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Author: **Rescan Environmental Services Ltd.**
Date: **November 2007**



the BATHURST INLET PORT AND ROAD PROJECT

Bathurst Inlet Port and Road Project

Nunavut, Canada

Freshwater Environment Baseline Studies, 2001



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EXECUTIVE SUMMARY

Executive Summary

The Bathurst Inlet Port and Road Project is located in the Kitikmeot region of Nunavut. The proposed marine Port is located on the west side of Bathurst Inlet about 40 km south of the community of Bathurst Inlet. The all-weather Road will be from Bathurst Inlet to Contwoyto Lake, a distance of about 211 km. Baseline information on the freshwater environment of the Project was collected during August 2001, as part of an environmental impact assessment. This report describes the physical characteristics, water and sediment quality, primary producers (aquatic plants), secondary producers (aquatic invertebrates), fish habitat and fish communities of the streams crossed by the Road, as well as at the terminal end of the Road on Contwoyto Lake.

Streams

Aquatic Biology and Chemistry

Six streams crossing the proposed Road route were selected for sampling of water and sediment quality, as well as types and abundance of aquatic plants living on rocks (periphyton) and aquatic invertebrates. Streams were selected based on their potential to provide high-quality fish habitat and to represent a wide range of stream sizes. Water, sediments and aquatic plants and invertebrates were sampled once in shallow riffles and glides between August 20 and 23, 2001.

The majority of streams were very low in hardness and in total dissolved solids. In contrast, one stream draining into Bathurst Inlet (km 2.2) had hard water with high ion content, probably reflecting differences in drainage basin bedrock. Nutrient and metal concentrations in stream waters were generally low, although copper was above Canadian guidelines for the protection of aquatic life in streams located at km 2.2 and km 72.2 of the proposed road route, and aluminum and iron were above guideline concentrations at km 2.2.

Sediment samples were only collected from three streams because most sampling stations had streambeds composed of boulder, cobble and gravel. Sediment samples consisted primarily of sand, or sand and gravel. Sediments were low in nutrients and metal concentrations and all metals were below Canadian guidelines for the protection of aquatic life.

Plant biomass (periphyton) varied widely among streams along the proposed Road route. In most streams, cobble was covered with thin periphyton films and had low chlorophyll *a* concentrations. However, at km 134.6, boulders and cobble were covered in abundant growth of filamentous algae that extended, in some cases, to lengths of more than 30 cm. Cyanobacteria were the most abundant group of algae in most streams.

The densities of benthic invertebrates were generally low in streams. Communities were mostly dominated by dipteran insects (*i.e.,* true flies), particularly chironomids, but taxonomic composition differed considerably in a few of the streams.

Fish Habitat Assessment

Fifty-five potentially fish-bearing stream crossings of the Road were surveyed for fish habitat and fish community composition in mid-August 2001.

Watershed areas of 42 of the 55 streams ranged from 0.6 to 1,825.6 km^2 with an average of 11.5 km^2. The streams ranged in size from caribou trails to large rivers, but, on average, were narrow (wetted width of 3.1 m) and shallow (wetted depth of 0.21 m) with low gradient (1%), low water velocity (0.2 m/sec) and low August discharge (0.04 m^3/sec). Their water was clear with near-neutral pH and very low conductivity (average = 25 µS/cm). Most habitat units were glides, followed by riffles and pools. Cascades were rare. Cobbles were the most common type of substrate, followed by boulder, sand and gravel. Bedrock was rare. Boulders provide most of the cover for fish, followed by instream vegetation, overhanging grasses and shrubs, pools and undercut banks. Streams were generally too shallow to have significant numbers of pools, and the few pools that exist were usually shallow. Twenty-four of the 55 streams had barriers to fish migration, of which 12 were classified as permanent and 12 as temporary.

Fish Habitat Analysis

The 34 habitat variables measured for each stream shared much information, hence statistical analysis was used to simplify the data set. Four major variables were identified: stream size (wetted area, wetted width and depth), maximum pool depth, the frequency of riffle habitat, and percent of cascade habitat, in descending order of importance. They explained a total of 41% of the variation in habitat data. The results of the factor analysis were generally intuitive. The first result showed that the six variables of stream size (discharge, wetted area, wetted width, wetted depth, velocity and bankful depth) were all positively related to one another, and therefore increase together. Temporary barriers were found to be inversely related to stream size, indicating that larger streams have fewer temporary barriers to fish migration. The second result showed that maximum pool depth was positively related to crest pool depth, percent pool cover, and percent pool habitat. The third result found that riffle habitat (and gravel substrate) occurs most often in streams containing a diversity of short habitat types, and is least common in streams with long, uniform habitat types. Lastly, as the frequency of cascade habitat increased so did percent slope and the frequency of permanent fish barriers.

