STATE OF ALASKA

DEPARTMENT OF NATURAL RESOURCES

DIVISION OF GEOLOGICAL AND GEOPHYSICAL SURVEYS

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Report of Investigation 84-27
WATER-QUALITY DATA FROM THE BELUGA COAL-FIELD AREA, ALASKA JUNE 1982 THROUGH MARCH 1983

By
Mary A. Maurer and Douglas C. Toland

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WATER-QUALITY DATA FROM THE BELUGA COAL AREA, ALASKA
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By
Mary A. Maurer[1] and Douglas C. Toland[2]

INTRODUCTION

The Alaska Departments of Natural Resources (DNR) and Environmental Conservation (DEC) are mandated to collect and evaluate water-quality data in the state. In this project, surface-water quality and benthic-invertebrate data were collected in five streams in the Beluga coal-field area from June 1982 through March 1983. This report contains the tabulated data from the first year of the 2-yr study. Background information, data-collection procedures, and analytical methods are also presented.

The potential effects of coal mining on surface-water quality in Alaska have been identified by Zemansky and others (1975; 1976), University of Alaska Arctic Environmental Information and Data Center (1980), and Kolankiewicz (1982). Baseline data on the surface-water quality of the Beluga coal-field area have been presented by Scully and others (1980; 1981), Cook Inlet Region, Inc. and Placer Amex, Inc. (1981), and Environmental Research and Technology, Inc. (1983).

The purpose of this study is to obtain and evaluate water-quality information from five streams (Bishop Creek, Capps Creek, Middle Creek, Lone Creek, and the Chuitna River) in the Beluga coal-field area prior to mining. Specific objectives of the study are to: 1) determine the baseline chemical water quality of the streams; 2) assess the biological water quality in two streams by determining the distribution and abundance of benthic invertebrates; and 3) supplement the data base of the streams to assess the effects of future coal mining on water quality.

ACKNOWLEDGMENTS

This study is a cooperative effort between DGGS and DEC. We thank Tom Trible and staff at the DEC Laboratory in Douglas for providing sample quality assurance and state-of-the-art analyses. We also thank George McCoy (DGGS) for providing technical advice, assisting with fieldwork, and reviewing the manuscript, Jim Munter (DGGS) for reviewing the manuscript, Roger Allely and Stan Carrick (DGGS) for assisting with fieldwork, and Jenny Weir and Roberta Mann (DGGS) for typing the tables. We appreciate the loan of laboratory equipment from the U.S. Geological Survey Water Resources Division, Anchorage and the assistance of personnel at Alaska Helicopters, Inc.

STUDY AREA

The Beluga coal-field area is located in south-central Alaska on the

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west side of Cook Inlet, about 80 km west of Anchorage (fig. 1). The terrain is covered with birch, poplar, and spruce forests and numerous muskegs. The piedmont lowlands gradually rise to a treeless plateau that extends northwest to the Alaska Range. Surficial deposits are predominantly of glacial origin. Coal (subbituminous to lignite) is located in the Tyonek Formation of the Tertiary Kenai Group (Calderwood and Fackler, 1972). Coal reserves are estimated at 2.26 billion short tons (McGee, 1973). Four state coal leases presently exist in the area: Lone Ridge, Center Ridge, Capps Creek, and Middle Creek Chuitna River (Diamond Shamrock) (fig. 1). Large-scale mining development of these areas is proposed to begin within the next two decades. Active exploration and test mining have occurred.

Climate in the study area is transitional between maritime and continental. Annual precipitation is about 100 cm in the Chuitna River basin, mostly in the form of rainfall in September and October and heavy snowfall during the winter (Scully and others, 1981). Streams are ice-covered from December to April. The snow pack in late winter 1982 was about 0.7 m at Congahbuna Lake (fig. 1) and 2.1 m at Capps plateau (U.S. Soil Conservation Service, 1983).

Three principal rivers, the Beluga, the Chichantna, and the Chuitna flow through the coal-field area. The Chichantna and the Beluga Rivers are the only glacial streams in the area.

Bishop Creek and Capps Creek are in the Beluga River drainage. Bishop Creek has an average slope of 12.9 m/km and meanders in its lowermost 20 km. The stream picks up a significant sediment load in its lower reaches from banks composed of "very fine banded plastic clay" (Barnes, 1966). Bishop Creek was chosen as a control stream because no mining operation is proposed within the watershed. Capps Creek has an average slope of 61.5 m/km as it flows through the Capps coal field and the large landslide on the north flank of Capps plateau. The stream picks up a heavy sediment load under high flow conditions. Stream slope averages 3.8 m/km over the lowermost 3.2 km.

Middle and Lone Creeks (fig. 1) have their headwaters in the Chuitna coal field and slope about 12.5 and 10.4 m/km, respectively. Both streams meander in their middle reaches, carry little suspended sediment, and have an iron-colored stain in the water column and on substrates during periods of low flow.

The slope of the Chuitna River is about 12.3 m/km. Slab-shaped coal boulders and cobbles make up part of the stream's substrate. The river carries very little suspended sediment except during high-flow conditions.

Locations of sampling sites are shown on figure 1. The sites on Capps Creek and the Chuitna River are located at U.S. Geological Survey (USGS) gaging stations. All chemical water-quality sampling sites are downstream from prospective coal-mining areas in the lower portion of the drainage basin.

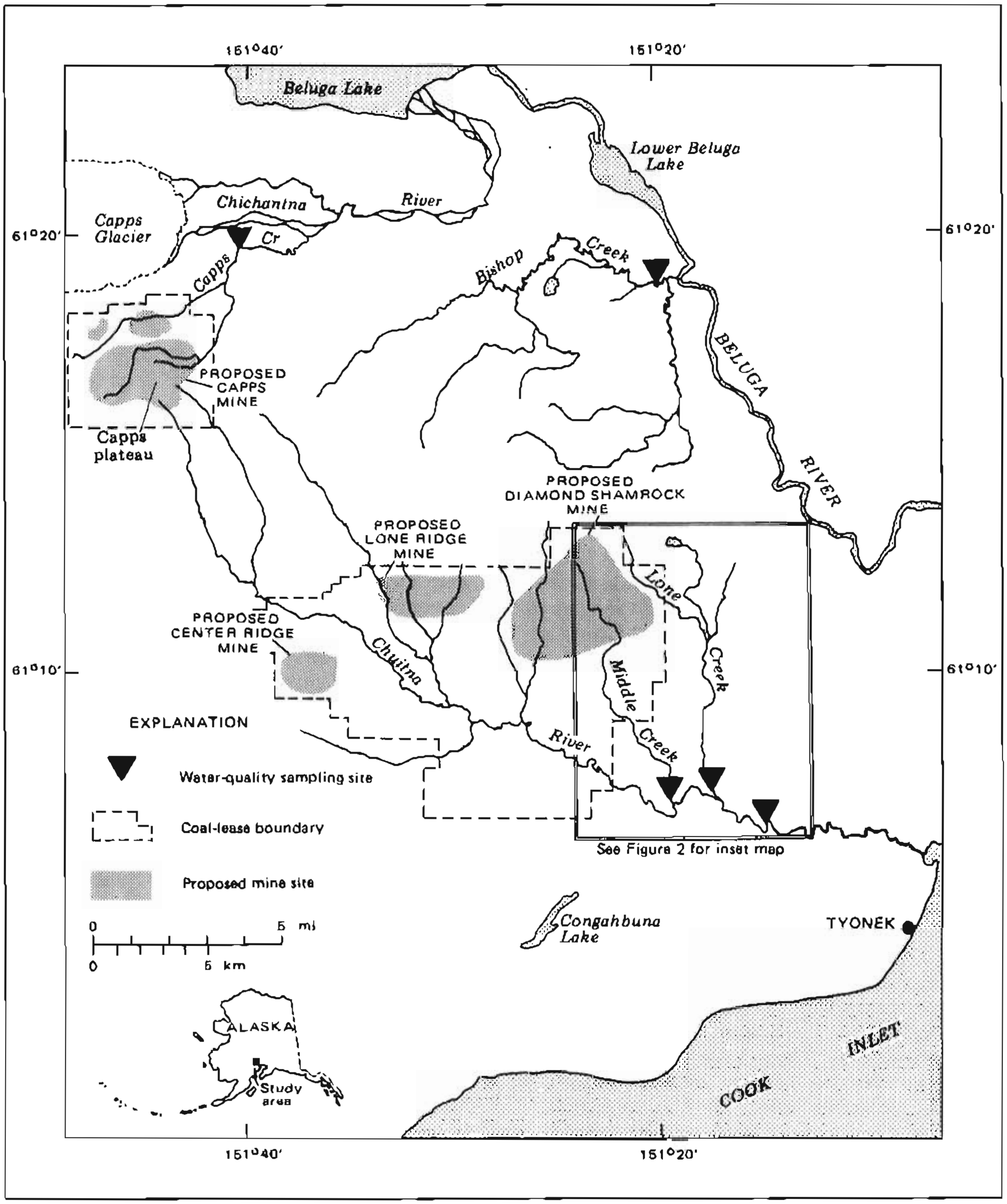

Figure 1. Location map of water-quality sampling sites, Beluga coal-field area, Alaska.

