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Water Quality of the Chokosna, Gilahina, Lakina Rivers, and Long Lake Watershed along McCarthy Road, Wrangell-St. Elias National Park and Preserve, Alaska, 2007–08

Scientific Investigations Report 2011–5185

U.S. Department of the Interior
U.S. Geological Survey

Cover: Gilahina River looking upstream towards Copper River and Northwestern Railroad tressel. Photograph taken by Dan Long, U.S. Geological Survey, May 21, 2007.

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KEN SALAZAR, Secretary

U.S. Geological Survey
Marcia K. McNutt, Director

U.S. Geological Survey, Reston, Virginia, 2011

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Suggested citation:
Brabets, T.P., Ourso, R.T., Miller, M.P., and Brasher, A.M., 2011, Water quality of the Chokosna, Gilahina, Lakina Rivers, and Long Lake watershed along McCarthy Road, Wrangell-St. Elias National Park and Preserve, Alaska, 2007–08: U.S. Geological Survey Scientific Investigations Report 2011-5185, 56 p.

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Conversion Factors

Multiply	By	To obtain
	Length	
inch (in.)	2.54	centimeter (cm)
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Area	
square mile (mi^2)	2.590	square kilometer (km^2)
	Volume	
cubic foot (ft^3)	0.02832	cubic meter (m^3)
cubic yard (yd^3)	0.7646	cubic meter (m^3)
	Flow rate	
foot per second (ft/s)	0.3048	meter per second (m/s)
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]	0.01093	cubic meter per second per square kilometer [(m^3/s)/km^2]

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

$$°F=(1.8\times°C)+32.$$

Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as follows:

$$°C= (°F-32)/1.8.$$

Specific conductance is given in microsiemens per centimeter at 25 degrees Celsius (µS/cm at 25 °C).

Concentrations of chemical constituents in water are given either in milligrams per liter (mg/L) or micrograms per liter (µg/L).

Datums

Vertical coordinate information is referenced to the North American Vertical Datum of 1988 (NAVD 88).

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).

Altitude, as used in this report, refers to distance above the vertical datum.

Abbreviations and Acronyms

ADAS	Algal Data Analysis System
ADOT&PF	Alaska Department of Transportation and Public Facilities
ANILCA	Alaska National Interest Lands Conservation Act
CCME	Canadian Council of Ministers of the Environment
DOC	dissolved organic carbon
EPT	Ephemeroptera (mayfly), Plecotera (stonefly), and Trichoptera (caddisfly)
HCO_3	Bicarbonate
IDAS	Invertebrate Data Analysis System
Mn	manganese
N	nitrogen
NAWQA	National Water-Quality Assessment program
NH_3	ammonia
NH_4	ammonium
NMDS	non-metric multidimensional scaling
NSC	Nash-Sutcliffe coefficient
NTU	Nephelometric Turbidity Unit
NWQL	National Water-Quality Laboratory
P	phosphorus
PEC	probable effect concentration
PEL	probable effect level
QMH	Qualitative Multi-Habitat
RMSE	root mean square error
RTH	Richest Targeted Habitat
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
WRST	Wrangell-St. Elias National Park and Preserve

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Abstract

The Chokosna, Gilahina, and Lakina River basins, and the Long Lake watershed are located along McCarthy Road in Wrangell–St. Elias National Park and Preserve. The rivers and lake support a large run of sockeye (red) salmon that is important to the commercial and recreational fisheries in the larger Copper River. To gain a better understanding of the water quality conditions of these watersheds, these basins were studied as part of a cooperative study with the National Park Service during the open water periods in 2007 and 2008.

Water type of the rivers and Long Lake is calcium bicarbonate with the exception of that in the Chokosna River, which is calcium bicarbonate sulfate water. Alkalinity concentrations ranged from 63 to 222 milligrams per liter, indicating a high buffering capacity in these waters. Analyses of streambed sediments indicated that concentrations of the trace elements arsenic, chromium, and nickel exceed levels that might be toxic to fish and other aquatic organisms. However, these concentrations reflect local geology rather than anthropogenic sources in this nearly pristine area.

Benthic macroinvertebrate qualitative multi-habitat and richest targeted habitat samples collected from six stream sites along McCarthy Road indicated a total of 125 taxa. Insects made up the largest percentage of macroinvertebrates, totaling 83 percent of the families found. Dipterans (flies and midges) accounted for 43 percent of all macroinvertebrates found. Analysis of the macroinvertebrate data by non-metric multidimensional scaling indicated differences between (1) sites at Long Lake and other stream sites along McCarthy Road, likely due to different basin characteristics, (2) the 2007 and 2008 data, probably from the higher rainfall in 2008, and (3) macroinvertebrate data collected in south-central Alaska, which represents a different climate zone. The richness, abundance, and community composition of periphytic algae taxa was variable between sampling sites. Taxa richness and diversity were highest at the Long Lake outflow site, suggesting that the lake may have contributed planktonic taxa to the periphytic community and (or) created physical and chemical conditions at the outlet that were favorable to a variety of taxa.

Long Lake is fed by groundwater and by clear water (non glacial) streams, resulting in relatively high Secchi-disc readings ranging from 17.5 to 23 feet. Depth profiles of water temperature in the lake show a strong stratification during the summer from the surface to about 13 feet, with temperatures ranging from 16 to 5 °C. Depth profiles of dissolved oxygen in the lake show a strong stratification between 26 and 33 feet, below which the concentrations of dissolved oxygen decrease from 10 to 2 milligrams per liter. Because the Long Lake outlet stream supports a large run of sockeye salmon and water temperature is an important factor during its life cycle, a logistic model was used to simulate 1998–2006 water temperatures at this site. Analysis of simulation results for 1998–2008 indicated no significant trends in water temperature. 2007 water temperatures were the highest during the 10-year period.

Introduction

Wrangell-St. Elias National Park and Preserve (WRST) is the largest unit of the National Park System (fig. 1). This park includes North America's largest assemblage of glaciers, as well as the largest collection of peaks with elevations higher than 16,000 ft. The landscape is dominated by parts of the Alaska, Wrangell, St. Elias, and Chugach Mountain ranges. WRST is one of four contiguous conservation units (including Kluane National Park Reserve in the Yukon Territory, Alsek-Tatshenshini Provincial Park in British Columbia, and Glacier Bay National Park and Preserve in southeast Alaska) spanning some 24 million acres that have been recognized by the United Nations as an International World Heritage Site. Several of North America's highest peaks are within the park and preserve, including Mt. St. Elias (18,008 ft) and Mt. Wrangell (14,163 ft), which is an active volcano. The Malaspina Glacier, located in the southeast part of WRST, is the longest piedmont lobe glacier in North America.

WRST is approximately 200 mi east of Anchorage and 120 mi northeast of Valdez (fig. 1). The park/preserve is bounded by the Gulf of Alaska on the south, Mentasta Mountains and the Tetlin National Wildlife Refuge on the north, the Canadian border on the east, and the Copper River on the west. Many visitors to WSRT travel to McCarthy, in the heart of the park to visit the historic Kennecott Mine. Road access to McCarthy is by the 61-mi long McCarthy Road; however, its gravel and dirt surface makes for slow travel and it usually takes 3 hours or more to travel one way from Chitina to McCarthy. Other hazards can make travel time even longer. For example, heavy rain can make the road muddy and slippery, potholes can form, sharp rocks can cause flat tires, and narrow and one-lane bridges make maneuvering large vehicles difficult.

The McCarthy and the Nabesna Roads (fig. 1) are the only public roads into WRST that provide reasonable access for park visitors and residents. The continued maintenance of these roads by the Alaska Department of Transportation and Public Facilities (ADOT&PF) is mutually beneficial to WRST, the State, local communities, and residents. The demands of increasing visitor use have prompted ongoing discussions concerning the improvement of McCarthy Road. WRST completed a Scenic Corridor Plan, incorporating the State of Alaska's plans for a major upgrade to the McCarthy Road. The plan called for the opening of scenic overlooks, the construction of pullouts and interpretive waysides, and the development of foot and bike trails.

Section 201 (a) of the 1980 Alaska National Interest Lands Conservation Act (ANILCA, 1980) states that WRST will be managed for the following purposes, among others: "To maintain the scenic beauty and quality of high mountain peaks, foothills, glacial systems, lakes and streams, valleys, and coastal landscapes in their natural state: to protect habitat for, and populations of fish and wildlife…" Fish in many parts of WRST are not abundant due to naturally harsh stream conditions such as high gradients, velocities, sediment loads, and winter ice conditions. However, the clear water streams that originate in WRST along the McCarthy Road serve an important function in perpetuating local fish populations (National Park Service, 1998), as well as fish populations of the Copper River. Lakes along the McCarthy Road contain Dolly Varden, sockeye salmon, coho salmon, grayling, lake trout, and burbot.

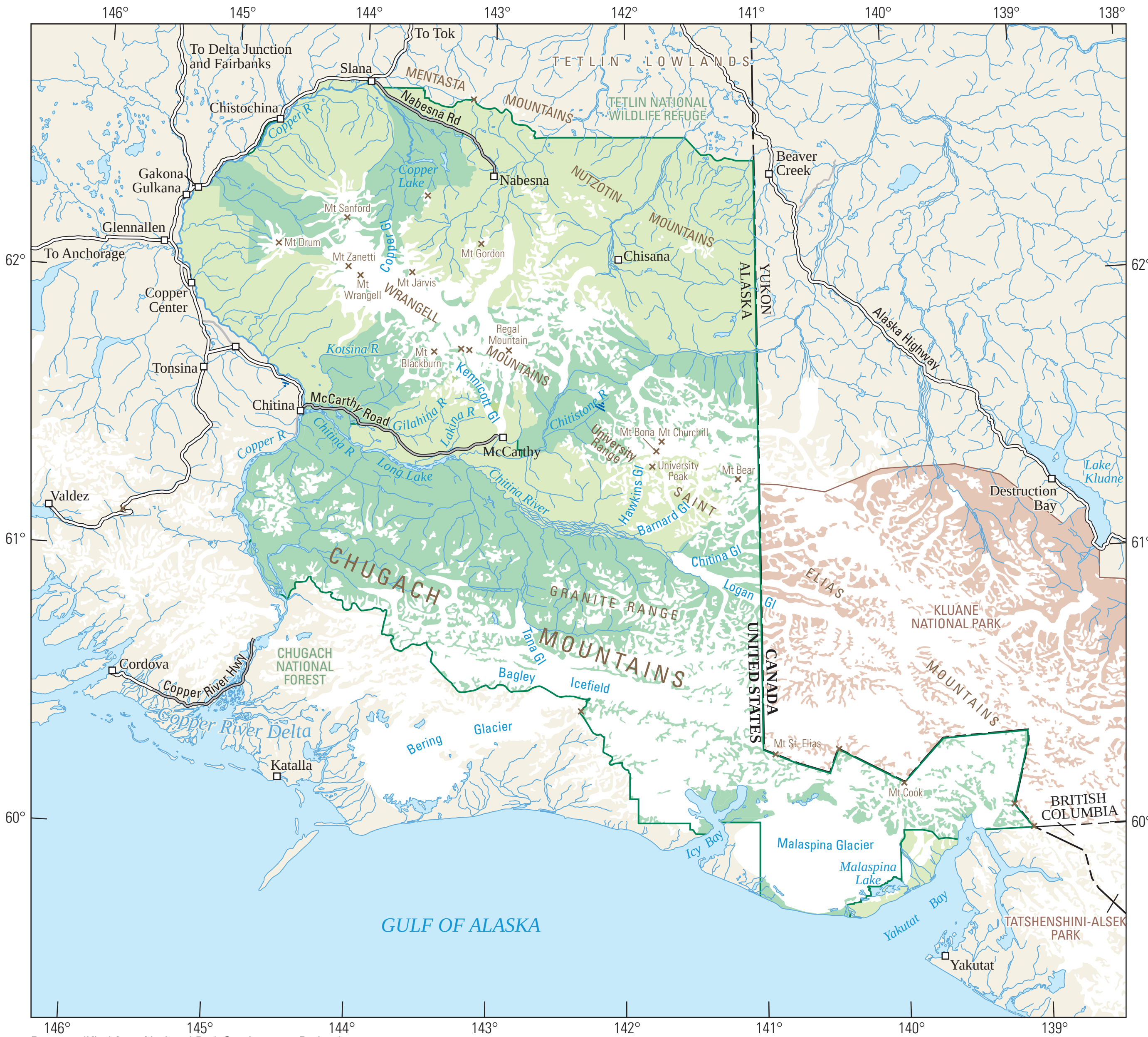
The McCarthy Road is the former Copper River and Northwestern Railway, which operated from 1911 to 1938. Improvements to the road would be considered a large construction project since the upgrades would need to meet ADOT&PF standards. The potential effects on water quality and aquatic habitat by construction activities, and the increase in road use that would likely result from those activities, pose several issues of concern, including:

Sedimentation: The effects on aquatic habitat from increased sedimentation are well understood. Sediment loading in a channel generally results in the downstream deposition of the sediment. Gravel substrates, a critical component for successful spawning, become clogged and eventually cemented in place. Such clogging also severely affects habitat for benthic invertebrates, an important food source for fish.

Flow regimes: Road construction on sloped terrain can significantly change the hydrology of a local stream. For example, roads often intercept subsurface flow on slopes and convert it to surface flow. Loss of base flow can be detrimental to fish. Icing or large floods can severely affect the geomorphology of the stream.

Fish passage: Culverts can act in a number of ways to significantly reduce or completely block fish access to an upstream watershed. Undersized culverts can result in excessive water velocities at each end and through the culvert barrel. Such excessive velocities may completely prevent the entrance of a fish into the culvert, or exhaust a fish that has partially progressed upstream. Culverts installed at greater than the natural channel slope may also create excessive water velocities, especially at higher flows. Other culvert characteristics also determine fish passage status; for example, the roughness of the culvert material, and the size of the corrugation on steel culverts has a direct effect on the velocity of water flowing inside the culvert.

The McCarthy Road crosses many small streams (drainage area less than 0.5 mi^2) and a few mid-size rivers (fig. 2). Many of these streams support sockeye salmon from the Copper River, a major commercial fishery. However, the hydrology of the streams and limnology of the lakes is essentially unknown. To gain a basic understanding of these characteristics in this part of WRST, the U.S. Geological Survey (USGS), in cooperation with WRST, conducted a water-quality investigation of a number of streams along the McCarthy Road and the Long Lake watershed from 2007 to 2008.



Base modified from National Park Service map. Projection: Alaska State Plane FIPS 5002. Datum is North American Datum of 1983.

0 10 20 30 40 50 Miles
0 10 20 30 40 50 Kilometers

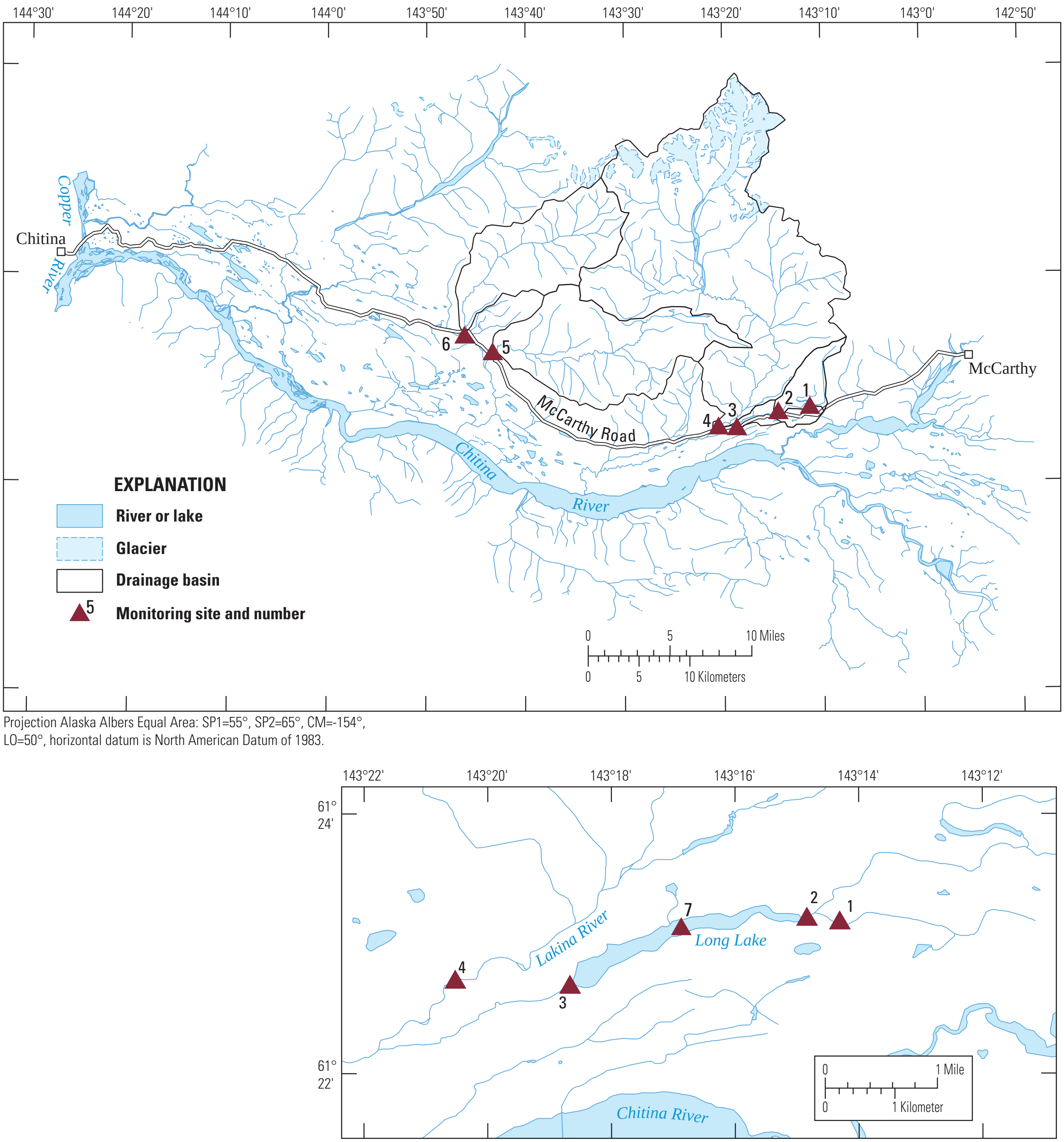
EXPLANATION

- Wrangell - St. Elias National Park
- Wrangell - St. Elias National Preserve
- Unpaved road
- Paved road

Selected peaks

Mountain name	Height in feet	Height in meters
Mt. Bear	14,831	4,521
Mt. Blackburn	16,390	4,996
Mt. Bona	16,421	5,005
Mt. Churchill	15,638	4,767
Mt. Cook	13,760	4,194
Mt. Drum	12,010	3,661
Mt. Gordon	9,040	2,755
Mt. Jarvis	13,421	4,091
Mt. Sanford	16,237	4,949
Mt. St. Elias	18,074	5,509
Mt. Wrangell	14,163	4,317
Mt. Zanetti	13,009	3,965
Regal Mountain	13,845	4,220
University Peak	14,470	4,411

Figure 1. Location of Wrangell-St. Elias National Park and Preserve, Alaska.



Projection Alaska Albers Equal Area: SP1=55°, SP2=65°, CM=-154°, LO=50°, horizontal datum is North American Datum of 1983.

Figure 2. Locations of monitoring sites along McCarthy Road, Alaska.

Purpose and Scope

This report describes current water quality, physical habitat, and aquatic biology characteristics of selected streams and lakes along the McCarthy Road—focusing on the Chokosna, Gilahina, and Lakina Rivers, and Long Lake—that were collected as part of a joint WRST/USGS study in 2007 and 2008. This information will assist both WRST and ADOT&PF officials in planning improvements to the McCarthy Road in a manner that will minimize or avoid effects on the water quality and habitat of these streams and lakes.

Physical Setting

Because the Chugach Mountains act as a barrier, the climate of the study area is minimally affected by maritime influences. The climate is continental, with large temperature variability, low humidity, and relatively light and irregular precipitation. Summers are generally warm and sunny and winters are cold. Gulkana, a long-term representative National Weather Service index station for the study area and the upper Copper River Basin (fig. 1), has an average high temperature in July of 69 °F and an average low temperature in January of -13 °F. Average annual air temperature is 27 °F, average annual precipitation is 11 in., and average annual snowfall is 57 in. (Shulski and Wendler, 2007). Much of the region's annual precipitation falls in summer as sporadic, local rain showers or thunderstorms. In late summer, the rainfall occurs over larger areas since it originates from large low-pressure systems that move across the northern Pacific Ocean and onto the Alaska mainland, typically from the southwest. During the study period, total average rainfall from May through September, 2007, was 7.51 in., with July, August, and September rainfall totals of 1.17, 0.96, and 3.83 in., respectively. Total average rainfall in 2008 was 8.73 in. In contrast to 2007, July, August, and September rainfall totaled 3.50, 3.53, and 0.75 in., respectively.

The Chokosna, Gilahina, and Lakina River basins, and the Long Lake watershed (fig. 2) all drain the south side of the Wrangell Mountains. Although the watersheds are adjacent to each other, their basin characteristics are different. For example, the Chokosna and Gilahina River watersheds contain no glaciers; however, approximately 13 percent of the Lakina River watershed consists of glaciers. Glacier-fed rivers such as the Lakina River have different flow and water quality characteristics than non-glacier-fed streams.

The Chokosna River basin (39.2 mi^2) consists of surficial deposits of glacial and glaciolacustrine origin, and sedimentary and volcanic rocks of the Station Creek and McCarthy Formation. Adjacent to the Chokosna River basin, the Gilahina River basin (51.6 mi^2) consists of sedimentary and volcanic rocks of the Station Creek Formation to the north and intrusive rocks, primarily gabbro, to the south. The valley floor is covered by surficial deposits of glacial and glaciolacustrine origin. Adjacent to the Gilahina River basin is the Lakina River basin (141 mi^2), which is underlain by several types of geologic materials, including unconsolidated surficial deposits; volcaniclastic deposits from the Wrangell Volcanic Field; and sedimentary, volcanic, intrusive, and metamorphic rocks from what is termed (by Richter and others, 2006) the Wrangellia Terrane. The Long Lake watershed (11 mi^2) consists primarily of the surficial glacial and glaciolacustrine deposits with about 1 mi^2 of sedimentary and volcanic rocks from the Pleistocene and early and late Cretaceous age. The reader is referred to Richter and others (2006) for a more comprehensive view of the geology.

Long Lake, at approximately Mile 50 of the McCarthy Road, is about 2 mi long and about 650 ft wide (fig. 3). The deepest part of the lake is about 60 ft, near the outlet. A stream draining about 9.0 mi^2 from the east contributes most of the inflow to Long Lake and the remaining 2 mi^2 of the watershed drains from the north. Long Lake is partly fed by groundwater, and the watershed is dominated by wetlands. Substantial runs of sockeye salmon spawn in Long Lake (table 1).

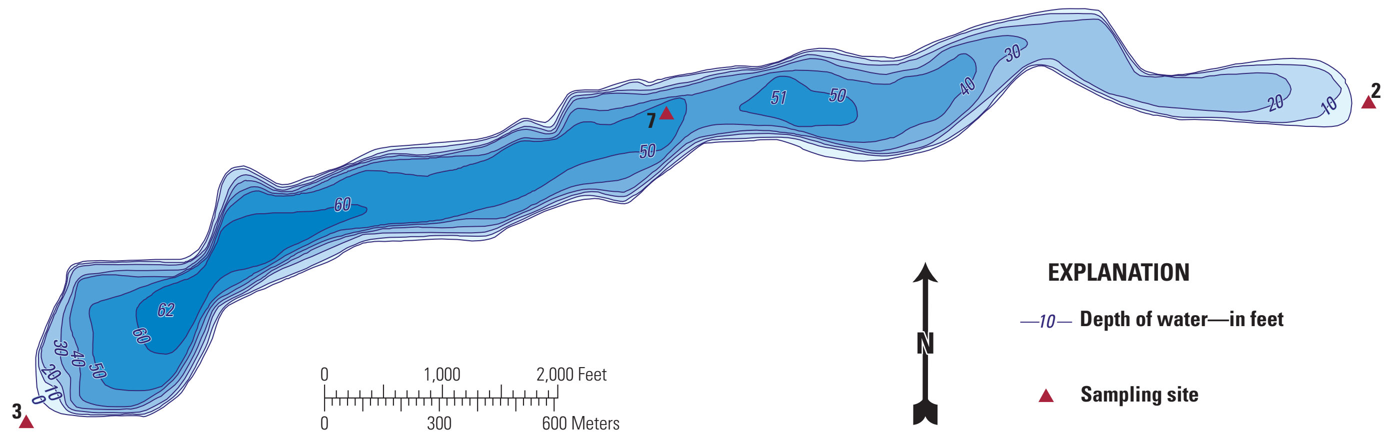


Figure 3. Bathymetry of Long Lake near McCarthy, Alaska.

Table 1. Annual number of salmon passing through the weir at Long Lake near McCarthy, Alaska, 1974-2008.

Year	Long Lake weir salmon count	Year	Long Lake weir salmon count
1974	4,684	1992	10,091
1975	6,768	1993	16,101
1976	24,689	1994	18,289
1977	8,624	1995	17,923
1978	15,458	1996	6,309
1979	46,110	1997	4,443
1980	39,038	1998	8,441
1981	12,659	1999	12,922
1982	28,047	2000	8,645
1983	28,133	2001	26,999
1984	10,637	2002	49,747
1985	21,131	2003	4,604
1986	16,997	2004	19,215
1987	13,633	2005	7,770
1988	7,543	2006	9,239
1989	14,981	2007	7,846
1990	21,664	2008	831
1991	11,511		

Methods of Data Collection and Analysis

A wide variety of water quality and biological data were collected during the open water periods of 2007 and 2008 from the selected river and lake sites (fig. 2, table 2). Water samples collected from the rivers and Long Lake were analyzed for major ions, total dissolved solids, total and dissolved nutrients, dissolved organic carbon, phytoplankton, chlorophyll-*a*, and trace elements (table 3). The field-collection and processing equipment used was made from Teflon, glass, or stainless steel to prevent sample contamination and to minimize analyte losses through adsorption. All sampling equipment was cleaned prior to use with a non-phosphate laboratory detergent and deionized water, followed by a native-water rinse prior to sample collection. Depth-integrated water samples were collected across the stream using the equal-width-increment method (U.S. Geological Survey National Field Manual, variously dated) and processed in the field using methods and equipment described by Shelton (1994). Samples were collected from Long Lake using a 3.0 liter acrylic Van Dorn sampler. Samples to be analyzed for dissolved constituents were filtered through 0.45-micrometer (µm) capsule filters. Water samples were sent to the USGS National Water-Quality Laboratory for analysis using standard USGS analytical methods (Fishman and Friedman, 1989; Patton and Truitt, 1992; Fishman, 1993).

A Yellow Springs Instrument multi-parameter sonde was used to measure water temperature, dissolved-oxygen concentration, specific conductance, turbidity, and pH at the time of sampling. Discharge measurements also were made at the time of sampling using methods of Turnipseed and Sauer (2010). Instruments were installed at all sites to collect water temperature on an hourly basis. At the time of sampling, the instruments would be cleaned and compared to the field measurement to insure accurate readings. Adjustments to the continuous water-temperature data were made using methods outlined by Wagner and others (2006).

The water-quality and temperature data were compared to known or published guidelines that are recommended for fish survival to determine if particular stream conditions may be affecting aquatic life. Water-quality data were analyzed to determine if seasonal patterns exist and to identify the basic composition of each particular stream. Water-temperature data were compared with air-temperature data from a climate station located at McCarthy and used in a logistic regression to determine a 10-year time series of water temperature.

Samples of streambed sediments were collected from several depositional areas at each site and analyzed for trace elements. The samples were collected from the surface of the streambed using Teflon tubes or Teflon coated spoons and composited in glass bowls (Shelton and Capel, 1994). Because the concentration of trace elements from streambed materials is strongly affected by the particle-size distribution of the sample, only that portion of the sample that was finer than 63 µm was analyzed. Stream water was used for sieving the trace-element sample through a 63-µm mesh. Water included in the trace-element sample was decanted after very fine-grained sediments had settled (about 24 hours). Trace elements in streambed sediments were analyzed following a total digestion procedure as described by Arbogast (1990). The trace-element concentrations in streambed sediments then were compared with those collected by the USGS, National Water-Quality Assessment (NAWQA) Program, and with guidelines established by the Canadian Council of Ministers of the Environment (CCME) (1999).

Samples for benthic macroinvertebrates were collected at six different sites in the study area (table 2). Richest Targeted Habitat (RTH) and Qualitative Multi-Habitat (QMH) samples were collected and processed using protocols established by the NAWQA Program (Cuffney and others, 1993) and were identified by EcoAnalysts, Inc. in Moscow, Idaho. RTH samples are semi-quantitative, providing taxa abundance and richness measures by sampling from a delineated area to a predetermined depth of bed sediment, carefully removing macroinvertebrates, and then immediately washing those macroinvertebrates downstream into a fine (425-µm mesh) net. Five sites in stream riffles within the reach were selected in advance for collection. QMH sampling is a measure of the presence or absence of macroinvertebrates obtained by collecting samples with a standard D-frame net (210-µm mesh net) from all possible microhabitats to give a broad account of organisms within the stream reach.

