwelling unit per acre.

DESCRIPTION OF STUDY AREA

Campbell Creek drainage basin (fig. 2) has an area of about 74 mi^2 from its headwaters in the Chugach Mountains to its confluence with Turnagain Arm. The stream has a steep gradient of about 260 ft/mi in its upper reaches, but has a much gentler slope of about 160 ft/mi downstream from the mountain front.

South Fork Campbell Creek subbasin (South Fork) has an area of 25.2 mi^2. The stream is approximately 10 mi long and drains two small canyons to the northwest from the Chugach Mountains. The basin is forested at the lower altitudes and tundra dominated at altitudes above 1500 ft. The basin is primarily undeveloped parkland. Snowmelt and ground-water discharge contribute much of the flow in the creek, and peak flows usually occur during summer and early fall. Discharge records have been collected at this site since 1966.

North Fork Campbell Creek subbasin (North Fork) has an area of 13.4 mi^2. The stream is approximately 10 mi long and drains in a west-northwest direction through a single canyon. The lower part of the basin is relatively flat and forested while the upper portion is tundra covered and steep. About 30 homes have been built near the timberline but most of the basin is undeveloped parkland. Some peat bogs in the lower part of the basin drain into the stream. Discharge records have been collected at this site since 1974.

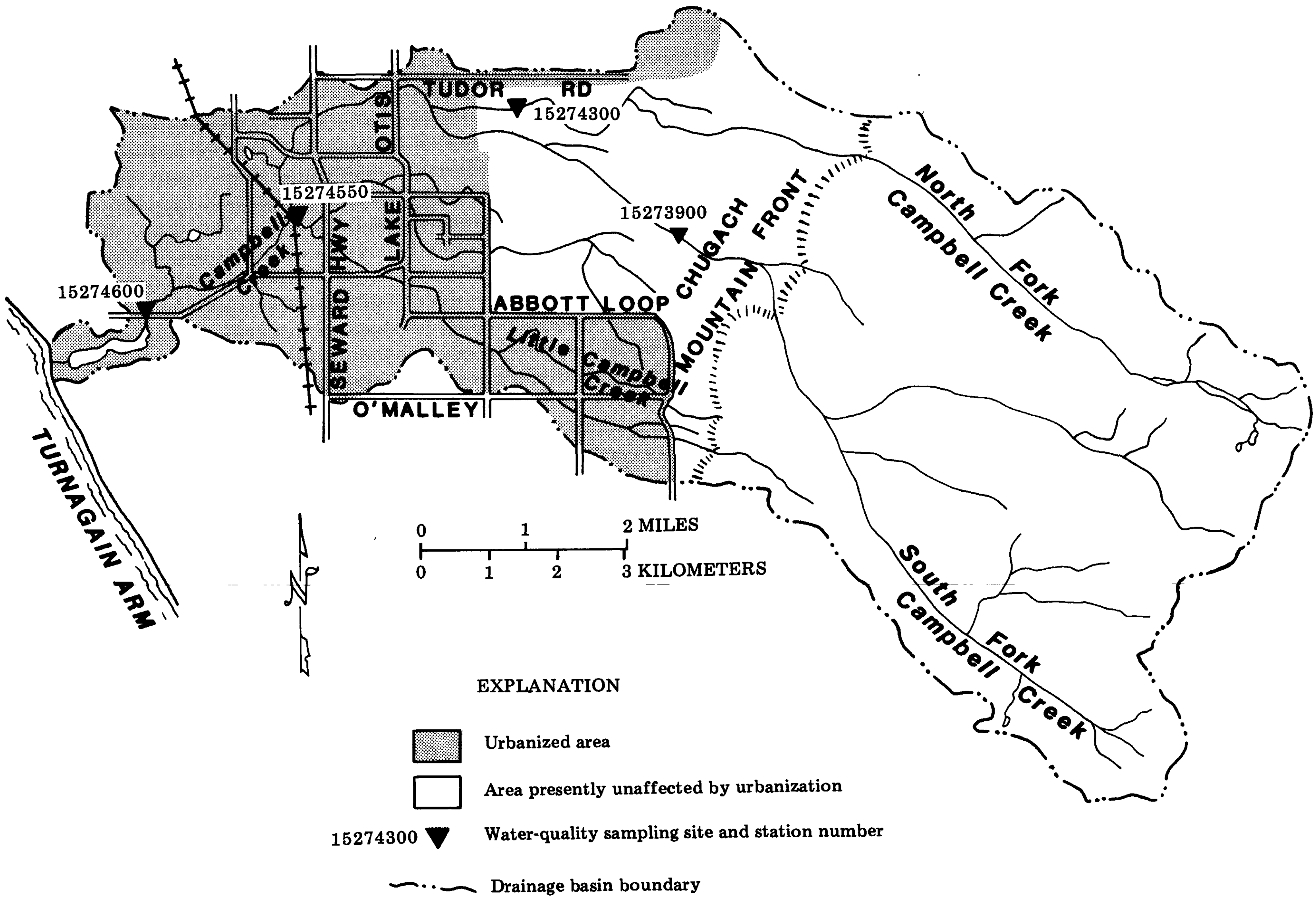

Figure 2.--Campbell Creek drainage basin.

Little Campbell Creek subbasin (Little Campbell) has an area of 15.1 mi^2. The stream is approximately 8 mi long and drains to the west-northwest through areas of low, medium, and high density housing, light industry, and commercial development. Continuous discharge records were collected at this site from April 1981 to October 1981.

Campbell Creek subbasin (Campbell Creek) has an area of 16.0 mi^2 and the sampling site is located just upstream from Campbell Lake. The main stem of Campbell Creek is 8 mi long. It begins at the confluence of the South Fork and North Fork Campbell Creeks and receives flow from Little Campbell as well as from other small, unnamed tributaries. A large portion of the main stem is flanked by parkland commonly referred to as the Campbell Creek greenbelt. Discharge records have been collected at this site since 1966.

SAMPLE COLLECTION AND ANALYSIS

Water-quality samples were collected by hand at all four sites from March 1980 to September 1981, except at Little Campbell Creek where an automatic sampler was used for one storm event in August 1981. Samples were taken during different flow periods in accordance with procedures established by the American Public Health Association (1980), Skougstad and others (1979), and Greeson and others (1977). Samples were analyzed for constituents generally considered to be indicative of urbanization: several dissolved ion species, nutrients, trace metals, organics, and fecal coliform bacteria. Water-quality data collected during the study period are published by the U.S. Geological Survey (1981, 1982).

Water-quality data have been collected at South Fork Campbell Creek, North Fork Campbell Creek, and Campbell Creek periodically from 1959 to 1970. Where possible, these data were compared with the water-quality data collected during the study period.

STREAMFLOW CHARACTERISTICS

Precipitation-Runoff Relations

Average annual precipitation in the Anchorage area is approximately 15 in., measured at the International Airport (fig. 1). About half the precipitation occurs as rain, generally from May through September, and the rest as snow from October through April. Actual precipitation during the study period (March 1980-September 1981) totaled 32.3 in. (measured at the airport). Average total for the same period would have been 24 in. (fig. 3). Much of the "above normal" precipitation occurred in July and August 1981.

Monthly runoff for the four subbasins for the study period was calculated along with long-term monthly runoff for South Fork Campbell Creek, North Fork Campbell Creek, and Campbell Creek (table 2). The highest runoff occurs in the two undeveloped subbasins. The increase in precipitation with increasing altitude in those two mountain-front basins probably overrides the effects of a particular land use in influencing runoff. In addition, porous glacial and alluvial-fan deposits in the upper parts of the subbasins of Little Campbell and main stem Campbell Creeks favor infiltration of ground water, which further reduces surface runoff from these more developed areas (Barnwell and others, 1972, p. 23).