METHODS AND MATERIALS

Physical and Chemical Parameters

Water-quality data were collected quarterly to correspond with summer high flow (June), summer low flow (August), early-winter flow (December), and late-winter flow (March). A digital 4041 Hydrolab was used to collect field data on water temperature, dissolved oxygen, pH, and specific conductance. An Orion digital pH meter was used with the Hydrolab, and readings were taken in areas of low velocities to avoid streaming effects across membrane probes.

Stream discharge was measured at each water-chemistry sampling site according to USGS methods (Carter and Davidian, 1968; Buchanan and Somers, 1969). Velocities were measured with a Price or Marsh-McBirney current meter.

Bicarbonate alkalinity was determined in the field by titrating an untreated sample with 0.01639N sulfuric acid to an endpoint of pH 4.5 (U.S. Environmental Protection Agency, 1983).

Water samples were collected by grab sampling. Bottle preparation, sample preservation, and handling times for all samples were consistent with methods of the U.S. Environmental Protection Agency (1979; 1982) and the American Public Health Association (1980) except for trace-metal, nitrate-nitrogen, and ammonia samples. Metal and nutrient samples were treated in the laboratory in accordance with DEC procedures. Trace metals are designated as 'recoverable' instead of 'total recoverable' because the EPA methods on sample acidification and preparation were modified (appendix A). The dissolved concentration of a chemical constituent was determined by filtering the sample through a 0.45-μ membrane filter.

Selected constituents from the following groups were analyzed: recoverable and dissolved metals; major ions; nutrients; volatile, aromatic organics; and acid extractable and base/neutral extractable organics. Color, turbidity, total filtrable and nonfiltrable residue, chemical-oxygen demand, and gross alpha radiation were determined in the laboratory. All chemical samples except selected organic samples were analyzed at the DEC laboratory in Douglas.

Analytical results expressed as less than (<) a specified concentration (for example, <200 mg/l) are below the limit of quantitation. The limit of quantitation is the lowest concentration of a chemical constituent that the analytical process can quantitate at a statistically chosen level of accuracy. This level is determined by the laboratory. The limit of detection is the lowest concentration of a chemical constituent that the analytical process can, on the average, determine. Appendix A lists the limit of quantitation, limit of detection, method of analysis, and instrumentation for each chemical constituent.

Biological Sampling

A synoptic survey of benthic invertebrates was conducted in August 1982 at five sites on Middle Creek and six sites on Lone Creek (fig. 2). Sampling sites were approximately equally spaced along the streams. Sites are numbered downstream (sites 1-5 on Middle Creek and sites 6-11 on Lone Creek).

U.S. Geological Survey quantitative methods were used to sample invertebrates (Slack and others, 1973). Two sampling points were randomly picked on a belt transect at each site. A 0.1-m^2 modified Hess bottom sampler was used. The leading half of the sampler contained 600-μ nylon Nitex netting, and the trailing half and bag contained 300-μ Nitex mesh.

Habitat parameters measured at benthic sampling sites included water depth, water temperature, stream width, and stream gradient. Stream-substrate composition, riparian habitat, and benthic-habitat type were estimated.

Benthic invertebrates were preserved in 70-percent alcohol and sorted and identified into major taxonomic groups. Insects were identified to the genus or species level. Some early instar specimens were identified to order or family only. Midges, predominantly chironomids, were identified to family.

Invertebrate density, species richness, Shannon-Weaver diversity index (log base 2), and evenness were calculated for each sample. Densities were standardized to organisms/m^2.

RESULTS

The results of the chemical water-quality analyses are presented in tables 1-4. Results are expressed in micrograms per liter (μg/l) or milligrams per liter (mg/l). Analytical procedures are described in appendix A.

The results of the benthic invertebrate survey are shown in tables 5 and 6. Benthic-habitat parameters are listed in table 7.

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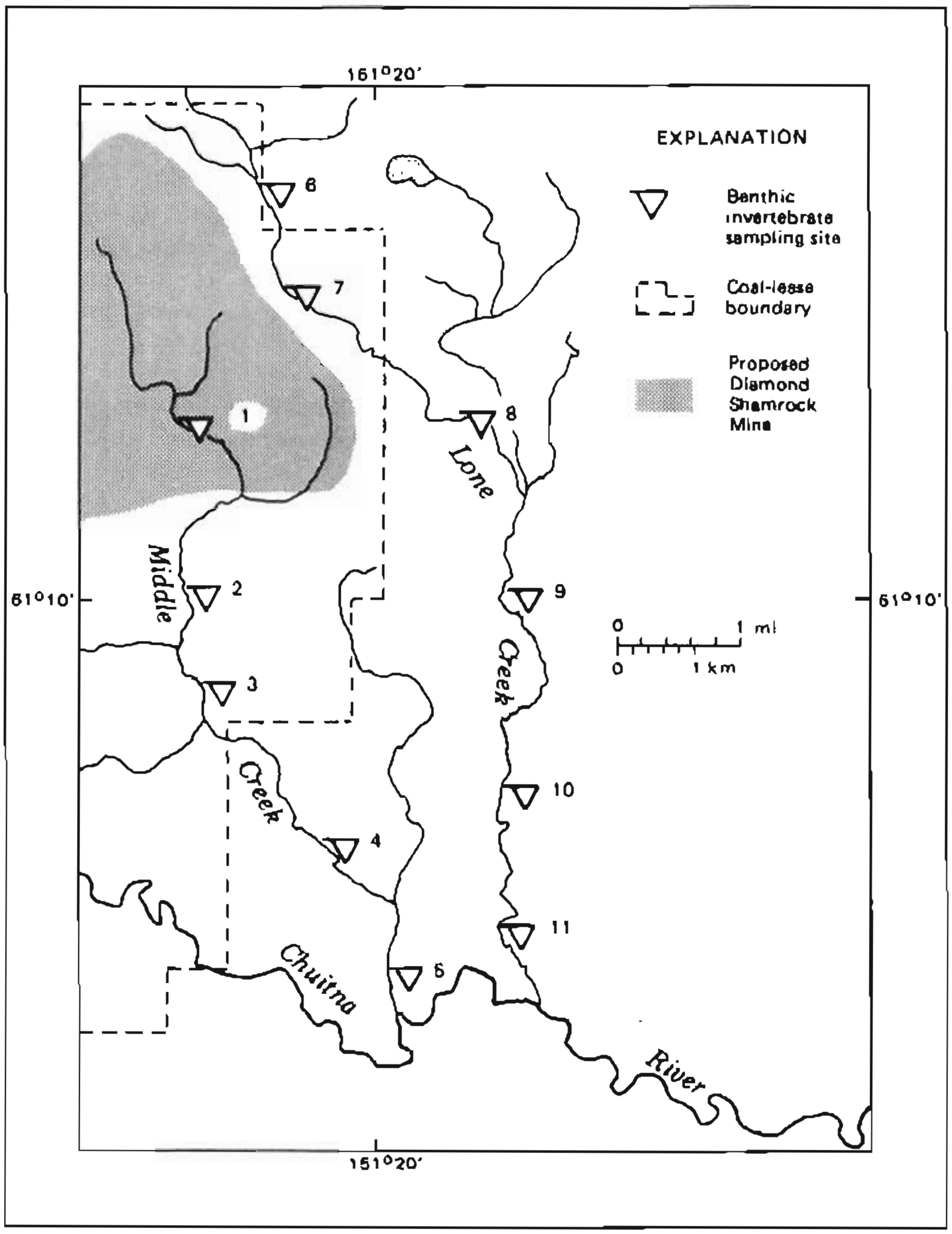

Figure 2. Location map of benthic-invertebrate sampling sites, Beluga coal-field area, Alaska.

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Table 1. Field parameters and major inorganic constituents of Beluga water-quality samples.