Five of the six sites were sampled in 2007, and four of the six sites were sampled in 2008 (table 2). Sites 1 (Long Lake tributary 2) and 4 (Lakina River) were sampled only in 2007, as they were considered too dissimilar to the rest of the sites. Site 1 was located upstream of McCarthy Road as it issued from a very steep incline and then flowed into a roadside ditch before being channeled into a culvert under the road. After this site had been initially sampled (QMH techniques only), the discovery of the major inflow tributary to Long Lake led to the establishment of site 2 the following year. This site was more representative of the natural streams found throughout the area. Site 4, the Lakina River, was sampled in 2007 using only QMH techniques, as riffle areas were unavailable for RTH sampling. This site was not sampled in 2008 because the flow and velocity were too high for safe sampling. Because the Lakina River is a glacial river, it exhibits depauperate macroinvertebrate communities due to glacial fines and the subsequent deleterious effect on the growth of periphyton, a primary food source for many benthic macroinvertebrates, while also adversely affecting filtration by macroinvertebrates (Gislason and others, 2000). The Gilahina River was unable to be sampled using RTH techniques in 2008 as the high water level obscured any riffle areas and the Chokosna River was likewise too high to facilitate RTH sampling techniques in 2007. Long Lake Creek, site 3, was initially sampled using only RTH techniques on July 29, 2007, but was followed 2 days later by RTH and QMH sampling.

The macroinvertebrate data gathered at the McCarthy Road sites were used in the calculation of metrics for comparison against all other sites in Alaska similarly sampled using the NAWQA protocols. Converting both RTH and QMH data to metrics used for comparing or contrasting sites was accomplished using the Invertebrate Data Analysis System (IDAS) (Cuffney and Brightbill, 2011). The IDAS software is designed to parse, organize, and calculate metrics related to macroinvertebrate data collected as part of the NAWQA protocols. The software adds accuracy and precision to data interpretation by tracking and documenting settings used in metric generation, thereby yielding easily reproducible and comparable results. The options for data processing were set for the default, with the exception of the combination of parent taxa with children.

Macroinvertebrate data were further analyzed using the ordination technique, non-metric multidimensional scaling (NMDS) (Venables and Ripley, 2002; Oksanen and others, 2010) using the R software (R Development Core Team, 2010) and specifically the vegan (Oksanen and others, 2010) and MASS (Venables and Ripley, 2002) packages. Macroinvertebrate presence/absence data were standardized to the lowest identifiable taxonomic level for each sample in order to generate a Bray-Curtis dissimilarity (distance) input matrix. NMDS plots were then generated from the two distance matrices for the McCarthy Road samples, and the McCarthy Road samples combined with other Alaska macroinvertebrate samples.

QMH and RTH algae samples were collected according to protocols outlined by Porter and others (1993). The algal QMH sample is similar to the macroinvertebrate QMH sample; its purpose is to identify the species of algae present at multiple habitats within each stream reach. Algae samples were collected in habitats similar to the QMH and RTH macroinvertebrate samples (depositional zones, woody debris, and riffles) and were analyzed by the Philadelphia Academy of Natural Science. Periphytic algae QMH and RTH samples were collected in 2007 and 2008 from the inlet and outlet of Long Lake, as well as from the Lakina, Gilahina, and Chokosna Rivers (table 2). Preparation of the QMH and

RTH data was accomplished using the Algal Data Analysis System (ADAS) (Cuffney and Brightbill, USGS, written commun., 2010). Similar to IDAS, ADAS was designed to parse, organize, and calculate metrics related to algal data. Samples were kept separate while resolving ambiguities and parents were distributed among children for QMH and RTH data. Taxa richness for each sample was calculated using QMH and RTH data; abundance, diversity values, and multivariate analyses were generated using only the RTH data. Abundance data are reported for both density (number of individuals) and biovolume (algal biomass). The advantage of reporting abundance as biovolume in addition to density is that biovolume accounts for cell-size variation between taxa.

A similarity profile (SIMPROF) test (Clarke and others, 2008) was used to define groups of sites that are not statistically different from one another. The similarity in periphytic algal community structure between sites was investigated by generating a NMDS ordination plot based on a Bray-Curtis similarity resemblance matrix calculated using fourth-root transformed RTH biovolume data. Sites that are more similar to one another plot closer together and sites that are less similar to one another plot further apart. The PRIMER package (Clarke and Gorley, 2006) was used to generate the resemblance matrix and NMDS plot. The ability of the NMDS to represent differences in community structure was assessed through calculation of a two-dimensional stress value. Stress values less than 0.05 are indicative of an excellent representation of the site relations, whereas values between 0.05 and 0.1 indicate a good representation, and values greater than 0.3 suggest that the locations of the points in the plot are random (Carke and Warwick, 2001).

Zooplankton samples were collected from Long Lake in May, June, August, and September 2008. Samples were collected using a 1.5-ft diameter, 153-µm mesh, conical plankton net. Vertical tows were made from 3 ft above the lake bottom to the surface and the contents were preserved in 10 percent buffered formalin. Preserved zooplankton samples were concentrated by gently pouring the original sample (about 125–200 mL) through a 153-µm mesh, followed by re-suspension into about 65 mL 4 percent formalin (final concentration). Following methods used by Balcer and others (1984), and Ward and others (1959), 1 to 2 mL subsamples were enumerated by low power microscopy (dissecting microscope) to obtain approximately 100 total animals in each subsample. Broad groupings of zooplankton such as Daphnia, Bosmina, and Ceriodaphnia were enumerated. Net diameter, depth and number of tows were factored in when calculating number of animals per cubic meter of water sampled.

Table 2. Water-quality and biology sample collection sites along McCarthy Road, Alaska.

[**Site No.:** See figure 2 for location. **Abbreviations:** USGS, U.S. Geological Survey; mi^2, square mile; <, less than]

Site No.	USGS station No.	Latitude/longitude	Station name	Area (mi^2)	Glaciers (mi^2)	Lakes (mi^2)	Remarks
			Surface water sites				
1	15210250	61° 23' 14"143° 14' 23"	Long Lake Tributary 2 at McCarthy Road near McCarthy	2.0	0	0	Sampled in 2007
2	15210260	61° 23' 14" 143° 14' 46"	Long Lake Tributary 1, 150 ft above mouth near McCarthy	9.0	0	0	Sampled in 2008
3	15210300	61° 22' 43" 143° 18' 37"	Long Lake Creek at McCarthy Road near McCarthy	11.0	0	0.23	Sampled in 2007 and 2008
4	15210200	61° 22' 30" 143° 20' 50"	Lakina River near McCarthy	141.0	12	<1	Sampled in 2007
5	15210600	61° 26' 19" 143° 43' 00"	Gilahina River at McCarthy Road near Chitina	51.6	0	0	Sampled in 2007 and 2008
6	15210700	61° 27' 21" 143° 45' 43"	Chokosna River at McCarthy Road near Chitina	39.2	0	0	Sampled in 2007 and 2008
			Lake sites				
7		61° 23’ 10” 143° 16’ 45”	Long Lake site 1 near McCarthy				Sampled in 2008

Table 3. Analyses made on water samples and streambed sediments collected along McCarthy Road, Alaska, 2007 and 2008.

[**Abbreviations:** °C, degrees Celsius; µS/cm, microsiemens per centimeter; mg/L, milligram per liter; NTU, Naphelometric Turbidity Unit; ft^3/s, cubic foot per second; µg/L, microgram per liter; µg/g, microgram per gram]

Field measurements of water	Reporting level
Water temperature (°C)	0.1
Specific conductance (µS/cm)	5
pH	0.1
Dissolved oxygen (mg/L)	0.1
Turbidity (NTU)	1
Streamflow (ft^3/s)	0.01
Chemical constituents in water	**Reporting level (mg/L)**
Alkalinity	1
Bicarbonate	1
Calcium	0.022
Chloride	0.06
Dissolved solids	12
Fluoride	0.04
Magnesium	0.008
Potassium	0.022
Silica	0.029
Sodium	0.06
Sulfate	0.09
Nutrients in water	**Reporting level (mg/L)**
Nitrogen, ammonia - dissolved	0.010
Nitrogen, ammonia + organic - dissolved and total	0.050
Nitrogen, NO_2 - dissolved	0.001
Nitrogen, NO_2 + NO_3 - dissolved	0.008
Phosphorus - dissolved	0.003
Phosphorus - total	0.004
Orthophosphate - dissolved	0.004
Trace elements in water	**Reporting level (µg/L)**
Iron	3.2
Manganese	0.16
Suspended sediment in water	**Reporting level (mg/L)**
Concentration	1
Organics in water	**Reporting level**
Dissolved organic carbon (mg/L)	0.15
Pheophytin phytoplankton (µg/L)	0.1
Chlorophyll-*a* phytoplankton (µg/L)	0.1

Trace elements in streambed sediments	Reporting level (µg/g)
Aluminum	850
Antimony	0.04
Arsenic	1
Barium	0.2
Beryllium	0.03
Bismuth	0.06
Cadmium	0.007
Cerium	0.1
Cesium	0.05
Chromium	0.5
Cobalt	0.02
Copper	2
Gallium	0.02
Iron	5
Lanthanum	0.05
Lead	0.4
Lithium	0.3
Manganese	0.7
Mercury	0.01
Molybdenum	0.05
Nickel	0.3
Niobium	1
Scandium	0.04
Selenium	0.1
Silver	2
Strontium	0.8
Thallium	0.08
Thorium	0.1
Titanium	40
Uranium	0.02
Vanadium	0.2
Yttrium	0.05
Zinc	3
Chemical constituents in streambed sediments	**Reporting level**
Inorganic carbon (percent)	0.01
Organic carbon (percent)	0.01
Total carbon (percent)	0.01
Calcium (µg/g)	100
Magnesium (µg/g)	6
Phosphorus (µg/g)	5
Potassium (µg/g)	20
Sodium (µg/g)	20
Sulfur (percent)	0.05

Water Quality Characteristics

Water-quality data collected at streams located along the McCarthy Road and at Long Lake in 2007 and 2008 included (1) field measurements of streamflow, specific conductance, pH, water temperature, turbidity, and dissolved-oxygen concentration, (2) collection and analysis of water samples for suspended sediment, major inorganic ions, nutrients, dissolved organic carbon (DOC), and chlorophyll-*a*, (3) collection and analysis of hourly water temperature data, and (4) collection and analysis of streambed sediments for trace elements.

Streamflow, Suspended Sediment, and Turbidity

Typical of most rivers in interior Alaska, most of the annual flow of the Chokosna, Gilahina, and Lakina Rivers occurs from mid-May to mid-October. Above average flows in June are dominated by snowmelt, and in July through September, by rainfall. The highest flows, ranging from 259 to 932 ft^3/s, were measured at the glacier-fed Lakina River (table 4). The lowest flows, ranging from 0.2 to 17 ft^3/s, were measured at the Long Lake inlet and outlet streams. Measured flows at the Gilahina and Chokosna Rivers were similar, with flows at the Gilahina River (the larger basin) ranging from 53 to 124 ft^3/s and at the Chokosna River ranging from 38 to 179 ft^3/s. During the study period, discharges measured in May 2007 were higher than discharges measured in May 2008, reflecting an early snowmelt period in 2007. Based on discharge per unit area (mi^2), runoff is quite similar among the Lakina, Gilahina, and Chokosna Rivers, ranging from 1.0 to 6.6 $ft^3/s/mi^2$.

Sediment in rivers is transported in the water column and along the bed (bedload). Suspended sediment generally consists of fine particles such as clay, silt, and fine sand that are transported in the stream while being held in suspension by the turbulence of flowing water. Bedload consists of coarse sediment particles such as sands, gravels, and sometimes cobbles that are transported along or near the streambed. Measured suspended sediment concentrations in the streams were low—less than 6 milligrams per liter (mg/L)—at the Long Lake inlet and outlet sites (table 4). Minimum concentrations of 1.0 mg/L were measured several times at these two sites. In turn, Secchi-disc transparencies, an indicator of the clarity of lake water, were relatively high, and ranged between 17.5 and 23 ft at Long Lake (table 5).

The highest measured concentrations of suspended sediment were 101 mg/L at the Lakina River, and 69 mg/L at the Chokosna River. Both of these measurements were made during the snowmelt period in May 2007, though the glacier fed Lakina River would be expected to have higher suspended sediment concentrations throughout the summer. The highest concentration (17 mg/L) at the Gilahina River also was noted at this time. The largest variation in suspended sediment concentrations occurred at the Chokosna River. Turbidity values ranged from less than 2 to 42 NTU and showed some correlation with the suspended sediment concentrations.

Water Temperature

Water temperature determines the amount of oxygen water can contain when at equilibrium with the atmosphere, and it also controls the metabolic and growth rates of fish. Sockeye salmon have adapted to specific spawning times and water temperatures so that incubation and emergence occur at the most favorable time of the year during spring and early summer (Reiser and Bjornn, 1979). For sockeye salmon, the range in water temperature for all life stages (migration, spawning, incubation, and rearing) ranges from 2.0 to 17.8 °C (Reiser and Bjornn, 1979).

Water temperatures of the Chokosna and Gilahina Rivers were similar. During the 2 years of data collection, recorded average daily water temperatures in the streams did not exceed 10 °C (table 4, fig. 4), which likely reflects the effect of snowmelt in the upper portion of these two basins. Water temperature at these two rivers also correlates with air temperature (fig. 4). Air temperature in 2007 was warmer than in 2008, and the Gilahina River water temperature between mid-July and mid-August was approximately 3 °C warmer in 2007. At the glacier-fed Lakina River, water temperatures were less than 9 °C (table 4, fig. 5), and there is some correlation with air temperature. However, the variability between 2007 and 2008 is not as large compared with the Gilahina and Chokosna Rivers. The most pronounced differences in water temperature were noted in the inlet and outlet streams of Long Lake (table 4, fig. 6). Water temperatures were measured as high as 15 °C in the inlet stream and as high as 19 °C in the outlet stream. In the Long Lake watershed, there are no perennial snowfields, and water temperatures correlate more strongly with air temperature.

Depth profiles of the water temperature of Long Lake indicate that temperatures change with depth throughout the summer months (table 5, fig. 7). In May 2008, just after ice out, water temperatures in the top 6 ft were greater than 5 °C, but quickly decreased with increasing depth to 4 °C. By July and August, water temperatures from the surface to about 13 ft deep were about 15 °C; a strong stratification was present between 13 and 20 ft, and water temperatures steadily decreased with depth to about 5 °C. By mid to late September, temperatures from the surface to 26 ft had cooled to about 10 °C, a weak stratification was present between 26 and 33 ft, and then water temperatures steadily decreased to 6 °C.

Table 4. Physical field parameters and suspended sediment measured at stream sites along McCarthy Road, Alaska, 2007 and 2008.

[**Abbreviations:** ft^3/s, cubic foot per second; $(ft^3/s)/mi^2$, cubic foot per second per square mile; mg/L, milligram per liter; µS/cm at 25°C, microsiemens per centimeter at 25 degrees Celsius; °C, degrees Celsius; mi^2, square mile; NTU, Nephelometric Turbidity Unit; <, less than; –, no data]

Date	Time	Discharge (ft^3/s)	Discharge per unit area [$(ft^3/s)/mi^2$]	Dissolved oxygen (mg/L)	pH (units)	Specific conductance (µS/cm at 25°C)	Water temperature (°C)	Turbidity (NTU)	Suspended sediment (mg/L)
Lakina River (drainage area 141 mi^2)									
05-22-07	1530	259	1.8	11.1	8.2	278	6.7	42	101
07-31-07	1000	932	6.6	–	–	–	–	–	–
10-02-07	1715	294	2.1	11.8	8.2	358	4.4	5	63
Long Lake Inflow (drainage area 9.0 mi^2)									
05-22-07	1000	3.8	0.4	9.6	7.8	192	7.2	<2	1
07-30-07	0945	.2	.0	6.1	7.8	418	13.6	3.3	–
05-21-08	1030	2.1	.2	9.9	7.8	277	4.7	<2	<1
07-01-08	1000	1.9	.2	9.3	8.0	328	8.1	<2	1
08-06-08	1406	14	.2	9.8	7.8	267	9.2	3.7	4
09-24-08	1020	3.6	.4	10.8	7.8	338	5.2	<2	3
Long Lake Outflow (drainage area 11.0 mi^2)									
05-22-07	1210	15	1.4	11.5	8.1	271	10.0	<2	1
07-30-07	1900	4	.4	12.3	8.6	334	20.4	<2	–
05-20-08	1730	8	.7	–	8.1	350	8.0	<2	1
07-01-08	1125	5.7	.5	10.9	8.5	371	15.6	<2	6
08-05-08	1644	17	1.5	10.4	8.3	361	14.6	<2	1
09-23-08	1745	11	1.0	11.4	8.3	362	10.6	<2	4
Gilahina River (drainage area 51.6 mi^2)									
05-23-07	0900	96	1.9	12.9	8.1	173	3.1	6.4	17
08-01-07	1200	53	1.0	12.2	8.3	262	7.7	1.2	–
10-03-07	1600	88	1.7	13.1	8.2	248	2.8	–	5
05-19-08	1810	69	1.3	12.1	8.3	199	6.9	5.1	11
06-30-08	1730	124	2.4	11.5	8.3	224	8.8	2.8	11
09-24-08	1600	91	1.8	12.8	8.3	275	4.5	3.3	4
Chokosna River (drainage area 39.2 mi^2)									
05-23-07	1100	85	2.2	13.2	8.1	236	3.1	37	69
07-29-07	1400	38	1.0	–	8.3	504	9.1	–	–
10-03-07	1240	66	1.7	13.1	8.2	513	1.9	–	11
05-19-08	1545	46	1.2	12.1	8.1	327	7.0	13	22
06-30-08	1540	90	2.3	11.6	8.2	441	8.6	14	34
08-04-08	1635	179	4.6	11.7	8.3	456	6.7	21	57
09-24-08	1700	89	2.3	12.6	8.3	522	4.4	–	4

Table 5. Physical field parameters measured at Long Lake near McCarthy, Alaska, 2008.

[**Abbreviations:** ft, foot; mg/L, milligram per liter; µS/cm at 25°C, microsiemens per centimeter at 25 degrees Celsius; °C, degree Celsius; NTU, Nephelometric Turbidity Unit; –, no data]

Date	Sample depth (ft)	Dissolved oxygen (mg/L)	Oxygen saturation (percent)	pH (units)	Specific conductance (µS/cm at 25°C)	Water temperature (°C)	Turbidity (NTU)	Chlorophyll-α	Secchi disk depth (ft)
05-20-2008	0.0	10.2	94	7.7	326	6.9	<2	–	
	3.3	10.2	93	7.7	326	6.5	<2	–	
	4.9	10.2	93	7.7	326	6.3	<2	–	
	6.6	8.9	84	7.7	344	4.8	<2	–	
	8.2	7.7	81	7.8	353	4.7	<2	–	
	9.8	6.8	81	7.7	364	4.5	<2	–	
	11.4	5.7	79	7.7	376	4.2	<2	–	
	13.1	5.1	78	7.7	384	4.0	<2	–	
	16.4	4.2	73	7.7	394	3.7	<2	–	
	19.7	3.9	70	7.7	395	3.7	<2	–	
	23.0	3.7	65	7.7	395	3.7	<2	–	
	26.2	3.5	63	7.7	396	3.6	<2	–	
	29.5	3.5	62	7.7	396	3.6	<2	–	
	32.8	3.4	62	7.7	397	3.6	<2	–	
	36.1	3.3	59	7.7	397	3.6	<2	–	
	39.4	3.0	56	7.7	397	3.6	<2	–	
	42.6	2.2	41	7.7	398	3.5	<2	–	
	45.9	1.7	31	7.6	400	3.4	<2	–	
	49.2	1.6	30	7.6	400	3.4	<2	–	
07-01-2008	0.0	9.9	106	8.4	372	16.0	<2	1.0	17.5
	1.6	9.9	106	8.4	372	16.0	<2	1.4	
	3.3	9.9	106	8.4	372	15.9	<2	1.1	
	4.9	10.0	106	8.4	372	15.8	<2	1.0	
	6.6	10.0	106	8.4	372	15.7	<2	1.3	
	8.2	9.9	106	8.4	372	15.7	<2	.9	
	9.8	10.0	106	8.4	372	15.6	<2	1.4	
	11.4	9.9	105	8.4	372	15.5	<2	1.0	
	13.1	10.0	105	8.4	372	15.5	<2	1.2	
	14.8	10.8	111	8.3	375	14.3	<2	1.2	
	16.4	12.2	117	8.3	375	11.2	<2	2.3	
	18.0	12.1	114	8.3	377	10.4	<2	2.2	
	19.7	12.1	111	8.2	379	9.4	<2	3.6	
	21.3	11.7	105	8.2	382	8.5	<2	5.7	
	23.0	10.9	97	8.1	383	8.1	<2	8.4	
	24.6	9.9	88	8.1	385	7.6	<2	9.4	
	26.2	9.2	80	8.0	385	7.3	<2	11.0	
	27.9	8.6	74	8.0	387	7.0	<2	13.3	
	29.5	8.1	70	8.0	387	6.8	<2	16.7	
	31.2	7.4	64	7.9	387	6.7	<2	15.0	
	32.8	7.0	60	7.9	388	6.5	<2	17.0	
	34.4	6.3	54	7.9	388	6.2	<2	14.1	
	36.1	5.8	49	7.8	389	6.1	<2	12.6	
	37.7	5.5	46	7.8	389	6.0	<2	12.0	
	39.4	4.9	41	7.8	390	5.8	<2	10.5	
	41.0	4.3	36	7.8	390	5.6	<2	8.9	
	42.6	4.0	34	7.7	391	5.5	<2	8.6	
	44.3	3.9	32	7.7	391	5.5	<2	7.8	
	45.9	3.6	30	7.7	391	5.4	<2	7.8	
	47.6	3.5	29	7.7	391	5.3	<2	7.6	
	49.2	3.4	28	7.7	392	5.3	<2	7.7	

Table 5. Physical field parameters measured at Long Lake near McCarthy, Alaska, 2008.—Continued

[**Abbreviations:** ft, foot; mg/L, milligram per liter; µS/cm at 25°C, microsiemens per centimeter at 25 degrees Celsius; °C, degree Celsius; NTU, Nphelometric Turbidity Unit; –, no data]

Date	Sample depth (ft)	Dissolved oxygen (mg/L)	Oxygen saturation (percent)	pH (units)	Specific conductance (µS/cm at 25°C)	Water temperature (°C)	Turbidity (NTU)	Chlorophyll-α	Secchi disk depth (ft)
08-05-08	1.6	10.3	103	8.3	362	15.5	<2	1.1	20.9
	3.3	10.3	103	8.3	362	15.4	<2	1.1	
	4.9	10.2	102	8.3	362	15.4	<2	1.1	
	6.6	10.2	102	8.3	362	15.4	<2	.2	
	8.2	10.2	102	8.3	362	15.3	<2	.5	
	9.8	10.2	102	8.3	362	15.2	<2	.2	
	11.4	10.2	101	8.3	363	15.0	<2	.6	
	13.1	10.4	102	8.3	363	14.4	<2	1.0	
	14.8	10.5	102	8.3	363	13.9	<2	1.6	
	16.4	10.4	100	8.2	360	13.6	<2	1.7	
	18.0	10.3	98	8.2	362	13.1	<2	2.0	
	19.7	10.1	94	8.2	365	12.0	<2	2.6	
	21.3	9.9	89	8.1	368	10.9	<2	1.2	
	23.0	9.8	88	8.1	376	10.4	<2	1.5	
	24.6	9.8	86	8.0	382	9.8	<2	1.5	
	26.2	9.0	77	8.0	384	9.1	<2	1.5	
	27.9	7.8	67	7.9	385	8.7	<2	1.3	
	29.5	7.7	65	7.9	387	8.1	<2	1.6	
	31.2	7.4	62	7.9	388	7.8	<2	1.3	
	32.8	6.7	57	7.8	388	7.6	<2	2.4	
	34.4	6.3	52	7.8	388	7.5	<2	2.4	
	36.1	5.9	48	7.8	389	7.2	<2	2.2	
	37.7	4.9	39	7.8	389	6.7	<2	2.8	
	39.4	4.2	34	7.7	389	6.6	<2	3.9	
	42.6	2.8	22	7.7	391	5.9	<2	4.0	
	45.9	1.4	11	7.7	391	5.7	<2	5.1	
	49.2	1.0	8	7.6	391	5.6	<2	5.3	
09-23-08	1.6	9.8	92	8.2	360	10.4	<2	2.2	23
	3.3	9.8	92	8.2	360	10.4	<2	2.6	
	4.9	9.8	92	8.2	361	10.4	<2	3.1	
	6.6	9.8	92	8.2	360	10.4	<2	2.4	
	8.2	9.8	92	8.2	361	10.3	<2	2.1	
	9.8	9.8	92	8.2	360	10.3	<2	3.1	
	11.4	9.8	92	8.2	360	10.2	<2	2.8	
	13.1	9.8	91	8.2	361	10.2	<2	2.4	
	14.8	9.8	91	8.2	360	10.2	<2	3.0	
	16.4	9.8	91	8.2	361	10.2	<2	2.9	
	18.0	9.7	91	8.1	361	10.2	<2	2.5	
	19.7	9.6	89	8.1	361	10.2	<2	3.1	
	21.3	9.5	88	8.1	362	10.1	<2	2.4	
	23.0	9.2	86	8.1	362	10.1	<2	3.1	
	24.6	8.9	83	8.1	363	10.0	<2	2.6	
	26.2	8.8	81	8.0	364	10.0	<2	2.0	
	27.9	7.5	69	8.0	366	9.5	<2	3.0	
	29.5	4.5	40	7.8	379	8.9	<2	2.1	
	31.2	3.7	33	7.8	385	8.5	<2	2.3	
	32.8	2.9	26	7.7	388	7.9	<2	1.9	
	34.4	2.1	18	7.7	390	7.4	<2	2.0	
	36.1	1.6	14	7.7	391	7.2	<2	1.9	
	37.7	1.3	11	7.6	391	7.1	<2	1.7	

Table 5. Physical field parameters measured at Long Lake near McCarthy, Alaska, 2008.—Continued

[**Abbreviations:** ft, foot; mg/L, milligram per liter; µS/cm at 25°C, microsiemens per centimeter at 25 degrees Celsius; °C, degree Celsius; NTU, Nephelometric Turbidity Unit; –, no data]

Date	Sample depth (ft)	Dissolved oxygen (mg/L)	Oxygen saturation (percent)	pH (units)	Specific conductance (µS/cm at 25°C)	Water temperature (°C)	Turbidity (NTU)	Chlorophyll-α	Secchi disk depth (ft)
09-23-08—Continued	39.4	0.8	7	7.6	392	6.8	<2	1.8	
	41.0	0.5	4	7.6	392	6.6	<2	2.0	
	42.6	0.4	3	7.6	393	6.5	<2	2.4	
	44.3	0.3	2	7.5	393	6.5	<2	2.2	
	45.9	0.1	0	7.5	395	6.2	4.5	4.6	
	47.6	0.1	0	7.5	395	6.1	4.3	5.2	
	49.2	0.1	0	7.5	396	6.0	3.9	5.7	
	50.8	0.1	0	7.5	396	5.9	3.6	5.1	

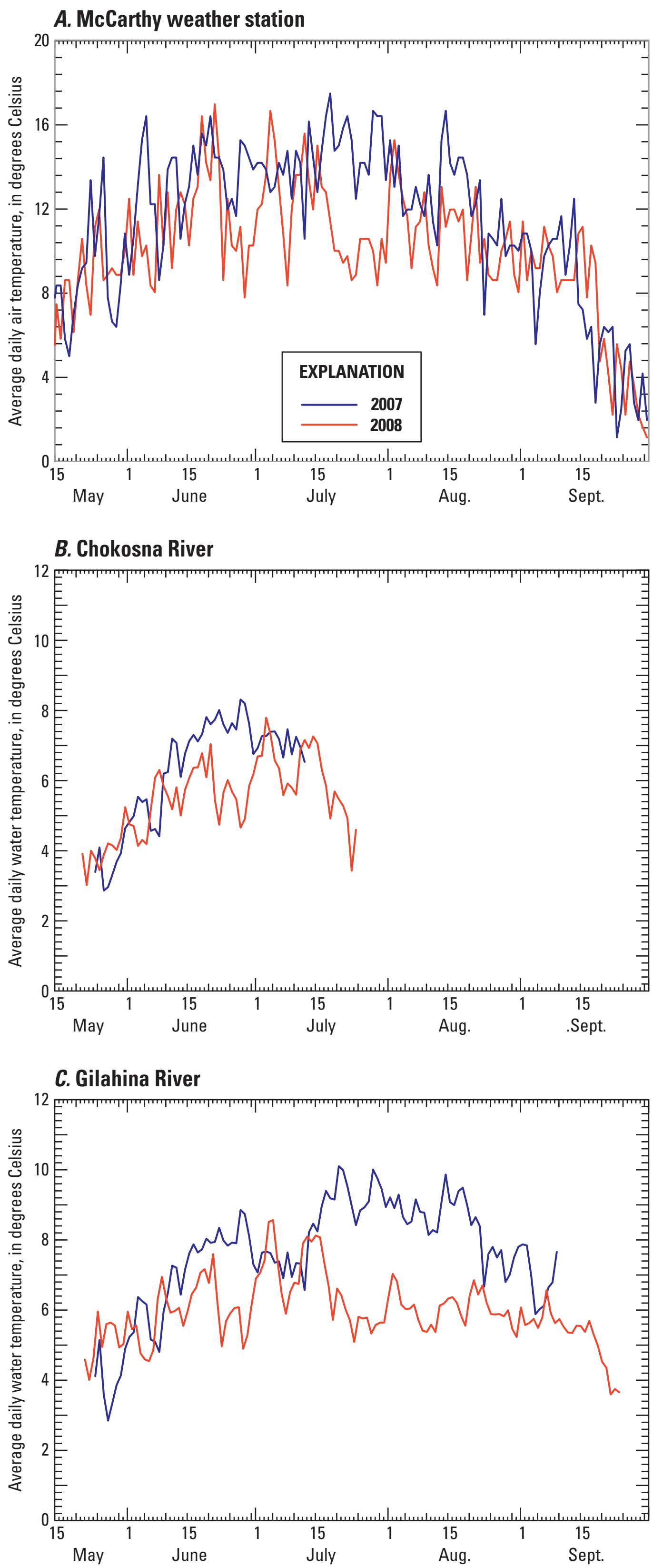


Figure 4. Average daily air temperature for (*A*) McCarthy and average daily water temperature for (*B*) Chokosna and (*C*) Gilahina Rivers, Alaska, May to September 2007 and 2008.