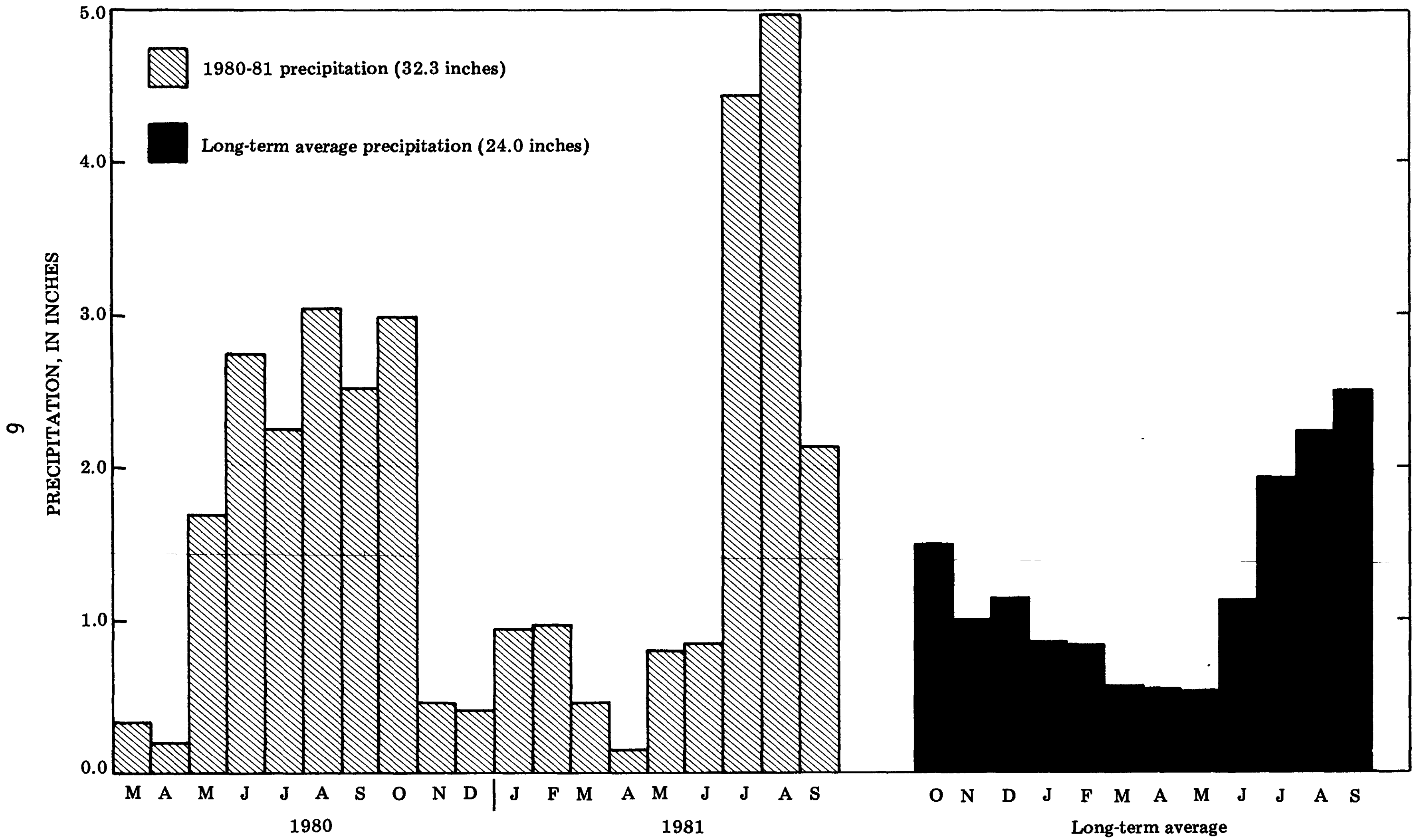

Figure 3.--Precipitation during the study period and long-term precipitation at Anchorage International Airport.

Table 2.--Monthly precipitation and runoff for subbasins within the Campbell Creek basin

[SP, study period; LT, long-term average; r, precipitation as rain; s, precipitation as snow]

Month	Precipitation (inches)	Runoff (inches)							
		South Fork		North Fork		Little Campbell		Campbell Creek	
		SP	LT	SP	LT	SP	LT	SP	LT
1980									
March	0.30s	0.50	0.53	0.52	0.39	No record available	No record available	0.37	0.23
April	.19r	.48	.50	.67	.54			.87	.48
May	1.68r	1.51	1.60	.82	.71			1.06	.94
June	2.73r	4.02	4.29	2.78	2.56			2.88	2.15
July	2.27r	3.67	3.87	4.79	3.36			3.69	2.13
August	3.06r	2.54	2.68	3.79	2.16			2.97	1.63
September	2.53r	2.59	2.73	3.25	2.16			2.32	1.55
October	2.99r	2.04	2.15	2.97	1.67			2.59	1.27
November	.49s	1.23	1.30	1.76	1.09			1.16	.73
December	.41r	.94	.99	1.15	.75			.64	.51
1981									
January	.93s	.73	.77	.66	.61			.80	.37
February	.97r	.82	.57	.31	.36			.52	.23
March	.41r	.66	.53	.34	.39			.67	.23
April	.19r	.64	.50	.36	.54			.49	.48
May	.81r	3.17	1.60	1.18	.71	1.09		1.34	.94
June	.83r	3.44	4.24	1.95	2.56	.24		1.68	2.15
July	4.39r	4.71	3.87	3.16	3.36	.50		2.52	2.13
August	4.96r	6.87	2.68	4.33	2.16	.88		3.62	1.63
September	2.15r	2.63	2.73	2.19	2.16	.43		1.67	1.55

Peak Flows

Peak flows for the four subbasins in the Campbell Creek basin are caused primarily by snowmelt runoff in the spring and by moderate, but persistent rainfall in late summer. Peak discharges of various recurrence intervals were determined for three of the sites (table 3) by standard statistical procedures (U.S. Water Resources Council, 1981). Estimating equations are available for the Anchorage area (Freethey and Scully, 1980). These equations were developed from streamflow and physical characteristics of natural basins and did not account for factors characteristic of urban areas. Therefore, in this study, no estimates of peak discharge were determined for Little Campbell Creek.

Table 3.--Peak discharge values

Station	Discharge, in cubic feet per second per square mile, for the recurrence interval indicated, in years				
	2	5	10	25	50
South Fork	9.2	13.0	15.6	19.2	22.0
North Fork	5.0	6.6	7.8	9.2	10.3
Campbell Creek	3.9	5.4	6.4	7.7	8.8

The highest peak discharges during the study period occurred during the storm of August 12, 1981. The peak at South Fork Campbell Creek was 18.8 $(ft^3/s)/mi^2$ (25-year peak), at North Fork Campbell Creek, 7.5 $(ft^3/s)/mi^2$ (10-year peak), and at Campbell Creek, 6.4 $(ft^3/s)/mi^2$ (15-year peak).

Peak discharges from South Fork Campbell Creek and North Fork Campbell Creek, the natural subbasins, are higher than the peak discharges of Campbell Creek, the partly urbanized subbasin. These differences are probably due to steeper slopes and higher rainfall in the South Fork and North Fork Campbell Creek subbasins. Also, water from South Fork Campbell Creek enters the ground-water system downstream from the measuring site. However, differences in peak discharges could change as urbanization continues and as more of the area becomes impervious (Laenen, 1980).

Low Flows

Low-flow discharges for various recurrence intervals were computed for three of the study sites (table 4). Low-flow characteristics for South Fork Campbell Creek, North Fork Campbell Creek, and Campbell Creek were obtained by analyzing streamflow records assuming a Log-Pearson Type III frequency distribution of low flows. Equations have been developed for estimating low-flow characteristics at ungaged sites in the Anchorage area. However, these equations were not used for Little Campbell Creek because they do not account for characteristics of urban areas, and the streamflow record at Little Campbell Creek is not of adequate length to make a frequency analysis.

Table 4.--Low-flow discharge values

Station	Discharge, in cubic feet per second per square mile for the recurrence interval indicated, in years — 7 consecutive days			30 consecutive days		
	2	10	20	2	10	20
South Fork	0.38	0.32	0.31	0.40	0.36	0.36
North Fork	.21	.10	.07	.25	.12	.09
Campbell Creek	.16	.05	.04	.17	.08	.06

Low flows are greatest in South Fork and North Fork Campbell Creeks. The much lower values for Campbell Creek probably reflect a combination of factors -- loss of streamflow to the ground-water system downstream from the measuring sites on the North Fork and South Fork Campbell Creeks, and more rapid runoff from the urbanizing lower portion of the basin.

WATER QUALITY

Campbell Creek is an important recreational stream. Thus, the quality of its water is important, not only for public health reasons but to protect the aquatic environment and maintain an aesthetically acceptable stream. A broad range of physical, chemical, and biological characteristics of surface water in the Campbell Creek basin was determined during the study period. Samples were collected during four flow conditions:

1. Baseflow: sustained or fair-weather runoff, usually composed largely of ground-water discharge into the stream.
2. Stormflow: runoff produced directly by rainfall.
3. Lowland snowmelt: meltwater from accumulated snow and ice at altitudes lower than 500 feet.
4. Highland snowmelt: meltwater from accumulated snow and ice at altitudes higher than 500 feet.