Fish Community Assessment

Of the 55 stream crossings, 52 had enough water to be electrofished. A total of 311 fish from seven species were caught. Arctic grayling was the dominant species by number (38.9%: mainly young-of-the-year), followed by slimy sculpin (32.5%), ninespine stickleback (15.4%) and burbot (11.3%). The remaining three species (Arctic cisco, lake trout, and round whitefish) represented only 1.9% of the catch for a total of six individual fish. No fish were caught in 23 of the 52 streams, and between one and four species each were caught in the other 29 streams. The streams were used mainly as juvenile rearing habitat for Arctic grayling, slimy sculpin, ninespine stickleback and burbot, and as adult feeding and spawning habitat for slimy sculpin and ninespine stickleback. They may also be used as a migration corridor for larger fish species.

Most streams contained few fish (catch per unit effort or CPUE was less than 0.009 fish per second of electrofishing), but a few had high densities of juvenile Arctic grayling.

Stream Rank by Fisheries Value

Streams were assigned a fisheries value based primarily on the electrofishing catch of the August survey. Habitat characteristics were not used to assign a fisheries value because of the lack of strong relationships between fish abundance and habitat and because there are no independent criteria for assessing the fisheries value of Nunavut streams. The three categories of fisheries value were:

1. ***Low***: streams in which no fish were caught or were assessed as non-fish-bearing during the July reconnaissance survey;
2. ***Medium***: streams that contained only small-bodied species with little commercial, food or cultural value (slimy sculpin and ninespine stickleback); and
3. ***High***: streams that contained either Arctic grayling, juvenile burbot or a large or migratory fish species (i.e., Arctic cisco, Arctic char, round whitefish, lake trout or longnose sucker). Arctic grayling are a food and sport fish and they indicate the presence of spawning substrate. Burbot are also considered as food fish. Large, migratory species of fish indicate that the stream may be used as a migration corridor.

Of the 55 streams surveyed in August 2001, 43 remained on the list of stream crossings after the Road route was revised, while 12 were by-passed. Of the 43 crossings, 21 were assigned a low fisheries value, 10 were assigned a medium value and 12 were assigned a high value.

Contwoyto Lake

Aquatic Biology and Chemistry

Contwoyto Lake was sampled to collect information on physical limnology, water quality, sediment quality and primary and secondary producers at the terminal end of the road. Samples were collected between August 17 and August 18, 2001.

The waters of Contwoyto Lake were very transparent and sufficient quantity of light for primary production reached depths of at least 12 m. The water column was not thermally stratified during the sampling period in August 2001, although stratification has been previously observed in Contwoyto Lake. Dissolved oxygen concentrations were around 100% saturation.

Nutrient and metal concentrations in surface water and lake-bottom sediment were low, as is typical for undisturbed northern lakes. Water and sediment metal concentrations were below Canadian guidelines for the protection of aquatic life. Lake-bottom sediment was predominately composed of silt or sand depending on the station.

Phytoplankton and zooplankton communities were high in diversity but low in total abundance. Green algae were the most abundant phytoplankton group and rotifera were the most abundant

zooplankton group. Benthic invertebrates in Contwoyto Lake were low in density and were dominated by dipteran taxa.

Fish Communities

A total of 145 fish were captured in Contwoyto Lake during the fish community survey conducted in August 2001. Fish were caught using gillnets, beach seines and minnow traps. Lake trout was the most abundant species representing 65% of the gillnet catches. Other species included Arctic char, round whitefish, lake cisco, Arctic grayling, ninespine stickleback, and burbot.

The lake trout captured had a mean length of 509 mm and mean weight of 2,272 g. The average length of Arctic char was 429 mm.

Juvenile burbot and a large number of ninespine sticklebacks were captured using minnow traps. The high abundance of emergent vegetation is the likely cause of the abundance of juvenile and small-bodied fish.