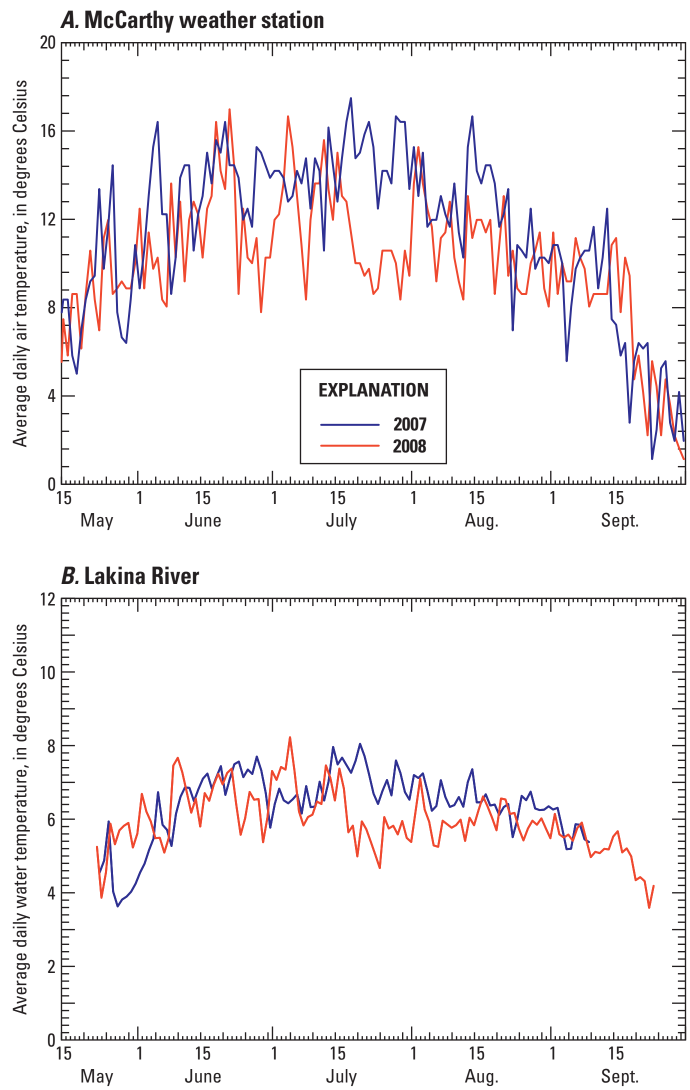


Figure 5. Average daily air temperature for (*A*) McCarthy and average daily water temperature for (*B*) Lakina River, Alaska, May to September 2007 and 2008.

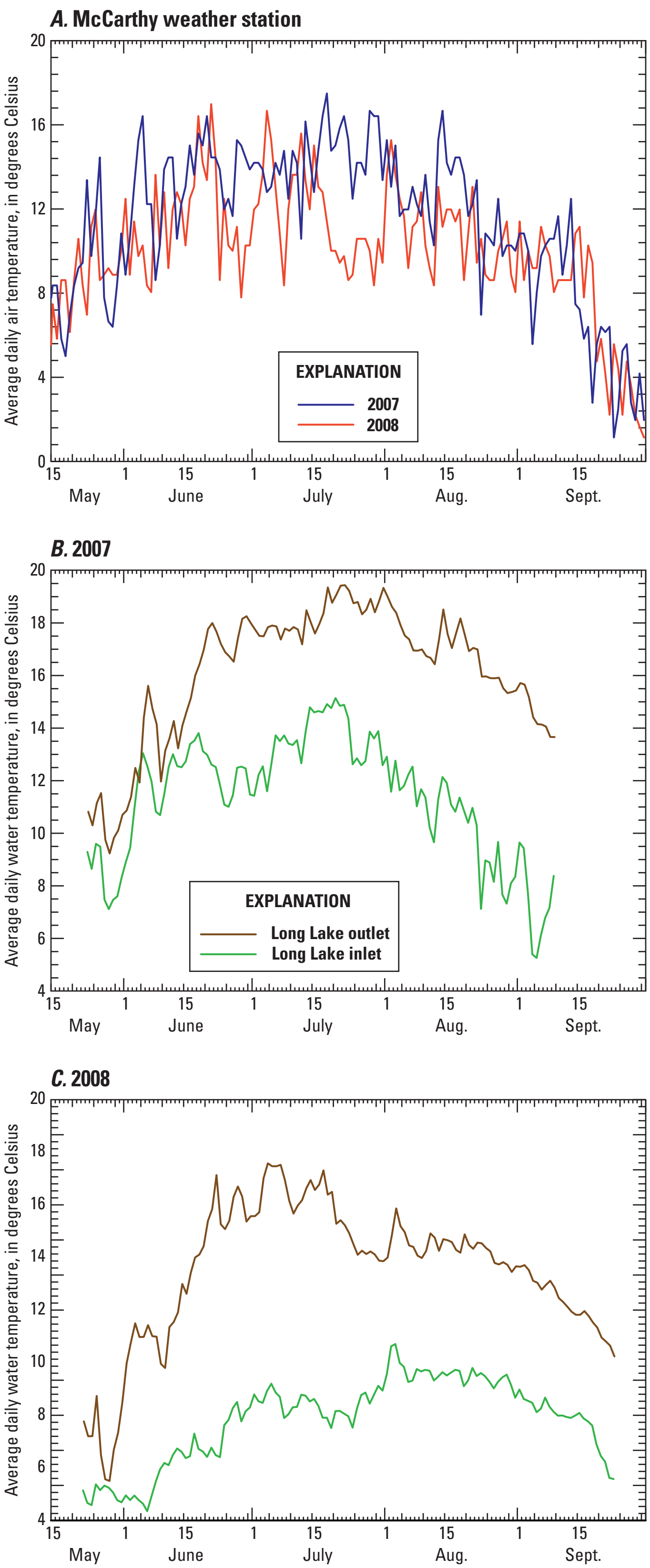


Figure 6. Average daily air temperature for (*A*) McCarthy and average daily water temperature for (*B–C*) Long Lake outlet and inlet streams, Alaska, May to September 2007 and 2008.

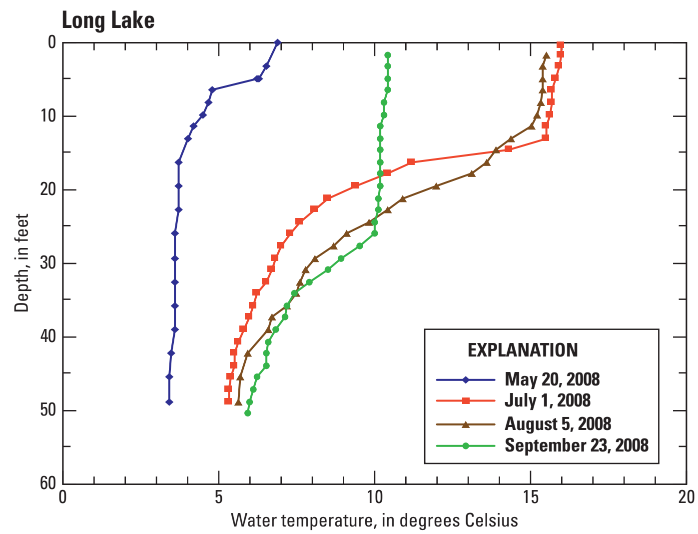


Figure 7. Water temperature profiles for Long Lake, Alaska, May to September 2008.

Water Temperature of Long Lake Outlet—1998–2008

Mohseni and others (1998) developed a non-linear-regression model that uses a logistic function to determine average weekly stream temperatures. Inputs to the model are weekly air temperature and weekly water temperature. The model then calculates a regression equation for a particular site. Provided the resulting regression equation is accurate, one can then input long-term air temperature into the regression equation to determine long-term water temperatures. The model was used to assess water temperatures in streams and rivers in the Cook Inlet Basin of Alaska with good results (Kyle and Brabets, 2001).

The regression model for stream temperatures developed by Mohseni and others (1998) was applied to the Long Lake outlet stream to examine water temperatures for the last 10 years (1998–2008) because this stream (and Long Lake) supports a large run of sockeye salmon. Air temperature data were obtained from the climate station operated by the National Weather Service at McCarthy from 1998 to 2008. Using the air temperature data for 2007 and 2008 and the water temperature for 2007 and 2008 from the outlet stream of Long Lake, the stream temperature model was calibrated to determine the following coefficients:

a the maximum weekly stream temperature,

m the minimum weekly stream temperature,

b the air temperature at the inflection point, and

g a measure of the steepest slope of the S function.

For Mohseni's model, the Nash-Sutcliffe coefficient (NSC) (Nash and Sutcliffe, 1970) is the main determinant of goodness of fit. Root mean square error (RMSE) expresses the standard error of prediction and also is evaluated. The values for NSC and RMSE for the outlet stream of Long Lake were 0.60 and 1.83, respectively, which would indicate a fair fit of the model.

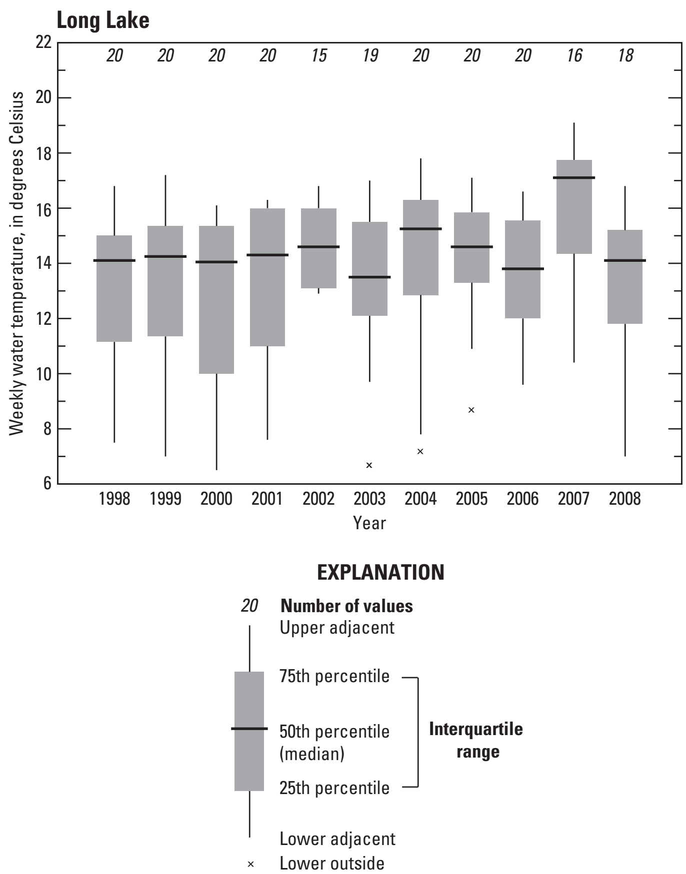


Figure 8. Distribution of simulated average weekly water temperatures from the outlet stream of Long Lake, Alaska, May through September, 1998–2008.

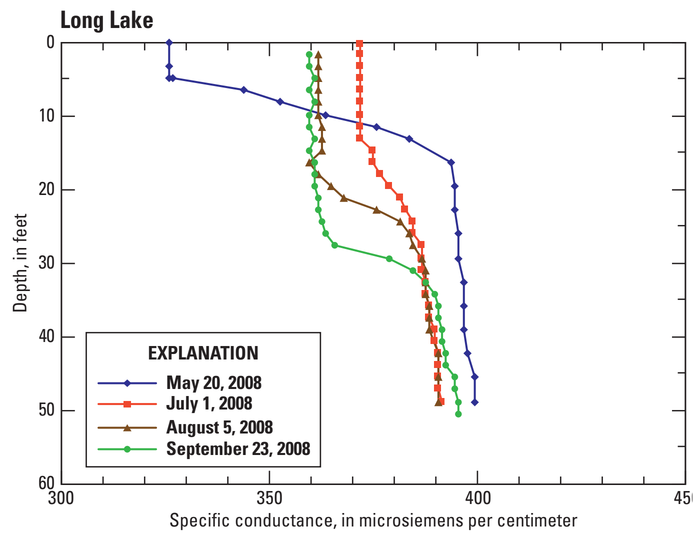


Figure 9. Specific conductance profiles for Long Lake, Alaska, May to September 2008.

After the coefficients *a*, *m*, *b*, and *g* were determined, the regression model was used with the 1998–2006 air temperature data to estimate the average weekly stream temperatures for these periods. Results from the regression model (fig. 8) indicate that between 1998 and 2008, there were no significant trends in water temperature. However, 2007 experienced the highest median and highest weekly water temperatures during this 10-year period.

Specific Conductance

Specific conductance is a measure of the ability of water to conduct an electric current, and can be used to indicate the concentrations of dissolved solids, or ions, in the water. As the concentration of ions in solution increases or decreases, so does the conductance of the solution. Frequently, a statistical relation can be developed between specific conductance and the ionic components making up the dissolved solids in water. During low flow, the conductance of stream water generally is the highest, indicating a greater component of groundwater in the total flow. Groundwater has greater potential to dissolve minerals than does rainwater or snowmelt, having spent more time in contact with rocks and soil materials. Periods of relatively low specific conductance in stream water reflect runoff of rain or snowmelt, which typically contain small amounts of dissolved ions.

During the study period, measured values of specific conductance did not correlate with discharge (table 4). Most likely, the variation in concentration with discharge is attributed to the mixing of the different components of discharge, which are quantities of water from multiple sources. Specific conductance values for the Long Lake outlet would not be expected to correlate with discharge due to the mixing characteristics of Long Lake. The highest average specific conductance was that for the Chokosna River (428 µS/cm at 25 °C —seven measurements), and the lowest average specific conductance (230 µS/cm at 25 °C—six measurements) was at the Gilahina River.

At Long Lake, profiles of specific conductance were fairly uniform throughout the water column from July through September (fig. 9). Values during this period ranged from 360 to 400 µS/cm at 25 °C. The highest variability was noted in May, when values were as low as 325 µS/cm in the upper 6 ft, and then increased to near 400 µS/cm at 16 ft and remained near this level to the bottom of the lake. The lower values of conductance near the surface reflect snowmelt or rainfall runoff into the lake.

pH

The pH of water is a measure of its hydrogen-ion activity and typically ranges from 0 (acidic) to 14 (alkaline) standard units. The pH of natural river water typically ranges between 6.5 and 8.0 standard units (Hem, 1985). During the study period, measured values of pH for all sites ranged from 7.8 to 8.6 (table 4). The pH values in profiles at Long Lake varied only slightly, ranging from 7.7 to 8.4 (table 5). All values were within an acceptable range for cold-water fish growth and survival.

Dissolved Oxygen

The dissolved-oxygen concentration in a stream is controlled by several factors, including water temperature, air temperature and atmospheric pressure, hydraulic characteristics of the stream, photosynthetic or respiratory activity of stream biota, and the quantity of organic matter present (Hem, 1985). Salmon and other species of fish require well-oxygenated water at every stage in their life history, as do many forms of aquatic invertebrates. Young fish tend to be more susceptible to oxygen deficiencies than adults. Measurements of dissolved oxygen at all stream sites during the study period ranged from 6.1 to 13.2 mg/L (table 4). The range of values was nearly identical at all sites.

At Long Lake, the levels of dissolved-oxygen concentration varied considerably with depth throughout the measurement period in 2008 (fig. 10). In May, dissolved-oxygen concentration was approximately 9 to 10 mg/L from the surface to 6 ft. A strong stratification exists between 6 and 13 ft where dissolved-oxygen concentration decreases to less than 4 mg/L. In July, concentrations were near 10 mg/L from the surface to 16 ft and then increased to 12 mg/L from 16 to 25 ft. This increased dissolved-oxygen concentration between 16 and 33 ft indicates the presence of phytoplankton that had settled to the top of the density barrier of the thermocline and were actively photosynthesizing. Dissolved-oxygen concentrations then steadily decreased to about 3 mg/L at the bottom. In August, concentrations were near 10 mg/L at the surface to 26 ft and then decrease to about 1 mg/L at the bottom, showing a profile similar to the July profile. In September, concentrations were between 9 and 10 mg/L from 0 to 23 ft. A strong stratification exists from 26 to 36 ft as concentrations decrease to 2 mg/L and then continued to decline to 0 mg/L at the lake bottom. The late summer stratification prevents the replenishment of oxygen below the thermocline where oxygen is consumed by respiration and decomposition.

Alkalinity

Alkalinity is a measure of the capacity of the substances dissolved in water to neutralize acid. In most natural waters, alkalinity is produced mainly by bicarbonate and carbonate ions, which are formed when carbon dioxide or carbonate rocks dissolve in water (Hem, 1985). The lowest alkalinity values were at the Gilahina River and ranged from 63 to 96 mg/L (table 6); the highest alkalinity values were measured at the Long Lake inlet and outlet streams, and ranged from 92 to 222 mg/L and 117 to 164 mg/L, respectively. The range of pH measured at all sites indicates that all of the alkalinity can be attributed to dissolved bicarbonate (Hem, 1985). Alkalinity concentrations at all sites would be considered average to high and would indicate a high buffering capacity.

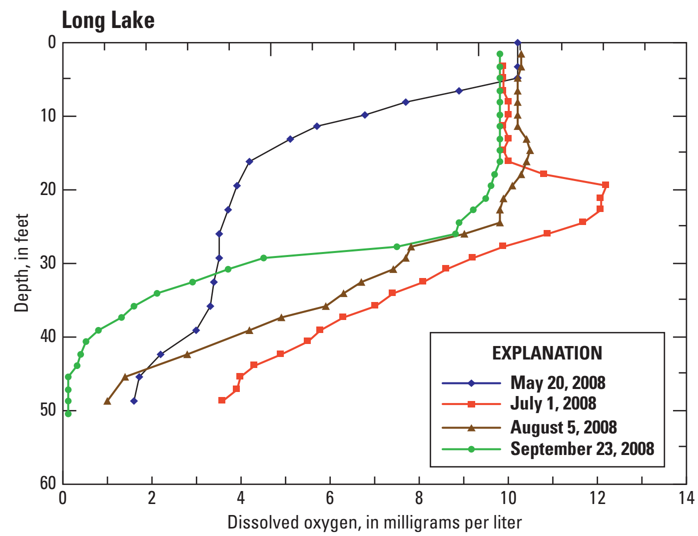


Figure 10. Dissolved oxygen profiles for Long Lake, Alaska, May to September 2008.

Major Dissolved Constituents and Iron and Manganese

Major dissolved constituents in streams consist of inorganic minerals derived primarily from soil and rock weathering. Dissolved cations that constitute a majority of the dissolved solids content in natural waters are calcium, magnesium, sodium, and potassium; the major anions are usually represented by sulfate, chloride, fluoride, nitrate and those making up the alkalinity (carbonate and bicarbonate) (Hem, 1985). Streams draining basins with rocks and soils containing insoluble minerals tend to have lower concentrations of dissolved solids than streams draining basins with easily dissolved minerals. Analyses of the water samples collected in this study indicated that total dissolved solid concentrations are highest (average of 291 mg/L) in the Chokosna River and lowest (average of 141 mg/L) in the Gilahina River (table 6). Dissolved solids concentrations in samples from Long Lake inlet and outlet averaged 187 and 211 mg/L, respectively. Concentrations of dissolved solids such as these are representative of basins containing soils and rocks that are easily dissolved.

Calcium and magnesium are common alkaline-earth metals that are essential elements in plant and animal nutrition. Both elements are major anion components in most natural waters (Hem, 1985). In the samples collected in this study, concentrations of calcium ranged from 28 to 86 mg/L, and those of magnesium ranged from 2.8 to 12.0 mg/L (table 6). Concentrations of these constituents tended to be higher at Chokosna River and Long Lake sites than at the Gilahina River. Sodium and potassium are both present in most natural waters, but usually in low concentrations in rivers. Sodium concentrations ranged from 1.8 to 9.2 mg/L and potassium concentrations ranged from 0.25 to 1.02 mg/L at all sites (table 6).

Table 6. Concentrations of major ions and trace elements iron and manganese in water samples collected from streams along McCarthy Road, Alaska, 2007 and 2008.

[All values in milligrams per liter unless otherwise noted. Values in parentheses with date for Long Lake are measurement depth. **Abbreviations**: µg/L, micrograms per liter; ft, foot; E, estimated; <, less than]

Date	Time	Depth (ft)	Alkalinity	Bicarbonate	Calcium	Chloride	Total dissolved solids	Fluoride	Iron (µg/L)	Magnesium	Manganese (µg/L)	Potassium	Silica	Sodium	Sulfate
Lakina River															
05-22-07	1530	–	92	112	42.6	0.36	147	E0.08	23	6.6	3.6	0.80	5.4	3.0	41.6
10-02-07	1715	–	106	129	53.4	.35	211	E.11	<8	8.5	1.1	.57	6.2	3.4	63.2
Long Lake Inflow															
05-22-07	1000	–	92	112	28.9	0.73	119	E0.09	64	4.8	12.6	0.54	7.0	3.7	2.8
07-30-07	0945	–	222	271	61.0	1.71	260	.10	464	10.3	476	.25	10.6	9.2	1.9
05-21-08	1030	–	140	171	44.2	.94	174	E.09	33	7.1	7.3	.60	7.6	6.0	6.2
07-01-08	1000	–	169	206	49.9	1.21	198	E.10	37	8.0	10.3	.46	8.0	7.4	4.8
08-06-08	0915	–	133	162	41.6	.82	172	E.09	39	6.8	7.7	.50	8.3	5.3	4.1
09-24-08	1020	–	171	209	54.6	1.12	199	E.10	32	8.5	11.8	.62	8.9	7.4	6.8
Long Lake Outflow															
05-22-07	1210	–	117	143	41.3	0.69	157	E0.07	20	7.1	4.8	0.69	6.1	4.1	16.0
07-30-07	1900	–	154	188	49.2	.86	204	E.08	E3	9.5	1.4	.82	5.6	5.3	26.0
05-20-08	1730	–	154	188	54.0	.88	220	E.10	10	9.2	3.3	.86	6.8	5.1	27.9
07-01-08	1125	–	164	202	56.9	.93	232	E.10	<8	10.2	2.2	.89	7.0	5.5	31.5
08-05-08	1644	–	164	200	54.7	.92	225	E.09	<8	9.8	.8	.89	6.2	5.2	30.0
09-23-08	1745	–	160	195	57.3	.92	226	E.10	<8	9.8	.9	.86	6.7	5.7	28.4
Gilahina River															
05-23-07	0900	–	63	76	28.2	0.20	92	<0.10	52	2.8	1.2	0.73	6.0	1.8	16.8
08-01-07	1200	–	91	111	41.8	.13	166	<.10	8	4.5	.5	.39	7.9	2.9	37.9
10-03-07	1600	–	88	107	41.2	.23	148	<.12	9	4.4	.9	.64	8.2	2.9	31.6
05-19-08	1810	–	82	100	31.8	.16	124	<.12	38	3.1	1.6	.62	6.8	1.9	18.0
06-30-08	1730	–	79	97	35.9	E.11	145	E.07	9	3.7	.8	.33	7.1	2.6	30.8
09-24-08	1600	–	96	117	46.8	.17	174	<.12	12	4.7	1.4	.42	8.2	2.9	38.1
Chokosna River															
05-23-07	1100	–	64	78	35.8	0.20	190	<0.10	29	4.8	4.2	0.77	4.0	3.1	44.7
07-29-07	1400	–	121	148	78.8	.22	334	E.07	64	10.5	.9	.47	5.9	6.2	134
10-03-07	1240	–	112	137	80.6	.25	326	.13	<8	11.1	.8	.43	6.4	6.5	138
05-19-06	1545	–	92	113	52.2	.26	220	E.08	16	7.0	2.0	.68	5.8	4.6	68.0
06-30-08	1540	–	110	134	69.5	.17	294	E.09	<8	9.4	.9	.45	5.5	5.8	116
08-04-08	1635	–	110	134	70.4	.17	310	E.09	<8	10.5	1.2	.46	5.7	5.5	122
09-24-08	1700	–	123	150	86.5	.24	366	E.07	<8	12.0	.5	.50	6.2	6.6	145
Long Lake															
05-20-08	1300	3	148	181	52.2	0.86	207	E0.09	11	9.0	1.8	0.85	6.8	4.7	25.9
05-20-08	1310	33	180	220	65.1	1.00	251	.12	<8	11.4	.5	.98	7.7	6.0	32.1
07-01-08	1415	10	169	206	58.7	1.00	236	E.10	<8	10.3	.8	.91	7.0	5.5	31.4
07-01-08	1425	39	174	212	59.4	1.00	240	E.11	<8	10.4	6.1	.94	8.3	5.4	32.6
08-05-08	1210	15	169	199	55.5	.98	219	E.10	<8	9.8	E.3	.93	6.4	5.4	29.5
08-05-08	1230	39	178	215	60.3	1.05	234	E.10	<8	10.6	2.1	1.02	8.0	5.6	31.5
09-23-08	1840	20	167	197	57.6	1.39	225	E.09	E6	9.7	.7	.89	6.7	5.6	28.3
09-23-08	1850	39	178	213	62.9	1.05	248	E.09	<8	10.5	2.7	1.00	9.2	5.8	31.3

Bicarbonate (HCO_3) was the dominant anion at all sites except the Chokosna River, where sulfate was also a dominant anion. Concentrations of bicarbonate were the highest at the Long Lake sites and more variable at the Gilahina and Chokosna Rivers. Silica and sulfate, which are dissolved from rocks and soils, are the next most abundant anions, with concentrations ranging from 4.0 to 10.6 mg/L for silica, and from 1.9 to 145 mg/L for sulfate. Chloride and fluoride concentrations were less than or equal to 1.71 and 0.13 mg/L, respectively at all sites (table 6).

Iron is dissolved from many rocks and soils and is an essential element in the metabolism of animals and plants. Iron in drinking water does not pose a health threat provided concentrations are less than 300 µg/L. Concentrations at all sites were less than 100 µg/L (table 6) with the exception of one sample at the Long Lake inlet, in which the concentration of iron was 464 µg/L. The chemistry of manganese (Mn) is similar to that of iron and Mn concentrations should generally be less than 50 µg/L. Concentrations of manganese were less than 13 µg/L in all but one sample, from the Long Lake inlet, with a concentration of 476 µg/L.

A trilinear diagram (Hem, 1985) was used to plot the concentrations of dissolved major ions in the water samples. This diagram permits the chemical composition of multiple samples to be represented on a single graph, and facilitates classification of the sample chemistry. On the basis of analyses of the samples collected during this study, the water of the Chokosna River can be classified as a calcium bicarbonate sulfate water (fig. 11). The water of the remaining sites would be classified as a calcium bicarbonate water.

Nutrients and Dissolved Organic Carbon

Nitrogen (N) is present in the crustal rocks of the earth and in the atmosphere. In its reduced or organic forms, it is converted by soil bacteria into nitrite (NO_2) and nitrate (NO_3). Biological fixation is accomplished by blue-green algae and certain related organisms that have the capacity for photosynthesis. Nitrogen is an important water-quality constituent largely due to its role as a component of the chlorophyll in plants and thus is essential for primary productivity in lakes, streams, and rivers. In aquatic ecosystems, N commonly occurs in three ionic forms: ammonium (NH_4), (NO_2), and (NO_3). In the laboratory, NH4 is analyzed as ammonia (NH_3); thus N concentrations are reported as: total and dissolved NH_3 plus organic N; dissolved NH_3; dissolved NO_2 plus NO_3; and dissolved NO_2. Nitrate is generally more abundant than NO_2 in natural waters because NO_2 readily oxidizes to NO_3 in oxygenated water (Hem, 1985). Total NH_3 plus organic N concentrations for whole water samples represent the sum of biologically derived organic N compounds, plus any NH_3 present. Nitrate and NO_2 are oxidized forms of inorganic N that make up most of the dissolved N in well-oxygenated streams such as those along the McCarthy Road. The dissolved concentrations represent the NH_4 or NO_2 plus NO_3 in solution and associated with material capable of passing through a 0.45-µm-pore filter.

All concentrations of the various N forms were less than 1 mg/L (table 7). Due to its toxicity to freshwater aquatic organisms, the U.S. Environmental Protection Agency (USEPA; 1976) suggests a limitation of 0.02 mg/L of NH_3 as un-ionized NH_3 for waters to be suitable for fish propagation. Concentrations of NH_3 (both ionized and unionized) were all below this level at all sites.

Phosphorus (P) is a rather common element in igneous rock. It is fairly abundant in sediments, but at concentrations in natural waters normally no more than a few tenths of a milligram per liter. Phosphorus is an element vital to all forms of aquatic biota because it is involved in the capture and transfer of chemical energy, and it is an essential element in nucleic acids (Gaudy and Gaudy, 1988). It occurs as organically bound P or as phosphate (PO_4^{3-}). Elevated concentrations of P in water are not considered toxic to human or aquatic life. Elevated concentrations can, however, stimulate the growth of algae in lakes and streams. Phosphorus concentrations are reported as total P and dissolved orthophosphate (PO_4). Total PO_4^{3-} concentrations represent the P in solution, associated with colloidal material, and contained in or attached to biotic and inorganic particulate matter. Dissolved concentrations are determined from the filtrate that passes through a filter with a nominal pore size of 0.45 µm. The PO_4 ion is a significant form of P because it is directly available for metabolic use by aquatic biota. Concentrations of total P, dissolved P and PO_4 were typically low, with values near or below minimum detection levels in nearly all samples (table 7).