Only conditions 1, 2, and 4 occur at North Fork and South Fork Campbell Creeks and only conditions 1, 2, and 3 occur at Little Campbell Creek. Baseflow conditions exist at Little Campbell Creek when highland snowmelt is contributing runoff to North Fork Campbell Creek and at South Fork Campbell Creek. Similarly, baseflow conditions exist at South Fork and North Fork Campbell Creeks during periods of runoff from lowland snowmelt at Little Campbell Creek. However, these three sites were sampled concurrently during each of the flow periods in order to compare differences in water quality even though flow conditions were different at the sites.

Specific Conductance

Specific conductance is a measure of the ability of water to conduct an electric current, expressed in micromhos per centimeter at 25°C. Specific conductance is related to the type and concentration of ions in solution. It is a readily measured property that can be used to indicate the dissolved-solids or ion content in water.

Ranges in specific-conductance values and discharge values measured at the four sites are shown in table 5. During baseflow conditions the highest specific conductance values measured were in Little Campbell Creek. These high values could be the results of local geology in the Little Campbell Creek subbasin rather than urbanization. The specific conductance of Campbell Creek does not appear to be affected by water from Little Campbell Creek during periods of baseflow, probably due to dilution by flows from South Fork and North Fork Campbell Creeks.

Table 5.--Observed values of specific conductance

Type of flow	Station	Number of samples	Range of discharge (ft^3/s)	Range of specific conductance (μmho/cm at 25°C)
Baseflow	South Fork	10	15-186	65-100
	North Fork	12	6-39	96-152
	Little Campbell	8	0.2-10	190-255
	Campbell Creek	11	19-154	100-150
Lowland snowmelt	South Fork	5	12-15	79-100
	North Fork	9	3.8-10	89-140
	Little Campbell	31	1.3-42	150-223
	Campbell Creek	30	24-103	103-150
Highland snowmelt	South Fork	11	109-218	45-60
	North Fork	14	16-87	85-115
	Little Campbell	3	7.3-9.7	200-210
	Campbell Creek	12	112-307	65-90
Stormflow	South Fork	5	245-450	39-55
	North Fork	6	56-98	76-91
	Little Campbell	10	15-33	175-275
	Campbell Creek	9	116-429	51-106

North Fork Campbell Creek, South Fork Campbell Creek, and Campbell Creek have similar ranges in specific-conductance values during highland snowmelt periods. Although Little Campbell Creek has high specific-conductance values during this period it has no apparent effect on water in Campbell Creek. This is probably due to the dilution of the main stem by inflow from North Fork and South Fork Campbell Creeks. This condition generally holds true during storm periods, although during small storms slightly higher values of specific conductance in Campbell Creek may be due in part to the influence of Little Campbell Creek.

During periods of snowmelt in the lowlands, the inflow from Little Campbell Creek has an apparent effect on the quality of water in the main stem of Campbell Creek. During this flow condition, discharges at North Fork Campbell Creek and South Fork Campbell Creek may not be sufficient to dilute the flow from Little Campbell Creek. Also, during lowland snowmelt there may be a flushing of street de-icing materials into Campbell Creek between Little Campbell Creek and the measuring site on Campbell Creek.

In South Fork Campbell Creek specific conductance is inversely proportional to discharge (fig. 4). Similar correlations were found at North Fork Campbell Creek and Campbell Creek but a poor correlation was found at Little Campbell Creek. Equations relating specific conductance to discharge were developed for the four study sites (table 6). The correlation coefficient for Little Campbell Creek indicates that specific conductance is not closely related to discharge. This suggests that during storms, urban areas may contribute runoff with higher dissolved constituents than natural areas. The good correlations at North Fork, South Fork, and Campbell Creeks may be the result of dilution during storm and snowmelt periods, which is more significant in these streams than in Little Campbell Creek.

Table 6.--Equations relating discharge and specific conductance

[SC, specific conductance, in micromhos per centimeter at 25°C; Q, discharge, in cubic feet per second]

Station	Equation	Correlation coefficient	Standard error of estimate (percent)
South Fork	$SC=175(Q)^{-0.232}$	-0.90	14
North Fork	$SC=179(Q)^{-0.169}$	-.85	12
Little Campbell	$SC=224(Q)^{-0.069}$	-.38	16
Campbell Creek	$SC=429(Q)^{-0.312}$	-.79	19

Linear regression techniques were used to relate specific conductance with other water-quality constituents. Good correlations were found between specific conductance, dissolved solids, and alkalinity (fig. 5, table 7).

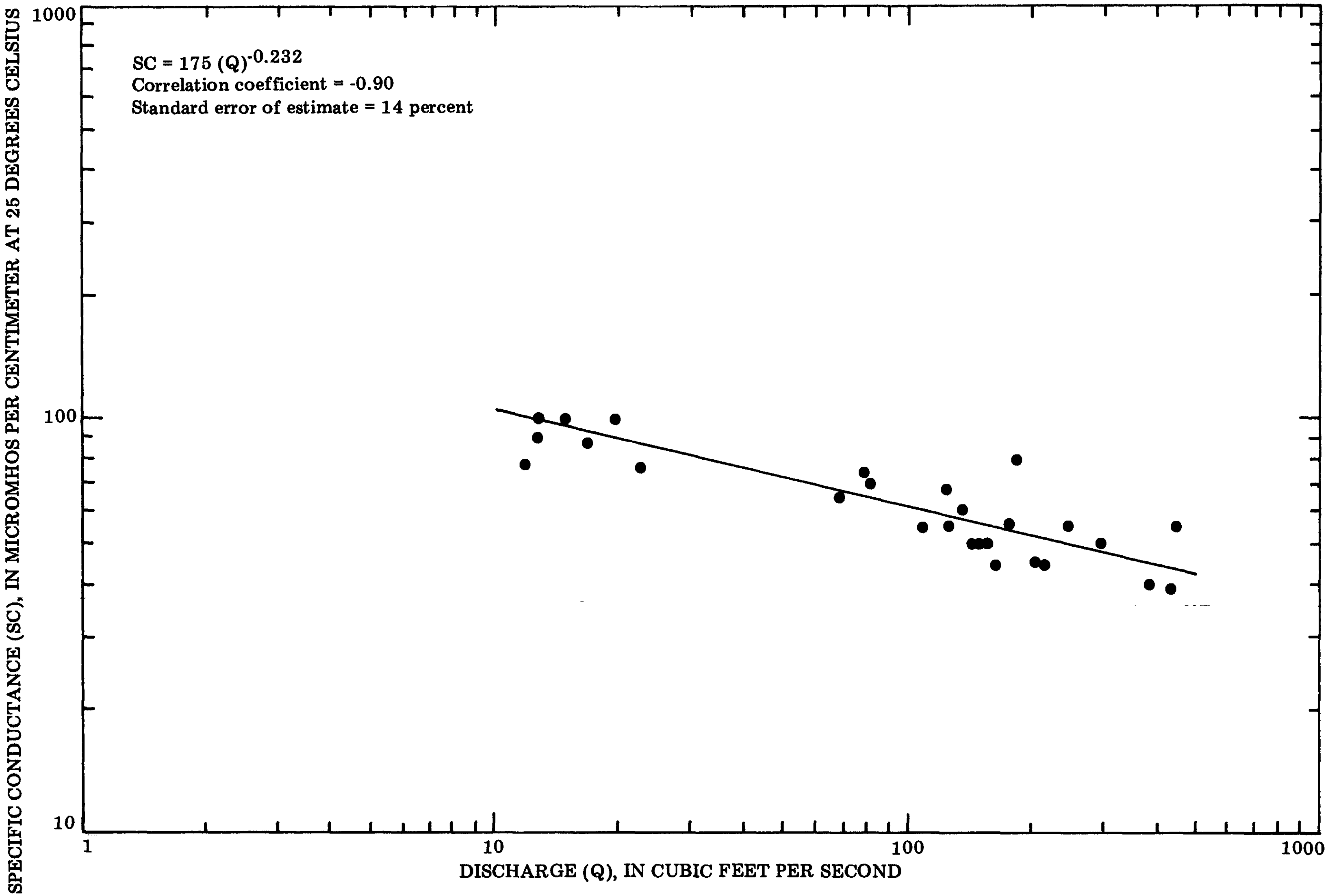

Figure 4.--Relation between discharge and specific conductance for South Fork Campbell Creek.