Date	Time	Stream-flow, instan-taneous (cfs)	Specific conductance (umhos at 25°C)	pH (units)	Water temperature (°C)	Color, (platinum cobalt units)	Oxygen, dissolved (mg/l)	Calcium, recoverable (mg/l as Ca)
Bishop Creek								
06-17-82	0930	170	28	6.45	8.6	40	10.5	<5
08-24-82	0900	14	53	7.15	11.8	45	10.4	5.4
12-15-82	0935	15	33	7.30	-0.1	35	11.3	<5
03-30-83	1230	13	61	6.85	-0.1	40	12.2	5.0
Capps Creek								
06-17-82	1230	153	39	6.10	6.8	60	10.9	10.6
08-24-82	1100	15	43	7.40	10.5	35	11.0	5.5
12-15-82	1225	9	48	6.90	0.5	30	12.4	5.1
03-30-83	1420	5	57	7.25	1.1	35	13.8	6.3
Middle Creek								
08-24-82	1305	8	56	[a] -	10.3	45	[a] -	7.0
12-16-82	1225	7	59	7.60	0	50	12.7	5.5
03-31-83	1410	4	77	6.85	0.2	45	14.2	7.4
Lone Creek								
08-24-82	1540	13	63	7.45	11.8	40	[a] -	6.2
12-16-82	1100	16	58	7.20	-1.0	45	12.9	5.5
03-31-83	1150	10	66	7.10	0	50	14.1	6.0
Chuitna River near Tyonek								
06-17-82	1700	[b]552	29	6.85	10.2	25	10.0	<5
08-24-82	1600	[c]105	51	7.75	14.2	30	10.5	5.3
12-16-82	0900	[d]116	42	7.00	-1.0	35	12.5	5.0
03-31-83	1100	[e]105	57	7.20	0.1	30	14.3	6.4

[a]Equipment failure, no measurement.
[b]USGS gaging-station measurement, C. Savard, oral communication, USGS-WRD office, Anchorage, Alaska.
[c]U.S. Geological Survey (1983).
[d]USGS measurement, 12-1-82, 1120 hr, provisional records subject to revision, unpublished data on file in USGS-WRD office, Anchorage, Alaska.
[e]USGS measurement, 3-7-83, 0930 hr, provisional records subject to revision, unpublished data on file in USGS-WRD office, Anchorage, Alaska.

Table 1. (con.)

Date	Time	Stream-flow, instan-taneous (cfs)	Calcium, dissolved, (mg/l as Ca)	Magnesium, recoverable (mg/l as Mg)	Magnesium, dissolved (mg/l as Mg)	Sodium, recoverable (mg/l as Na)	Sodium, dissolved (mg/l as Na)	Potassium, recoverable (mg/l as K)
Bishop Creek								
06-17-82	0930	170	<5	<5	<5	<10	<10	<1
08-24-82	0900	14	<5	<5	<5	<10	<10	<1
12-15-82	0935	15	<5	<5	<5	<10	<10	<1
03-30-83	1230	13	5.0	<5	<5	7.5	7.5	<1
Capps Creek								
06-17-82	1230	153	<5	13.3	<5	<10	<10	3.1
08-24-82	1100	15	6.0	<5	<5	<10	<10	1.6
12-15-82	1225	9	5.0	<5	<5	<10	<10	<1
03-30-83	1420	5	6.2	<5	<5	3.4	3.3	<1
Middle Creek								
08-24-82	1305	8	7.5	<5	<5	<10	<10	<1
12-16-82	1225	7	5.5	<5	<5	<10	<10	<1
03-31-83	1410	4	7.7	<5	<5	4.7	4.7	<1
Lone Creek								
08-24-82	1540	13	6.3	<5	<5	<10	<10	<1
12-16-82	1100	16	5.4	<5	<5	<10	<10	<1
03-31-83	1150	10	6.5	<5	<5	4.8	5.5	<1
Chuitna River near Tyonek								
06-17-82	1700	[b]552	<5	<5	<5	<10	<10	<1
08-24-82	1600	[c]105	5.3	<5	<5	<10	<10	<1
12-16-82	0900	[d]116	7.5	<5	2.8	<10	<10	<1
03-31-83	1100	[e]105	6.4	<5	<5	4.0	4.1	<1

[b]USGS gaging-station measurement, C. Savard, oral communication, USGS-WRD office, Anchorage, Alaska.
[c]U.S. Geological Survey (1983).
[d]USGS measurement, 12-1-82, 1120 hr, provisional records subject to revision, unpublished data on file in USGS-WRD office, Anchorage, Alaska.
[e]USGS measurement, 3-7-83, 0930 hr, provisional records subject to revision, unpublished data on file in USGS-WRD office, Anchorage, Alaska.

Table 1. (con.)

Date	Time	Stream-flow, instan-taneous (cfs)	Potassium, dissolved (mg/l as K)	Alkalinity, bicarbonate (field) (mg/l as HCO_3)	Sulfate, (mg/l as SO_4)	Nitrogen, nitrate total (mg/l as N)	Nitrogen, ammonia total (mg/l as N)	Phosphorus, ortho, total (mg/l as P)
Bishop Creek								
06-17-82	0930	170	<1	12	<10	<1	<0.1	<0.5
08-24-82	0900	14	<1	30	<10	<1	<0.1	<0.5
12-15-82	0935	15	<1	27	<10	<1	<0.1	<0.5
03-30-83	1230	13	<1	31	<10	<1	<1.0	<0.05
Capps Creek								
06-17-82	1230	153	<1	10	15	<1	<0.1	<0.5
08-24-82	1100	15	<1	31	<10	<1	<0.1	<0.5
12-15-82	1225	9	<1	31	<10	<1	<0.1	<0.5
03-30-83	1420	5	<1	36	<10	<1	<1.0	<0.05
Middle Creek								
08-24-82	1305	8	<1	45	<10	<1	<0.1	<0.5
12-16-82	1225	7	<1	35	<10	<1	<0.1	<0.5
03-31-83	1410	4	<1	46	<10	<1	<1.0	<0.05
Lone Creek								
08-24-82	1540	13	<1	[a] -	<10	<1	<0.1	<0.5
12-16-82	1100	16	<1	35	<10	<1	<0.1	<0.5
03-31-83	1150	10	<1	40	<10	<1	<1.0	<0.05
Chuitna River near Tyonek								
06-17-82	1700	[b]552	<1	12.5	<10	<1	<0.1	<0.5
08-24-82	1600	[c]105	<1	35	<10	<1	<0.1	<0.5
12-16-82	0900	[d]116	<1	34	<10	<1	<0.1	<0.5
03-31-83	1100	[e]105	<1	39	<10	<1	<1.0	<0.05

[a]Equipment failure, no measurement.
[b]USGS gaging-station measurement, C. Savard, oral communication, USGS-WRD office, Anchorage, Alaska.
[c]U.S. Geological Survey (1983).
[d]USGS measurement, 12-1-82, 1120 hr, provisional records subject to revision, unpublished data on file in USGS-WRD office, Anchorage, Alaska.
[e]USGS measurement, 3-7-83, 0930 hr, provisional records subject to revision, unpublished data on file in USGS-WRD office, Anchorage, Alaska.

Table 1. (con.)

Date	Time	Stream-flow, instan-taneous (cfs)	Residue, total filtrable at 180°C (mg/l)	Residue, total non-filtrable at 103-105°C (mg/l)	Turbidity (nephelo-metric turbidity units)	Gross Alpha (pCi/l)	Chemical oxygen demand (COD) (mg/l)
Bishop Creek							
06-17-82	0930	170	65	71	38	<1	<25
08-24-82	0900	14	68	1.5	1.6	<1	<25
12-15-82	0935	15	80	8	4.7	<1	<25
03-30-83	1230	13	40	10	6	[f]-	<25
Capps Creek							
06-17-82	1230	153	68	3400	150	<2	<25
08-24-82	1100	15	64	172.2	31	<1	<25
12-15-82	1225	9	[g]1079	43	21	<1	<25
03-30-83	1420	5	36	7	3.4	<1	<25
Middle Creek							
08-24-82	1305	8	59	0.6	1.4	<1	<25
12-16-82	1225	7	89	1	1.7	<1	<25
03-31-83	1410	4	62	4	4.0	<1	<25
Lone Creek							
08-24-82	1540	13	78	6.3	1.4	<1	<25
12-16-82	1100	16	85	2	2.6	<1	<25
03-31-83	1150	10	66	3	3.2	<1	<25
Chuitna River near Tyonek							
06-17-82	1700	[b]552	19	8	2.0	<1	<25
08-24-82	1600	[c]105	65	0.2	0.6	<1	<25
12-16-82	0900	[d]116	80	7	3.7	<1	<25
03-31-83	1100	[e]105	63	3	4.3	<1	<25

[b]USGS gaging-station measurement, C. Savard, oral communication, USGS-WRD office, Anchorage, Alaska.
[c]U.S. Geological Survey (1983).
[d]USGS measurement, 12-1-82, 1120 hr, provisional records subject to revision, unpublished data on file in USGS-WRD office, Anchorage, Alaska.
[e]USGS measurement, 3-7-83, 0930 hr, provisional records subject to revision, unpublished data on file in USGS-WRD office, Anchorage, Alaska.
[f]Gross alpha samples lost; results unavailable.
[g]Erroneous reading suspected.