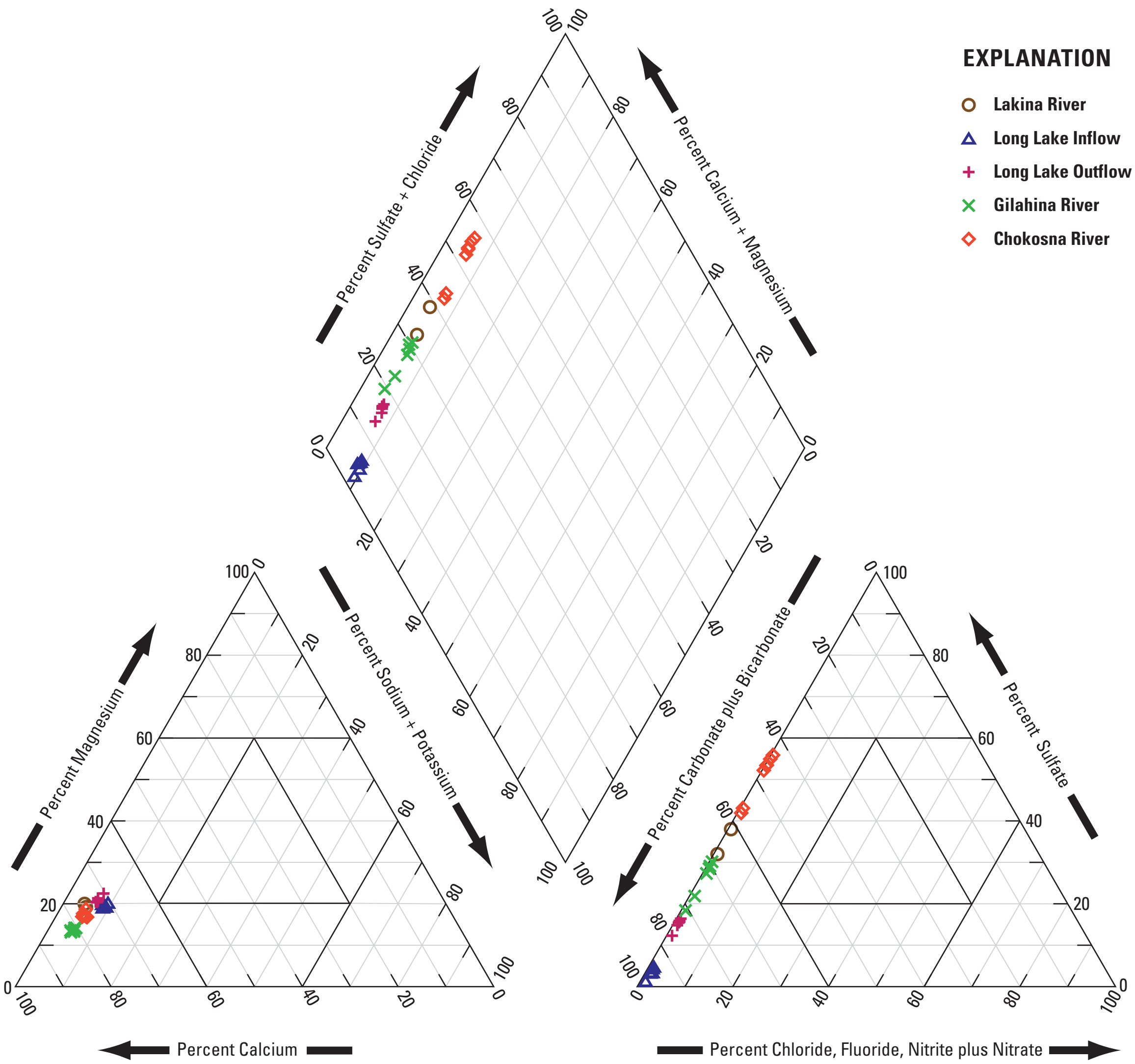


Figure 11. Chemical composition of water samples collected from sites along McCarthy Road, Alaska, 2007 and 2008.

Phytoplankton (algae) can assimilate only three of the several different nutrient (N and P) compounds commonly detected in aquatic ecosystems. The only forms of N that phytoplankton can use for growth are NO_2, NO_3, and NH_4 (inorganic nitrogen), whereas PO_4 is the only form of P that phytoplankton can use for growth(Horne and Goldman, 1994). An N:P ratio greater than 10 (by weight) generally indicates that P is the limiting nutrient, whereas a ratio less than 10 indicates that N is limiting (Horne and Goldman, 1994). For Long Lake, N:P ratios ranged from 6 to 12 above the thermocline and in the euphotic zone (table 7).These N:P ratios suggest that at the beginning of open water (May) and at the end of summer (September) phosphorus is the limiting nutrient but during the summer months (July and August) nitrogen is the limiting nutrient.

Dissolved organic carbon (DOC) is commonly a major component of organic matter in aquatic ecosystems. DOC is defined as organic carbon in the filtrate (dissolved and colloidal phases) that passes through a 0.45-µm pore-size filter (Aiken and Cotsaris, 1995). Generally, DOC is in greater abundance than particulate organic carbon, accounting for about 90 percent of the total organic carbon of most waters (Aiken and Cotsaris, 1995). At the McCarthy Road sites, the highest concentrations of DOC—6.3–11.7 mg/L—were detected at the inlet stream to Long Lake. This watershed is comprised primarily of wetlands; thus, DOC concentrations would be expected to be higher than the other streams. At the Gilahina and Chokosna Rivers, DOC concentrations did exhibit some seasonality and were highest in May 2007 and 2008, reflecting spring runoff.

Table 7. Concentrations of nutrients and dissolved organic carbon in water samples collected along McCarthy Road, Alaska, 2007 and 2008.

[All values in milligrams per liter unless otherwise noted. **Abbreviations:** ft, foot; N:P, nitrogen:phosphorus; <, less than; E, estimated; –, not applicable]

Date	Time	Depth (ft)	Dissolved ammonia nitrogen (NH_4)	Dissolved nitrogen (NH_4+Org)	Total nitrogen(NH_4+Org)	Dissolved nitrogen (NO_2+NO_3)	Dissolved nitrogen (NO_2)	Dissolved phosphorus	Dissolved ortho-phosphorus	Total phosphorus	Dissolved organic carbon	N:P ratio
Lakina River												
05-22-07	1530	–	<0.020	0.26	0.21	0.155	E0.002	<0.006	<0.006	0.106	3.3	–
10-02-07	1715	–	<.020	<.14	<.14	.197	<.004	<.006	E.004	.021	1.2	–
Long Lake Inflow												
05-22-07	1000	–	<0.020	0.43	0.30	<0.016	E0.001	E0.004	<0.006	E0.006	11.7	–
07-30-07	0945	–	<.020	.31	.29	<.016	<.002	.006	E.005	.009	10.3	–
05-21-08	1030	–	<.020	.26	.19	.037	E.001	<.006	E.004	E.005	6.3	–
07-01-08	1000	–	<.020	.26	.22	.02	<.002	E.003	<.006	<.008	8.8	–
08-06-08	0915	–	<.020	.32	.31	<.016	<.002	<.006	.006	E.007	11.5	–
09-24-08	1020	–	<.020	.21	.19	E.009	<.002	<.006	E.004	E.005	6.9	–
Long Lake Outflow												
05-22-07	1210	–	<0.020	0.28	0.23	<0.016	E0.001	<0.006	<0.006	0.011	5.8	–
07-30-07	1900	–	<.020	.19	.30	<.016	<.002	E.005	E.004	E.007	5.0	–
05-20-08	1730	–	<.020	.17	.21	.024	<.002	E.004	E.003	.013	3.6	–
07-01-08	1125	–	<.020	.28	.20	<.016	<.002	E.005	<.006	.008	4.1	–
08-05-08	1644	–	<.020	.19	.21	<.016	<.002	E.005	E.005	E.004	4.8	–
09-23-08	1745	–	<.020	.20	.19	<.016	<.002	E.004	E.003	E.007	4.3	–
Gilahina River												
05-23-07	0900	–	<0.020	0.21	0.19	0.038	E0.001	<0.006	<0.006	0.027	3.9	–
08-01-07	1200	–	<.020	E.07	<.10	.103	<.002	E.003	E.004	<.008	1.7	–
10-03-07	1600	–	<.020	E.11	E.09	.144	<.002	<.006	E.003	.011	2.2	–
05-19-08	1810	–	<.020	E.11	E.14	.046	<.002	<.006	.009	.019	2.9	–
06-30-08	1730	–	<.020	E.10	<.14	.122	<.002	<.006	<.006	.021	2.1	–
09-24-08	1600	–	<.020	E.11	E.13	.116	<.002	<.006	E.004	E.007	2.0	–
Chokosna River												
05-23-07	1100	–	<0.020	0.26	0.17	0.037	E0.001	E0.003	<0.006	0.079	3.5	–
07-29-07	1400	–	<.020	E.06	<.10	.098	<.002	E.003	E.004	E.007	.9	–
10-03-07	1240	–	<.020	E.07	<.10	.145	<.002	<.006	E.003	.013	1.1	–
05-19-06	1545	–	<.020	E.12	E.14	.055	E.001	<.006	<.006	.028	2.9	–
06-30-08	1540	–	<.020	E.09	<.14	.095	<.002	<.006	<.006	.041	1.3	–
08-04-08	1635	–	<.020	E.08	E.09	.132	<.002	<.006	E.006	.079	1.5	–
09-24-08	1700	–	<.020	E.08	E.12	.144	<.002	<.006	E.003	E.005	1.1	–

Table 7. Concentrations of nutrients and dissolved organic carbon in water samples collected along McCarthy Road, Alaska, 2007 and 2008.—Continued

[All values in milligrams per liter unless otherwise noted. **Abbreviations:** ft, foot; N:P, nitrogen:phosphorus; <, less than; E, estimated; <, less than; –, not applicable]

Date	Time	Depth (ft)	Dissolved ammonia nitrogen (NH_4)	Dissolved nitrogen (NH_4+Org)	Total nitrogen (NH_4+Org)	Dissolved nitrogen (NO_2+NO_3)	Dissolved nitrogen (NO_2)	Dissolved phosphorus	Dissolved ortho phosphorus	Total phosphorus	Dissolved organic carbon	N:P ratio
Long Lake												
05-20-08	1300	3	<0.020	0.16	0.29	E0.011	E0.001	<0.006	E0.003	0.019	3.7	10
05-20-08	1310	33	<.020	E.13	.18	.085	<.002	E.003	E.004	.012	3.3	26
07-01-08	1415	10	<.020	.20	.17	<.016	<.002	E.004	<.006	E.005	4.0	6
07-01-08	1425	39	<.020	.17	.23	.04	<.002	E.004	<.006	.012	3.8	10
08-05-08	1210	15	<.020	.18	.23	<.016	<.002	<.006	E.006	.009	5.3	6
08-05-08	1230	39	<.020	.19	.56	.033	<.002	E.004	.007	E.007	3.9	8
09-23-08	1840	20	<.020	.18	.19	<.016	<.002	<.006	E.003	.011	4.2	12
09-23-08	1850	39	<.020	.18	.19	.121	<.002	.006	E.006	.015	3.4	24

Trace Elements in Streambed Sediments

Streambed sediment samples collected at 5 stream sites along the McCarthy Road were analyzed for 33 trace elements and organic carbon content (tables 3 and 8). Aquatic-life criteria have not been established for most of the trace elements; therefore, to provide a general comparison, the concentrations of trace elements in samples from the McCarthy Road sites were compared to concentrations in the USGS NAWQA program data set, which consists of about 1,000 samples collected throughout the contiguous United States, Alaska, and Hawaii. Of these samples, about 250 represent reference or forested areas (Horowitz and Stephens, 2008). The concentrations of trace elements at the McCarthy Road stream sites were also compared to concentrations in streambed sediments collected from the south side of Denali National Park and Preserve (representative of another interior Alaska location with similar climate) in 1999 and 2000 (Brabets and Whitman, 2002).

The range in concentrations of most of the trace elements in sediment samples collected at the sites along the McCarthy Road were similar to the medians of the NAWQA reference/forested sites, with the exception of higher concentrations of arsenic, chromium, copper, strontium, and vanadium at the McCarthy Road sites (table 9). Concentrations of most trace elements detected in streambed samples from the south side of Denali National Park and Preserve were similar to concentrations in the McCarthy Road samples. Notable exceptions were higher concentrations of copper, manganese, and strontium in the McCarthy Road samples.

The focus in the literature on criteria for streambed sediments has been limited to nine trace elements: arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, and zinc. Guidelines have been established for these elements in unsieved streambed sediment. Because trace-element samples for this study are from sediments finer than 0.063 mm, in which concentrations tend to be greatest, comparisons with the guidelines may overestimate the effects on aquatic organisms (Deacon and Stephens, 1998). However, it was still felt that it would be acceptable to compare the concentrations from the finer than 0.063-mm size fraction to the published guidelines for this study.

The Canadian Council of Ministers of the Environment (1999) has established guidelines for the protection of aquatic life for some trace elements in unsieved streambed sediment. These guidelines use an assessment value called the probable effect level (PEL), which is the concentration above which adverse effects on aquatic organisms are expected to occur frequently (table 10). MacDonald and others (2000) proposed sediment quality guidelines for eight trace elements, and Van Derveer and Canton (1997) proposed guidelines for selenium (table 10). MacDonald and others (2000) use a value called the probable effect concentration (PEC) and assume a 1 percent organic carbon concentration. The PEC is the concentration above which toxicity is likely. Van Derveer and Canton (1997) suggested a value of 4 µg/g for selenium that is comparable to the PEC. Concentrations greater than the PEL for one or more trace elements were noted in samples from several sites: for arsenic (Lakina River, Long Lake inflow), chromium (Gilahina River), and nickel (Lakina River, Long Lake inflow, Gilahina River, and Chokosna River). Concentrations greater than the PEC for these elements were detected only at the Lakina River and Gilahina River. These concentrations reflect the local geology of this natural area rather than anthropogenic sources.

MacDonald and others (2000) developed a Mean PEC Quotient, to describe the toxicity of the combined trace element concentrations. The Mean PEC Quotient is computed by summing the concentrations of all the trace elements analyzed and dividing by the number of elements. MacDonald and others (2000) determined that sediments with mean PEC quotients less than 0.5 accurately predicted the absence of toxicity in 83 percent of the samples they examined. Mean PEC quotients greater than 0.5 accurately predicted toxicity in 85 percent of the samples. Comparison of the concentrations of the trace elements with the percent organic carbon and mean PEC Quotient provides some insights about the bioavailability of these trace elements. The concentration of organic carbon in sediment is used to indicate the concentration of organic matter. The ability of organic matter to concentrate some trace elements in stream sediment is well recognized (Gibbs, 1973; Horowitz, 1991), and this ability varies with the type of organic matter. For example, complexation by organic matter, such as humic and fulvic acids, has generally been thought to reduce bioavailability of certain metals (Spacie and Hamelink, 1985, Newman and Jagoe, 1994). Results of studies by Winner (1985) and Decho and Luoma (1994), however, suggest that organic carbon compounds may in some cases enhance uptake of certain trace elements. The organic carbon content in three of the five streambed sediment samples (Long Lake Inlet, Long Lake Outlet, and Gilahina River) was greater than 1 percent (3.5, 5.4, and 1.7, respectively), and the corresponding mean PEC quotient was less than 0.50 at these three sites (table 8). As MacDonald and others (2000) noted, sites containing relatively low concentrations of organic carbon have higher potential toxicity. When normalized to percent organic carbon, concentrations of arsenic at the Lakina River and concentrations of chromium and nickel at the Chokosna River were above the PEC level.

Table 8. Concentrations of trace elements and percentage of carbon measured in streambed sediments collected from sites along McCarthy Road, Alaska, 2007.

[**Site No.:** Locations shown in figure 2. Values of carbon, aluminum, sodium, iron, titanium, calcium, magnesium, phosphorus, and potassium in percent; all other values in micrograms per gram. **Abbreviations:** PEC, probable effect concentration; M, measured; I-Carbon, inorganic carbon; O-Carbon, organic carbon; <, less than]

Site No.	Site name	Date	Time	Carbon(total)	Aluminum	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cadmium
1	Lakina River	10-02-07	1445	4.3	5	2.4	46	550	0.9	M	0.4
2	Long Lake Inflow	07-30-07	0930	4.8	5.6	.8	29	740	1.2	M	.2
3	Long Lake Outflow	07-30-07	1800	5.4	5.4	1.1	9	490	1.0	M	.6
4	Gilahina River	08-01-07	0900	2.2	6.2	.9	13	550	1.1	M	.6
5	Chokosna River	07-29-07	1030	1.8	6.8	1.0	16	920	1.1	M	.7

Site No.	Site name	Date	Time	Cerium	Chromium	Cobalt	Copper	Gallium	Sulfur	Sodium
1	Lakina River	10-02-07	1445	27	66	13	49	11	0.07	1.1
2	Long Lake Inflow	07-30-07	0930	30	93	20	61	14	.06	1.4
3	Long Lake Outflow	07-30-07	1800	30	79	13	40	12	.24	1.4
4	Gilahina River	08-01-07	0900	45	170	28	90	15	.08	1.4
5	Chokosna River	07-29-07	1030	33	85	22	97	15	.20	1.0

Site No.	Site name	Date	Time	Iron	Lanthanum	Lead	Lithium	Manganese	Mercury	Molybdenum
1	Lakina River	10-02-07	1445	3.1	16	9	25	490	0.17	2.6
2	Long Lake Inflow	07-30-07	0930	6.7	15	6	26	10,000	.09	.8
3	Long Lake Outflow	07-30-07	1800	3.1	16	6	37	500	.15	.9
4	Gilahina River	08-01-07	0900	5.8	22	7	18	1,200	.09	1.4
5	Chokosna River	07-29-07	1030	5.8	18	16	25	1,300	.06	2.5

Site No.	Site name	Date	Time	Nickel	Niobium	Scandium	Selenium	Silver	Strontium	Thallium
1	Lakina River	10-02-07	1445	39	7	12	1.8	<1.0	690	M
2	Long Lake Inflow	07-30-07	0930	41	10	17	.3	<1.0	330	M
3	Long Lake Outflow	07-30-07	1800	32	9	14	3.6	<1.0	350	M
4	Gilahina River	08-01-07	0900	63	11	28	1.2	<1.0	370	M
5	Chokosna River	07-29-07	1030	36	9	20	1.7	<1.0	340	M

Site No.	Site name	Date	Time	Thorium	Titanium	Vanadium	Yttrium	Zinc	Uranium	I-Carbon
1	Lakina River	10-02-07	1445	3	0.32	120	21	98	2.6	3.4
2	Long Lake Inflow	07-30-07	0930	4	.46	150	20	93	1.7	1.2
3	Long Lake Outflow	07-30-07	1800	3	.43	120	20	92	2.2	1.0
4	Gilahina River	08-01-07	0900	5	.55	230	31	120	2.2	.5
5	Chokosna River	07-29-07	1030	5	.46	190	26	160	2.7	1.1

Site No.	Site name	Date	Time	Calcium	Cesium	Magnesium	Phosphorus	Potassium	O-Carbon	Mean PEC quotient
1	Lakina River	10-02-07	1445	9.4	2.2	1.3	0.09	0.96	0.89	0.51
2	Long Lake Inflow	07-30-07	0930	4.7	2.1	1.7	.10	.94	3.5	.12
3	Long Lake Outflow	07-30-07	1800	4.7	2.0	1.1	.13	.87	5.4	.06
4	Gilahina River	08-01-07	0900	5.1	1.7	2.7	.15	.79	1.7	.32
5	Chokosna River	07-29-07	1030	4.3	2.6	1.6	.13	1.30	0.7	.59

Table 9. Comparison of trace element concentrations measured in streambed sediments from the U.S. Geological Survey National Water-Quality Assessment program, and range of concentrations in sediment samples from streams along McCarthy Road, and 16 sites on the south side of Denali National Park and Preserve, Alaska.

[Values for aluminum, iron, and titanium in percent; all other values in micrograms per gram. **Abbreviations:** NAWQA, National Water-Quality Assessment; M, measured; –, no data; <, less than]

Trace element	Median of values for NAWQA reference forested sites (number of samples varies between 241 and 262)	Range in concentration from sites located along McCarthy Road	Range in concentration from sites located on the south side of Denali National Park	Trace element	Median of values for NAWQA reference forested sites (number of samples varies between 241 and 262)	Range in concentration from sites located along McCarthy Road	Range in concentration from sites located on the south side of Denali National Park
Aluminum	6.5	5 – 6.8	5.1 – 7.4	Manganese	955	490 – 10,000	240 – 1,600
Antimony	.7	0.8 – 2.4	0.1 – 4.2	Mercury	.07	0.06 – 0.17	<0.02 – 0.24
Arsenic	7.0	9 – 46	1.7 – 88	Molybdenum	1	0.8 – 2.6	0.5 – 1.6
Barium	470	490 – 920	480 – 1,400	Neodymium	–	–	15 – 180
Beryllium	2.0	0.9 – 1.2	1.2 – 4.0	Nickel	26	32 – 63	2 – 130
Bismuth	–	<1 (M)	<1	Niobium	–	7 – 11	7 – 23
Cadmium	.4	0.2 – 0.7	0.1 – 1.9	Scandium	12	12 – 28	2 – 17
Cerium	70	27 – 45	32 – 400	Selenium	.7	0.3 – 3.6	0.1 – 5.2
Chromium	63	66 – 170	3.0 – 220	Silver	.2	<1.0	0.1 – 0.8
Cobalt	15	13 – 28	1.0 – 26	Strontium	140	330 – 690	69 – 340
Copper	26	40 – 97	3 – 64	Tantalum	–	–	<1 – 2
Europium	1.0	–	1 – 2	Thallium	–	M	<1 – 1
Gallium	16	11 – 15	13 – 22	Thorium	12.0	3 – 5	6 – 63
Gold	–	–	1	Tin	2.5	–	2 – 5
Holmium	–	–	1 – 3	Titanium	.37	0.32 – 0.55	0.1 – 0.5
Iron	3.6	3.1 – 6.7	0.4 – 4.7	Uranium	3.9	1.7 – 2.7	2.7 – 22
Lanthanum	–	15 – 22	16 – 190	Vanadium	84	120 – 230	5 – 170
Lead	24	6 – 16	13 – 76	Yttrium	–	20 – 31	13 – 75
Lithium	–	18 – 37	37 – 75	Zinc	110	92 – 160	16 – 170

Table 10. Summary of streambed-sediment quality guidelines for nine priority trace elements in streambed sediment at selected sites along McCarthy Road, Alaska.

[**PEL:** Values from Canadian Council of Ministers of the Environment, 1995. **PEC:** Values from MacDonald and others, 2000. Selenium values from Van Derveer and Canton, 1997. **Abbreviations:** NAWQA, National Water-Quality Assessment; PEL, probable effect level; PEC, probable effect concentration; NG, no guidelines; µg/g, microgram per gram, dry weight]

Constituent	NAWQA national median (µg/g)	PEL (µg/g)	PEC (µg/g)	Sediment sample concentration	
				Greater than PEL	Greater than PEC
Arsenic	6.35	17	33	Lakina River Long Lake Inflow	Lakina River
Cadmium	.4	3.53	4.98		
Chromium	62	90	111	Gilahina River	Gilahina River
Copper	26	197	149		
Lead	24.3	91.3	128		
Mercury	.06	.486	1.06		
Nickel	25	36	48.6	Lakina River Long Lake Inflow Gilahina River Chokosna River	Gilahina River
Selenium	.7	NG	4		
Zinc	110	315	459		

Biological Characteristics

Lake Zooplankton

Zooplankton samples were collected four times in 2008—May, July, August, and September—from the sampling location on Long Lake. The total number of zooplankton individuals varied widely, ranging from a low of 97 in July to a high of 1,037 in September (table 11). For the two groups enumerated, cladoceran and copepod, equal numbers of both groups were found in May. The cladoceran group dominated in July and August, and the copepod group dominated in September. In the cladoceran group, cyclopoid1 was the dominant family and in the copepod group, cyclopoid2 was the dominant family in May, July, and August and nauplii the dominant family in September.

Macroinvertebrates

Samples for macroinvertebrates and algae were collected at similar times in the runoff season—in late July 2007 and early August 2008. In 2007, high flow (932 ft^3/s) at the Lakina River prevented any sample collection and the site was not sampled until October 2007. Flows at the other sites were 0.2, 4, 53, and 38 ft^3/s at the Long Lake inlet stream, outlet stream, Gilahina River and Chokosna River, respectively. In 2008, flows were too high at the Gilahina and Chokosna Rivers for sample collection and samples were not collected at these sites until September 2008. The flow at the Long Lake inlet stream was relatively high at the time of sampling (14 ft^3/s) and was sampled again in September 2008 at a lower flow (3.6 ft^3/s). Characteristics of each stream reach were documented with a set of notes and photographs, depicting major geomorphic channel units such as sloughs, riffles, rapids, and other features such as beaver dams or woody debris.

The channel gradients of the Lakina, Gilahina, and Chokosna Rivers are relatively steep, as evidenced by high velocities, ranging from 3.4 to 3.8 ft/s. In contrast, the gradients of the two Long Lake streams are relatively flat as evidenced by the low average velocities at each site, 1.1 and 1.2 ft/s, respectively. The Long Lake sites represent pristine complex habitats characterized by pools and woody debris in the inlet stream and grasses and overhanging shrub in the outlet stream (figs. 12–13). Substrate in both streams is dominated by sand, small cobbles and gravel and the banks are completely vegetated. In contrast, the substrate in the Lakina, Gilahina, and Chokosna Rivers is gravel and large boulders. The banks of these rivers are nearly free of vegetation.

A total of 125 taxa were collected during the 2 years of sampling at the stream sites (appendix A). Of the insect taxa, 83 percent were insects, and of those 83 percent, 60 percent were flies and midges (Diptera). Mayflies (Ephemeroptera), stoneflies (Plecoptera), and caddisflies (Trichoptera) comprised 14, 12, and 11 percent of the total number of taxa, respectively; collectively, these are referred to as EPT taxa. Of the taxa collected and identified, 49 taxa had not been detected at 43 other sites in Alaska sampled using identical protocols. Of these 49 newly collected taxa, 37 were insects including 12 EPT taxa; however, most (23) were flies and midges. Only three taxa were common to all sites—blackflies (Diptera, *Simulium* sp.), water mites (Arachnida, *Sperchon* sp.), and a stonefly (*Zapada oregonensis*).

Using the taxonomic information from the macroinvertebrate samples and IDAS, eleven metrics were calculated (table 12). Metric values from the macroinvertebrate data (table 13) reveal some differences among sites, such as a relatively higher number of gatherer/collector taxa and lower number of EPT taxa at the outlet stream of Long Lake (15210300). This site is affected strongly by Long Lake and a lower stream gradient as compared to the Gilahina and Chokosna Rivers (15210600 and 15210700). As previously noted, glacially dominated streams tend to have harsh habitat conditions for aquatic biota and the Lakina River (15210200) QMH sample reflects that with relatively low richness. Other than those exceptions, macroinvertebrate communities had little variability among sites reflecting the undisturbed nature of the streams.

Table 11. Macrozooplankton data for Long Lake, Alaska.