Average condition was similar between lake trout and Arctic char in Contwoyto Lake. Mean condition for lake trout was 1.09 g/mm^3, and for Arctic char 1.00 g/mm^3. Mean age of lake trout was 17 years, however, the age range was wide, with a high incidence of older individuals. Arctic char had a mean age of 9 years. Round whitefish and lake cisco both averaged 7 years in age, while Arctic grayling ranged from 9 to 18 years. The von Bertalanffy growth model showed that lake trout had a growth coefficient of 0.083 per year.

Forty-five percent of the lake trout that were sexed were imminent spawners. Stomach contents of lake trout consisted mainly of fish and terrestrial insects. Benthic invertebrates comprised only a small portion of the diet.

Fish Habitat

Fish habitat assessments of the littoral zone at the terminal end of the Road were conducted in August 2001. Sixteen habitat zones were delineated over 2,380 m of shoreline surveyed. The habitat was dominated by sand followed by boulder, cobble, and gravel. However, the littoral zone also had some bedrock and emergent vegetation.

Boulders are highly preferred habitat by all life stages of lake trout and several life stages of other species such as Arctic char, burbot and slimy sculpin. The peninsula at the terminal end of the road is almost entirely composed of boulder and some areas in its east bay are mainly composed of cobble. Areas composed of sand and silt are preferred habitat for spawning of lake cisco, ninespine stickleback, burbot and slimy sculpin. The low abundance of bedrock habitat observed is only preferred by adult burbot. Adult ninespine sticklebacks are often found in densely vegetated areas, as observed in certain locations near the terminal end of the road.

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1. INTRODUCTION

1. Introduction

1.1 Background

The Bathurst Inlet Port and Road Project (the "Project") is located in the Kitikmeot region of Nunavut (Figure 1.1-1). The proposed marine Port is located on the west side of Bathurst Inlet about 40 km south of the community of Bathurst Inlet. The all-weather Road will be from Bathurst Inlet to Contwoyto Lake, a distance of about 211 km.

Baseline information on the freshwater environment along the Road route was required as part of an environmental impact assessment of the Road. This report describes the physical characteristics, water and sediment quality, primary and secondary producers (*i.e.*, aquatic plants and animals), fish habitat and fish communities of the streams crossed by the Road as well as one sampling station in Contwoyto Lake at the terminal end of the Road. Surveys of lakes along the road were not planned, because lakes were not expected to be affected by the Road.