Table 2. Minor-element analysis of Beluga water-quality samples.

Date	Time	Stream-flow, instan-taneous (cfs)	Aluminum, recoverable (µg/l as Al)	Aluminum, dissolved (µg/l as Al)	Arsenic, recoverable (µg/l as As)	Arsenic, dissolved (µg/l as As)	Barium, recoverable (µg/l as Ba)	Barium, dissolved (µg/l as Ba)
Bishop Creek								
06-17-82	0930	170	3300	150	<5	<5	<200	<200
08-24-82	0900	14	295	38	<5	<5	<200	<200
12-15-82	0935	15	240	<50	<5	<5	<200	<200
03-30-83[a]	1230	13	-	-	<5	<5	<200	<200
Capps Creek								
06-17-82	1230	153	56000	13000	9	<5	280	<200
08-24-82	1100	15	300	5	5	<5	490	<200
12-15-82	1225	9	360	<50	<5	<5	<200	<200
03-30-83[a]	1420	5	-	-	<5	<5	<200	<200
Middle Creek								
08-24-82	1305	8	78	92	<5	<5	<200	<200
12-16-82	1225	7	60	<50	<5	<5	<200	<200
03-31-83[a]	1410	4	-	-	<5	<5	<200	<200
Lone Creek								
08-24-82	1540	13	89	45	<5	<5	<200	<200
12-16-82	1100	16	<50	<50	<5	<5	<200	<200
03-31-83[a]	1150	10	-	-	<5	<5	<200	<200
Chuitna River near Tyonek								
06-17-82	1700	[b]552	550	90	<5	<5	<200	<200
08-24-82	1600	[c]105	5	30	<5	<5	<200	<200
12-16-82	0900	[d]116	75	<50	<5	<5	<200	<200
03-31-83[a]	1100	[e]105	-	-	<5	<5	<200	<200

[a] Al, Be, Co, and Ni samples lost; results unavailable.
[b] USGS gaging-station measurement, C. Savard, oral communication, USGS-WRD office, Anchorage, Alaska.
[c] U.S. Geological Survey (1983, p. 171).
[d] USGS measurement, 12-1-82, 1120 hr, provisional records subject to revision, unpublished data on file in USGS-WRD office, Anchorage, Alaska.
[e] USGS measurement, 3-7-83, 0930 hr, provisional records subject to revision, unpublished data on file in USGS-WRD office, Anchorage, Alaska.

Table 2. (con.)

Date	Time	Stream-flow, instan-taneous (cfs)	Beryllium, recoverable (μg/l as Be)	Beryllium, dissolved (μg/l as Be)	Cadmium, recoverable (μg/l as Cd)	Cadmium, dissolved (μg/l as Cd)	Chromium, recoverable (μg/l as Cr)	Chromium, dissolved (μg/l as Cr)
Bishop Creek								
06-17-82	0930	170	<2	<2	<2	<2	<5	<5
08-24-82	0900	14	<2	<2	<2	<2	<10	<10
12-15-82	0935	15	<2	<2	<2	<2	<10	<10
03-30-83[a]	1230	13	-	-	<2	<2	<5	<5
Capps Creek								
06-17-82	1230	153	2.7	<2	<2	<2	36	<5
08-24-82	1100	15	<2	<2	<2	<2	<10	<10
12-15-82	1225	9	<2	<2	<2	<2	<10	<10
03-30-83[a]	1420	5	-	-	<2	<2	<5	<5
Middle Creek								
08-24-82	1305	8	<2	<2	<2	<2	<10	<10
12-16-82	1225	7	<2	<2	<2	<2	<10	<10
03-31-83[a]	1410	4	-	-	<2	<2	<5	<5
Lone Creek								
08-24-82	1540	13	<2	<2	<2	<2	<10	<10
12-16-82	1100	16	<2	<2	<2	<2	<10	<10
03-31-83[a]	1150	10	-	-	<2	<2	<5	<5
Chuitna River near Tyonek								
06-17-82	1700	[b]552	<2	<2	<2	<2	<5	<5
08-24-82	1600	[c]105	<2	<2	<2	<2	<10	<10
12-16-82	0900	[d]116	<2	<2	<2	<2	<10	<10
03-31-83[a]	1100	[e]105	-	-	<2	<2	<5	<5

[a] Al, Be, Co, and Ni samples lost; results unavailable.
[b] USGS gaging-station measurement, C. Savard, oral communication, USGS-WRD office, Anchorage, Alaska.
[c] U.S. Geological Survey (1983, p. 171).
[d] USGS measurement, 12-1-82, 1120 hr, provisional records subject to revision, unpublished data on file in USGS-WRD office, Anchorage, Alaska.
[e] USGS measurement, 3-7-83, 0930 hr, provisional records subject to revision, unpublished data on file in USGS-WRD office, Anchorage, Alaska.

Table 2. (con.)

Date	Time	Stream-flow, instan-taneous (cfs)	Cobalt, recoverable (µg/l as Co)	Cobalt, dissolved (µg/l as Co)	Copper, recoverable (µg/l as Cu)	Copper, dissolved (µg/l as Cu)	Iron, recoverable (µg/l as Fe)	Iron, dissolved (µg/l as Fe)
Bishop Creek								
06-17-82	0930	170	<5	<5	5	5	2800	260
08-24-82	0900	14	<5	<5	<5	7	800	400
12-15-82	0935	15	<5	<5	<5	<5	1200	800
03-30-83[a]	1230	13	-	-	<5	<5	1200	100
Capps Creek								
06-17-82	1230	153	40	<5	110	7	41000	700
08-24-82	1100	15	<5	<5	12	5	4300	<200
12-15-82	1225	9	<5	<5	<5	<5	1000	230
03-30-83[a]	1420	5	-	-	16	<5	600	100
Middle Creek								
08-24-82	1305	8	<5	<5	<5	<5	1500	750
12-16-82	1225	7	<5	<5	<5	<5	1200	700
03-31-83[a]	1410	4	-	-	<5	<5	1300	730
Lone Creek								
08-24-82	1540	13	<5	<5	<5	<5	1800	1300
12-16-82	1100	16	<5	<5	<5	<5	1200	500
03-31-83[a]	1150	10	-	-	<5	<5	1400	570
Chuitna River near Tyonek								
06-17-82	1700	[b]552	<5	<5	<5	<5	750	250
08-24-82	1600	[c]105	<5	<5	<5	<5	450	350
12-16-82	0900	[d]116	<5	<5	<5	<5	6100	250
03-31-83[a]	1100	[e]105	-	-	<5	<5	890	350

[a] Al, Be, Co, and Ni samples lost; results unavailable.
[b] USGS gaging-station measurement, C. Savard, oral communication, USGS-WRD office, Anchorage, Alaska.
[c] U.S. Geological Survey (1983, p. 171).
[d] USGS measurement, 12-1-82, 1120 hr, provisional records subject to revision, unpublished data on file in USGS-WRD office, Anchorage, Alaska.
[e] USGS measurement, 3-7-83, 0930 hr, provisional records subject to revision, unpublished data on file in USGS-WRD office, Anchorage, Alaska.

Table 2. (con.)