[Values indicate number of individuals]

Date	Macrozooplankton									Macro-zooplankton total
	Small		Large cladoceran		Small copepod	Large copepod	Small copepod	Copepod		
	Bosmina	Ceriodaphnia	Daphnia	Cyclopoid1	Cyclopoid2	Calanoid1	Calanoid2	Nauplii	Copepedid	
05-20-08	11	0	2	191	155	2	5	66	24	456
07-01-08	2	1	9	73	10	2	0	0	0	97
08-05-08	62	3	99	137	16	10	0	0	0	327
09-23-08	14	5	55	172	11	180	264	315	21	1,037

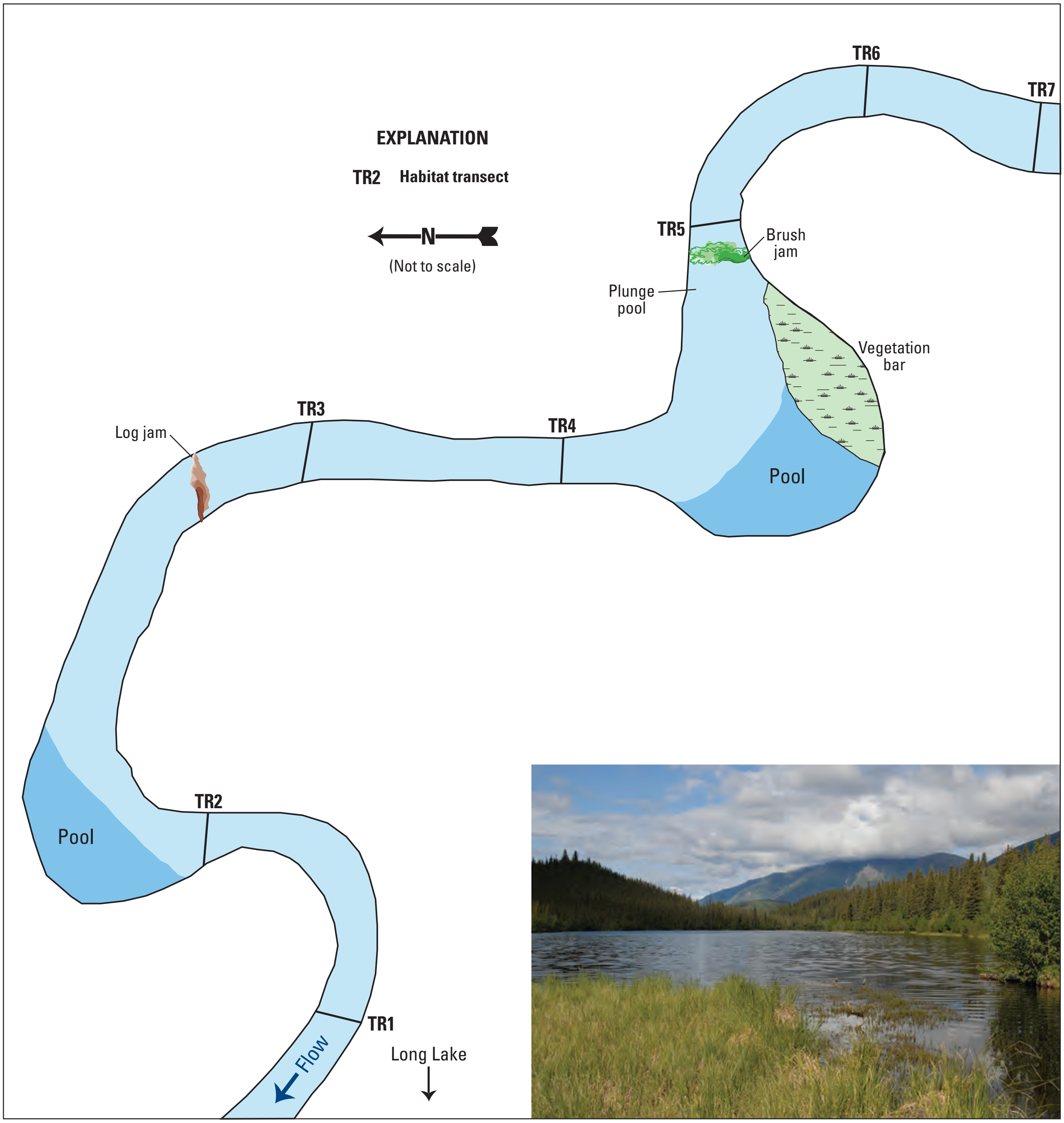


Figure 12. Major geomorphic features and photograph of the Long Lake inlet stream study reach near McCarthy, Alaska.

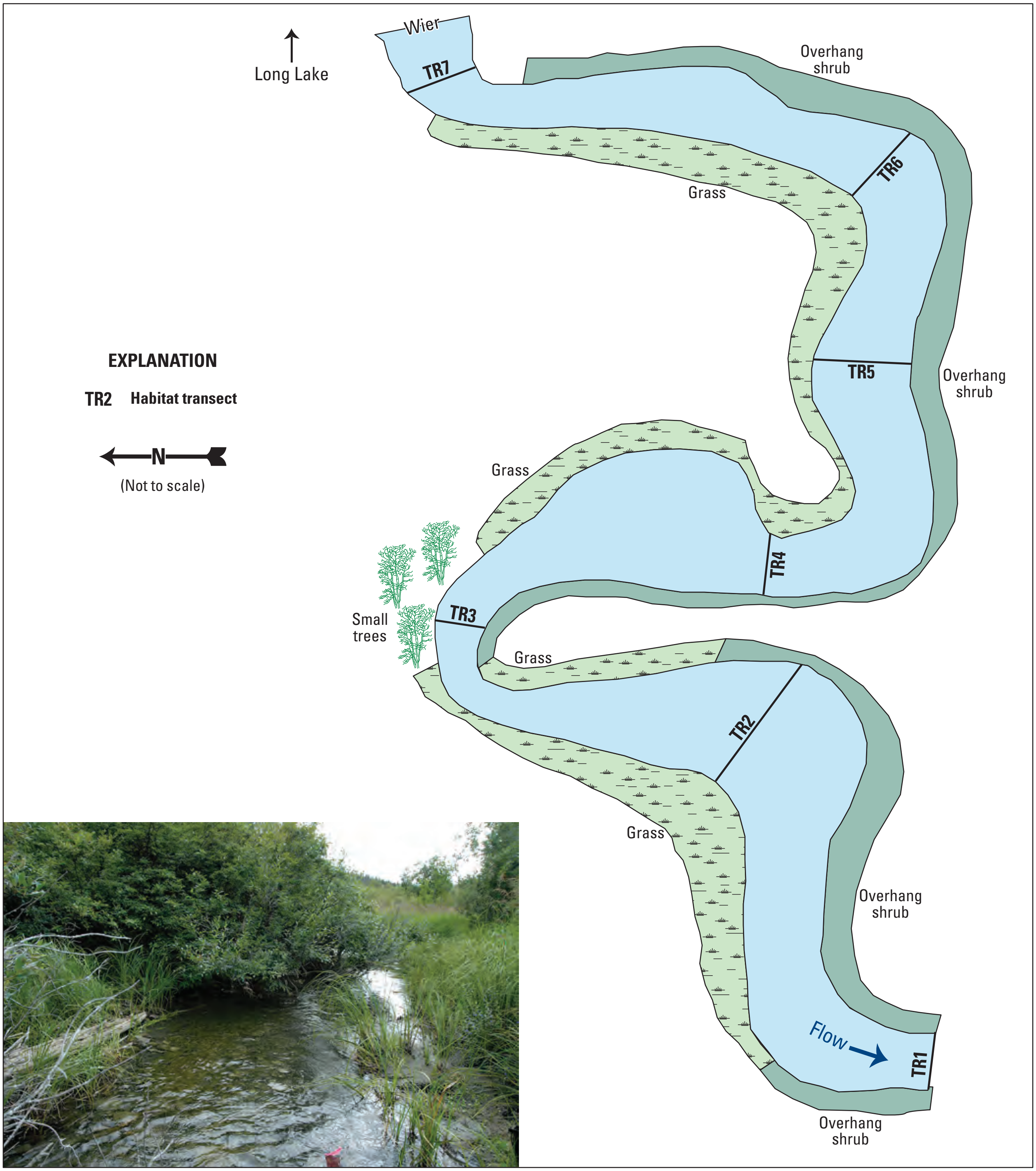


Figure 13. Major geomorphic features and photograph of the Long Lake outlet stream study reach, near McCarthy, Alaska.

Table 12. Definitions of macroinvertebrate metrics.

[**Abbreviations:** EPT, Ephemeroptera (mayfly), Plecoptera (stonefly), and Trichoptera (caddisfly); USEPA, U.S. Environmental Protection Agency]

Metric	Description
Taxa richness	Total richness (number of non-ambiguous taxa)
EPT richness	Richness composed of mayflies, stoneflies, and caddisflies
Percent EPT richness	Percentage of total richness composed of mayflies, stoneflies, and caddisflies
Percent chironomid richness	Percentage of total richness composed of midges
Richness of tolerant taxa	Average USEPA tolerance values for sample based on richness
Abundance of tolerant taxa	Abundance (density)-weighted USEPA tolerance value for sample
Shannon diversity	Shannon-Wiener diversity index
Evenness	Evenness (Shannon-Wiener diversity/maximum diversity)
Predator richness	Richness composed of predators
Collector/gatherer richness	Richness composed of collector-gatherers
V2DOM	Percentage of total abundance represented by the two most abundant taxon

Table 13. Metric values for all macroinvertebrate samples collected at sites along McCarthy Road, Alaska, 2007 and 2008.

[Metric definitions are shown in table 12. **Type:** Q, Qualitative Multi-Habitat; R, Richest Targeted Habitat. **Abbreviations:** EPT, Ephemeroptera (mayfly), Plecoptera (stonefly), and Trichoptera (caddisfly); V2DOM, Percentage of total abundance represented by the two most abundant taxon; NA, not applicable]

USGS station No.	Collection date	Type	Taxa richness	EPT richness	Percent EPT richness	Percent chironomid richness	Richness of tolerant taxa	Abundance of tolerant taxa	Shannon diversity	Evenness	Predator richness	Gatherer/ collector richness	V2DOM
15210200	10-02-2007	Q	22	9	40.91	31.82	4.00	NA	NA	NA	4	9	NA
15210250	07-30-2007	Q	36	8	22.22	41.67	4.80	NA	NA	NA	7	13	NA
15210260	08-06-2008	R,Q	49	10	20.41	40.82	4.99	5.15	1.06	0.67	10	20	50.00
15210260	09-24-2008	R,Q	41	11	26.83	36.59	4.76	3.88	1.20	.78	8	14	26.56
15210300	07-29-2007	R	22	11	50.00	36.36	3.49	2.55	1.11	.83	4	7	37.55
15210300	07-31-2007	R,Q	55	10	18.18	41.82	5.21	4.67	1.16	.77	14	20	38.26
15210300	08-05-2008	R,Q	51	10	19.61	37.25	4.93	5.54	1.15	.73	10	17	44.86
15210600	08-01-2007	R,Q	42	14	33.33	40.48	4.29	2.01	.98	.68	9	10	43.50
15210600	09-25-2008	Q	34	13	38.24	26.47	3.94	NA	NA	NA	8	8	NA
15210700	07-29-2007	Q	30	10	33.33	43.33	4.35	NA	NA	NA	7	11	NA
15210700	09-25-2008	R,Q	32	14	43.75	21.88	3.89	3.96	1.10	.80	7	10	36.42

Another way to visually compare the macroinvertebrate communities among sites is through the use of an ordination resulting from a multivariate statistical analysis such as NMDS (figs. 14–15, table 14). For macroinvertebrate presence/absence data from sites sampled in 2007 and 2008 (fig. 14), the first (x) axis provides the greatest discrimination among sites and appears to distinguish the small, lower gradient, and wetland dominated sites on the left side of the diagram (Long Lake inlet and outlet streams) from the higher gradient sites or larger rivers on the right (Lakina, Gilahina, and Chokosna Rivers), supporting the interpretation of the metric data above. Sample M-3, the inlet stream to Long Lake, was collected at a relatively high discharge of 14 ft^3/s, although the remaining samples at the site were collected at discharges less than 5 ft^3/s, which may explain why it plotted between the two groups. The second (y) axis by definition has less discriminatory power than the first axis, and here may show the effect of the higher precipitation that occurred in 2008 relative to 2007. The 2008 samples generally plot higher that the 2007 samples with the exception of the 2008 sample from the Long Lake outlet stream. As previously noted, this site is affected more by Long Lake than precipitation events. The Lakina River does not fall within an easily identified group, but rather plots far to the right indicating a high gradient. Not only is this a glacier-fed river, but also the largest basin with the highest flow at the time of sampling.

The second NMDS plot (fig. 15) shows that the McCarthy Road sites form a distinctly different group from the rest of the sites in Alaska sampled by the USGS using the same protocols. Of the 71 other sites (table 14), 34 are located on streams in Anchorage, and 21 streams are located on the Kenai Peninsula, south of Anchorage. These areas and the remaining sites represent a transitional climate between maritime and continental (Brabets and others, 1999). It is interesting to note that within the McCarthy Road sites, the larger, higher gradient sites form a fairly tight sub-group on the left side of the plot. Because most of the sites shown on this plot represent minimally disturbed areas, the distinction among groups likely reflects the effects of Interior Alaska climate.

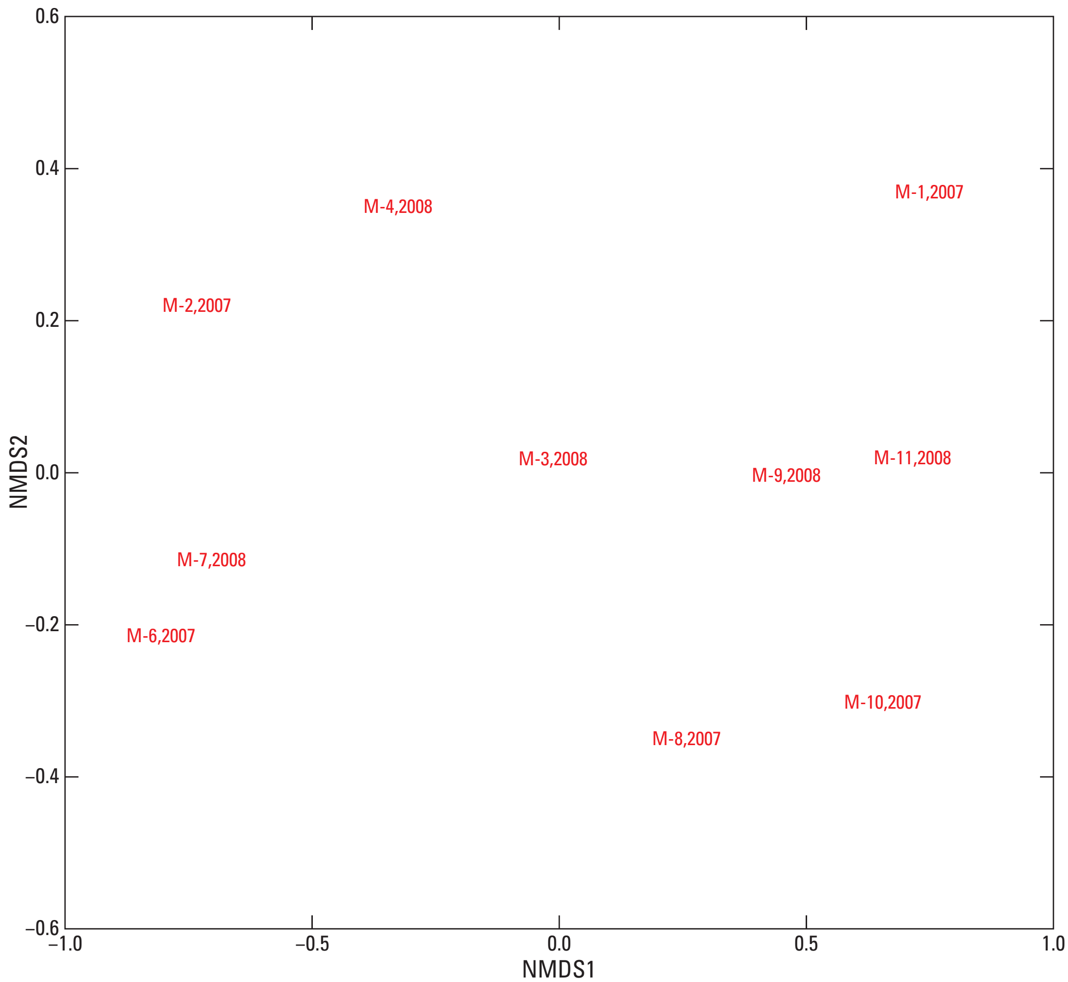


Figure 14. Similarity of macroinvertebrate communities at sites along McCarthy Road, Alaska, 2007 and 2008, based on the first and second dimension from a non-metric multi-dimensional scaling (NMDS) analysis.

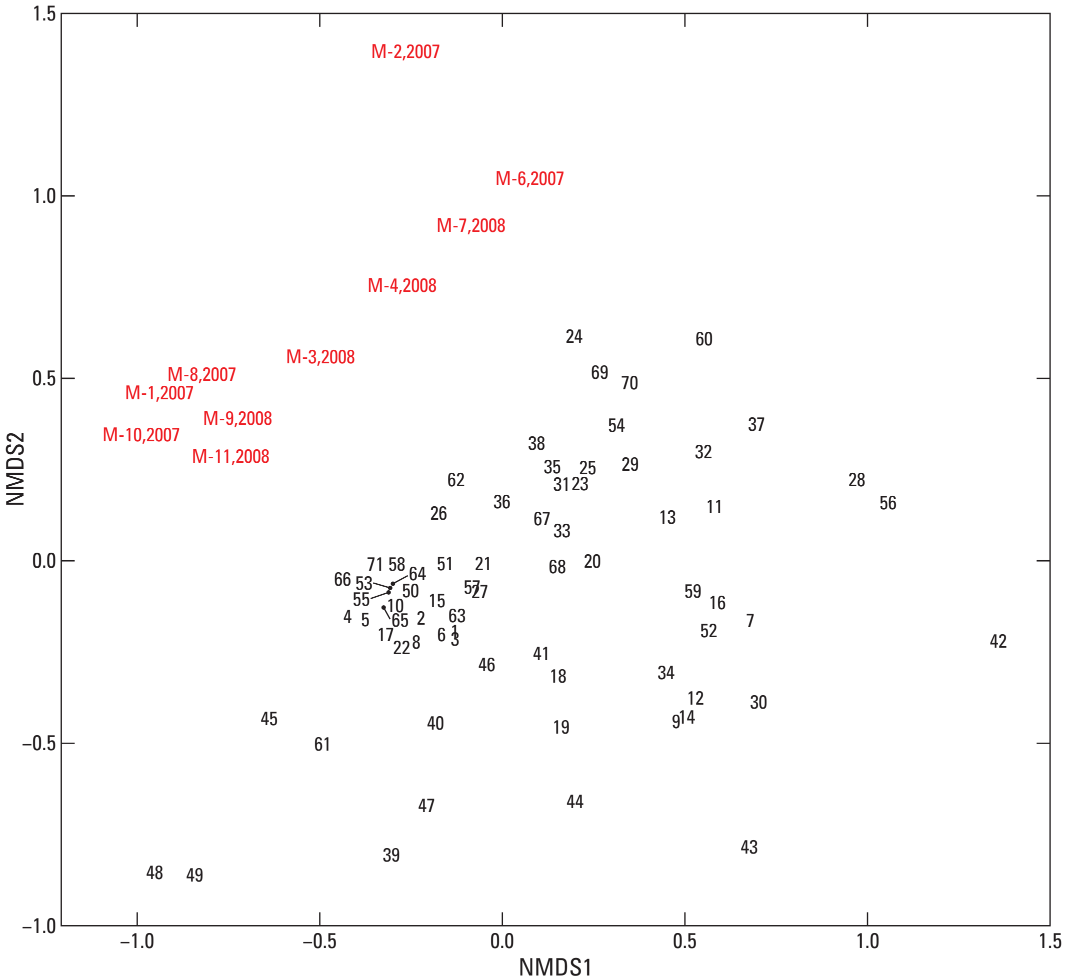


Figure 15. Similarity of macroinvertebrate communities at sites along McCarthy Road, Alaska, 2007 and 2008, and at other sites in Alaska where USGS has collected macroinvertebrate data, based on the first and second dimension from a non-metric multi-dimensional scaling (NMDS) analysis.

Table 14. Stations used in non-metric multi-dimensional scaling analysis, Alaska.

Site No.	USGS station No.	Station name
1	15274000	South Fork Campbell Creek near Anchorage
2	15273040	Rabbit Creek at Porcupine Trail Road near Anchorage
3	15274000	South Fork Campbell Creek near Anchorage
4	15273030	Rabbit Creek at East 140 Avenue near Anchorage
5	15273020	Rabbit Creek at Hillside Drive near Anchorage
6	15274000	South Fork Campbell Creek near Anchorage
7	15266110	Kenai River below Skilak Lake Outlet near Sterling
8	15273100	Little Rabbit Creek near Anchorage
9	15275100	Chester Creek at Arctic Boulevard at Anchorage
10	15273090	Little Rabbit Creek at Nickleen Street near Anchorage
11	15241600	Ninilchik River at Ninilchik
12	15275100	Chester Creek at Arctic Boulevard at Anchorage
13	15294100	Deshka River near Willow
14	15275100	Chester Creek at Arctic Boulevard at Anchorage
15	15276200	Ship Creek at Glenn Hwy near Anchorage
16	15266300	Kenai River at Soldotna
17	15273097	Little Rabbit Creek at Goldenview Dr near Anchorage
18	15274395	Campbell Creek at New Seward Highway near Anchorage
19	15274557	Campbell Creek at C Street near Anchorage
20	15274830	South Branch of South Fork Chester Creek at Boniface Parkway near Anchorage
21	15276570	Ship Creek below Power Plant at Elmendorf Air Force Base
22	15274796	South Branch of South Fork Chester Creek at Tank Trail near Anchorage
23	15240300	Stariski Creek near Anchor Point
24	15240000	Anchor River at Anchor Point
25	600204151401800	Deep Creek 0.6 mile above Sterling Highway near Ninilchik
26	600107151112800	North Fork Deep Creek 4 miles above mouth near Ninilchik
27	15274000	South Fork Campbell Creek near Anchorage
28	15294100	Deshka River near Willow
29	600321151325000	Ninilchik River below Tributary 3 near Ninilchik
30	15266110	Kenai River below Skilak Lake Outlet near Sterling
31	15241600	Ninilchik River at Ninilchik
32	15275100	Chester Creek at Arctic Boulevard at Anchorage
33	594507151290000	Beaver Creek 2 miles above mouth near Bald Mountain near Homer
34	15266300	Kenai River at Soldotna
35	595506151403300	Stariski Creek 2 miles below Unnamed Tributary near Ninilchik
36	595126151391000	Chakok River 7.5 miles above mouth near Anchor Point
37	600945151210900	Ninilchik River 1.5 miles below Tributary 1 near Ninilchik
38	15239840	Anchor River above Twitter Creek near Homer
39	601708154203500	Little Kijik River above Kijik Lake near Port Alsworth
40	601801154143600	Kijik River 1.5 miles above Mouth near Port Alsworth
41	601833154154100	Kijik River above Little Kijik River near Port Alsworth
42	601828154171700	Little Kijik River below Kijik Lake near Port Alsworth
43	15266020	Kenai River at Jims Landing near Cooper Landing
44	15266010	Kenai River below Russian River near Cooper Landing
45	631018149323700	Costello Creek near Colorado
46	15292700	Talkeetna River near Talkeetna
47	585750154101100	Kamishak River near Kamishak
48	631629149352000	Colorado Creek near Colorado
49	15294700	Johnson River above Lateral Glacier near Tuxedni Bay
50	15273100	Little Rabbit Creek near Anchorage
51	15274000	South Fork Campbell Creek near Anchorage
52	15266110	Kenai River below Skilak Lake Outlet near Sterling
53	15273020	Rabbit Creek at Hillside Dr near Anchorage
54	15241600	Ninilchik River at Ninilchik
55	15273040	Rabbit Creek at Porcupine Trail Road near Anchorage
56	15294100	Deshka River near Willow
57	15276200	Ship Creek at Glenn Highway near Anchorage
58	15273030	Rabbit Creek at East 140 Avenue near Anchorage
59	15266300	Kenai River at Soldotna
60	15275100	Chester Creek at Arctic Boulevard at Anchorage
61	15292304	Costello Creek below Camp Creek near Colorado
62	15292302	Camp Creek at Mouth near Colorado
63	15283700	Moose Creek near Palmer
64	15273090	Little Rabbit Creek at Nickleen Street near Anchorage
65	15283550	Moose Creek above Wishbone Hill near Sutton
66	15273097	Little Rabbit Creek at Goldenview Drive near Anchorage
67	15274395	Campbell Creek at New Seward Highway near Anchorage
68	15276570	Ship Creek below Power Plant at Elmendorf Air Force Base
69	15274557	Campbell Creek at C Street near Anchorage
70	15274830	South Branch of South Fork Chester Creek at Boniface Parkway near Anchorage
71	15274796	South Branch of South Fork Chester Creek at Tank Trail near Anchorage
M-1	15210200	Lakina River near McCarthy
M-2	15210250	Long Lake Creek Tributary 2 at McCarthy Road near McCarthy
M-3	15210260	Long Lake Trib 1 150 Ft above Mouth near McCarthy
M-4	15210260	Long Lake Trib 1 150 Ft above Mouth near McCarthy
M-6	15210300	Long Lake Creek at McCarthy Road near McCarthy
M-7	15210300	Long Lake Creek at McCarthy Road near McCarthy
M-8	15210600	Gilahina River at McCarthy Road near Chitina
M-9	15210600	Gilahina River at McCarthy Road near Chitina
M-10	15210700	Chokosna River at McCarthy Road near Chitina
M-11	15210700	Chokosna River at McCarthy Road near Chitina

Algae

Periphytic algal taxa richness and the number of unique taxa at each site (that is, the number of taxa at a given site in a given sample type—QMH or RTH—that were not at any other sites for a given sample type) were variable between sample type and sample locations (table 15, appendix B–C). No RTH sample was collected at the Lakina River due to the high flow and velocities. Taxa richness in RTH samples was consistently higher than taxa richness in QMH samples and the number of unique taxa in RTH samples was generally lower than the number of unique taxa in QMH samples; therefore, both QMH and RTH taxa richness and numbers of unique taxa are shown for a more complete representation of the algal community at a site. The Long Lake outflow sample collected on July 31, 2007, had the highest richness (59 taxa in the RTH sample and 52 in the QMH sample) and the highest number of unique taxa (19 in the RTH sample and 24 in the QMH sample). Generally, the Long Lake outflow had higher taxa richness and more unique taxa than the inflow tributaries, whereas the Long Lake inflow tributaries generally had higher taxa richness than the other river sites. At a given sample site, 60–100 percent of the taxa were non-motile, suggesting relatively stable habitat conditions.

The abundance of periphytic algal taxa identified to the five algae groups varied by sample location and by abundance measure (density compared with biovolume) (fig. 16). Algae groups are defined by phylum, with the exception of diatoms and yellow-green algae, which are defined by class (appendix C). Algae groups reported here, including green algae (Chlorophyta), Diatoms (Bacillariophyceae), Yellow-Green Algae (Chrysophyceae), Blue-Green Algae (Cyanophyta), and Red Algae (Rhodophyta) are all taxa commonly found in lotic (swift moving water) ecosystems. The taxa with the highest relative abundance, as measured by density and biomass, in the inflow tributaries to Long Lake were the red algae (47–96 percent), a community mainly of an unknown rhodophyte (appendix C). In contrast, blue-green algae had the highest relative abundance (about 50 percent), as measured by density, at the Long Lake outflow. The remaining 50 percent of the taxa at the Long Lake outflow, as measured by density, were green algae, diatoms, and red algae. However, 92 percent of the relative abundance, as measured by biovolume, in samples collected from Long Lake outflow on August 5, 2008, were green algae that are composed mainly of the large-bodied chlorophyte (*Spirogyra* sp.), a filamentous algae common in various freshwater environments. Spirogyra often are free floating, which may contribute to their high biovolume at the outlet to Long Lake. At the Gilahina and Chokosna River sites, the type of abundance measure used (density compared with biovolume) produced similar trends in the relative abundance data. The Gilahina River, as measured by a density to biovolume ratio, was dominated by two cyanophytes, *Homoeothrix janthina* and one unknown bloom. The yellow-green algae *Hydrurus foetidus* was the dominant taxa in the Chokosna River in 2007, yet there was no yellow-green algae detected in the 2008 sample. The dominant taxa, with respect to density, were the unknown cyanophyte and *Chamaesiphon* sp. (also a cyanophyte), as well as the undetermined *Centric* sp. diatom. With respect to biovolume, the undetermined *Centric* sp. diatom was the most dominant taxa, followed by *Hannaea arcus* and the cyanophyte *Chamaesiphon* sp., respectively, in the Chokosna River in 2008. Accurate assessment of specific drivers (for example, physical habitat) of temporal change in algal community composition requires taxa-specific habitat preference information and is beyond the scope of this study.

Table 15. Periphytic algae taxa richness for Qualitative Multi-Habitat and Richest Targeted Habitat samples and Simpson index of diversity values for Richest Targeted Habitat samples, and number of unique taxa at sites along McCarthy Road, Alaska, 2007 and 2008.

[**Abbreviations:** QMH, Qualitative Multi-Habitat; RTH, Richest Targeted Habitat; –, sample not collected]

Date	Taxa richness		Simpson diversity	Number of unique taxa	
	QMH sample	RTH sample		QMH sample	RTH sample
Lakina River					
10-02-07	21	–	–	4	–
Long Lake Inflow-Tributary 1					
08-06-08	19	44	0.33	8	6
09-24-08	–	32	.72	–	3
Long Lake Inflow-Tributary 2					
07-30-07	40	48	0.27	12	13
Long Lake Outflow					
07-31-07	52	59	0.84	24	19
08-05-08	25	49	.85	8	13
Gilahina River					
08-01-07	19	33	0.57	5	1
Chokosna River					
07-29-07	9	14	0.49	2	1
08-04-08	–	29	.85	–	12

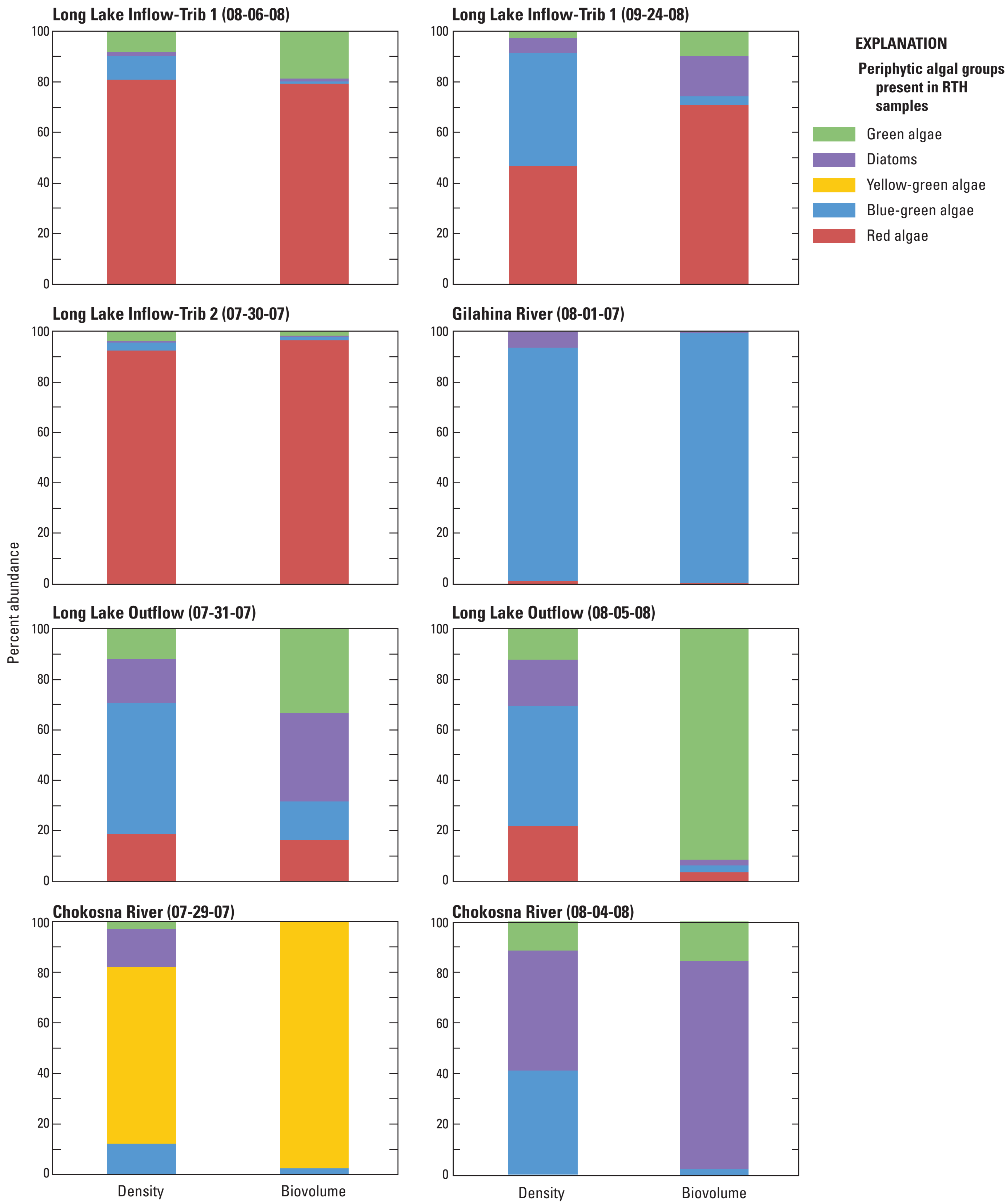


Figure 16. Percent abundance as density and biovolume of periphytic algal groups in richest targeted habitat (RTH) samples collected at sites along McCarthy Road, Alaska, 2007 and 2008.