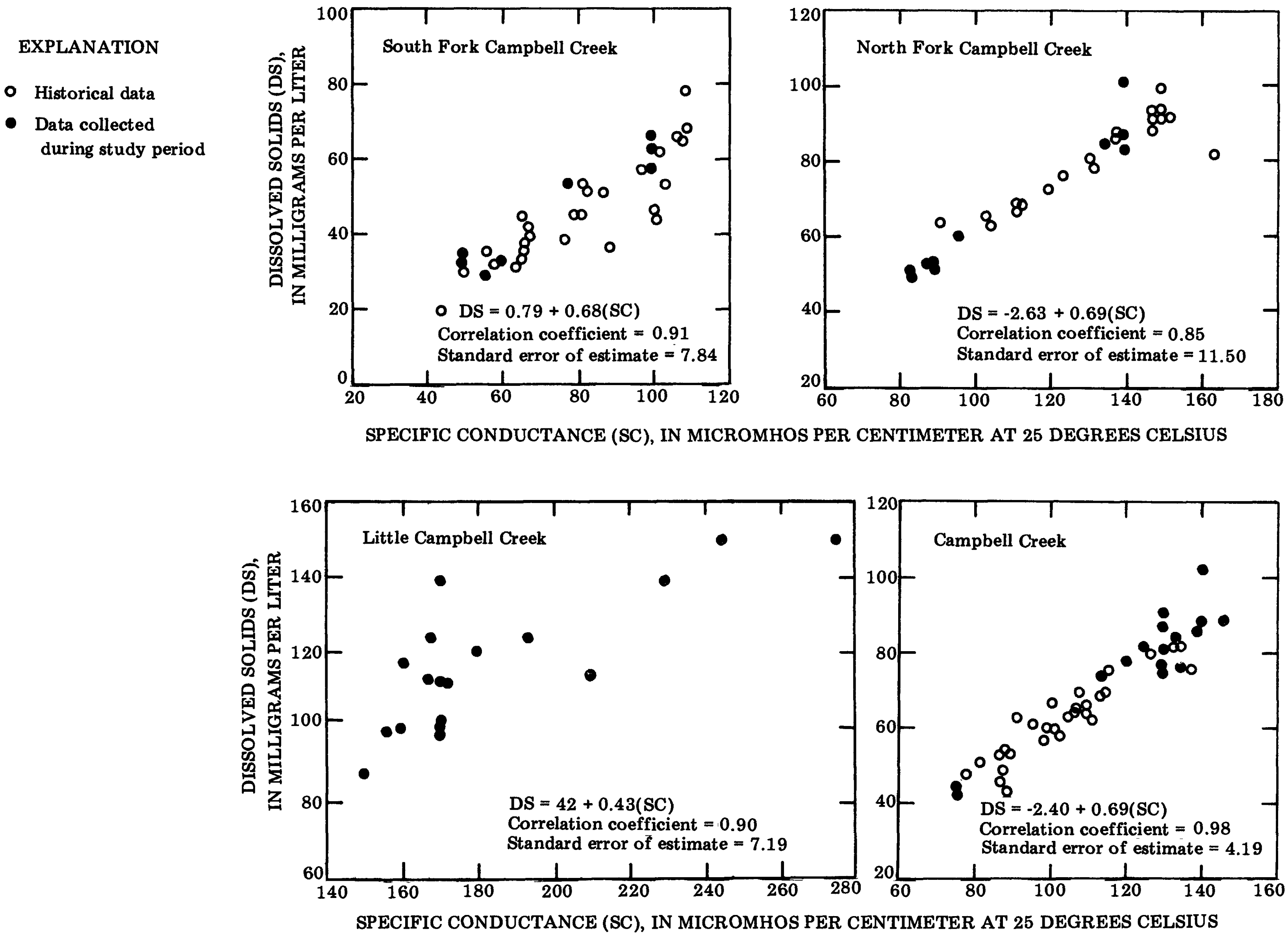

Figure 5.--Relation between dissolved solids and specific conductance.

Table 7.--Results of regression analyses between specific conductance with alkalinity and dissolved solids

[DS, dissolved solids; Alk, alkalinity; both in milligrams per liter. SC, specific conductance, in micromhos per centimeter at 25°C]

Station	Number of samples	Equations	Correlation coefficient	Standard error of estimate (mg/L)
South Fork	15	DS= 0.79 + 0.68(SC)	0.91	7.84
	20	Alk= -2.67 + 0.36(SC) $SC \geq 39$	.97	2.04
North Fork	17	DS= -2.63 + 0.69(SC)	.85	11.50
	19	Alk= -3.77 + 0.37(SC) $SC \geq 76$	.98	1.49
Little Campbell	19	DS= 42.0 + 0.43(SC)	.90	7.19
	22	Alk= -47.4 + 0.60(SC) $SC \geq 155$	.94	4.48
Campbell Creek	23	DS= -2.40 + 0.69(SC)	.98	4.19
	32	Alk= 1.63 + 0.31(SC) $SC \geq 65$	.97	2.38

Dissolved Constituents

Values of dissolved constituents were determined for the four streams during the four conditions of flow (table 8). Although only a few samples were taken during the four flow conditions, some general observations can be made.

During highland snowmelt periods and during baseflow periods, the concentrations of dissolved constituents in Campbell Creek are similar to that in North Fork and South Fork Campbell Creeks. This suggests that Little Campbell Creek does not measurably affect the main stem Campbell Creek during either flow condition because its flow is then only a small percentage of the total flow in Campbell Creek.

The high concentrations of dissolved constituents from Little Campbell Creek during lowland snowmelt impacts Campbell Creek. Also, concentrations during storm flows are higher at Campbell Creek than those at North Fork and South Fork Campbell Creeks suggesting that some effects may be due to Little Campbell Creek and other small tributaries draining lowland areas.

A linear regression analysis was made between concentration of dissolved solids and selected dissolved constituents (fig. 6 and table 9). Historical data are also plotted on the graphs for South Fork and North Fork Campbell Creeks and Campbell Creek. No significant changes in water quality with time are apparent. The

Table 8.--Observed values of dissolved consituents

[Data in milligrams per liter; constituents and conditions where multiple samples were taken and only one value is shown indicate that all the samples had the same value]

Constituent	Station	Baseflow: Number of samples	Baseflow: Range	Lowland snowmelt: Number of samples	Lowland snowmelt: Range	Highland snowmelt: Number of samples	Highland snowmelt: Range	Stormflow: Number of samples	Stormflow: Range
Calcium	South Fork	3	13-15	1	14	2	7.2	5	5.8-7.6
	North Fork	3	19-20	1	19	2	13	6	11-13
	Little Campbell	3	24-32	5	17-21	1	27	3	28-30
	Campbell Creek	3	15-19	8	15-18	3	10	5	9.3-22
Chloride	South Fork	3	.4-.6	1	1.6	2	.1-1.8	5	.1
	North Fork	3	.9-1.4	1	4.6	2	.2-.3	6	.1-.3
	Little Campbell	3	6.3-16	5	8.2-13	1	5.2	3	12-15
	Campbell Creek	3	1.9-4.4	8	5.2-11	3	.8-1.0	5	1.0-5.9
Magnesium	South Fork	3	1.8-2.5	1	2.4	2	.9-1.1	5	.4-1.0
	North Fork	3	2.9-3.3	1	3.3	2	1.8-2.0	6	1.5-1.8
	Little Campbell	3	5.3-6.5	5	4.1-5.3	1	5.7	3	6.5-7.4
	Campbell Creek	3	3.0-4.0	8	3.1-3.9	3	1.5-1.8	5	1.8-4.1
Potassium	South Fork	3	.3-.5	1	.3	2	.2-.3	5	.2
	North Fork	3	.4-.8	1	.8	2	.2	6	.3-.4
	Little Campbell	3	.8-1.3	5	1.4-2.5	1	.7	3	1.3-1.5
	Campbell Creek	3	.4-.7	8	.9-2.0	3	.2	5	.4-.6
Silica	South Fork	3	6.9-8.8	1	8.5	2	5.0-5.1	5	4.1-5.3
	North Fork	3	7.7-8.9	1	9.0	2	5.7	6	4.6-5.6
	Little Campbell	3	9.3-12.0	5	6.2	1	9.0	3	8.6-11.0
	Campbell Creek	3	7.1-8.7	8	5.7-8.5	3	5.6-5.8	5	5.7-8.5
Sodium	South Fork	3	1.2-1.7	1	1.5	2	.8-1.5	5	.6-.7
	North Fork	3	1.8-2.1	1	3.5	2	1.2	6	1.1-1.3
	Little Campbell	3	3.6-4.3	5	5.3-7.7	1	3.5	3	6.7-7.6
	Campbell Creek	3	2.0-2.8	8	3.7-8.4	3	1.1-1.2	5	1.6-4.0