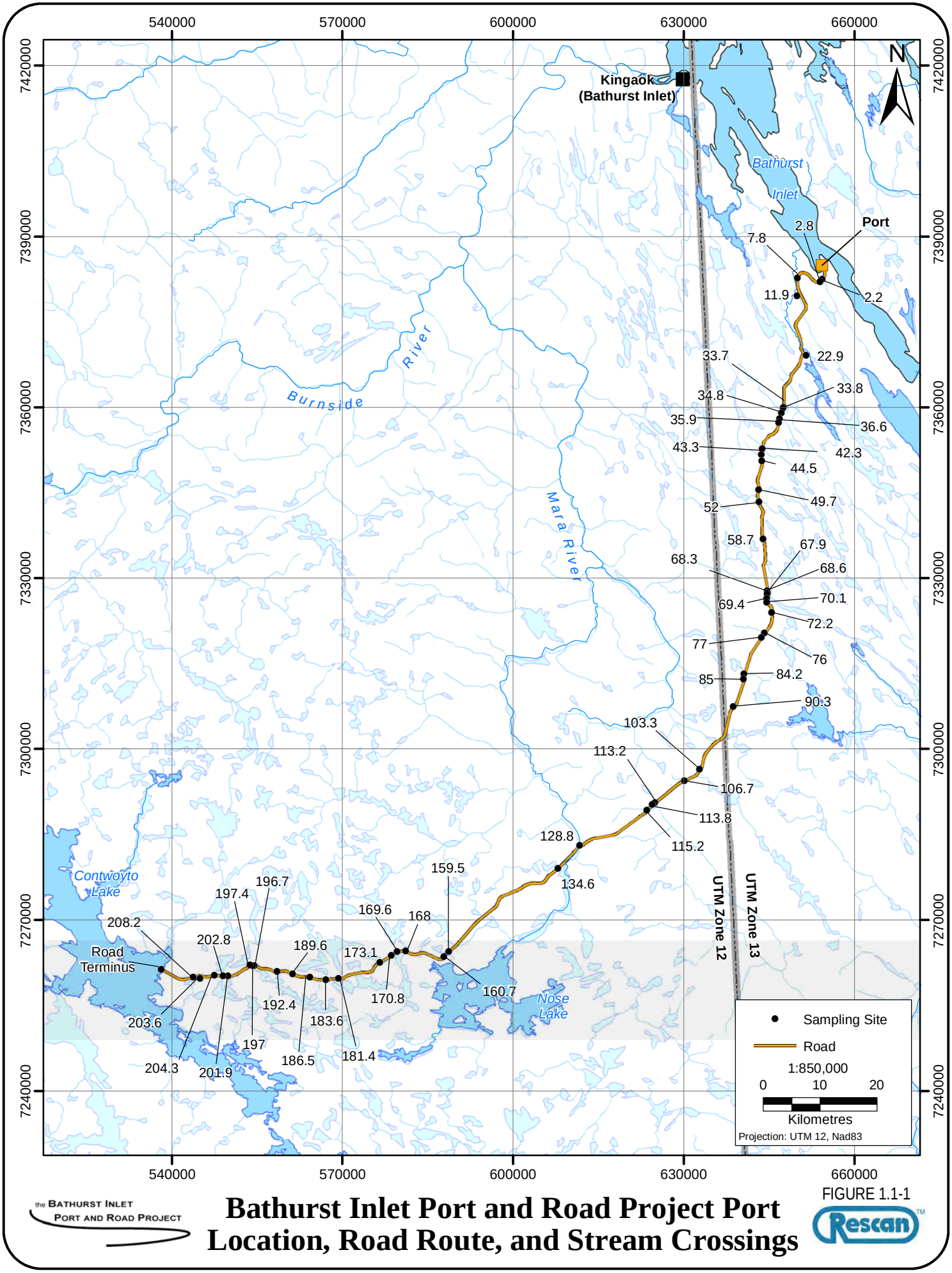
Some information has been previously collected on the physical, chemical and biological characteristics of Contwoyto Lake and surrounding lakes in the form of published and unpublished material. The data were collected as part of baseline environmental studies for the Lupin Mine (Moore, 1978a, Beak Consultants Ltd. and Mary Collins Consultants Ltd., 1980; Reid Crowther, 1985; Ash *et al*., 1991; RL&L, 1993a; CANMET, 1996), and for the Izok Lake property (Beak Consultants Ltd., 1977; Moore, 1978b; Klohn-Crippen Consultants Ltd., 1993; RL&L, 1993b).

1.2 Objectives

The objectives of the study were to characterize the physical characteristics, water quality, sediment quality, primary and secondary producers, fish habitat and fish communities of streams crossing the proposed Road route, as well as the area of Contwoyto Lake at the terminal end of the Road. This baseline information will provide a reference from which potential impacts of development on these ecosystems may be detected. The specific objectives of the study were divided into two categories: streams and Contwoyto Lake:

1.2.1 Streams

- Describe nutrient concentrations, total metal concentrations and physical characteristics of surface waters;
- Describe nutrient concentrations, metal concentrations, grain size and physical characteristics of sediments;
- Describe the taxonomic composition and abundance of periphyton and benthic invertebrate communities;
- Describe the characteristics of fish habitat;
- Describe fish species richness, fish length and weight, and fish abundance;



the Bathurst Inlet Port and Road Project

Bathurst Inlet Port and Road Project Port Location, Road Route, and Stream Crossings

FIGURE 1.1-1

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- Describe the relationships between stream habitat and fish species richness and abundance; and
- Rank the stream crossings in order of their relative fisheries values and compare those values with the stream crossing plan of the Road route.

1.2.2 Contwoyto Lake

- Describe the depth of light penetration and the vertical structure of temperature and dissolved oxygen in the water column;
- Describe nutrient concentrations, total metal concentrations and physical characteristics of surface waters;
- Describe nutrient concentrations, metal concentrations, grain size and physical characteristics of sediments;
- Describe extractable hydrocarbon concentrations in surface waters and sediments;
- Describe the taxonomic composition and abundance of phytoplankton, zooplankton and benthic invertebrate communities;
- Describe the fish communities at the terminal end of the road in terms of species richness, relative abundance, size distribution, condition, diet, age composition, growth and muscle metal concentrations; and
- Describe the lake fish habitat at the terminal end of the road.

1.3 Overview of Report

This report is organized into two major sections: the streams along the Road route and Contwoyto Lake. Within the stream section there are two sub-sections: the aquatic biology and chemistry and the fish habitat and fish communities. The Contwoyto Lake section is divided into three sections: aquatic biology and chemistry, fish communities and fish habitat. Methods are described for each subsection, followed by results and discussion. A summary chapter is included at the end of the report. All data and analytical results are provided as appendices.