However, it is possible that difference between years may be a result of difference in physical habitat conditions (for example, higher precipitation and higher discharge in 2008).

In addition to taxa richness and abundance, diversity is a common metric used to assess community structure. Diversity measures integrate information on both taxa richness and evenness (relative abundance of each taxon). Values of the Simpson index of diversity range from 0 to 1, with larger numbers indicating greater diversity. The Simpson index of diversity at the Long Lake inflow sites was variable with values ranging from 0.27 to 0.72 (table 15). In contrast, diversity was consistently high at the Long Lake outlet (0.85). The Simpson index of diversity was intermediate at the Gilahina River site (0.57) and varied from 0.49 to 0.85 at the Chokosna River. Temporal and spatial differences in algal diversity may be reflective of changing biotic or abiotic conditions, including environmental and (or) physical habitat conditions. Our ability to identify which biotic or abiotic variables are important drivers of change in algal diversity is limited by data availability. However, the diversity values presented in table 15 may be informative to future studies at these sites. For example, differences in biogeochemical nutrient cycles between sites may be influenced by the abundance and diversity of the algae at a given site.

A NMDS ordination plot of the eight RTH samples is shown in figure 17. The two-dimensional stress associated with the ordination was 0.05, indicating that the plot gives an excellent representation of the relations between samples. The two Long Lake outflow samples grouped close together and had periphytic algal communities that were 41 percent similar. Similarly, the Long Lake inflow samples and the Gilahina River samples were grouped together and had communities that were 30–58 percent similar. On the other hand, the two Chokosna River samples had unique algal communities that were not similar between years or to any of the other samples.

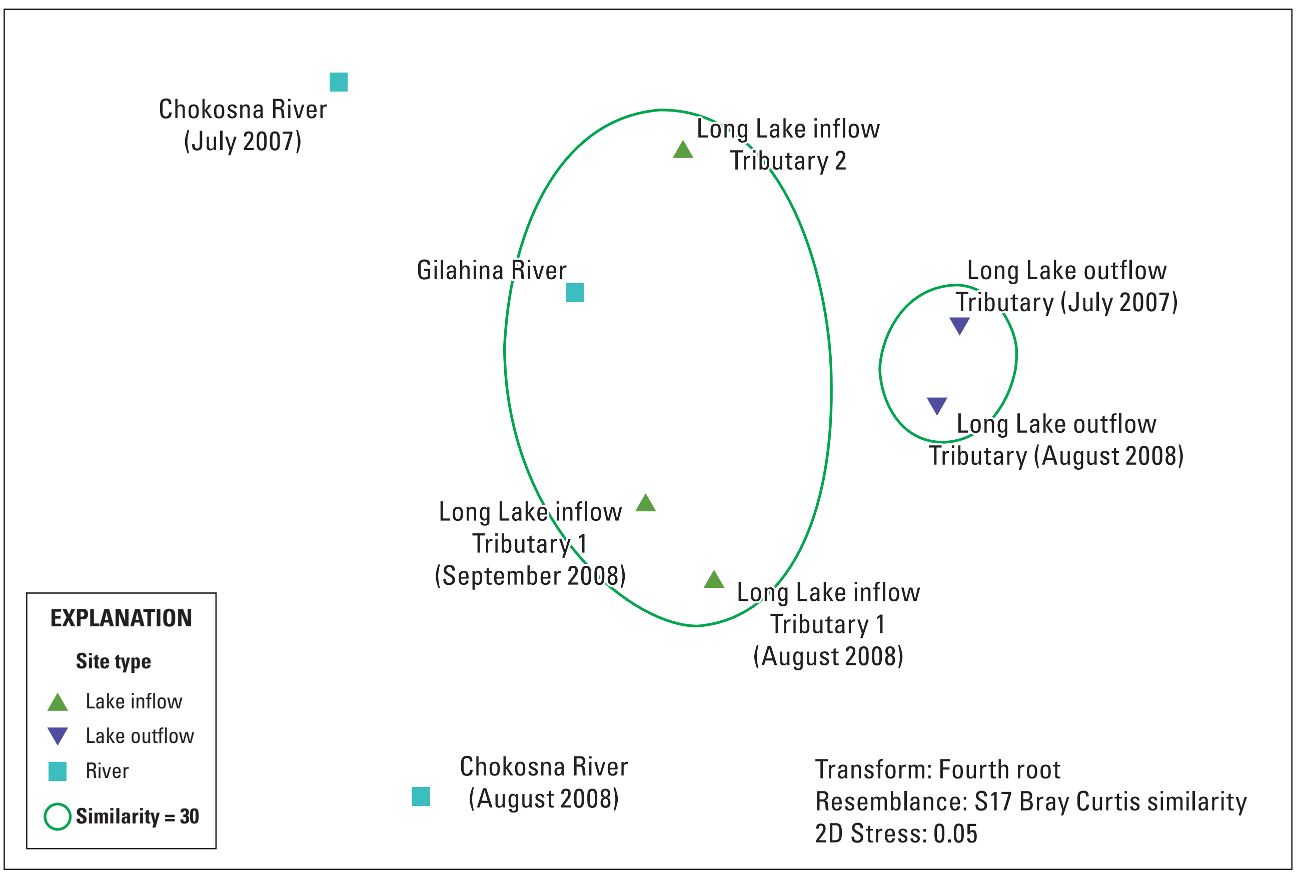


Figure 17. Non-metric multi-dimensional scaling ordination plot of richest targeted habitat periphytic algae biovolume data from samples collected at sites along McCarthy Road, Alaska, 2007 and 2008.

Summary

The Chokosna, Gilahina, and Lakina Rivers, and Long Lake watershed, along McCarthy Road within Wrangell-St. Elias National Park and Preserve (WRST), Alaska, support popular recreational activities as well as an important commercial sockeye salmon fishery of the Copper River. To gain a better knowledge of the hydrology and limnology of this area, a study of the streams and the Long Lake system was undertaken in 2007 and 2008. Major findings of the study include:

- Water samples from all sites indicate the water type at all sites is calcium bicarbonate—with the exception of the Chokosna River, which is calcium bicarbonate sulfate. Alkalinity concentrations ranged from 63 to 222 milligrams per liter, indicating a high buffering capacity of these waters.

- During the 2 years of data collection recorded water temperatures did not exceed 10 °C at the Chokosna and Gilahina Rivers. At the Lakina River, a glacier-fed river, water temperatures were less than 9 °C. The most pronounced differences in water temperature were noted in the inlet and outlet streams of Long Lake. Water temperatures for the inlet stream were as high as 15 °C and as high as 19 °C at the outlet stream.

- A water temperature logistic model was calibrated with known air temperature and water temperature from 2007 and 2008 and then used to simulate water temperature from 1998 to 2006 for the Long Lake outlet stream. Analysis of the stream temperature during this period showed no trends but did indicate the 2007 water temperatures were the highest during this period.

- Depth profiles of Long Lake show strong temperature stratification during the summer from the surface to about 13 feet with water temperatures ranging from 16 to 5 °C. Dissolved oxygen profiles of Long Lake show strong stratifications between 26 and 33 feet, below which the concentrations of dissolved oxygen decreases from 10 to 2 mg/L.

- Analyses of trace elements in samples of streambed sediments collected from five sites indicated that concentrations of arsenic, chromium, and nickel exceeded levels that are believed to cause adverse effects to aquatic habitat. Given the nearly pristine nature of the study area, however, these concentrations most likely reflect local geology of the area rather than anthropogenic sources.

- One hundred twenty-five macroinvertebrate taxa were identified over the 2-year sampling period. Eighty-three percent of macroinvertebrates were insects. Dipterans (flies and midges) accounted for 43 percent of all aquatic macroinvertebrates found at the 6 sites. Forty-nine new taxa, not found in other USGS sampled sites using NAWQA protocols, were identified in the samples collected along McCarthy Road.

- Analysis of the macroinvertebrate data by non-metric multi-dimensional scaling (NMDS) showed a separation of sites by size of the stream gradient or proximity to Long Lake and a separation between the 2007 and 2008 samples, likely due to the higher precipitation in 2008. A second NMDS of the McCarthy Road macroinvertebrate data with other Alaska macroinvertebrate data collected by the USGS showed a distinct separation between the two data sets. This separation suggests that macroinvertebrate data at sites along the McCarthy Road represent a continental type climate; other USGS Alaska macroinvertebrate data represent a transitional climate between maritime and continental.

- Periphytic algal taxa richness, abundance, and community composition was variable between sites. Taxa richness was highest at the Long Lake outflow, suggesting that the lake may have contributed planktonic taxa to the periphytic community and (or) created physical and chemical conditions at the outlet favorable to a variety of taxa. Lake inflow and river sites tended to be dominated by specific taxa. Specifically, red algae were the dominant taxa at the lake inflow sites and blue-green algae were abundant at the Gilahina River. Shifts in the dominant taxa between years at the Chokosna River may be indicative of differences in physical and chemical conditions between the two sample times.

- Site groupings defined by NMDS of periphytic algal communities suggest that the Long Lake outflow site formed one group and Long Lake inflow tributaries and the Gilahina River formed another group. However, periphytic algal communities in the Chokosna River samples were not similar to each other between years to any of the other samples.

Acknowledgments

The authors wish to thank Eric Veach of Wrangell-St. Elias National Park and Preserve for his support of this study.

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Appendix A. Benthic Macroinvertebrate Community Detected at Stream Sites along McCarthy Road, Wrangell-St. Elias National Park and Preserve, Alaska, 2007–08

Table A1. Benthic macroinvertebrate community detected at stream sites along McCarthy Road, Wrangell-St. Elias National Park and Preserve, Alaska, 2007–08.

Count	Phylum	Class	Order	SubOrder	Family	SubFamily	Tribe	Genus	Species
1	Cnidaria	Hydrozoa	Hydroida		Hydridae			*Hydra* sp.	
2	Platyhelminthes	Turbellaria							
	Platyhelminthes	Turbellaria	Tricladida		Planariidae			*Polycelis* sp.	
3	Nematoda								
4	Mollusca	Gastropoda	Basommatophora		Lymnaeidae				
	Mollusca	Gastropoda	Basommatophora		Lymnaeidae			*Lymnaea* sp.	
5	Mollusca	Gastropoda	Basommatophora		Planorbidae			*Gyraulus* sp.	
6	Mollusca	Gastropoda	Mesogastropoda		Valvatidae			*Valvata* sp.	*Valvata lewisi*
7	Mollusca	Gastropoda	Mesogastropoda		Valvatidae			*Valvata* sp.	
8	Mollusca	Bivalvia	Veneroida		Sphaeriidae				
	Mollusca	Bivalvia	Veneroida		Sphaeriidae	Pisidiinae		*Pisidium* sp.	
9	Annelida	Oligochaeta							
10	Annelida	Hirudinea	Rhynchobdellae		Glossiphoniidae				
11	Arthropoda								
	Arthropoda	Arachnida	Prostigmata		Lebertiidae			*Lebertia* sp.	
12	Arthropoda	Arachnida	Prostigmata		Sperchontidae			*Sperchon* sp.	
13	Arthropoda	Arachnida	Prostigmata		Sperchontidae			*Sperchonopsis* sp.	
14	Arthropoda	Arachnida	Sarcoptiformes	Oribatei					
15	Arthropoda	Arachnida	Trombidiformes	Prostigmata	Hygrobatidae			*Atractides* sp.	
16	Arthropoda	Arachnida	Trombidiformes	Prostigmata	Hygrobatidae			*Hygrobates* sp.	
17	Arthropoda	Ostracoda							
18	Arthropoda	Malacostraca	Amphipoda	Gammaridea	Gammaridae			*Gammarus* sp.	
19	Arthropoda	Malacostraca	Amphipoda	Gammaridea	Hyalellidae			*Hyalella* sp.	
20	Arthropoda	Insecta	Collembola		Isotomidae				
21	Arthropoda	Insecta	Collembola		Sminthuridae				
22	Arthropoda	Insecta	Ephemeroptera	Furcatergalia	Caenidae			*Caenis* sp.	
23	Arthropoda	Insecta	Ephemeroptera	Furcatergalia	Ephemerellidae			*Drunella* sp.	*Drunella doddsi*
24	Arthropoda	Insecta	Ephemeroptera	Furcatergalia	Leptohyphidae			*Tricorythodes* sp.	
25	Arthropoda	Insecta	Ephemeroptera	Furcatergalia	Leptophlebiidae				
	Arthropoda	Insecta	Ephemeroptera	Furcatergalia	Leptophlebiidae			*Paraleptophlebia* sp.	
26	Arthropoda	Insecta	Ephemeroptera	Pisciforma	Ameletidae			*Ameletus* sp.	
27	Arthropoda	Insecta	Ephemeroptera	Pisciforma	Baetidae			*Baetis* sp.	
	Arthropoda	Insecta	Ephemeroptera	Pisciforma	Baetidae			*Baetis* sp.	*Baetis bicaudatus*
28	Arthropoda	Insecta	Ephemeroptera	Pisciforma	Baetidae			*Baetis* sp.	*Baetis flavistriga*
29	Arthropoda	Insecta	Ephemeroptera	Pisciforma	Baetidae			*Baetis* sp.	*Baetis tricaudatus*
30	Arthropoda	Insecta	Ephemeroptera	Pisciforma	Baetidae			*Procloeon* sp.	
31	Arthropoda	Insecta	Ephemeroptera	Setisura	Heptageniidae				
	Arthropoda	Insecta	Ephemeroptera	Setisura	Heptageniidae			*Cinygmula* sp.	
32	Arthropoda	Insecta	Ephemeroptera	Setisura	Heptageniidae			*Epeorus* sp.	
33	Arthropoda	Insecta	Ephemeroptera	Setisura	Heptageniidae			*Epeorus* sp.	*Epeorus deceptivus*
34	Arthropoda	Insecta	Ephemeroptera	Setisura	Heptageniidae			*Epeorus* sp.	*Epeorus grandis*
35	Arthropoda	Insecta	Plecoptera	Euholognatha	Capniidae				

Table A1. Benthic macroinvertebrate community detected at stream sites along McCarthy Road, Wrangell-St. Elias National Park and Preserve, Alaska, 2007–08.—Continued

Count	Phylum	Class	Order	SubOrder	Family	SubFamily	Tribe	Genus	Species
36	Arthropoda	Insecta	Plecoptera	Euholognatha	Capniidae	Capniinae		*Eucapnopsis* sp.	*Eucapnopsis brevicauda*
37	Arthropoda	Insecta	Plecoptera	Euholognatha	Nemouridae	Amphinemurinae		*Amphinemura* sp.	
38	Arthropoda	Insecta	Plecoptera	Euholognatha	Nemouridae	Nemourinae		*Nemoura* sp.	
39	Arthropoda	Insecta	Plecoptera	Euholognatha	Nemouridae	Nemourinae		*Zapada* sp.	
40	Arthropoda	Insecta	Plecoptera	Euholognatha	Nemouridae	Nemourinae		*Zapada* sp.	*Zapada cinctipes*
41	Arthropoda	Insecta	Plecoptera	Euholognatha	Nemouridae	Nemourinae		*Zapada* sp.	*Zapada oregonensis* group
42	Arthropoda	Insecta	Plecoptera	Euholognatha	Taeniopterygidae				
	Arthropoda	Insecta	Plecoptera	Euholognatha	Taeniopterygidae	Brachypteryinae		*Taenionema* sp.	
43	Arthropoda	Insecta	Plecoptera	Systellognatha	Chloroperlidae				
	Arthropoda	Insecta	Plecoptera	Systellognatha	Chloroperlidae	Chloroperlinae		*Suwallia* sp.	
44	Arthropoda	Insecta	Plecoptera	Systellognatha	Perlodidae				
	Arthropoda	Insecta	Plecoptera	Systellognatha	Perlodidae	Isoperlinae		*Isoperla* sp.	
45	Arthropoda	Insecta	Plecoptera	Systellognatha	Pteronarcyidae	Pteronarcyinae	Pteronarcellini	*Pteronarcella* sp.	
46	Arthropoda	Insecta	Trichoptera	Integripalpia	Brachycentridae			*Brachycentrus* sp.	*Brachycentrus americanus*
47	Arthropoda	Insecta	Trichoptera	Integripalpia	Brachycentridae			*Micrasema* sp.	
48	Arthropoda	Insecta	Trichoptera	Integripalpia	Limnephilidae				
	Arthropoda	Insecta	Trichoptera	Integripalpia	Limnephilidae	Dicosmoecinae		*Ecclisomyia* sp.	
49	Arthropoda	Insecta	Trichoptera	Integripalpia	Limnephilidae	Dicosmoecinae		*Onocosmoecus* sp.	
50	Arthropoda	Insecta	Trichoptera	Integripalpia	Limnephilidae	Limnephilinae		*Limnephilus* sp.	
51	Arthropoda	Insecta	Trichoptera	Integripalpia	Limnephilidae	Limnephilinae		*Psychoglypha* sp.	
52	Arthropoda	Insecta	Trichoptera	Integripalpia	Limnephilidae	Limnephilinae	Chilostigmini	*Glyphopsyche* sp.	
53	Arthropoda	Insecta	Trichoptera	Spicipalpia	Glossosomatidae	Glossosomatinae		*Glossosoma* sp.	
54	Arthropoda	Insecta	Trichoptera	Spicipalpia	Hydroptilidae	Hydroptilinae		*Hydroptila* sp.	
55	Arthropoda	Insecta	Trichoptera	Spicipalpia	Hydroptilidae	Hydroptilinae		*Ochrotrichia* sp.	
56	Arthropoda	Insecta	Trichoptera	Spicipalpia	Hydroptilidae	Hydroptilinae		*Oxyethira* sp.	
57	Arthropoda	Insecta	Trichoptera	Spicipalpia	Rhyacophilidae			*Rhyacophila* sp.	*Rhyacophila vofixa* group
58	Arthropoda	Insecta	Lepidoptera						
59	Arthropoda	Insecta	Diptera	Nematocera	Ceratopogonidae	Ceratopogoninae			
	Arthropoda	Insecta	Diptera	Nematocera	Ceratopogonidae	Ceratopogoninae		*Bezzia/Palpomyia* sp.	
60	Arthropoda	Insecta	Diptera	Nematocera	Ceratopogonidae	Ceratopogoninae		*Probezzia* sp.	
61	Arthropoda	Insecta	Diptera	Nematocera	Chironomidae	Chironominae	Chironomini	*Cryptochironomus* sp.	
62	Arthropoda	Insecta	Diptera	Nematocera	Chironomidae	Chironominae	Chironomini	*Microtendipes* sp.	*Microtendipes pedellus* group
63	Arthropoda	Insecta	Diptera	Nematocera	Chironomidae	Chironominae	Chironomini	*Parachironomus* sp.	
64	Arthropoda	Insecta	Diptera	Nematocera	Chironomidae	Chironominae	Chironomini	*Polypedilum* sp.	
65	Arthropoda	Insecta	Diptera	Nematocera	Chironomidae	Chironominae	Chironomini	*Sergentia* sp.	

Table A1. Benthic macroinvertebrate community detected at stream sites along McCarthy Road, Wrangell-St. Elias National Park and Preserve, Alaska, 2007–08.—Continued

Count	Phylum	Class	Order	SubOrder	Family	SubFamily	Tribe	Genus	Species
66	Arthropoda	Insecta	Diptera	Nematocera	Chironomidae	Chironominae	Chironomini	*Stictochironomus* sp.	
67	Arthropoda	Insecta	Diptera	Nematocera	Chironomidae	Chironominae	Tanytarsini	*Constempellina* sp.	
68	Arthropoda	Insecta	Diptera	Nematocera	Chironomidae	Chironominae	Tanytarsini	*Micropsectra* sp.	
69	Arthropoda	Insecta	Diptera	Nematocera	Chironomidae	Chironominae	Tanytarsini	*Rheotanytarsus* sp.	
70	Arthropoda	Insecta	Diptera	Nematocera	Chironomidae	Chironominae	Tanytarsini	*Stempellinella* sp.	
71	Arthropoda	Insecta	Diptera	Nematocera	Chironomidae	Diamesinae	Diamesini	*Diamesa* sp.	
72	Arthropoda	Insecta	Diptera	Nematocera	Chironomidae	Diamesinae	Diamesini	*Pagastia* sp.	
73	Arthropoda	Insecta	Diptera	Nematocera	Chironomidae	Diamesinae	Diamesini	*Potthastia* sp.	*Potthastia longimana* group
74	Arthropoda	Insecta	Diptera	Nematocera	Chironomidae	Diamesinae	Diamesini	*Pseudodiamesa* sp.	
75	Arthropoda	Insecta	Diptera	Nematocera	Chironomidae	Orthocladiinae		*Brillia* sp.	
76	Arthropoda	Insecta	Diptera	Nematocera	Chironomidae	Orthocladiinae		*Cardiocladius* sp.	
77	Arthropoda	Insecta	Diptera	Nematocera	Chironomidae	Orthocladiinae		*Chaetocladius* sp.	
78	Arthropoda	Insecta	Diptera	Nematocera	Chironomidae	Orthocladiinae		*Corynoneura* sp.	
79	Arthropoda	Insecta	Diptera	Nematocera	Chironomidae	Orthocladiinae		*Cricotopus* sp.	
	Arthropoda	Insecta	Diptera	Nematocera	Chironomidae	Orthocladiinae		*Cricotopus* sp.	*Cricotopus bicinctus* group
80	Arthropoda	Insecta	Diptera	Nematocera	Chironomidae	Orthocladiinae		*Diplocladius* sp.	
81	Arthropoda	Insecta	Diptera	Nematocera	Chironomidae	Orthocladiinae		*Eukiefferiella* sp.	*Eukiefferiella brevicalcar*
82	Arthropoda	Insecta	Diptera	Nematocera	Chironomidae	Orthocladiinae		*Eukiefferiella* sp.	*Eukiefferiella claripennis* group sp. C
83	Arthropoda	Insecta	Diptera	Nematocera	Chironomidae	Orthocladiinae		*Eukiefferiella* sp.	*Eukiefferiella coerulescens* group
84	Arthropoda	Insecta	Diptera	Nematocera	Chironomidae	Orthocladiinae		*Eukiefferiella* sp.	*Eukiefferiella devonica* group
85	Arthropoda	Insecta	Diptera	Nematocera	Chironomidae	Orthocladiinae		*Eukiefferiella* sp.	*Eukiefferiella gracei* group
86	Arthropoda	Insecta	Diptera	Nematocera	Chironomidae	Orthocladiinae		*Eukiefferiella* sp.	*Eukiefferiella tirolensis*
87	Arthropoda	Insecta	Diptera	Nematocera	Chironomidae	Orthocladiinae		*Heterotanytarsus* sp.	
88	Arthropoda	Insecta	Diptera	Nematocera	Chironomidae	Orthocladiinae		*Heterotrissocladius* sp.	*Heterotrissocladius marcidus* group
89	Arthropoda	Insecta	Diptera	Nematocera	Chironomidae	Orthocladiinae		*Hydrobaenus* sp.	
90	Arthropoda	Insecta	Diptera	Nematocera	Chironomidae	Orthocladiinae		*Limnophyes* sp.	
91	Arthropoda	Insecta	Diptera	Nematocera	Chironomidae	Orthocladiinae		*Metriocnemus* sp.	
92	Arthropoda	Insecta	Diptera	Nematocera	Chironomidae	Orthocladiinae		*Orthocladius (Euorthocladius)* sp.	

Table A1. Benthic macroinvertebrate community detected at stream sites along McCarthy Road, Wrangell-St. Elias National Park and Preserve, Alaska, 2007–08.—Continued

Count	Phylum	Class	Order	SubOrder	Family	SubFamily	Tribe	Genus	Species
93	Arthropoda	Insecta	Diptera	Nematocera	Chironomidae	Orthocladiinae		*Orthocladius Complex* sp.	
94	Arthropoda	Insecta	Diptera	Nematocera	Chironomidae	Orthocladiinae		*Orthocladius* sp.	
95	Arthropoda	Insecta	Diptera	Nematocera	Chironomidae	Orthocladiinae		*Orthocladius* sp.	*Orthocladius (Euortho.) rivicola*
96	Arthropoda	Insecta	Diptera	Nematocera	Chironomidae	Orthocladiinae		*Parakiefferiella* sp.	
97	Arthropoda	Insecta	Diptera	Nematocera	Chironomidae	Orthocladiinae		*Parametriocnemus* sp.	
98	Arthropoda	Insecta	Diptera	Nematocera	Chironomidae	Orthocladiinae		*Paraphaenocladius* sp.	
99	Arthropoda	Insecta	Diptera	Nematocera	Chironomidae	Orthocladiinae		*Psectrocladius* sp.	
100	Arthropoda	Insecta	Diptera	Nematocera	Chironomidae	Orthocladiinae		*Rheocricotopus* sp.	
101	Arthropoda	Insecta	Diptera	Nematocera	Chironomidae	Orthocladiinae		*Synorthocladius* sp.	
102	Arthropoda	Insecta	Diptera	Nematocera	Chironomidae	Orthocladiinae		*Thienemanniella* sp.	
103	Arthropoda	Insecta	Diptera	Nematocera	Chironomidae	Orthocladiinae		*Tokunagaia* sp.	
104	Arthropoda	Insecta	Diptera	Nematocera	Chironomidae	Orthocladiinae		*Tvetenia* sp.	*Tvetenia bavarica*
105	Arthropoda	Insecta	Diptera	Nematocera	Chironomidae	Podonominae	Boreochlini	*Boreochlus* sp.	
106	Arthropoda	Insecta	Diptera	Nematocera	Chironomidae	Podonominae	Boreochlini	*Trichotanypus* sp.	
107	Arthropoda	Insecta	Diptera	Nematocera	Chironomidae	Prodiamesinae		*Prodiamesa* sp.	
108	Arthropoda	Insecta	Diptera	Nematocera	Chironomidae	Tanypodinae	Pentaneurini	*Paramerina* sp.	
109	Arthropoda	Insecta	Diptera	Nematocera	Chironomidae	Tanypodinae	Pentaneurini	*Thienemannimyia gr* sp.	
110	Arthropoda	Insecta	Diptera	Nematocera	Chironomidae	Tanypodinae	Procladiini	*Procladius* sp.	
111	Arthropoda	Insecta	Diptera	Nematocera	Dixidae			*Dixella* sp.	
112	Arthropoda	Insecta	Diptera	Nematocera	Psychodidae	Psychodinae		*Pericoma/ Telmatoscopus* sp.	
113	Arthropoda	Insecta	Diptera	Nematocera	Simuliidae			*Prosimulium* sp.	
114	Arthropoda	Insecta	Diptera	Nematocera	Simuliidae			*Simulium* sp.	
115	Arthropoda	Insecta	Diptera	Nematocera	Simuliidae	Simuliinae	Prosimuliini	*Greniera* sp.	
116	Arthropoda	Insecta	Diptera	Nematocera	Tipulidae	Limoniinae		*Dicranota* sp.	
117	Arthropoda	Insecta	Diptera	Nematocera	Tipulidae	Limoniinae Limoniinae	Eriopterini	*Rhabdomastix* sp.	*Rhabdomastix setigera*
118	Arthropoda	Insecta	Diptera	Nematocera	Tipulidae	Limoniinae Limoniinae	Eriopterini	*Rhabdomastix* sp.	*Rhabdomastix tricophora*
119	Arthropoda	Insecta	Diptera	Brachycera	Empididae				
120	Arthropoda	Insecta	Diptera	Brachycera	Empididae	Clinocerinae		*Clinocera* sp.	
121	Arthropoda	Insecta	Diptera	Brachycera	Empididae	Clinocerinae		*Trichoclinocera* sp.	
122	Arthropoda	Insecta	Diptera	Brachycera	Empididae	Empidinae		*Oreogeton* sp.	
123	Arthropoda	Insecta	Diptera	Brachycera	Empididae	Hemerodromiinae		*Chelifera/Metachela* sp.	
124	Arthropoda	Insecta	Diptera	Brachycera	Sciomyzidae				
125	Arthropoda	Insecta	Diptera	Brachycera	Syrphidae				

Appendix B. Periphytic Algae Taxa Present in Qualitative Multi-Habitat Samples Collected at Stream Sites along McCarthy Road, Wrangell-St. Elias National Park and Preserve, Alaska, 2007–08

Table B1. Periphytic algae taxa present in Qualitative Multi-Habitat samples collected at stream sites along McCarthy Road, Wrangell-St. Elias National Park and Preserve, Alaska.