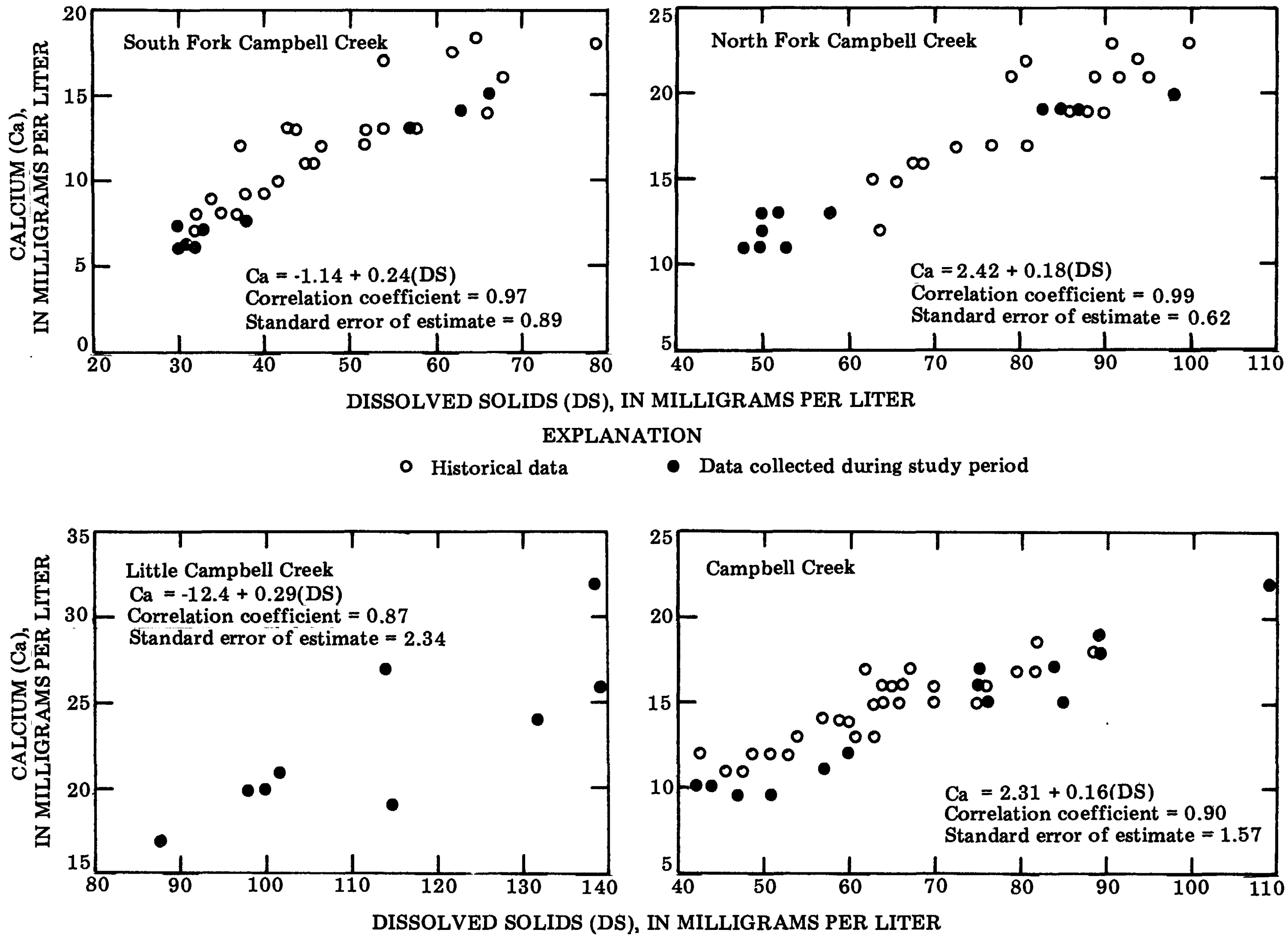

Figure 6.--Relation between calcium and dissolved solids.

historical dissolved-solids concentrations are calculated values (sum of constituents), but in this study dissolved-solids values are gravimetrically determined (residue on evaporation). The equations given in figure 6 were developed using only the data collected during this study.

Table 9.--Results of regression analyses between dissolved solids and selected dissolved constituents

[Ca, calcium; Cl, chloride; Na, sodium; DS, dissolved solids; all in milligrams per liter]

Station	Number of samples	Equations	Correlation coefficient	Standard error of estimate (mg/L)
South Fork	10	Ca= -1.14 + 0.24(DS)	0.97	0.89
	10	Cl= -0.15 + 0.01(DS)	.36	.61
	10	Na= 0.09 + 0.02(DS)	.79	.27
		$DS \geq 30$		
North Fork	12	Ca= 2.42 + 0.18(DS)	.99	.62
	12	Cl= -2.15 + 0.04(DS)	.69	.97
	12	Na= -0.36 + 0.03(DS)	.79	.45
		$DS \geq 54$		
Little Campbell	10	Ca= -12.4 + 0.29(DS)	.87	2.34
	10	Cl= 22.2 - 0.10(DS)	-.40	3.34
	10	Na= 14.3 - 0.07(DS)	-.63	1.28
		$DS \geq 112$		
Campbell Creek	17	Ca= 2.31 + 0.16(DS)	.90	1.57
	17	Cl= -4.92 + 0.12(DS)	.75	2.31
	17	Na= -1.69 + 0.07(DS)	.68	1.50
		$DS \geq 49$		

Suspended Sediment

Concentrations of suspended sediment in streams in the Campbell Creek basin are relatively low. The highest concentration of suspended sediment determined for the main stem of Campbell Creek was 312 mg/L in a sample collected in August 1981. During the same period a sample containing a concentration of 1350 mg/L suspended sediment was taken from Little Campbell Creek. This relatively high value may have been the result of road and parking lot construction occurring in the subbasin at the time.

Sediment transport curves were constructed to show the relation between discharge and suspended-sediment load (fig. 7). A comparison of suspended-sediment loads at

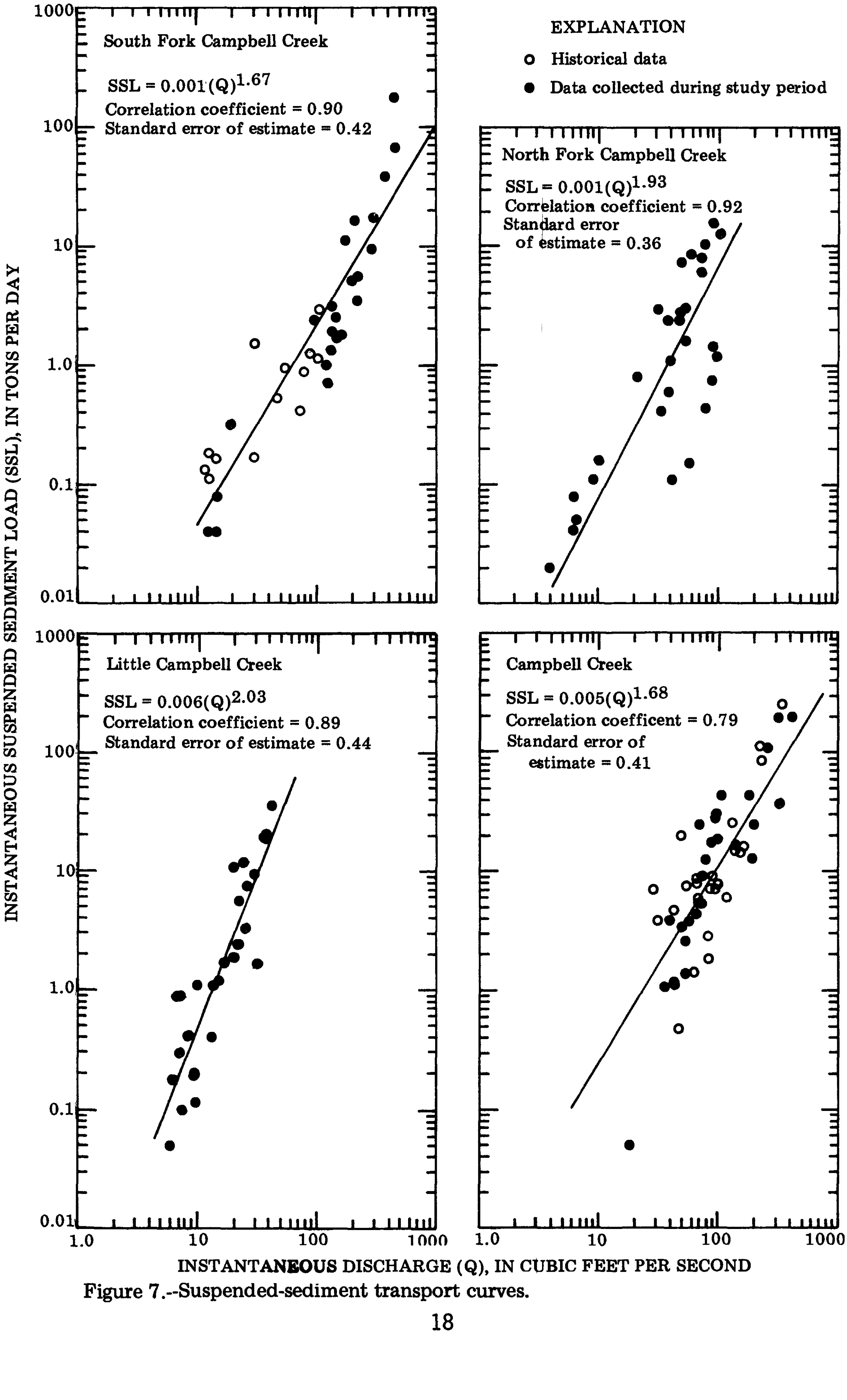

Figure 7.--Suspended-sediment transport curves.