2. METHODS

2. Methods

2.1 Streams

2.1.1 Aquatic Biology and Chemistry

2.1.1.1 Study Design

Six streams crossing the proposed Road route were surveyed for baseline ecological data (Table 2.1-1). Streams were selected based on three criteria initially obtained from the fish and fish habitat assessments: presence of Arctic grayling or larger migratory fish, stream size and geographical location. The streams represent a wide range of stream size and were distributed along the entire Road.

Table 2.1-1
Co-ordinates and Variables Measured at Stream Sampling Station

	GPS Co-ordinates			
Station	**Latitude**	**Longitude**	**Date Sampled**	**Variables Measured**
km 206.9	65°27.498	110°01.795	August 21, 2001	Water quality, sediment quality, periphyton, benthic invertebrates
km 192.4a	65°28.136	109°44.689	August 21, 2001	Water quality, periphyton, benthic invertebrates
km 134.6	65°36.984	108°39.514	August 21, 2001	Water quality, periphyton, benthic invertebrates
km 84.2	65°54.506	107°54.642	August 22, 2001	Water quality, periphyton, benthic invertebrates
km 72.2	66°00.172	107°47.560	August 20, 2001	Water quality, sediment quality, periphyton, benthic invertebrates
km 2.2	66°31.208	107°31.359	August 22, 2001	Water quality, sediment quality, periphyton, benthic invertebrates

Each stream was sampled once between August 20 and August 22, 2001. All stations were located at the proposed Road crossing. Samples were collected for water quality, sediment quality, periphyton, and benthic invertebrates in order to characterize stream ecosystems in the region.

Stream samples were collected in riffle and glide sections with depths less than 50 cm. Most streambeds were composed primarily of boulders, cobble and gravel. Only three stream stations had depositional areas of fine gravel and sand where sediment samples could be taken.

2.1.1.2 Habitat Characteristics

A detailed examination of stream physical characteristics was performed at each of the six stations during the fish habitat survey. Habitat types were noted (*i.e.*, pools, glides, riffles, cascades and others) and proportions of streambed material (sand, gravel, cobble, boulder and

bedrock) were estimated. Stream widths, depths and discharge were also measured. Section 2.1.2 describes the methods used in the habitat survey.

2.1.1.3 Water Quality

Water quality samples were collected with surface grabs in each of the streams. Sample bottles were rinsed with stream water and then submerged just below the water surface. Samples were preserved in the field when necessary and stored in a dark, cool place until shipment to ALS in Vancouver, British Columbia, for analysis. Water samples were analyzed for physical variables and concentrations of total ions, anions, nutrients and total metals.

2.1.1.4 Sediment Quality

Sediment samples were collected in triplicate using a coring tube. Most streambeds were composed primarily of boulders, cobble and gravel. Only three streams had depositional areas with fine gravel and sand where sediment samples could be taken. These stations were km 72.2, km 206.9 and km 2.2. Sediment samples were photographed and visually examined for grain size, texture, layering, colour, biological material and debris. Colour descriptions were made using a Munsell Colour Chart. Samples were stored in Whirl-Pak bags and kept in a cool, dark place until shipment to ALS for chemical and grain size analyses.

2.1.1.5 Primary and Secondary Producers

Samples for periphyton biomass and taxonomy were collected in triplicate from each stream. Periphyton were removed from naturally occurring cobble-sized stones by scraping a pre-measured surface area (10 cm x 10 cm) with a fine brush. Two separate samples were obtained from each stone: one for taxonomic enumeration and one for chlorophyll *a* analysis. Taxonomic samples were preserved with Lugol's solution and shipped to Bio-Limno Research and Consulting for identification and enumeration. Periphyton biomass was estimated by chlorophyll *a* concentration. Chlorophyll *a* samples were collected by filtering a subsample of the scraped periphyton sample through a 0.45 µm filter. Filters were wrapped in aluminum foil and frozen until processing at ALS.

Samples for benthic invertebrate community abundance and taxonomy were collected from each stream. Invertebrate samples were collected in triplicate using a Surber sampler with a mesh size of 500 µm. A streambed area of 0.09 m^2 was disturbed by hands to a depth of approximately 5 cm for 3 minutes. Suspended invertebrates were carried by current into the Surber net directly downstream. Benthic invertebrate samples were preserved in formalin and sent to Applied Technical Services for enumeration and identification.