Algae group	Phylum	Class	Family	Genus species
		Lakina River (10-02-07)		
Diatoms	Chrysophyta	Bacillariophyceae	Achnanthaceae	*Cocconeis placentula*
Diatoms	Chrysophyta	Bacillariophyceae	Achnanthaceae	*Cocconeis pseudolineata*
Diatoms	Chrysophyta	Bacillariophyceae	Achnanthidiaceae	*Achnanthidium minutissimum*
Diatoms	Chrysophyta	Bacillariophyceae	Bacillariaceae	*Nitzschia paleacea*
Diatoms	Chrysophyta	Bacillariophyceae	Catenulaceae	*Amphora pediculus*
Diatoms	Chrysophyta	Bacillariophyceae	Cymbellaceae	*Encyonema minutum*
Diatoms	Chrysophyta	Bacillariophyceae	Cymbellaceae	*Encyonema silesiacum*
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Diatoma mesodon*
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Diatoma moniliformis*
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Fragilaria vaucheriae*
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Hannaea arcus*
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Meridion circulare*
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Staurosira construens*
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Staurosirella pinnata*
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Synedra ulna*
Diatoms	Chrysophyta	Bacillariophyceae	Gomphonemataceae	*Gomphonema drutelingense*
Diatoms	Chrysophyta	Bacillariophyceae	Gomphonemataceae	*Gomphonema longilineare*
Diatoms	Chrysophyta	Bacillariophyceae	Gomphonemataceae	*Reimeria sinuata*
Diatoms	Chrysophyta	Bacillariophyceae	Naviculaceae	*Navicula cryptotenella*
Yellow-Green	Chrysophyta	Chrysophyceae	Hydruraceae	*Hydrurus foetidus*
Red Algae	Rhodophyta	(Undetermined)		Unknown Rhodophyte
		Long Lake Inflow-Tributary 1 (08-06-08)		
Diatoms	Chrysophyta	Bacillariophyceae	Achnanthaceae	*Psammothidium chlidanos*
Diatoms	Chrysophyta	Bacillariophyceae	Achnanthidiaceae	*Achnanthidium deflexum*
Diatoms	Chrysophyta	Bacillariophyceae	Achnanthidiaceae	*Achnanthidium minutissimum*
Diatoms	Chrysophyta	Bacillariophyceae	Achnanthidiaceae	*Achnanthidium pyrenaicum*
Diatoms	Chrysophyta	Bacillariophyceae	Achnanthidiaceae	*Eucocconeis laevis*
Diatoms	Chrysophyta	Bacillariophyceae	Catenulaceae	*Amphora inariensis*
Diatoms	Chrysophyta	Bacillariophyceae	Catenulaceae	*Amphora pediculus*
Diatoms	Chrysophyta	Bacillariophyceae	Cymbellaceae	*Cymbella cymbiformis*
Diatoms	Chrysophyta	Bacillariophyceae	Cymbellaceae	*Cymbella tumida*
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Meridion circulare*
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Synedra acus*
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Synedra ulna*
Diatoms	Chrysophyta	Bacillariophyceae	Gomphonemataceae	*Gomphonema drutelingense*
Diatoms	Chrysophyta	Bacillariophyceae	Gomphonemataceae	*Reimeria sinuata*
Diatoms	Chrysophyta	Bacillariophyceae	Naviculaceae	*Navicula* sp.
Diatoms	Chrysophyta	Bacillariophyceae	Naviculaceae	*Navicula minima*
Diatoms	Chrysophyta	Bacillariophyceae	Neidiaceae	*Neidium hercynicum*
Diatoms	Chrysophyta	Bacillariophyceae	Pinnulariaceae	*Caloneis bacillum*
Diatoms	Chrysophyta	Bacillariophyceae	Sellaphoraceae	*Sellaphora pupula*

Table B1. Periphytic algae taxa present in Qualitative Multi-Habitat samples collected at stream sites along McCarthy Road, Wrangell-St. Elias National Park and Preserve, Alaska.—Continued

Algae group	Phylum	Class	Family	Genus species
		Long Lake Inflow-Tributary 2 (07-30-07)		
Green Algae	Chlorophyta	Chlorophyceae	Chaetophoraceae	*Stigeoclonium* sp.
Diatoms	Chrysophyta	Bacillariophyceae	Achnanthaceae	*Cocconeis pediculus*
Diatoms	Chrysophyta	Bacillariophyceae	Achnanthaceae	*Cocconeis placentula*
Diatoms	Chrysophyta	Bacillariophyceae	Achnanthaceae	*Cocconeis pseudolineata*
Diatoms	Chrysophyta	Bacillariophyceae	Achnanthaceae	*Karayevia clevei*
Diatoms	Chrysophyta	Bacillariophyceae	Achnanthaceae	*Platessa conspicua*
Diatoms	Chrysophyta	Bacillariophyceae	Achnanthidiaceae	*Achnanthidium minutissimum*
Diatoms	Chrysophyta	Bacillariophyceae	Achnanthidiaceae	*Achnanthidium rivulare*
Diatoms	Chrysophyta	Bacillariophyceae	Bacillariaceae	*Nitzschia angustata*
Diatoms	Chrysophyta	Bacillariophyceae	Bacillariaceae	*Nitzschia dissipata*
Diatoms	Chrysophyta	Bacillariophyceae	Bacillariaceae	*Nitzschia linearis*
Diatoms	Chrysophyta	Bacillariophyceae	Bacillariaceae	*Nitzschia palea*
Diatoms	Chrysophyta	Bacillariophyceae	Bacillariaceae	*Nitzschia pumila*
Diatoms	Chrysophyta	Bacillariophyceae	Bacillariaceae	*Nitzschia sociabilis*
Diatoms	Chrysophyta	Bacillariophyceae	Catenulaceae	*Amphora pediculus*
Diatoms	Chrysophyta	Bacillariophyceae	Cymbellaceae	*Cymbella* sp.
Diatoms	Chrysophyta	Bacillariophyceae	Cymbellaceae	*Cymbella cymbiformis*
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Diatoma mesodon*
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Fragilaria tenera*
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Fragilaria vaucheriae*
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Meridion circulare*
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Staurosirella leptostauron*
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Staurosirella pinnata*
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Synedra ulna*
Diatoms	Chrysophyta	Bacillariophyceae	Gomphonemataceae	*Gomphonema drutelingense*
Diatoms	Chrysophyta	Bacillariophyceae	Naviculaceae	*Geissleria acceptata*
Diatoms	Chrysophyta	Bacillariophyceae	Naviculaceae	*Navicula antonii*
Diatoms	Chrysophyta	Bacillariophyceae	Naviculaceae	*Navicula cryptocephala*
Diatoms	Chrysophyta	Bacillariophyceae	Naviculaceae	*Navicula cryptotenella*
Diatoms	Chrysophyta	Bacillariophyceae	Naviculaceae	*Navicula lanceolata*
Diatoms	Chrysophyta	Bacillariophyceae	Rhopalodiaceae	*Epithemia adnata*
Diatoms	Chrysophyta	Bacillariophyceae	Rhopalodiaceae	*Rhopalodia gibba*
Diatoms	Chrysophyta	Bacillariophyceae	Stauroneidaceae	*Stauroneis smithii*
Diatoms	Chrysophyta	Bacillariophyceae	Stephanodiscaceae	*Cyclotella rossii*
Diatoms	Chrysophyta	Bacillariophyceae	Thalassiosiraceae	*Puncticulata radiosa*
Blue-Green	Cyanophyta	Myxophyceae	Chroococcaceae	*Chroococcus* sp.
Blue-Green	Cyanophyta	Myxophyceae	Phormidiaceae	*Phormidium* sp.
Blue-Green	Cyanophyta	Myxophyceae	Pseudanabaenaceae	*Pseudanabaena* sp.
Blue-Green	Cyanophyta	Myxophyceae	Rivulariaceae	*Calothrix* sp.
Red Algae	Rhodophyta	Rhodophyceae	Batrachospermaceae	*Batrachospermum* sp.
		Long Lake Outflow (07-31-07)		
Green Algae	Chlorophyta	(undetermined)		Unknown Chlorophyte
Green Algae	Chlorophyta	Chlorophyceae	Chaetophoraceae	*Stigeoclonium* sp.
Green Algae	Chlorophyta	Chlorophyceae	Cladophoraceae	*Cladophora glomerata*
Green Algae	Chlorophyta	Chlorophyceae	Cylindrocapsaceae	*Cylindrocapsa geminella*
Green Algae	Chlorophyta	Chlorophyceae	Desmidiaceae	*Closterium moniliferum*
Green Algae	Chlorophyta	Chlorophyceae	Desmidiaceae	*Staurastrum* sp.
Green Algae	Chlorophyta	Chlorophyceae	Oedogoniaceae	*Oedogonium* sp.
Green Algae	Chlorophyta	Chlorophyceae	Oocystaceae	*Ankistrodesmus fusiformis*
Green Algae	Chlorophyta	Chlorophyceae	Tetrasporaceae	*Tetraspora gelatinosa*
Green Algae	Chlorophyta	Chlorophyceae	Zygnemataceae	*Mougeotia* sp.
Green Algae	Chlorophyta	Chlorophyceae	Zygnemataceae	*Spirogyra* sp.
Diatoms	Chrysophyta	Bacillariophyceae	Achnanthaceae	*Cocconeis pediculus*
Diatoms	Chrysophyta	Bacillariophyceae	Achnanthaceae	*Cocconeis placentula*

Table B1. Periphytic algae taxa present in Qualitative Multi-Habitat samples collected at stream sites along McCarthy Road, Wrangell-St. Elias National Park and Preserve, Alaska.—Continued

Algae group	Phylum	Class	Family	Genus species
Long Lake Outflow (07-31-07)—Continued				
Diatoms	Chrysophyta	Bacillariophyceae	Achnanthaceae	*Cocconeis pseudolineata*
Diatoms	Chrysophyta	Bacillariophyceae	Achnanthaceae	*Karayevia clevei*
Diatoms	Chrysophyta	Bacillariophyceae	Achnanthaceae	*Karayevia ploenensis*
Diatoms	Chrysophyta	Bacillariophyceae	Achnanthaceae	*Karayevia suchlandtii*
Diatoms	Chrysophyta	Bacillariophyceae	Achnanthaceae	*Platessa conspicua*
Diatoms	Chrysophyta	Bacillariophyceae	Achnanthidiaceae	*Achnanthidium minutissimum*
Diatoms	Chrysophyta	Bacillariophyceae	Achnanthidiaceae	*Achnanthidium rivulare*
Diatoms	Chrysophyta	Bacillariophyceae	Bacillariaceae	*Nitzschia amphibia*
Diatoms	Chrysophyta	Bacillariophyceae	Bacillariaceae	*Nitzschia linearis*
Diatoms	Chrysophyta	Bacillariophyceae	Bacillariaceae	*Nitzschia sociabilis*
Diatoms	Chrysophyta	Bacillariophyceae	Catenulaceae	*Amphora pediculus*
Diatoms	Chrysophyta	Bacillariophyceae	Cymbellaceae	*Cymbella naviculiformis*
Diatoms	Chrysophyta	Bacillariophyceae	Cymbellaceae	*Cymbella subturgidula*
Diatoms	Chrysophyta	Bacillariophyceae	Cymbellaceae	*Encyonema auerswaldii*
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Diatoma moniliformis*
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Fragilaria capucina*
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Fragilaria vaucheriae*
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Staurosirella leptostauron*
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Synedra acus*
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Synedra ulna*
Diatoms	Chrysophyta	Bacillariophyceae	Gomphonemataceae	*Gomphonema drutelingense*
Diatoms	Chrysophyta	Bacillariophyceae	Gomphonemataceae	*Gomphonema minutum*
Diatoms	Chrysophyta	Bacillariophyceae	Melosiraceae	*Melosira varians*
Diatoms	Chrysophyta	Bacillariophyceae	Naviculaceae	*Navicula cryptocephala*
Diatoms	Chrysophyta	Bacillariophyceae	Naviculaceae	*Navicula cryptotenella*
Diatoms	Chrysophyta	Bacillariophyceae	Not Designated	*Encyonopsis microcephala*
Diatoms	Chrysophyta	Bacillariophyceae	Pinnulariaceae	*Caloneis bacillum*
Diatoms	Chrysophyta	Bacillariophyceae	Rhopalodiaceae	*Epithemia sorex*
Diatoms	Chrysophyta	Bacillariophyceae	Rhopalodiaceae	*Epithemia turgida*
Diatoms	Chrysophyta	Bacillariophyceae	Rhopalodiaceae	*Rhopalodia gibba*
Diatoms	Chrysophyta	Bacillariophyceae	Stephanodiscaceae	*Cyclotella bodanica*
Blue-Green	Cyanophyta	Myxophyceae	(undetermined)	*Unknown Cyanophyte*
Blue-Green	Cyanophyta	Myxophyceae	Homoeotrichaceae	*Heteroleibleinia* sp.
Blue-Green	Cyanophyta	Myxophyceae	Merismopediaceae	*Merismopedia* sp.
Blue-Green	Cyanophyta	Myxophyceae	Nostocaceae	*Anabaena* sp.
Blue-Green	Cyanophyta	Myxophyceae	Oscillatoriaceae	*Oscillatoria princeps*
Blue-Green	Cyanophyta	Myxophyceae	Phormidiaceae	*Phormidium* sp.
Blue-Green	Cyanophyta	Myxophyceae	Rivulariaceae	*Calothrix* sp.
Red Algae	Rhodophyta	(Undetermined)		Unknown Rhodophyte
Long Lake Outflow (08-05-08)				
Diatoms	Chrysophyta	Bacillariophyceae	Achnanthaceae	*Cocconeis placentula*
Diatoms	Chrysophyta	Bacillariophyceae	Achnanthidiaceae	*Achnanthidium minutissimum*
Diatoms	Chrysophyta	Bacillariophyceae	Bacillariaceae	*Nitzschia angustata*
Diatoms	Chrysophyta	Bacillariophyceae	Bacillariaceae	*Nitzschia fonticola*
Diatoms	Chrysophyta	Bacillariophyceae	Bacillariaceae	*Nitzschia gracilis*
Diatoms	Chrysophyta	Bacillariophyceae	Bacillariaceae	*Nitzschia inconspicua*
Diatoms	Chrysophyta	Bacillariophyceae	Bacillariaceae	*Nitzschia palea*
Diatoms	Chrysophyta	Bacillariophyceae	Catenulaceae	*Amphora inariensis*

Table B1. Periphytic algae taxa present in Qualitative Multi-Habitat samples collected at stream sites along McCarthy Road, Wrangell-St. Elias National Park and Preserve, Alaska.—Continued

Algae group	Phylum	Class	Family	Genus species
Long Lake Outflow (08-05-08)—Continued				
Diatoms	Chrysophyta	Bacillariophyceae	Catenulaceae	*Amphora pediculus*
Diatoms	Chrysophyta	Bacillariophyceae	Cymbellaceae	*Cymbella* sp.
Diatoms	Chrysophyta	Bacillariophyceae	Cymbellaceae	*Cymbella affinis*
Diatoms	Chrysophyta	Bacillariophyceae	Cymbellaceae	*Encyonema auerswaldii*
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Diatoma moniliformis*
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Fragilaria capucina*
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Fragilaria vaucheriae*
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Staurosira construens*
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Staurosirella leptostauron*
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Staurosirella pinnata*
Diatoms	Chrysophyta	Bacillariophyceae	Naviculaceae	*Adlafia minuscula*
Diatoms	Chrysophyta	Bacillariophyceae	Naviculaceae	*Kobayasiella subtilissima*
Diatoms	Chrysophyta	Bacillariophyceae	Naviculaceae	*Navicula minima*
Diatoms	Chrysophyta	Bacillariophyceae	Naviculaceae	*Navicula tripunctata*
Diatoms	Chrysophyta	Bacillariophyceae	Naviculaceae	*Navicula veneta*
Diatoms	Chrysophyta	Bacillariophyceae	Rhopalodiaceae	*Epithemia turgida*
Diatoms	Chrysophyta	Bacillariophyceae	Stephanodiscaceae	*Cyclotella rossii*
Gilahina River (08-01-07)				
Green Algae	Chlorophyta	Chlorophyceae	Desmidiaceae	*Closterium littorale*
Green Algae	Chlorophyta	Chlorophyceae	Desmidiaceae	*Cosmarium* sp.
Green Algae	Chlorophyta	Chlorophyceae	Ulotrichaceae	*Klebsormidium* sp.
Diatoms	Chrysophyta	Bacillariophyceae	Achnanthaceae	*Cocconeis placentula*
Diatoms	Chrysophyta	Bacillariophyceae	Achnanthidiaceae	*Achnanthidium minutissimum*
Diatoms	Chrysophyta	Bacillariophyceae	Cymbellaceae	*Cymbella subturgidula*
Diatoms	Chrysophyta	Bacillariophyceae	Cymbellaceae	*Encyonema minutum*
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Diatoma moniliformis*
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Fragilaria vaucheriae*
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Hannaea arcus*
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Synedra ulna*
Diatoms	Chrysophyta	Bacillariophyceae	Gomphonemataceae	*Gomphonema drutelingense*
Diatoms	Chrysophyta	Bacillariophyceae	Naviculaceae	*Navicula cryptotenella*
Diatoms	Chrysophyta	Bacillariophyceae	Tabellariaceae	*Tabellaria fenestrata*
Blue-Green	Cyanophyta	Myxophyceae	Phormidiaceae	*Phormidium autumnale*
Blue-Green	Cyanophyta	Myxophyceae	Phormidiaceae	*Phormidium granulatum*
Blue-Green	Cyanophyta	Myxophyceae	Pseudanabaenaceae	*Homoeothrix janthina*
Blue-Green	Cyanophyta	Myxophyceae	Pseudanabaenaceae	*Pseudanabaena catenata*
Red Algae	Rhodophyta	(Undetermined)		Unknown Rhodophyte
Chokosna River (07-29-07)				
Diatoms	Chrysophyta	Bacillariophyceae	Achnanthidiaceae	*Achnanthidium minutissimum*
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Diatoma moniliformis*
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Synedra ulna*
Diatoms	Chrysophyta	Bacillariophyceae	Gomphonemataceae	*Gomphonema* sp.
Diatoms	Chrysophyta	Bacillariophyceae	Gomphonemataceae	*Gomphonema drutelingense*
Blue-Green	Cyanophyta	Myxophyceae	Chamaesiphonaceae	*Chamaesiphon* sp.
Blue-Green	Cyanophyta	Myxophyceae	Phormidiaceae	*Phormidium autumnale*
Blue-Green	Cyanophyta	Myxophyceae	Phormidiaceae	*Phormidium granulatum*
Blue-Green	Cyanophyta	Myxophyceae	Pseudanabaenaceae	*Homoeothrix janthina*

Appendix C. Density and Biovolume of Periphytic Algae Taxa Present in Richest Targeted Habitat Samples Collected at Stream Sites along McCarthy Road, Wrangell-St. Elias National Park and Preserve, Alaska, 2007–08

Table C1. Density and biolvolume of periphytic algae taxa present in Richest Targeted Habitat samples collected at stream sites along McCarthy Road, Wrangell-St. Elias National Park and Preserve, Alaska.

[**Abbreviations:** cells/cm^2, cells per square centimeter; µm^3/cm^2, cubic micrometer per square centimeter]

Algae group	Phylum	Class	Family	Genus species	Density (cells/cm^2)	Biovolume (µm^3/cm^2)
			Long Lake Inflow-Tributary 1 (08-06-08)			
Green Algae	Chlorophyta	Chlorophyceae	Chaetophoraceae	*Gongrosira* sp.	9,423	20,698,574
Diatoms	Chrysophyta	Bacillariophyceae	Achnanthaceae	*Cocconeis placentula*	16	10,063
Diatoms	Chrysophyta	Bacillariophyceae	Achnanthaceae	*Karayevia ploenensis*	8	411
Diatoms	Chrysophyta	Bacillariophyceae	Achnanthidiaceae	*Achnanthidium deflexum*	111	7,350
Diatoms	Chrysophyta	Bacillariophyceae	Achnanthidiaceae	*Achnanthidium minutissimum*	1,402	38,052
Diatoms	Chrysophyta	Bacillariophyceae	Achnanthidiaceae	*Achnanthidium rivulare*	79	3,769
Diatoms	Chrysophyta	Bacillariophyceae	Achnanthidiaceae	*Eucocconeis laevis*	71	764
Diatoms	Chrysophyta	Bacillariophyceae	Bacillariaceae	*Nitzschia amphibia*	16	2,753
Diatoms	Chrysophyta	Bacillariophyceae	Bacillariaceae	*Nitzschia fonticola*	8	655
Diatoms	Chrysophyta	Bacillariophyceae	Catenulaceae	*Amphora inariensis*	8	934
Diatoms	Chrysophyta	Bacillariophyceae	Catenulaceae	*Amphora pediculus*	87	7,043
Diatoms	Chrysophyta	Bacillariophyceae	Cymbellaceae	*Cymbella affinis*	24	19,588
Diatoms	Chrysophyta	Bacillariophyceae	Cymbellaceae	*Cymbella diversistigmata*	48	88,104
Diatoms	Chrysophyta	Bacillariophyceae	Cymbellaceae	*Cymbella* sp.	24	12,610
Diatoms	Chrysophyta	Bacillariophyceae	Cymbellaceae	*Cymbella subturgidula*	8	1,307
Diatoms	Chrysophyta	Bacillariophyceae	Cymbellaceae	*Encyonema auerswaldii*	8	1,791
Diatoms	Chrysophyta	Bacillariophyceae	Cymbellaceae	*Encyonema silesiacum*	158	43,355
Diatoms	Chrysophyta	Bacillariophyceae	Diploneidaceae	*Diploneis parma*	8	7,889
Diatoms	Chrysophyta	Bacillariophyceae	Eunotiaceae	*Eunotia bilunaris*	16	4,550
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Diatoma mesodon*	8	6,696
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Fragilaria capucina*	8	296
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Fragilaria vaucheriae*	16	2,888
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Meridion circulare*	459	206,866
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Staurosira construens*	8	718
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Staurosirella leptostauron*	8	3,804
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Staurosirella pinnata*	16	1,961
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Synedra acus*	79	88,055
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Synedra ulna*	24	130,115
Diatoms	Chrysophyta	Bacillariophyceae	Gomphonemataceae	*Gomphonema cf. longilineare*	55	1,478
Diatoms	Chrysophyta	Bacillariophyceae	Gomphonemataceae	*Gomphonema drutelingense*	808	71,576
Diatoms	Chrysophyta	Bacillariophyceae	Gomphonemataceae	*Gomphonema parvulum*	87	19,322
Diatoms	Chrysophyta	Bacillariophyceae	Gomphonemataceae	*Gomphonema* sp.	8	3,522
Diatoms	Chrysophyta	Bacillariophyceae	Gomphonemataceae	*Reimeria sinuata*	206	28,466
Diatoms	Chrysophyta	Bacillariophyceae	Naviculaceae	*Navicula cryptotenella*	8	1,604
Diatoms	Chrysophyta	Bacillariophyceae	Naviculaceae	*Navicula minima*	16	672
Diatoms	Chrysophyta	Bacillariophyceae	Naviculaceae	*Navicula radiosa*	48	32,957
Diatoms	Chrysophyta	Bacillariophyceae	Pinnulariaceae	*Caloneis bacillum*	55	25,242
Diatoms	Chrysophyta	Bacillariophyceae	Pinnulariaceae	*Caloneis schumanniana*	8	6,424
Diatoms	Chrysophyta	Bacillariophyceae	Pinnulariaceae	*Pinnularia* sp.	8	59,408
Diatoms	Chrysophyta	Bacillariophyceae	Rhopalodiaceae	*Epithemia adnata*	16	20,090
Diatoms	Chrysophyta	Bacillariophyceae	Rhopalodiaceae	*Rhopalodia gibba*	32	159,132
Blue-Green	Cyanophyta	Myxophyceae	Chamaesiphonaceae	*Chamaesiphon* sp.	13,985	830,676
Blue-Green	Cyanophyta	Myxophyceae	Pseudanabaenaceae	*Leptolyngbya* sp.	8,546	27,867
Red Algae	Rhodophyta	(Undetermined)		Unknown Rhodophyte	195,399	87,631,256

Table C1. Density and biolvolume of periphytic algae taxa present in Richest Targeted Habitat samples collected at stream sites along McCarthy Road, Wrangell-St. Elias National Park and Preserve, Alaska.—Continued

[**Abbreviations:** cells/cm^2, cells per square centimeter; µm^3/cm^2, cubic micrometer per square centimeter]

Algae group	Phylum	Class	Family	Genus species	Density (cells/cm^2)	Biovolume (µm^3/cm^2)
			Long Lake Inflow-Tributary 1 (09-24-08)			
Green Algae	Chlorophyta	Chlorophyceae	Chaetophoraceae	*Gongrosira* sp.	7,974	8,497,309
Diatoms	Chrysophyta	Bacillariophyceae	Achnanthaceae	*Cocconeis placentula*	29	16,380
Diatoms	Chrysophyta	Bacillariophyceae	Achnanthaceae	*Planothidium frequentissimum*	29	2,022
Diatoms	Chrysophyta	Bacillariophyceae	Achnanthidiaceae	*Achnanthidium deflexum*	467	30,977
Diatoms	Chrysophyta	Bacillariophyceae	Achnanthidiaceae	*Achnanthidium minutissimum*	4,440	120,508
Diatoms	Chrysophyta	Bacillariophyceae	Achnanthidiaceae	*Achnanthidium pyrenaicum*	58	3,781
Diatoms	Chrysophyta	Bacillariophyceae	Achnanthidiaceae	*Eucocconeis laevis*	204	2,190
Diatoms	Chrysophyta	Bacillariophyceae	Brachysiraceae	*Brachysira microcephala*	29	2,087
Diatoms	Chrysophyta	Bacillariophyceae	Catenulaceae	*Amphora pediculus*	117	9,445
Diatoms	Chrysophyta	Bacillariophyceae	Cymbellaceae	*Cymbella affinis*	29	24,079
Diatoms	Chrysophyta	Bacillariophyceae	Cymbellaceae	*Cymbella diversistigmata*	467	866,428
Diatoms	Chrysophyta	Bacillariophyceae	Cymbellaceae	*Encyonema reichardtii*	29	1,346
Diatoms	Chrysophyta	Bacillariophyceae	Cymbellaceae	*Encyonema silesiacum*	29	7,994
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Diatoma moniliformis*	29	4,274
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Fragilaria vaucheriae*	380	69,232
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Meridion circulare*	613	276,215
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Synedra acus*	29	32,473
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Synedra ulna*	2,103	11,516,096
Diatoms	Chrysophyta	Bacillariophyceae	Gomphonemataceae	*Gomphonema longilineare*	88	2,336
Diatoms	Chrysophyta	Bacillariophyceae	Gomphonemataceae	*Gomphonema drutelingense*	7,331	649,544
Diatoms	Chrysophyta	Bacillariophyceae	Gomphonemataceae	*Gomphonema parvulum*	58	12,956
Diatoms	Chrysophyta	Bacillariophyceae	Gomphonemataceae	*Gomphonema pygmaeum*	117	2,378
Diatoms	Chrysophyta	Bacillariophyceae	Gomphonemataceae	*Gomphonema* sp.	88	38,968
Diatoms	Chrysophyta	Bacillariophyceae	Gomphonemataceae	*Reimeria sinuata*	1,314	181,689
Diatoms	Chrysophyta	Bacillariophyceae	Pinnulariaceae	*Caloneis bacillum*	58	26,597
Diatoms	Chrysophyta	Bacillariophyceae	Rhopalodiaceae	*Rhopalodia gibba*	29	146,712
Diatoms	Chrysophyta	Bacillariophyceae	Stephanodiscaceae	*Cyclotella rossii*	29	14,604
Blue-Green	Cyanophyta	Myxophyceae	Phormidiaceae	*Phormidium* sp.	27,602	2,210,149
Blue-Green	Cyanophyta	Myxophyceae	Pseudanabaenaceae	*Geitlerinema splendidum*	40,482	776,016
Blue-Green	Cyanophyta	Myxophyceae	Pseudanabaenaceae	*Homoeothrix janthina*	53,976	223,535
Blue-Green	Cyanophyta	Myxophyceae	Pseudanabaenaceae	*Pseudanabaena* sp.	10,018	86,821
Red Algae	Rhodophyta	(Undetermined)		Unknown Rhodophyte	139,439	62,534,809
			Long Lake Inflow-Tributary 2 (07-30-07)			
Green Algae	Chlorophyta	(undetermined)		Unknown Chlorophyte	36,276	5,795,181
Green Algae	Chlorophyta	Chlorophyceae	Chaetophoraceae	*Stigeoclonium* sp.	75,415	73,198,807
Diatoms	Chrysophyta	Bacillariophyceae	Achnanthaceae	*Cocconeis placentula*	338	189,378
Diatoms	Chrysophyta	Bacillariophyceae	Achnanthaceae	*Karayevia clevei*	169	24,255
Diatoms	Chrysophyta	Bacillariophyceae	Achnanthidiaceae	*Achnanthidium minutissimum*	1,688	45,831
Diatoms	Chrysophyta	Bacillariophyceae	Bacillariaceae	*Nitzschia amphibia*	169	29,346
Diatoms	Chrysophyta	Bacillariophyceae	Bacillariaceae	*Nitzschia tropica*	84	17,999
Diatoms	Chrysophyta	Bacillariophyceae	Catenulaceae	*Amphora pediculus*	591	47,772
Diatoms	Chrysophyta	Bacillariophyceae	Cymbellaceae	*Cymbella cymbiformis*	507	939,114
Diatoms	Chrysophyta	Bacillariophyceae	Cymbellaceae	*Cymbella subturgidula*	253	41,810
Diatoms	Chrysophyta	Bacillariophyceae	Cymbellaceae	*Encyonema auerswaldii*	169	38,177
Diatoms	Chrysophyta	Bacillariophyceae	Cymbellaceae	*Encyonema minutum*	253	42,338
Diatoms	Chrysophyta	Bacillariophyceae	Cymbellaceae	*Encyonema prostratum*	84	45,585
Diatoms	Chrysophyta	Bacillariophyceae	Cymbellaceae	*Encyonema silesiacum*	338	92,426
Diatoms	Chrysophyta	Bacillariophyceae	Diploneidaceae	*Diploneis pseudovalis*	338	290,098
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Fragilaria vaucheriae*	169	30,785
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Pseudostaurosira brevistriata*	84	12,043
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Staurosirella leptostauron*	84	40,545