Date	Time	Stream-flow, instan-taneous (cfs)	Lead, recoverable (ug/l as Pb)	Lead, dissolved (ug/l as Pb)	Manganese, recoverable (ug/l as Mn)	Manganese, dissolved (ug/l as Mn)	Mercury, recoverable (ug/l as Hg)	Mercury, dissolved (ug/l as Hg)
Bishop Creek								
06-17-82	0930	170	<5	<5	90	35	<1	<1
08-24-82	0900	14	<5	<5	31	28	<1	<1
12-15-82	0935	15	<5	<5	63	54	<1	<1
03-30-83	1230	13	<5	<5	77	65	<1	<1
Capps Creek								
06-17-82	1230	153	60	<5	1300	75	<1	<1
08-24-82	1100	15	<5	<5	170	82	<1	<1
12-15-82	1225	9	<5	<5	84	70	<1	<1
03-30-83	1420	5	<5	<5	63	57	<1	<1
Middle Creek								
08-24-82	1305	8	<5	<5	61	50	<1	<1
12-16-82	1225	7	<5	<5	150	150	<1	<1
03-31-83	1410	4	<5	<5	68	62	<1	<1
Lone Creek								
08-24-82	1540	13	<5	<5	100	82	<1	<1
12-16-82	1100	16	<5	<5	89	82	<1	<1
03-31-83	1150	10	<5	<5	96	81	<1	<1
Chuitna River near Tyonek								
06-17-82	1700	[b]552	<5	<5	22.8	14.3	<1	<1
08-24-82	1600	[c]105	<5	<5	25	23	<1	<1
12-16-82	0900	[d]116	<5	<5	49	32	<1	<1
03-31-83	1100	[e]105	<5	<5	35	25	<1	<1

[b]USGS gaging-station measurement, C. Savard, oral communication, USGS-WRD office, Anchorage, Alaska.
[c]U.S. Geological Survey (1983, p. 171).
[d]USGS measurement, 12-1-82, 1120 hr, provisional records subject to revision, unpublished data on file in USGS-WRD office, Anchorage, Alaska.
[e]USGS measurement, 3-7-83, 0930 hr, provisional records subject to revision, unpublished data on file in USGS-WRD office, Anchorage, Alaska.

Table 2. (con.)

Date	Time	Stream-flow, instantaneous (cfs)	Nickel, recoverable (µg/l as Ni)	Nickel, dissolved (µg/l as Ni)	Selenium, recoverable (µg/l as Se)	Selenium, dissolved (µg/l as Se)	Silver, recoverable (µg/l as Ag)	Silver, dissolved (µg/l as Ag)	Zinc, recoverable (µg/l as Zn)	Zinc, dissolved (µg/l as Zn)
Bishop Creek										
06-17-82	0930	170	<10	<10	<2	<2	<5	<5	<10	20.8
08-24-82	0900	14	<10	<10	<2	<2	<5	<5	<5	15
12-15-82	0935	15	<10	<10	<2	<2	<5	<5	<10	<10
03-30-83[a]	1230	13	-	-	<2	<2	<5	<5	5.3	<5
Capps Creek										
06-17-82	1230	153	260	29	<2	<2	<5	<5	170	<10
08-24-82	1100	15	12	<10	<2	<2	<5	<5	20	<5
12-15-82	1225	9	<10	<10	<2	<2	<5	<5	<10	<10
03-30-83[a]	1420	5	-	-	<2	<2	<5	<5	11	<5
Middle Creek										
08-24-82	1305	8	<10	<10	<2	<2	<5	<5	<5	<5
12-16-82	1225	7	<10	<10	<2	<2	<5	<5	<10	<10
03-31-83[a]	1410	4	-	-	<2	<2	<5	<5	<5	<5
Lone Creek										
08-24-82	1540	13	<10	<10	<2	<2	<5	<5	<5	<5
12-16-82	1100	16	<10	<10	<2	<2	<5	<5	<10	<10
03-31-83[a]	1150	10	-	-	<2	<2	<5	<5	<5	<5
Chuitna River near Tyonek										
06-17-82	1700	[b]552	<10	<10	<2	<2	<5	<5	<10	<10
08-24-82	1600	[c]105	<10	<10	<2	<2	<5	<5	<5	<5
12-16-82	0900	[d]116	<10	<10	<2	<2	<5	<5	<10	<10
03-31-83[a]	1100	[e]105	-	-	<2	<2	<5	<5	<5	<5

[a] Al, Be, Co, and Ni samples lost; results unavailable.
[b] USGS gaging-station measurement, C. Savard, oral communication, USGS-WRD office, Anchorage, Alaska.
[c] U.S. Geological Survey (1983, p. 171).
[d] USGS measurement, 12-1-82, 1120 hr, provisional records subject to revision, unpublished data on file in USGS-WRD office, Anchorage, Alaska.
[e] USGS measurement, 3-7-83, 0930 hr, provisional records subject to revision, unpublished data on file in USGS-WRD office, Anchorage, Alaska.

Table 3. Volatile-organics analysis of Beluga water-quality samples.

Date	Time	Streamflow, instantaneous (cfs)	Benzene (µg/l)	Ethylbenzene (µg/l)	Toluene (µg/l)	p-Xylene (µg/l)	m-Xylene (µg/l)	o-Xylene (µg/l)
Bishop Creek								
06-17-82	0930	170	[a]ND	[a]ND	[a]ND	[b]---	[b]---	[b]---
12-15-82	0935	15	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
03-30-83	1230	13	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Capps Creek								
06-17-82	1230	153	[a]ND	[a]ND	[a]ND	[b]---	[b]---	[b]---
12-15-82	1225	9	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
03-30-83	1420	5	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Middle Creek								
08-24-82	1305	8	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
12-16-82	1225	7	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
03-31-83	1410	4	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Lone Creek								
08-24-82	1540	13	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
12-16-82	1100	16	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
03-31-83	1150	10	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Chuitna River near Tyonek								
06-17-82	1700	[c]552	[a]ND	[a]ND	[a]ND	[b]---	[b]---	[b]---
12-16-82	0900	[d]116	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
03-31-83	1100	[e]105	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2

[a]ND = not detected.
[b]No laboratory measurement made.
[c]USGS gaging-station measurement, C. Savard, oral communication, USGS-WRD office, Anchorage, Alaska.
[d]USGS measurement, 12-1-82, 1120 hr, provisional records subject to revision, unpublished data on file in USGS-WRD office, Anchorage, Alaska.
[e]USGS measurement, 3-7-83, 0930 hr, provisional records subject to revision, unpublished data on file in USGS-WRD office, Anchorage, Alaska.

Table 4. Organic-priority-pollutant analysis of Beluga water-quality samples.

Site	Bishop Creek		Capps Creek		Middle Creek		Lone Creek		Chuitna River	
Date	06-17-82	12-15-82	06-17-82	12-15-82	08-24-82	12-16-82	08-24-82	12-16-82	06-17-82	12-16-82
Time	0930	0935	1230	1225	1305	1225	1540	1100	1700	0900
Streamflow (cfs)	170	15	153	9	8	7	13	16	[a]552	[b]116
Parameter (µg/l)										
ACID EXTRACTABLES										
2,4,6-Trichlorophenol	<1	<2	<1	<2	<1	<2	<1	<2	<1	<2
Parachlorometacresol	<1	<2	<1	<2	<1	<2	<1	<2	<1	<2
2-Chlorophenol	<1	<2	<1	<2	<1	<2	<1	<2	<1	<2
2,4-Dichlorophenol	<1	<2	<1	<2	<1	<2	<1	<2	<1	<2
2,4-Dimethylphenol	<1	<2	<1	<2	<1	<2	<1	<2	<1	<2
2-Nitrophenol	<1	<2	<1	<2	<1	<2	<1	<2	<1	<2
4-Nitrophenol	<1	<5	<1	<5	<1	<5	<1	<5	<1	<5
2,4-Dinitrophenol	<1	<5	<1	<5	<1	<5	<1	<5	<1	<5
4,6-Dinitro-o-cresol	<1	<10	<1	<10	<1	<10	<1	<10	<1	<10
Pentachlorophenol	<1	<10	<1	<10	<1	<10	<1	<10	<1	<10
Phenol	<1	<2	<1	<2	<1	<2	<1	<2	<1	<2
BASE/NEUTRAL EXTRACTABLES										
Acenaphthene	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Benzidine	<1	<10	<1	<10	<1	<10	<1	<10	<1	<10
1,2,4-Trichlorobenzene	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Hexachlorobenzene	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Hexachloroethane	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Bis(2-chloroethyl)ether	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
2-Chloronaphthalene	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
1,2-Dichlorobenzene	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
1,3-Dichlorobenzene	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1

[a]USGS gaging-station measurement, C. Savard, oral communication, USGS-WRD office, Anchorage, Alaska.
[b]USGS measurement, 12-1-82, 1120 hr, provisional records subject to revision, unpublished data on file in USGS-WRD office, Anchorage, Alaska.

Table 4. (con.)