various discharges for North Fork and South Fork Campbell Creeks and Little Campbell Creek with the suspended-sediment loads for Campbell Creek suggests that Little Campbell Creek often provides much of the sediment in Campbell Creek. This can be further illustrated by comparing synoptic discharges and samples (taken within one hour of each other) for both stations (figs. 8 and 9). These illustrations indicate that although the flow of Little Campbell Creek provides from 10 to 50 percent of the flow of Campbell Creek, much of the time from 50 to 100 percent of the suspended-sediment load in Campbell Creek is contributed by Little Campbell Creek.

For this study the sampler used did not permit sampling closer than about 0.3 ft above the stream bottom. Therefore, the sediment below this level, which constitutues the bedload, was not measured.

Historical suspended-sediment data for South Fork Campbell Creek and Campbell Creek, were compared with data collected during this study; no significant changes have taken place in the suspended-sediment transport relationship to water discharge in these two streams.

Trace Metals

Although there is no precise definition of "trace metals", the term is generally applied to metals that occur in water in concentrations less than 1.0 mg/L. Samples were collected at all four sites for determination of the following metals (table 10): aluminum, arsenic, iron, lead, and manganese. Maximum allowable concentrations for Alaska State finished drinking water are 0.01 mg/L (10 µg/L) for aluminum, 0.3 mg/L (300 µg/L) for iron, 0.05 mg/L (50 µg/L) for lead, arsenic, and manganese (Alaska Department of Environmental Conservation, 1979). Comparison of the data collected for this study with the State standard is not possible because analyses included metals on the sediment as well as in the water.

Because the highest concentrations of trace metals occurred during periods of high runoff, when suspended-sediment concentrations were also relatively high, and because these metals have an affinity for sorption on sediment, linear regression techniques were used to relate suspended-sediment concentrations to trace metals. Concentrations of aluminum and iron correlate well with concentrations of suspended sediment at all four sites, but the relation between suspended sediment and lead and manganese varied from site to site (table 11). Since arsenic concentrations did not correlate well with suspended-sediment concentrations, no regression analysis was performed. The trace-metal concentrations are given as total, which include both the dissolved and suspended components. Thus, the regression equations given do not represent the actual correlation between suspended trace metals and suspended sediment.

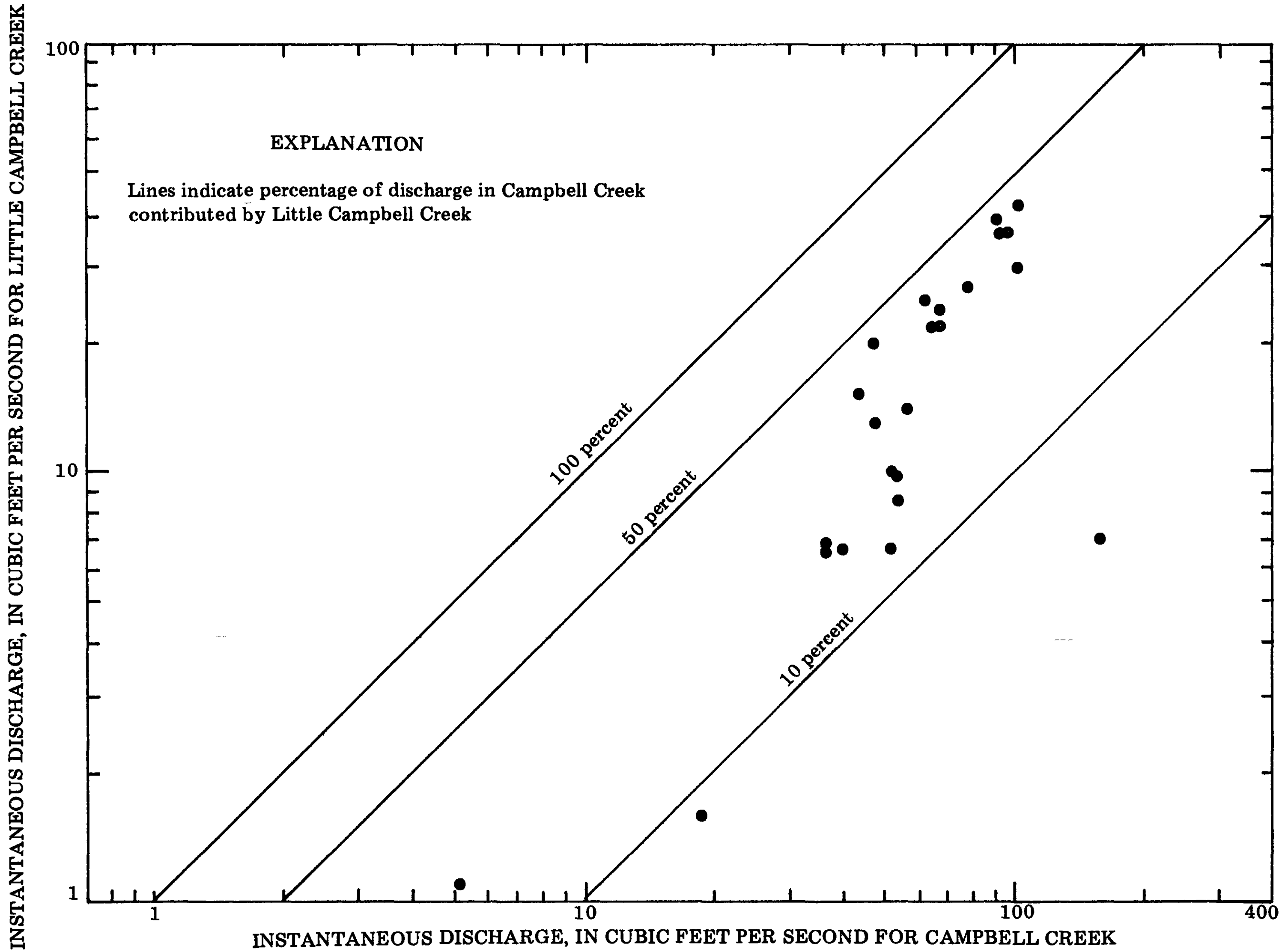

Figure 8.--Comparison of instantaneous discharge values between Little Campbell Creek and Campbell Creek.