Table C1. Density and biolvolume of periphytic algae taxa present in Richest Targeted Habitat samples collected at stream sites along McCarthy Road, Wrangell-St. Elias National Park and Preserve, Alaska.—Continued

[**Abbreviations:** cells/cm^2, cells per square centimeter; µm^3/cm^2, cubic micrometer per square centimeter]

Algae group	Phylum	Class	Family	Genus species	Density (cells/cm^2)	Biovolume (µm^3/cm^2)
			Long Lake Inflow-Tributary 2 (07-30-07)—Continued			
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Staurosirella pinnata*	422	52,266
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Synedra acus*	338	375,436
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Synedra ulna*	253	1,386,911
Diatoms	Chrysophyta	Bacillariophyceae	Gomphonemataceae	*Gomphonema longilineare*	1,351	36,014
Diatoms	Chrysophyta	Bacillariophyceae	Gomphonemataceae	*Gomphonema drutelingense*	3,377	299,192
Diatoms	Chrysophyta	Bacillariophyceae	Gomphonemataceae	*Gomphonema minutum*	338	55,206
Diatoms	Chrysophyta	Bacillariophyceae	Gomphonemataceae	*Gomphonema* sp. 1	844	11,524
Diatoms	Chrysophyta	Bacillariophyceae	Gomphonemataceae	*Gomphonema* sp. 2	1,857	825,964
Diatoms	Chrysophyta	Bacillariophyceae	Gomphonemataceae	*Gomphonema truncatum*	169	67,822
Diatoms	Chrysophyta	Bacillariophyceae	Gomphonemataceae	*Reimeria sinuata*	338	46,680
Diatoms	Chrysophyta	Bacillariophyceae	Naviculaceae	*Navicula radiosa*	2,533	1,756,455
Diatoms	Chrysophyta	Bacillariophyceae	Naviculaceae	*Navicula* sp.	422	58,084
Diatoms	Chrysophyta	Bacillariophyceae	Pinnulariaceae	*Caloneis schumanniana*	169	136,945
Diatoms	Chrysophyta	Bacillariophyceae	Pinnulariaceae	*Caloneis silicula*	507	480,153
Diatoms	Chrysophyta	Bacillariophyceae	Pinnulariaceae	*Caloneis tenuis*	1,942	224,623
Diatoms	Chrysophyta	Bacillariophyceae	Pinnulariaceae	*Pinnularia acrosphaeria*	253	387,770
Diatoms	Chrysophyta	Bacillariophyceae	Pinnulariaceae	*Pinnularia* sp.	84	633,249
Diatoms	Chrysophyta	Bacillariophyceae	Pleurosigmataceae	*Gyrosigma acuminatum*	84	582,100
Diatoms	Chrysophyta	Bacillariophyceae	Rhopalodiaceae	*Epithemia adnata*	338	428,286
Diatoms	Chrysophyta	Bacillariophyceae	Rhopalodiaceae	*Rhopalodia gibba*	3,630	18,234,325
Diatoms	Chrysophyta	Bacillariophyceae	Stephanodiscaceae	*Cyclotella rossii*	84	42,211
Diatoms	Chrysophyta	Bacillariophyceae	Stephanodiscaceae	*Cyclotella* sp.	84	42,211
Diatoms	Chrysophyta	Bacillariophyceae	Tabellariaceae	*Tabellaria fenestrata*	84	184,476
Blue-Green	Cyanophyta	Myxophyceae	(undetermined)	Unknown Cyanophyte	7,637	60,779,934
Blue-Green	Cyanophyta	Myxophyceae	Nostocaceae	*Cylindrospermum cf.* sp.	16,229	412,967
Blue-Green	Cyanophyta	Myxophyceae	Pseudanabaenaceae	*Homoeothrix janthina*	32,457	134,416
Blue-Green	Cyanophyta	Myxophyceae	Pseudanabaenaceae	*Pseudanabaena* sp.	18,138	157,185
Blue-Green	Cyanophyta	Myxophyceae	Rivulariaceae	*Calothrix* sp.	23,866	5,411,181
Red Algae	Rhodophyta	(Undetermined)		Unknown Rhodophyte	235,792	105,746,297
Red Algae	Rhodophyta	Rhodophyceae	Batrachospermaceae	*Batrachospermum* sp.	2,742,629	4,683,477,481
			Long Lake Outflow (07-31-07)			
Green Algae	Chlorophyta	Chlorophyceae	Chaetophoraceae	*Gongrosira* sp.	171,472	182,729,933
Green Algae	Chlorophyta	Chlorophyceae	Scenedesmaceae	*Scenedesmus* sp.	5,196	91,913
Green Algae	Chlorophyta	Chlorophyceae	Zygnemataceae	*Mougeotia* sp.	15,588	88,825,173
Diatoms	Chrysophyta	Bacillariophyceae	Achnanthaceae	*Cocconeis pediculus*	7,848	27,456,405
Diatoms	Chrysophyta	Bacillariophyceae	Achnanthaceae	*Cocconeis placentula*	2,452	1,667,688
Diatoms	Chrysophyta	Bacillariophyceae	Achnanthaceae	*Karayevia clevei*	2,943	422,770
Diatoms	Chrysophyta	Bacillariophyceae	Achnanthaceae	*Karayevia suchlandtii*	490	15,373
Diatoms	Chrysophyta	Bacillariophyceae	Achnanthaceae	*Planothidium calcar*	490	116,280
Diatoms	Chrysophyta	Bacillariophyceae	Achnanthaceae	*Planothidium frequentissimum*	490	33,950
Diatoms	Chrysophyta	Bacillariophyceae	Achnanthaceae	*Planothidium lanceolatum*	490	91,894
Diatoms	Chrysophyta	Bacillariophyceae	Achnanthaceae	*Psammothidium lauenburgianum*	981	21,316
Diatoms	Chrysophyta	Bacillariophyceae	Achnanthidiaceae	*Achnanthidium minutissimum*	34,335	931,973
Diatoms	Chrysophyta	Bacillariophyceae	Amphipleuraceae	*Amphipleura pellucida*	1,471	948,202
Diatoms	Chrysophyta	Bacillariophyceae	Bacillariaceae	*Nitzschia dissipata*	2,943	669,949
Diatoms	Chrysophyta	Bacillariophyceae	Bacillariaceae	*Nitzschia linearis*	981	2,549,380
Diatoms	Chrysophyta	Bacillariophyceae	Bacillariaceae	*Nitzschia paleacea*	1,471	62,099
Diatoms	Chrysophyta	Bacillariophyceae	Bacillariaceae	*Nitzschia pumila*	1,471	153,204
Diatoms	Chrysophyta	Bacillariophyceae	Bacillariaceae	*Nitzschia sociabilis*	981	206,000
Diatoms	Chrysophyta	Bacillariophyceae	Bacillariaceae	*Nitzschia* sp.	2,452	28,728,364

Table C1. Density and biolvolume of periphytic algae taxa present in Richest Targeted Habitat samples collected at stream sites along McCarthy Road, Wrangell-St. Elias National Park and Preserve, Alaska.—Continued

[**Abbreviations:** cells/cm^2, cells per square centimeter; µm^3/cm^2, cubic micrometer per square centimeter]

Algae group	Phylum	Class	Family	Genus species	Density (cells/cm^2)	Biovolume (µm^3/cm^2)
			Long Lake Outflow (07-31-07)—Continued			
Diatoms	Chrysophyta	Bacillariophyceae	Bacillariaceae	*Nitzschia tropica*	4,414	941,202
Diatoms	Chrysophyta	Bacillariophyceae	Catenulaceae	*Amphora ovalis*	981	5,554,866
Diatoms	Chrysophyta	Bacillariophyceae	Catenulaceae	*Amphora pediculus*	135,377	10,943,673
Diatoms	Chrysophyta	Bacillariophyceae	Cymbellaceae	*Cymbella affinis*	490	404,360
Diatoms	Chrysophyta	Bacillariophyceae	Cymbellaceae	*Cymbella cymbiformis*	490	909,380
Diatoms	Chrysophyta	Bacillariophyceae	Cymbellaceae	*Cymbella naviculiformis*	490	41,855
Diatoms	Chrysophyta	Bacillariophyceae	Cymbellaceae	*Cymbella* sp.	12,262	6,508,016
Diatoms	Chrysophyta	Bacillariophyceae	Cymbellaceae	*Encyonema auerswaldii*	5,395	1,219,961
Diatoms	Chrysophyta	Bacillariophyceae	Diploneidaceae	*Diploneis marginestriata*	490	49,149
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Fragilaria tenera*	490	76,014
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Fragilaria vaucheriae*	6,867	1,252,056
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Pseudostaurosira brevistriata*	490	69,972
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Pseudostaurosira parasitica*	1,471	8,800
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Staurosira construens*	490	97,906
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Staurosirella leptostauron*	981	471,138
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Staurosirella pinnata*	3,433	425,132
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Synedra ulna*	490	2,685,998
Diatoms	Chrysophyta	Bacillariophyceae	Gomphonemataceae	*Gomphonema gracile*	490	355,587
Diatoms	Chrysophyta	Bacillariophyceae	Gomphonemataceae	*Gomphonema minutum*	490	80,188
Diatoms	Chrysophyta	Bacillariophyceae	Gomphonemataceae	*Gomphonema rhombicum*	490	240,506
Diatoms	Chrysophyta	Bacillariophyceae	Gomphonemataceae	*Reimeria sinuata*	981	135,606
Diatoms	Chrysophyta	Bacillariophyceae	Mastogloiaceae	*Mastogloia smithii*	490	744,925
Diatoms	Chrysophyta	Bacillariophyceae	Melosiraceae	*Melosira varians*	3,924	18,450,438
Diatoms	Chrysophyta	Bacillariophyceae	Naviculaceae	*Navicula antonii*	1,471	127,912
Diatoms	Chrysophyta	Bacillariophyceae	Naviculaceae	*Navicula cryptocephala*	2,452	721,438
Diatoms	Chrysophyta	Bacillariophyceae	Naviculaceae	*Navicula cryptotenella*	13,243	2,682,386
Diatoms	Chrysophyta	Bacillariophyceae	Naviculaceae	*Navicula lanceolata*	490	511,140
Diatoms	Chrysophyta	Bacillariophyceae	Naviculaceae	*Navicula radiosa*	981	680,337
Diatoms	Chrysophyta	Bacillariophyceae	Naviculaceae	*Navicula tripunctata*	981	845,697
Diatoms	Chrysophyta	Bacillariophyceae	Not Designated	*Encyonopsis microcephala*	1,962	97,259
Diatoms	Chrysophyta	Bacillariophyceae	Rhopalodiaceae	*Epithemia adnata*	3,433	4,354,623
Diatoms	Chrysophyta	Bacillariophyceae	Rhopalodiaceae	*Epithemia turgida*	981	27,361,140
Diatoms	Chrysophyta	Bacillariophyceae	Rhopalodiaceae	*Rhopalodia gibba*	1,471	7,391,295
Diatoms	Chrysophyta	Bacillariophyceae	Stephanodiscaceae	*Cyclotella rossii*	2,943	1,471,489
Diatoms	Chrysophyta	Bacillariophyceae	Thalassiosiraceae	*Puncticulata radiosa*	9,810	129,530,244
Blue-Green	Cyanophyta	Myxophyceae	Chroococcaceae	*Chroococcus* sp.	5,196	769,570
Blue-Green	Cyanophyta	Myxophyceae	Phormidiaceae	*Phormidium* sp.	237,723	19,035,213
Blue-Green	Cyanophyta	Myxophyceae	Pseudanabaenaceae	*Homoeothrix janthina*	155,884	645,569
Blue-Green	Cyanophyta	Myxophyceae	Rivulariaceae	*Calothrix* sp.	450,764	102,204,435
Red Algae	Rhodophyta	(Undetermined)		Unknown Rhodophyte	303,973	136,323,979
			Long Lake Outflow (08-05-08)			
Green Algae	Chlorophyta	Chlorophyceae	Chaetophoraceae	Gongrosira sp.	41,835	44,581,543
Green Algae	Chlorophyta	Chlorophyceae	Desmidiaceae	*Staurastrum* sp.	1,195	7,342,459
Green Algae	Chlorophyta	Chlorophyceae	Oedogoniaceae	*Oedogonium* sp.	7,172	156,479,320
Green Algae	Chlorophyta	Chlorophyceae	Scenedesmaceae	*Scenedesmus ecornis*	5,976	155,606
Green Algae	Chlorophyta	Chlorophyceae	Zygnemataceae	*Spirogyra* sp.	18,527	1,350,895,557
Diatoms	Chrysophyta	Bacillariophyceae	Achnanthaceae	*Achnanthes oblongella*	380	25,165
Diatoms	Chrysophyta	Bacillariophyceae	Achnanthaceae	*Cocconeis placentula*	950	674,396
Diatoms	Chrysophyta	Bacillariophyceae	Achnanthaceae	*Karayevia clevei*	380	54,595
Diatoms	Chrysophyta	Bacillariophyceae	Achnanthaceae	*Planothidium frequentissimum*	190	13,153
Diatoms	Chrysophyta	Bacillariophyceae	Achnanthaceae	*Psammothidium bioretii*	950	312,380

Table C1. Density and biolvolume of periphytic algae taxa present in Richest Targeted Habitat samples collected at stream sites along McCarthy Road, Wrangell-St. Elias National Park and Preserve, Alaska.—Continued

[**Abbreviations:** cells/cm^2, cells per square centimeter; μm^3/cm^2, cubic micrometer per square centimeter]

Algae group	Phylum	Class	Family	Genus species	Density (cells/cm^2)	Biovolume (μm^3/cm^2)
			Long Lake Outflow (08-05-08)—Continued			
Diatoms	Chrysophyta	Bacillariophyceae	Achnanthaceae	*Psammothidium lauenburgianum*	760	16,516
Diatoms	Chrysophyta	Bacillariophyceae	Achnanthidiaceae	*Achnanthidium minutissimum*	26,223	711,800
Diatoms	Chrysophyta	Bacillariophyceae	Amphipleuraceae	*Amphipleura pellucida*	190	122,448
Diatoms	Chrysophyta	Bacillariophyceae	Bacillariaceae	*Nitzschia dissipata*	1,520	346,062
Diatoms	Chrysophyta	Bacillariophyceae	Bacillariaceae	*Nitzschia fonticola*	380	31,421
Diatoms	Chrysophyta	Bacillariophyceae	Bacillariaceae	*Nitzschia frustulum*	760	35,944
Diatoms	Chrysophyta	Bacillariophyceae	Bacillariaceae	*Nitzschia inconspicua*	380	9,608
Diatoms	Chrysophyta	Bacillariophyceae	Catenulaceae	*Amphora pediculus*	48,456	3,917,130
Diatoms	Chrysophyta	Bacillariophyceae	Cymbellaceae	*Cymbella affinis*	12,732	10,495,836
Diatoms	Chrysophyta	Bacillariophyceae	Cymbellaceae	*Cymbella subturgidula*	380	62,739
Diatoms	Chrysophyta	Bacillariophyceae	Cymbellaceae	*Encyonema auerswaldii*	570	128,899
Diatoms	Chrysophyta	Bacillariophyceae	Cymbellaceae	*Encyonema reichardtii*	380	17,508
Diatoms	Chrysophyta	Bacillariophyceae	Cymbellaceae	*Encyonema silesiacum*	380	104,020
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Fragilaria vaucheriae*	380	69,295
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Pseudostaurosira parasitica*	380	2,273
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Staurosira construens*	190	75,711
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Staurosira construens*	950	86,113
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Staurosirella pinnata*	2,090	258,817
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Synedra ulna*	190	1,040,590
Diatoms	Chrysophyta	Bacillariophyceae	Gomphonemataceae	*Gomphonema drutelingense*	190	16,836
Diatoms	Chrysophyta	Bacillariophyceae	Gomphonemataceae	*Gomphonema parvulum*	380	84,289
Diatoms	Chrysophyta	Bacillariophyceae	Gomphonemataceae	*Gomphonema pygmaeum*	760	15,474
Diatoms	Chrysophyta	Bacillariophyceae	Gomphonemataceae	*Reimeria sinuata*	190	26,268
Diatoms	Chrysophyta	Bacillariophyceae	Naviculaceae	*Geissleria acceptata*	570	63,071
Diatoms	Chrysophyta	Bacillariophyceae	Naviculaceae	*Navicula cryptotenella*	4,561	923,725
Diatoms	Chrysophyta	Bacillariophyceae	Naviculaceae	*Navicula minima*	190	8,067
Diatoms	Chrysophyta	Bacillariophyceae	Not Designated	*Encyonopsis microcephala*	3,420	169,557
Diatoms	Chrysophyta	Bacillariophyceae	Pinnulariaceae	*Caloneis bacillum*	380	173,036
Diatoms	Chrysophyta	Bacillariophyceae	Rhoicospheniaceae	*Rhoicosphenia abbreviata*	190	61,029
Diatoms	Chrysophyta	Bacillariophyceae	Rhopalodiaceae	*Epithemia adnata*	1,140	1,446,030
Diatoms	Chrysophyta	Bacillariophyceae	Rhopalodiaceae	*Epithemia turgida*	760	9,736,695
Diatoms	Chrysophyta	Bacillariophyceae	Sellaphoraceae	*Fallacia subhamulata*	190	9,454
Diatoms	Chrysophyta	Bacillariophyceae	Stephanodiscaceae	*Cyclotella rossii*	1,710	855,110
Diatoms	Chrysophyta	Bacillariophyceae	Thalassiosiraceae	*Puncticulata radiosa*	570	7,527,244
Blue-Green	Cyanophyta	Myxophyceae	Homoeotrichaceae	*Heteroleibleinia* sp.	40,640	382,760
Blue-Green	Cyanophyta	Myxophyceae	Phormidiaceae	*Phormidium* sp.	72,912	5,838,318
Blue-Green	Cyanophyta	Myxophyceae	Rivulariaceae	*Calothrix* sp.	154,789	35,096,300
Blue-Green	Cyanophyta	Myxophyceae	Rivulariaceae	*Dichothrix* sp.	27,492	2,078,496
Red Algae	Rhodophyta	(Undetermined)		*Unknown Rhodophyte*	136,860	61,378,063
			Gilahina River (08-01-07)			
Green Algae	Chlorophyta	Chlorophyceae	Chaetophoraceae	*Gongrosira* sp.	1,961	2,089,822
Diatoms	Chrysophyta	Bacillariophyceae	Achnanthaceae	*Cocconeis placentula*	1,583	887,731
Diatoms	Chrysophyta	Bacillariophyceae	Achnanthidiaceae	*Achnanthidium deflexum*	83	5,522
Diatoms	Chrysophyta	Bacillariophyceae	Achnanthidiaceae	*Achnanthidium minutissimum*	11,414	309,817
Diatoms	Chrysophyta	Bacillariophyceae	Bacillariaceae	*Nitzschia angustata*	83	438,196
Diatoms	Chrysophyta	Bacillariophyceae	Bacillariaceae	*Nitzschia* sp.	167	1,951,865
Diatoms	Chrysophyta	Bacillariophyceae	Catenulaceae	*Amphora pediculus*	1,083	87,554
Diatoms	Chrysophyta	Bacillariophyceae	Cymbellaceae	*Cymbella affinis*	167	137,365
Diatoms	Chrysophyta	Bacillariophyceae	Cymbellaceae	*Cymbella* sp.	417	221,084

Table C1. Density and biolvolume of periphytic algae taxa present in Richest Targeted Habitat samples collected at stream sites along McCarthy Road, Wrangell-St. Elias National Park and Preserve, Alaska.—Continued

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Algae group	Phylum	Class	Family	Genus species	Density (cells/cm^2)	Biovolume (μm^3/cm^2)
Gilahina River (08-01-07)—Continued						
Diatoms	Chrysophyta	Bacillariophyceae	Cymbellaceae	*Encyonema auerswaldii*	583	131,865
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Diatoma mesodon*	83	70,437
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Diatoma moniliformis*	83	12,190
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Fragilaria vaucheriae*	83	15,191
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Pseudostaurosira brevistriata*	333	47,541
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Staurosira construens*	167	49,824
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Staurosirella pinnata*	417	51,579
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Synedra acus*	250	277,878
Diatoms	Chrysophyta	Bacillariophyceae	Gomphonemataceae	*Gomphonema longilineare*	12,497	333,201
Diatoms	Chrysophyta	Bacillariophyceae	Gomphonemataceae	*Gomphonema drutelingense*	12,830	1,136,758
Diatoms	Chrysophyta	Bacillariophyceae	Gomphonemataceae	*Gomphonema rhombicum*	83	40,851
Diatoms	Chrysophyta	Bacillariophyceae	Gomphonemataceae	*Gomphonema* sp.	1,333	18,197
Diatoms	Chrysophyta	Bacillariophyceae	Gomphonemataceae	*Reimeria sinuata*	5,665	783,137
Diatoms	Chrysophyta	Bacillariophyceae	Naviculaceae	*Navicula cryptotenella*	250	50,624
Diatoms	Chrysophyta	Bacillariophyceae	Naviculaceae	*Navicula tripunctata*	500	430,938
Diatoms	Chrysophyta	Bacillariophyceae	Not Designated	*Encyonopsis microcephala*	83	4,130
Diatoms	Chrysophyta	Bacillariophyceae	Rhopalodiaceae	*Rhopalodia gibba*	250	1,255,450
Diatoms	Chrysophyta	Bacillariophyceae	Stephanodiscaceae	*Cyclotella rossii*	167	83,313
Diatoms	Chrysophyta	Bacillariophyceae	Thalassiosiraceae	*Puncticulata radiosa*	333	4,400,278
Blue-Green	Cyanophyta	Myxophyceae	(undetermined)	Unknown Cyanophyte	314,752	2,504,995,554
Blue-Green	Cyanophyta	Myxophyceae	Phormidiaceae	*Phormidium* sp.	4,903	392,573
Blue-Green	Cyanophyta	Myxophyceae	Pseudanabaenaceae	*Homoeothrix janthina*	444,673	1,841,544
Red Algae	Rhodophyta	(Undetermined)		Unknown Rhodophyte	3,432	1,539,104
Red Algae	Rhodophyta	Rhodophyceae	Batrachospermaceae	*Batrachospermum* sp.	6,373	10,883,732
Chokosna River (07-29-07)						
Green Algae	Chlorophyta	(undetermined)		Unknown Chlorophyte	47,886	7,649,922
Diatoms	Chrysophyta	Bacillariophyceae	Achnanthaceae	*Cocconeis placentula*	405	287,415
Diatoms	Chrysophyta	Bacillariophyceae	Achnanthidiaceae	*Achnanthidium minutissimum*	100,016	2,714,817
Diatoms	Chrysophyta	Bacillariophyceae	Cymbellaceae	*Encyonema minutum*	405	67,691
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Diatoma moniliformis*	17,817	2,606,877
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Fragilaria vaucheriae*	810	147,660
Diatoms	Chrysophyta	Bacillariophyceae	Gomphonemataceae	*Gomphonema longilineare*	31,584	842,109
Diatoms	Chrysophyta	Bacillariophyceae	Gomphonemataceae	*Gomphonema drutelingense*	61,953	5,489,062
Diatoms	Chrysophyta	Bacillariophyceae	Gomphonemataceae	*Gomphonema gracile*	2,025	1,467,760
Diatoms	Chrysophyta	Bacillariophyceae	Gomphonemataceae	*Gomphonema* sp.	31,179	425,627
Diatoms	Chrysophyta	Bacillariophyceae	Gomphonemataceae	*Reimeria sinuata*	1,215	167,923
Yellow-Green	Chrysophyta	Chrysophyceae	Hydruraceae	*Hydrurus foetidus*	1,141,274	58,955,137,675
Blue-Green	Cyanophyta	Myxophyceae	(undetermined)	Unknown Cyanophyte	189,148	1,505,361,995
Blue-Green	Cyanophyta	Myxophyceae	Pseudanabaenaceae	*Homoeothrix janthina*	11,971	49,578

Table C1. Density and biolvolume of periphytic algae taxa present in Richest Targeted Habitat samples collected at stream sites along McCarthy Road, Wrangell-St. Elias National Park and Preserve, Alaska.—Continued

[**Abbreviations:** cells/cm^2, cells per square centimeter; μm^3/cm^2, cubic micrometer per square centimeter]

Algae group	Phylum	Class	Family	Genus species	Density (cells/cm^2)	Biovolume (μm^3/cm^2)
Chokosna River (08-04-08)						
Green Algae	Chlorophyta	Chlorophyceae	Chaetophoraceae	*Gongrosira* sp.	730	778,266
Diatoms	Chrysophyta	Bacillariophyceae	(Undetermined)	Undetermined Centric sp.	1,341	3,556,711
Diatoms	Chrysophyta	Bacillariophyceae	Achnanthaceae	*Cocconeis placentula*	39	21,800
Diatoms	Chrysophyta	Bacillariophyceae	Achnanthidiaceae	*Achnanthidium minutissimum*	39	1,055
Diatoms	Chrysophyta	Bacillariophyceae	Aulacoseiraceae	*Aulacoseira ambigua*	58	20,654
Diatoms	Chrysophyta	Bacillariophyceae	Aulacoseiraceae	*Aulacoseira granulata*	58	26,356
Diatoms	Chrysophyta	Bacillariophyceae	Bacillariaceae	*Nitzschia brevissima*	39	4,162
Diatoms	Chrysophyta	Bacillariophyceae	Bacillariaceae	*Nitzschia dissipata*	19	4,424
Diatoms	Chrysophyta	Bacillariophyceae	Bacillariaceae	*Tryblionella levidensis*	19	788
Diatoms	Chrysophyta	Bacillariophyceae	Cymbellaceae	*Encyonema silesiacum*	19	5,320
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Diatoma mesodon*	19	16,432
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Diatoma moniliformis*	19	2,844
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Fragilaria capucina*	39	1,453
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Fragilaria vaucheriae*	39	7,088
Diatoms	Chrysophyta	Bacillariophyceae	Fragilariaceae	*Hannaea arcus*	408	287,325
Diatoms	Chrysophyta	Bacillariophyceae	Gomphonemataceae	*Gomphonema* cf. *longilineare*	39	1,036
Diatoms	Chrysophyta	Bacillariophyceae	Gomphonemataceae	*Gomphonema drutelingense*	19	1,722
Diatoms	Chrysophyta	Bacillariophyceae	Gomphonemataceae	*Gomphonema olivaceoides*	19	1,544
Diatoms	Chrysophyta	Bacillariophyceae	Gomphonemataceae	*Gomphonema parvulum*	39	8,621
Diatoms	Chrysophyta	Bacillariophyceae	Gomphonemataceae	*Reimeria sinuata*	78	10,747
Diatoms	Chrysophyta	Bacillariophyceae	Naviculaceae	*Navicula cryptocephala*	39	11,435
Diatoms	Chrysophyta	Bacillariophyceae	Naviculaceae	*Navicula cryptotenella*	39	7,873
Diatoms	Chrysophyta	Bacillariophyceae	Naviculaceae	*Navicula recens*	19	8,418
Diatoms	Chrysophyta	Bacillariophyceae	Stephanodiscaceae	*Cyclotella atomus*	253	19,858
Diatoms	Chrysophyta	Bacillariophyceae	Stephanodiscaceae	*Cyclotella distinguenda*	58	11,752
Diatoms	Chrysophyta	Bacillariophyceae	Stephanodiscaceae	*Cyclotella meneghiniana*	97	78,617
Diatoms	Chrysophyta	Bacillariophyceae	Thalassiosiraceae	*Thalassiosira visurgis*	155	57,445
Blue-Green	Cyanophyta	Myxophyceae	(undetermined)	Unknown Cyanophyte	1,095	29,261
Blue-Green	Cyanophyta	Myxophyceae	Chamaesiphonaceae	*Chamaesiphon* sp.	1,552	92,182

Publishing support provided by the U.S. Geological Survey
Publishing Network, Tacoma Publishing Service Center

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U.S. Geological Survey
4210 University Dr.
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