Site	Bishop Creek		Capps Creek		Middle Creek		Lone Creek		Chuitna River	
Date	06-17-82	12-15-82	06-17-82	12-15-82	08-24-82	12-16-82	08-24-82	12-16-82	06-17-82	12-16-82
Time	0930	0935	1230	1225	1305	1225	1540	1100	1700	0900
Streamflow (cfs)	170	15	153	9	8	7	13	16	[a]552	[b]116
Parameter (µg/l)										
1,4-Dichlorobenzene	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
3,3'-Dichlorobenzidine	<1	<10	<1	<10	<1	<10	<1	<10	<1	<10
2,4-Dinitrotoluene	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
2,6-Dinitrotoluene	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
1,2-Diphenylhydrazine(b)	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Fluoranthene	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
4-Chlorophenylphenylether	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
4-Bromophenylphenylether	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Bis(2-chloroisopropyl)ether	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Bis(2-chloroethoxy)methane	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Hexachlorobutadiene	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Hexachlorocyclopentadiene	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Isophorone	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Naphthalene	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Nitrobenzene	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
N-Nitrosodiphenylamine (a)	<1	<10	<1	<10	<1	<10	<1	<10	<1	<10
N-Nitrosodi-n-propylamine	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Bis(2-ethylhexyl)phthalate	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Butylbenzylphthalate	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Di-n-butylphthalate	[c]4.0	<1	[c]5.4	<1	[c]6.6	<1	[c]18.6	<1	[c]3.6	<1
Di-n-octylphthalate	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Diethylphthalate	[c]0.6	<1	[c]1.0	<1	[c]3.4	<1	[c]3.6	<1	[c]0.8	<1
Dimethylphthalate	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Benzo(a)anthracene	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Benzo(a)pyrene	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
3,4-Benzofluoranthene	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1

[a]USGS gaging-station measurement, C. Savard, oral communication, USGS-WRD office, Anchorage, Alaska.
[b]USGS measurement, 12-1-82, 1120 hr, provisional records subject to revision, unpublished data on file in USGS-WRD office, Anchorage, Alaska.
[c]Background contamination suspected.

Table 4. (con.)

Site	Bishop Creek		Capps Creek		Middle Creek		Lone Creek		Chuitna River	
Date	06-17-82	12-15-82	06-17-82	12-15-82	08-24-82	12-16-82	08-24-82	12-16-82	06-17-82	12-16-82
Time	0930	0935	1230	1225	1305	1225	1540	1100	1700	0900
Streamflow (cfs)	170	15	153	9	8	7	13	16	[a]552	[b]116
Parameter (µg/l)										
Benzo(k)fluoranthene	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Chrysene	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Acenaphthylene	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Anthracene	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Benzo(g,h,i)perylene	<1	[d]—	<1	[d]—	<1	[d]—	<1	[d]—	<1	[d]—
Fluorene	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Phenanthrene	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Dibenzo(a,h)anthracene	<1	[d]—	<1	[d]—	<1	[d]—	<1	[d]—	<1	[d]—
Ideno(1,2,3-c,d)pyrene	<1	—	<1	—	<1	—	<1	—	<1	—
Pyrene	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1

[a]USGS gaging-station measurement, C. Savard, oral communication, USGS-WRD office, Anchorage, Alaska.
[b]USGS measurement, 12-1-82, 1120 hr, provisional records subject to revision, unpublished data on file in USGS-WRD office, Anchorage, Alaska.
[d]No laboratory measurement made.

Table 5. Density (numbers/m^2), number of species, species diversity, and evenness of benthic invertebrates collected in Middle Creek, Beluga coal-field area, August 27, 1982.

	Site									
	1		2		3		4		5	
Taxon	I	II	I	II	I	II	I	II	I	II
Insecta										
Ephemeroptera										
Ameletus sp.						10				
Baetis tricaudatus		10				10		20		10
Baetis sp.	2250	700	2210	6710	8150	3640	180	2150	70	610
Cinygmula sp.	10								10	
Ephemerella doddsi	70						10	40	50	90
Ephemerella infrequens/ *E. inermis* complex	70	80	60	320	100	90	10	80	30	10
Unidentified Leptophlebiidae	1010	680	160	260	10	70	50	50	220	100
Rhithrogena sp.										60
Plecoptera										
Unidentified Plecoptera	1490	1030	360	1560	1400	870	230	350	560	90
Unidentified Chloroperlidae	20		10	30	30	30			40	80
Unidentified Perlodidae	10			10	10	20		20		10
Skwala sp.	10		30	30	10					
Taenionema sp.			10	10	10	10			10	30
Zapada cinctipes	640	560	170	980	70	150	140	890	370	230
Zapada sp.									10	10
Trichoptera										
Unidentified Trichoptera	80	10	80	80	500	120		290	10	10
Apatania sp.			30	140		20				
Arctopsyche sp.								10		
Brachycentrus sp.	50	10	70	50						20
Ecclisomyia sp.	10	20						10	10	
Glossosoma sp.	380	250	10	110			130	230	140	270
Unidentified Limnephilidae			10		10			20	20	40
Rhyacophila sp.		10			30					
Diptera										
Chelifera sp.	10	20						20	10	
Unidentified Chironomidae	1110	1370	420	1990	3140	2510	230	7560	270	120
Dicranota sp.	80	170	620	640	190	140	110	110	60	20
Hesperoconopa sp.		10						10	20	
Palpomyia sp.	30	60	20	180	30	30		20	10	
Pericoma sp.	150	190		100	10		80	90	130	40
Unidentified Simuliidae	40	10	10	40	140	10	10	30		
Simulium sp.	40	30	20	180	40					

Table 5. (con.)

Taxon	Site 1 I	1 II	2 I	2 II	3 I	3 II	4 I	4 II	5 I	5 II
Hymenoptera										
Unidentified Braconidae			10							
Unidentified Chalcidoidea		10								
Collembola										
Unidentified Isotomidae							10			
Unidentified Sminthuridae					10					
Turbellaria		20							50	
Nematoda								10	10	
Oligochaeta	40	30	320	30	10	10	90	70	400	80
Gastropoda				10						
Pelecypoda				170	10	20				
Arachnida										
Acarina	270	200	40	390	120	280	10	510	140	20
Crustacea										
Cladocera	20		10				10			
Ostracoda	20	30	10	100	120	80		30	70	10
Copepoda	10		10	20	80	70				
Total number of organisms/m²	7920	5510	4700	14140	14230	8190	1300	12620	2720	1960
Total number of insects/m²	7560	5230	4310	13420	13890	7730	1190	12000	2050	1850
Total number of taxa	26	24	24	25	24	21	15	24	25	22
Number of taxa-insects only	21	20	19	19	19	16	12	20	20	19
Shannon-Weaver Diversity Index (all invertebrates)	3.11	3.22	2.76	2.75	1.98	2.28	3.28	2.11	3.65	3.44
Evenness (all invertebrates)	0.66	0.70	0.60	0.59	0.43	0.52	0.83	0.46	0.78	0.77

Table 6. Density (numbers/m^2), number of species, species diversity, and evenness of benthic invertebrates collected in Lone Creek, Beluga coal field area, August 27, 1982.

	Site											
	6		7		8		9		10		11	
Taxon	I	II	I	II	I	II	I	II	I	II	I	II
Insecta												
Ephemeroptera												
Unidentified Ephemeroptera								20			10	
Ameletus sp.			10							10		
Baetis tricaudatus							10	20			20	
Baetis sp.	890	850	990	790	720	490	530	870	1080	1150	2270	1920
Cinygmula sp.	30	30										
Epeorus deceptivus			10									
Ephemerella doddsi	330	80	200	160	160	40			160	240	120	310
Ephemerella infrequens/ *E. inermis* complex	20		50	10	50	10	30	50	300	190	90	260
Unidentified Leptophlebiidae	680	480	1180	890	340	250	100	120	90	180	50	240
Rhithrogena sp.									10		40	20
Plecoptera												
Unidentified Plecoptera	410	290	280	740	600	440	410	590	360	1020	380	290
Unidentified Chloroperlidae	50	60	10	20	10	60	200	30	50	360	120	20
Unidentified Perlodidae	20		60	40	50	90	50	20	250	70	40	140
Pteronarcella spp.									10	30	10	150
Skwala sp.			10	10	20	10				20		10
Taenionema sp.			10					10	10		110	160
Zapada cinctipes	380	210	560	520	290	160	110	220	1250	730	280	1330
Zapada sp.	30	20									10	
Trichoptera												
Unidentified Trichoptera	210	50	170	80	70	10		20	530	40	20	160
Apatania sp.									20	20		
Brachycentrus sp.	310	110	20	20	80	50			20	60	10	60
Ecclisomyia sp.		20						20		170		20
Glossosoma sp.	920	360	760	1220	890	460	40	30	470	610	730	860
Unidentified Hydroptilidae								10				
Unidentified Limnephilidae	50		10	10	10	10	20		30			140
Rhyacophila sp.	60	10		10								

Table 6. (con.)