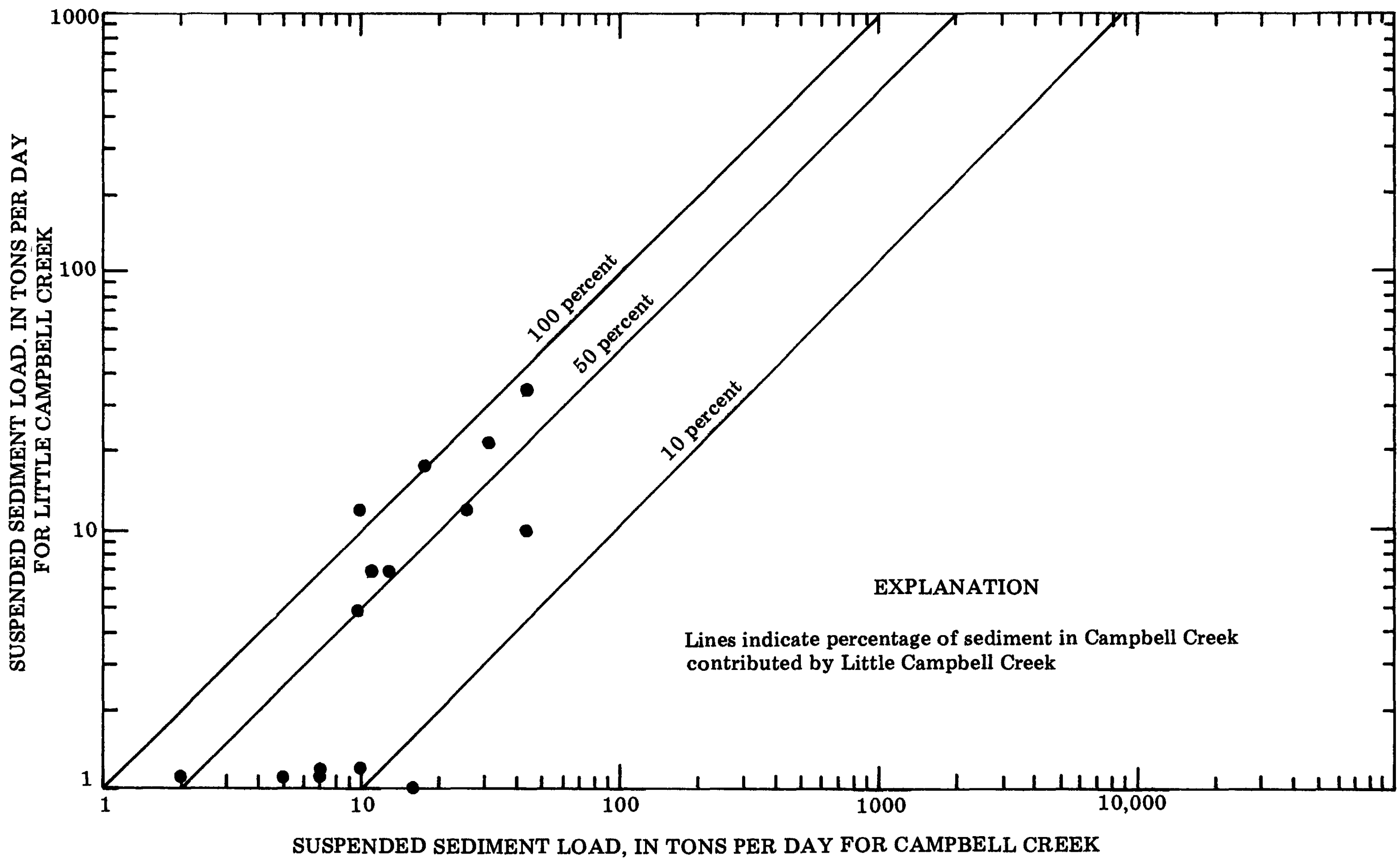

Figure 9.--Comparison of instantaneous suspended-sediment loads between Little Campbell Creek and Campbell Creek.

Table 10.--Trace-metal concentrations

Constituent	Station	Number of samples	Range (µg/L)
Aluminum	South Fork	10	50-1,100
	North Fork	11	80-1,200
	Little Campbell	20	280-18,000
	Campbell Creek	17	70-4,000
Arsenic	South Fork	10	1-2
	North Fork	11	1-3
	Little Campbell	20	1-12
	Campbell Creek	17	1-4
Iron	South Fork	10	50-2,400
	North Fork	11	240-1,800
	Little Campbell	20	1,000-40,000
	Campbell Creek	17	370-8,500
Lead	South Fork	10	0-30
	North Fork	11	0-7
	Little Campbell	20	2-97
	Campbell Creek	17	0-49
Manganese	South Fork	10	0-70
	North Fork	11	10-50
	Little Campbell	20	110-1,300
	Campbell Creek	17	20-440

Table 11.--Results of regression analyses between trace metals and suspended sediment

[Al, aluminum; Mn, manganese; Pb, lead; Fe, iron; all in micrograms per liter. SS, suspended sediment, in milligrams per liter]

Station	Number of samples	Equations	Correlation coefficient	Standard error of estimate (µg/L)
South Fork	10	Al=187 + 6.6(SS)	0.79	253
	10	Mn=8.8 + 0.45(SS)	.81	16
	10	Pb=8.6 - 0.07(SS)	-.32	10
	10	Fe=290 + 12(SS)	.69	619
		SS≥1		
North Fork	11	Al=113 + 13.2(SS)	.97	130
	11	Mn=24 + 0.253(SS)	.52	18
	11	Pb=2.6 - 0.006(SS)	-.09	3
	11	Fe=329 + 15.2(SS)	.91	292
		SS≥2		
Little Campbell	20	Al=2800 + 7.6(SS)	.53	4,614
	20	Mn=304 + 0.83(SS)	.89	169
	20	Pb=21.5 + 0.063(SS)	.72	23
	20	Fe=4120 + 33.6(SS)	.94	4,450
		SS≥5		
Campbell Creek	16	Al=550 + 10.1(SS)	.60	950
	16	Mn=99 + 0.94(SS)	.55	100
	16	Pb=8.5 + 0.027(SS)	.13	14
	16	Fe=776 + 33.9(SS)	.92	1,040
		SS≥1		

Fecal Coliform Bacteria

The percentages of fecal coliform bacteria counts from the four stream sites which exceeded 20 FC/100 mL (Alaska State drinking water standard) and 200 FC/100 mL (Alaska State standard for contact recreation) are shown in figure 10. The highest coliform counts measured were those during snowmelt periods and storm periods. The highest bacteria count observed, 9700 FC/100 mL sample, was at Little Campbell Creek, and may be attributed to a gradual buildup of fecal contaminants on land and the subsequent runoff of the contaminants during periods of snowmelt or rainfall.

Fecal coliform samples (taken within one hour of each other) and the corresponding instantaneous discharge values were used to illustrate the impact of Little Campbell Creek on loads of fecal coliform bacteria in the main stem of Campbell Creek. Generally, Little Campbell Creek contributes 10-50 percent of the flow of Campbell Creek (fig. 8). However, much of the time 50-100 percent of the bacteria load passing the sampling site at Campbell Creek is from Little Campbell Creek (fig. 11).

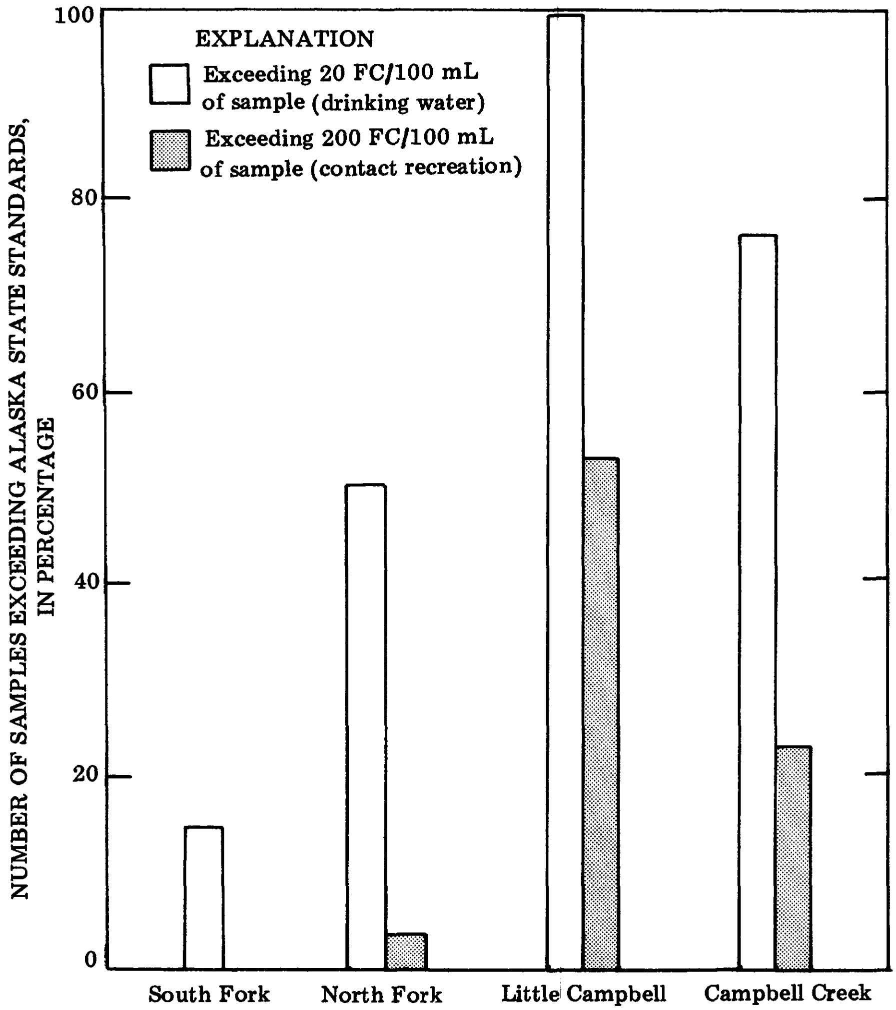

Figure 10.--Percentage of fecal coliform samples exceeding Alaska State standards.