Taxon	Site 6 I	6 II	7 I	7 II	8 I	8 II	9 I	9 II	10 I	10 II	11 I	11 II
Diptera												
<u>Chelifera</u> sp.					10				10			10
Unidentified Chironomidae	1420	2400	1040	2370	1610	810	270	710	1920	2240	290	380
<u>Dicranota</u> sp.	30	70	50	110	140	110	40	130	70	110	30	10
<u>Hesperoconopa</u> sp.						10				10		
<u>Palpomyia</u> sp.			20	40	120	10	10		30	10		
<u>Pericoma</u> sp.	600	380	600	1610	980	790	10		260	50	140	160
<u>Prosimulium</u> sp.												10
Unidentified Simuliidae	40	10	100					30	50			10
<u>Simulium</u> sp.	160	40	50	30			90	10			40	90
Hymenoptera												
Unidentified Hymenoptera				10								
Unidentified Chalcidoidea			20				20					10
Unidentified Ichneumonidae	10											
Collembola												
Unidentified Isotomidae		10			10							
Turbellaria	50		10			10				40		10
Nematoda			30	10	10			110	140	90		
Oligochaeta	20	90	170	70	70	310	80	180	180	140	10	370
Pelecypoda					10		10	40		10	10	
Arachnida												
Acarina	90	100	90	190	190	80	30	90	530	380	30	
Crustacea												
Cladocera			10	10				10		10	10	10
Ostracoda	10	110	10	60	20	10	40	20	20	150	20	20
Copepoda					30		10	30	10	10		10
Total number of organisms/m²	6820	5780	6530	9030	6490	4220	2110	3390	7860	8150	4890	7190
Total number of insects/m²	6650	5480	6210	8690	6160	3810	1940	2910	6980	7320	4810	6770
Total number of taxa	25	22	29	25	25	22	21	25	27	29	26	30
Number of taxa-insects only	21	19	23	20	19	18	16	18	22	21	21	25
Shannon-Weaver Diversity Index (all invertebrates)	3.60	3.03	3.53	3.18	3.40	3.41	3.40	3.31	3.54	3.53	2.88	3.54
Evenness (all invertebrates)	0.77	0.67	0.72	0.68	0.73	0.76	0.77	0.71	0.74	0.73	0.61	0.72

Table 7. Habitat parameters at benthic-invertebrate sampling sites, August 27, 1982.

Middle Creek

Site	1	2	3	4	5
Time	1300	1218	1130	1050	1015
Water temperature (°C)	10.0	10.0	9.0	9.5	8.0
Stream width (m)	3.5	5.5	2.3	4.0	5.5
Stream gradient (%)[a]	0.75	0.55	-	-	1.03
Riparian habitat (%)					
Conifers	-	-	-	-	-
Deciduous trees	-	-	-	85	100
Shrubs/brush	6	-	10	-	-
Grasses	94	100	90	15	-

Benthos collection point	I	II	I	II	I	II	I	II	I	II
Water depth (m)	0.08	0.08	0.08	0.10	0.18	0.20	0.19	0.33	0.23	0.28
Stream substrate composition (%)										
Boulder	-	-	-	-	-	-	-	90	-	-
Rubble	40	40	-	-	-	-	60	5	75	30
Gravel	50	40	50	70	100	90	25	5	20	50
Sand/silt	10	20	50	30	-	10	15	-	5	20
Benthos habitat										
Run		x	x	x	x		x	x	x	x
Riffle	x					x				

Lone Creek

Site	6	7	8	9	10	11
Time	1330	1400	1425	1500	1540	1620
Water temperature (°C)	10.5	12.5	12.5	11.0	11.5	12.0
Stream width (m)	2.1	4.3	2.6	4.9	6.4	6.1
Stream gradient[a] (%)	-	0.95	0.50	-	-	0.96
Riparian habitat (%)						
Conifers	-	2	-	-	-	-
Deciduous trees	-	18	25	-	55	80
Shrubs/brush	50	40	45	5	15	10
Grasses	50	40	30	95	30	10

Benthos Collection point	I	II	I	II	I	II	I	II	I	II	I	II
Water depth (m)	0.08	0.11	0.15	0.08	0.10	0.08	0.30	0.36	0.41	0.41	0.15	0.25
Stream substrate composition (%)												
Boulder	-	-	-	-	-	-	-	-	-	-	-	-
Rubble	90	80	50	30	15	10	-	5	60	40	87	90
Gravel	10	20	40	50	80	75	70	.47	25	30	8	10
Sand/silt	-	-	10	20	5	15	30	48	15	30	5	-
Benthos habitat												
Run					x	x		x	x			x
Riffle	x	x	x	x			x			x	x	

[a]Determined in August 1983

Appendix A - Analytical procedures

Parameter	Sample container, hold times, handling, preservation, preparation for analysis	Method of analysis with quantitation limits (QL) and detection limits (DL)
Chemical oxygen demand (COD)	500-ml glass, wide-top jar with Teflon-lined lid. Acidified with concentrated H_2SO_4 to $pH \leq 2$. Kept chilled, analysis begun within 7 days.	Colorimetric, Manual-Hach low-level miniscale: 25 mg/l.
Color	500-ml polyethylene bottle, chilled to 4°C. Analyses begun within 7 days.	Color: Visual comparison, using platinum-cobalt method and reporting to the nearest 5 platinum cobalt units (PCU's). American Public Health Association (1980, p. 60-63).
Turbidity	As above	Turbidity: Hach 2100-A Turbidimeter reported in nephelometric turbidity units (NTU's). Report to the nearest 0.05 unit in the 0 to 1 NTU range; 0.1 in the 1 to 10 range; 1 in the 10 to 40 range; and 5 in the 40 to 100 range. American Public Health Association (1980, p. 131-134).
Residues, total filtrable and nonfiltrable	As above	Residues, total filtrable, dried at 180°C; Total nonfiltrable, dried at 103°-105°C. Report to nearest 0.1 mg/l. American Public Health Association (1980, p. 90-95).
Nitrate nitrogen	500-ml polyethylene bottle, chilled to 4°C, and delivered to lab within 24 hr. On arrival at lab, samples are frozen until just before determinations are made.[a]	Nitrate N: Automated cadmium reduction method. Lower limit of quantitation <1.0 mg/l. Limit of detection is 0.05 mg/l. American Public Health Association (1980, p. 376).

[a]Procedure differs from American Public Health Association (1980).

Parameter	Sample container, hold times, handling, preservation, preparation for analysis	Method of analysis with quantitation limits (QL) and detection limits (DL)
Ammonia	As with nitrate nitrogen[a]	Ammonia: Selective electrode method. Lower limit of quantitation (OL) is <0.1 mg/l. Lower limit of detection (DL) is 0.03 mg/l. American Public Health Association (1980, p. 362).
Orthophosphate	As above[a]	Orthophosphate: Ascorbic acid method. Report OL as <0.5 mg/l. DL is 0.05 mg/l. American Public Health Association (1980), p. 420.
Sulfate	As above	Sulfate: Barium sulfate turbidity method. Report QL as <10 mg/l. DL is 1.0 mg/l. American Public Health Association (1980, p. 439).
Silver (Ag)	500-ml polyethylene bottle for all metal samples. Chilled at 4°C. Promptly acidified in lab with sub-boiling-distilled concentrated HNO_3 to pH ≤2.2.[b] Stored at room temperature for up to 6 months. Prior to analysis, sample digested to 60°C overnight. Sediment allowed to settle or removed by filtration.	Atomic absorption, graphite furnace Perkin-Elmer HGA 2100. Report QL as <5.0 µg/l. DL is 0.3 µg/l. U.S. Environmental Protection Agency (1979, method 272.2).
Aluminum (Al)	As above[b]	As above. QL <50 µg/l. DL is 20 µg/l. U.S. Environmental Protection Agency (1979, method 202.2).

[a]Procedure differs from American Public Health Association (1980).
[b]Procedure differs from U.S. Environmental Protection Agency (1979).

Appendix A (con.)

Parameter	Sample container, hold times, handling, preservation, preparation for analysis	Method of analysis with quantitation limits (QL) and detection limits (DL)
Arsenic (As)	As above[b]	As above. QL <5.0 µg/l. DL is 1.0 µg/l. U.S. Environmental Protection Agency (1979, method 206.2).
Barium (Ba)	As above[b]	As above. QL is <0.2 mg/l. DL is 0.002 mg/l. U.S. Environmental Protection Agency (1979, method 208.2).
Beryllium (Be)	As above[b]	As above. QL is <2.0 µg/l. DL is 0.2 µg/l. U.S. Environmental Protection Agency (1979, method 210.2).
Calcium (Ca)	As above[b]	Atomic absorption, flame. 1000 mg/l lanthanum oxide. QL <5.0 mg/l. DL is 0.1 mg/l. U.S. Environmental Protection Agency (1979, method 215.1).
Cadmium (Cd)	As above[b]	Atomic absorption, graphite furnace Perkin Elmer HGA 2100. QL <2.0 µg/l. DL is 0.2 µg/l. U.S. Environmental Protection Agency (1979, method 213.2).
Cobalt (Co)	As above[b]	As above. QL <5.0 µg/l. DL is 1.0 µg/l. U.S. Environmental Protection Agency (1979, method 219.2).
Chromium (Cr)	As above[b]	As above. QL is <5 µg/l. DL is 0.7 µg/l. U.S. Environmental Protection Agency (1979, method 218.2).
Copper (Cu)	As above[b]	As above. QL <5.0 µg/l. DL is 1.0 µg/l. U.S. Environmental Protection Agency (1979, method 220.2).

[b]Procedure differs from U.S. Environmental Protection Agency (1979).

Parameter	Sample container, hold times, handling, preservation, preparation for analysis	Method of analysis with quantitation limits (QL) and detection limits (DL)
Iron (Fe)	As above[b]	Atomic absorption, flame. QL <0.2 mg/l. DL is 0.01 mg/l. U.S. Environmental Protection Agency (1979, method 236.1).
Mercury (Hg)	As with other metals[b]. Organics in sample, if any, are oxidized with UV radiation prior to analysis.	Cold-vapor atomic-absorption technique (potassium permanganate). QL <1.0 µg/l. DL is 0.2 µg/l. U.S. Environmental Protection Agency (1979, method 245.1).
Potassium (K)	As above[b]	Atomic absorption, flame. 10.0 mg/l K solution added. QL <1.0 mg/l. DL is 0.05 mg/l. U.S. Environmental Protection Agency (1979, method 258.1).
Magnesium (Mg)	As above[b]	Atomic absorption, flame. 1000 mg/l lanthanum oxide solution added. QL <5.0 mg/l. DL is 0.1 mg/l. U.S. Environmental Protection Agency (1979, method 242.1).
Manganese (Mn)	As above[b]	Atomic absorption, graphite furnace Perkin Elmer HGA 2100. QL <10 µg/l. DL is 2.0 µg/l. U.S. Environmental Protection Agency (1979, method 243.2).
Sodium (Na)	As above[b]	Atomic absorption, flame. 1000 mg/l K solution added. QL <2 mg/l. DL is 0.1 mg/l. U.S. Environmental Protection Agency (1979, method 273.1).

[b]Procedure differs from U.S. Environmental Protection Agency (1979).

Appendix A (con.)

Parameter	Sample container, hold times, handling, preservation, preparation for analysis	Method of analysis with quantitation limits (QL) and detection limits (DL)
Nickel (Ni)	As above[b]	Atomic absorption, graphite furnace Perkin Elmer HGA 2100. QL <10 μg/l. DL 3.0 μg/l. U.S. Environmental Protection Agency (1979, method 249.2).
Lead (Pb)	As above[b]	As above. QL <5.0 μg/l. DL is 3.0 μg/l. U.S. Environmental Protection Agency (1979, method 239.2).
Selenium (Se)	As above[b]	Atomic absorption, gaseous hydride method (nitrogen). QL <2.0 μg/l. DL is 1.0 μg/l. U.S. Environmental Protection Agency (1979, method 270.3).
Zinc (Zn)	As above[b]	Atomic absorption, graphite furnace Perkin Elmer HGA 2100. QL <10 μg/l. DL is 0.5 μg/l. U.S. Environmental Protection Agency (1979, method 289.2).
Gross Alpha	Obtained with metals samples.	Internal proportional-counter Converter. Nuclear Measurements Corp. model PCC 11T with decade scaler, model DS-3. QL <1 pico-curie/l.

[b]Procedure differs from U.S. Environmental Protection Agency (1979).

Organics (see following pages for species in each group)	Sample containers, hold times, handling, preservation, preparation for analysis	Method of analysis, limits of quantitation in micrograms per liter (μg/l)
Purgeable (volatile) organics	Two 40-ml glass septum vials (sample and duplicate); 0.15 ml of 1:1 HCl in bottle prior to sampling as preservative. Analyze within 14 days of collection. When sampling, fill bottles so that no air bubbles remain after closing cap. Keep chilled to 4°C.	EPA test method 602 (July, 1982). Automated purge and trap system using Tekmar ALS-LSC II and a Varian 6000 gas chromatograph with a Vista 401 chromatography data system. Limit of quantitation is <0.2 μg/l.
Base neutral and acid extractables	One-liter amber glass bottle. Chill samples to 4°C and extract within 7 days. Samples likely to have pollution levels of these compounds are to be completely analyzed within 40 days of extraction.	EPA test method 625 (July, 1982). One set of samples was analyzed at Laucks Laboratories[c] for selected organics on the U.S. EPA priority pollutant list. Laucks uses a Finnigan Organics in Water Analyzer (OWA). Although limits of detection may vary somewhat between species, Laucks reported all limits of quantitation as <1.0 μg/l. The second set of analyses was performed at the DEC lab using a Finnigan 4023 gas chromatograph (mass spectrometer/data system) (GC/MS/DS). Quantitation limit for each species reported on following pages.

[c] Laucks Testing Laboratories, Inc., Seattle.

Appendix A (con.)

Organics by group

1. Purgeable (volatile) aromatics	Limit of quantitation (μg/l)
Benzene	<0.2
Ethylbenzene	<0.2
Toluene	<0.2
p-Xylene	<0.2
m-Xylene	<0.2
o-Xylene	<0.2

2. Acid extractables	Limit of quantitation (μg/l)
2,4,6-Trichlorophenol	<2
Parachlorometacresol	<2
2-Chlorophenol	<2
2,4-Dichlorophenol	<2
2,4-Dimethylphenol	<2
2-Nitrophenol	<2
4-Nitrophenol	<2
2,4-Dinitrophenol	<2
4,6-Dinitro-o-cresol	<10
Pentachlorophenol	<10
Phenol	<2

3. Base neutral extractables

Limit of quantitation (µg/l)

Acenaphthene	<1
Benzidine	<10
1,2,4-Trichlorobenzene	<1
Hexachlorobenzene	<1
Hexachloroethane	<1
Bis(2-chloroethyl) ether	<1
2-Chloronaphthalene	<1
1,2-Dichlorobenzene	<1
1,3-Dichlorobenzene	<1
1,4-Dichlorobenzene	<1
3,3'-Dichlorobenzidine	<10
2,4-Dinitrotoluene	<1
2,6-Dinitrotoluene	<1
1,2-Diphenylhydrazine (b)	<1
Fluoranthene	<1
4-Chlorophenyl phenyl ether	<1
4-Bromophenyl phenyl ether	<1
Bis(2-chloroisopropyl)ether	<1
Bis(2-chloroethoxy)methane	<1
Hexachlorobutadiene	<1
Hexachlorocyclopentadiene	<1
Isophorone	<1
Naphthalene	<1
Nitrobenzene	<1
N-Nitrosodiphenyl amine (a)	<10
N-Nitrosodi-n-propyl amine	<1
Bis(2-ethylhexyl)phthalate	<1
Butylbenzylphthalate	<1
Di-n-butylphthalate	<1
Di-n-octylphthalate	<1
Diethylphthalate	<1
Dimethylphthalate	<1
Benzo(a)anthracene	<1
Benzo(a)pyrene	<1
3,4-Benzofluoranthene	<1
Benzo(k)fluoranthene	<1
Chrysene	<1
Acenaphthylene	<1
Anthracene	<1
Benzo(g,h,i)perylene	--
Fluorene	<1
Phenanthrene	<1
Dibenzo(a,h)anthracene	--
Indeno(1,2,3-c,d)pyrene	--
Pyrene	<1