Nitrogen and Phosphorus

Concentrations of several species of nitrogen--ammonia nitrogen (dissolved), ammonia plus organic nitrogen (dissolved, suspended, and total), and nitrite plus nitrate nitrogen (dissolved)--were determined at each of the four sampling sites (table 12). Nitrogen concentrations did not vary markedly between any of the flow conditions. Concentrations greater than 1 mg/L nitrite and 10 mg/L nitrate in drinking water may cause methemoglobinemia (oxygen starvation) in infants. Campbell Creek is not currently used as a source of public water supply, but concentrations of nitrite and nitrate were significantly less than the above limits.

Because trace concentrations of ammonia nitrogen can be toxic to aquatic life, the U.S. Environmental Protection Agency (1977) suggests that un-ionized ammonia not exceed 0.02 mg/L. Based on average temperature and pH in these streams the total

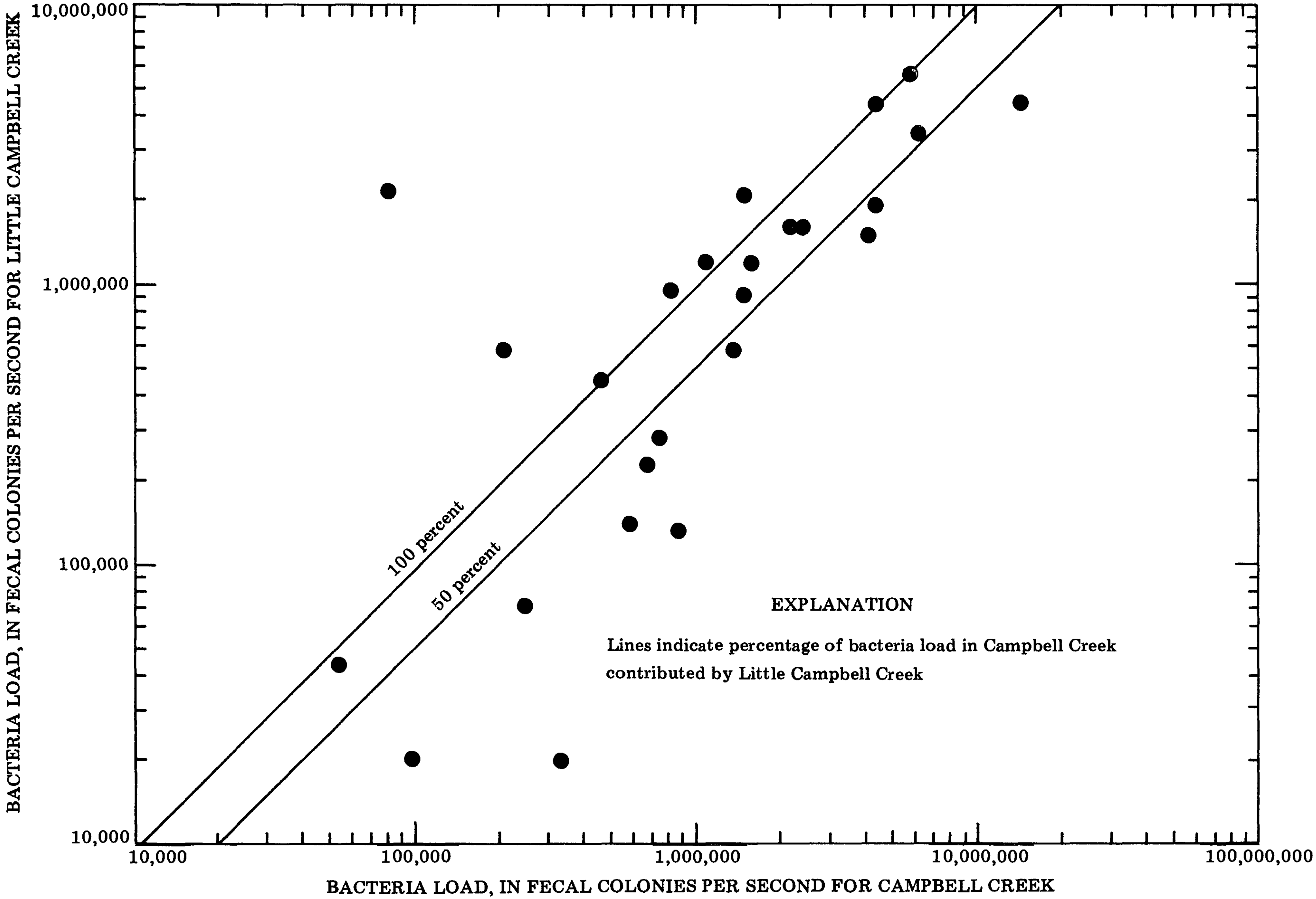

Figure 11.--Comparison of bacteria load between Little Campbell Creek and Campbell Creek.

Table 12.--Observed concentrations of nitrogen and phosphorus

[Data in milligrams per liter]

Constituent	South Fork		North Fork		Little Campbell		Campbell Creek	
	Number of samples	Range	Number of samples	Range	Number of samples	Range	Number of samples	Range
Ammonia nitrogen (dissolved)	16	0-0.16	17	0-0.14	23	0.01-0.48	27	0.01-0.50
Organic nitrogen (dissolved)	16	.15- .46	17	.13-1.7	23	.34-1.3	27	.21-1.1
Ammonia plus organic nitrogen (dissolved)	16	.20- .46	17	.18-1.7	23	.46-1.4	27	.26-1.4
Ammonia plus organic nitrogen (suspended)	15	0- .78	16	0-1.4	23	0-1.8	26	0-2.0
Ammonia plus organic nitrogen (total)	15	.29-1.2	16	.31-1.4	23	.43-3.2	26	.28-1.6
Nitrate plus nitrite nitrogen (dissolved)	16	.03-1.2	17	.09-1.1	27	.19- .98	27	.08- .82
Nitrate nitrogen (dissolved)	--	--	--	--	11	.08- .48	13	.04- .42
Nitrite nitrogen (dissolved)	--	--	--	--	11	.01- .04	13	0- .02
Phosphorus (dissolved)	15	0- .017	16	0- .025	23	.003-.048	27	0- .081
Phosphorus (total)	15	0- .102	16	0- .105	23	.008-.970	27	.005- .290

ammonia (ionized plus un-ionized) should not exceed about 1.5 mg/L. The highest concentrations of ammonia nitrogen observed, 0.48 and 0.50 mg/L, were in waters of Little Campbell Creek and Campbell Creek, respectively. Maximum concentrations observed in North Fork Campbell Creek and South Fork Campbell Creek were 0.14 mg/L and 0.16 mg/L respectively.

Dissolved phosphorus concentrations ranged from 0 mg/L to 0.081 mg/L and total phosphorus concentrations ranged from 0 mg/L to 0.97 mg/L at the four sites. The highest concentrations were observed in samples collected at Little Campbell Creek and Campbell Creek during a storm in August 1981. These concentrations may have been caused by a flushing of accumulated phosphorus by high runoff (15-year peak discharge) during the storm.

SUMMARY AND CONCLUSIONS

Data collected during this study of the Campbell Creek basin provided the following information:

1. Differences exist in dissolved constituents between streams draining urbanized basins and streams draining nonurbanized basins in the Anchorage area. Little Campbell Creek (a partly urbanized basin) had the highest concentrations of dissolved solids, suspended sediment, and fecal coliform bacteria.

2. Little Campbell Creek affects the water quality in Campbell Creek during lowland snowmelt periods by increasing the loading of dissolved solids, suspended sediment, and fecal coliform bacteria. However, during storm periods, North Fork and South Fork Campbell Creeks tend to dilute the water and lessen the impact of Little Campbell Creek.

3. Further and more detailed study of Little Campbell Creek is needed in order to identify specific sources of higher concentrations of constituents.

ADDITIONAL DATA NEEDS

The data collected during the 18-month period indicate differences in water-quality characteristics of streams in urban and nonurban areas of Anchorage. However, additional data would be needed to:

1. Evaluate changes in runoff caused by urbanization. It is generally thought that increased imperviousness resulting from urbanization would increase peak discharge. Comparison of runoff from areas of high urbanization with nearby natural areas would provide information needed for this evaluation.

2. Evaluate differences in runoff and water quality between different land uses such as commercial areas, high-density housing areas, and low-density housing areas.

3. Evaluate mathematical models which could be used to simulate runoff and water-quality characteristics of areas of different land use. Models which could be successfully calibrated would save considerable costs in data collection.

4. Evaluate the effects of total rainfall and rainfall intensity on runoff and water-quality loads.

5. Evaluate the effects of rainfall quality on the quality of surface-water runoff.

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