2.1.1.6 Data Analysis

Concentrations of water and sediment chemistry variables are presented as averages of replicate samples. In the case of concentrations below detection limits, half of the detection limit value was used. Only selected chemical variables are discussed in the Results section because of the large number of chemical variables analyzed. Analytical results of all measured variables are shown in the appendices. Particular focus was given to chemical variables that have Canadian

guideline concentrations for the protection of aquatic life (CCME, 1999a, 1999b), and those that are widely regarded as indicators of water or sediment quality.

Periphyton and benthic invertebrate density are presented as averages of replicate samples. Periphyton density and chlorophyll *a* were standardized to numbers or µg per square centimetre of scraped cobble surface, respectively. Benthic invertebrate density was standardized to numbers per square metre of sampled surface area in the streambed.

Several different indices of taxonomic richness and diversity were calculated for periphyton communities: taxonomic richness (number of taxa), the number of taxa contributing to 90% of community abundance, the Shannon diversity index and the Simpson diversity index. Only richness indices were calculated for benthic invertebrates because benthos taxa were identified to various coarse taxonomic levels. The taxonomic composition of periphyton and benthic invertebrate communities were compared among streams by examining the dominance of major taxonomic groups and individual taxa.

Pearson correlation tests were performed to determine if there were statistically significant relationships among stream biota, surface water chemistry and stream habitat variables. Correlation coefficients (r) were calculated for relationships among the following variables: periphyton chlorophyll *a* (µg/cm^2), periphyton density (cells/cm^2), periphyton taxonomic richness (number of genera), benthic invertebrate density (organisms/m^2), benthic invertebrate taxonomic richness (number of taxa), fish abundance (number/sec), fish biomass (g/sec), stream width (m), stream depth (m), percent boulder cover (%), surface water total phosphorus concentration (µg/L) and surface water conductivity (µmhos/cm).

A correlation coefficient ranges in value between –1 and +1. A value of 0 indicates there is no relationship between two variables, a value of –1 indicates a perfect negative relationship and a value of +1 indicates a perfect positive relationship. Correlations were performed for each possible combination of variable pairs to test the null hypothesis:

There is no relationship between the two variables (*i.e.*, the correlation coefficient = 0).

The null hypothesis was rejected if the correlation coefficient had a probability value less than 0.05. Most variables were logarithmically transformed to meet the assumptions of the parametric test. Periphyton taxonomic richness, benthic invertebrate taxonomic richness and percent boulder cover did not require transformation. Fish abundance and biomass data for the six streams were obtained from the fish community assessments.

Correlations between periphyton, benthic invertebrates and fish were performed to determine if there were significant trophic relationships between these communities. Periphyton are grazed by benthic invertebrates, and invertebrates are consumed by fish. The density or biomass of a community may be related to the amount of food available (bottom-up trophic effect) or the amount of grazing/predation pressure (top-down trophic effect).

Correlations between periphyton and surface water chemistry variables were performed to determine if there were significant resource effects. Phosphorus is the primary limiting nutrient

for algal growth in streams (Peterson *et al*., 1985), and differences in periphyton communities may be related to the phosphorus concentration in the water column. Conductivity was also tested because it is an estimate of water ion content.

Correlations between stream biota and habitat characteristics were performed to determine if the distribution of stream biota was related to stream width, stream depth or percent boulder cover. Percent boulder cover was tested because boulders provide important refuge habitat for fish and invertebrates and increase the stability of the streambed for periphyton growth.

2.1.1.7 Quality Assurance/Quality Control

Quality assurance and quality control (QA/QC) steps were taken to assess and minimize possible contamination of water quality samples collected in streams. Water was collected using standard protocols and samples were kept cool with ice packs and by refrigeration. Water quality samples were collected in duplicate at each station.

Field blanks and travel blanks were analyzed to monitor possible contamination. Travel blanks were filled with distilled deionized water and remained with the samples but were not opened over the duration of the field work. These samples were analyzed to detect contamination from shipping and contamination in the lab. Field blanks were filled with distilled deionized water and handled in the same way as collected samples (*i.e*., exposed to the same environment and preservative). These blanks were analyzed to detect contamination from sampling techniques and chemical preservatives.

2.1.2 Fish Habitat and Fish Communities

2.1.2.1 Study Design

Map Inventory of Stream Crossings

The study was broken into three phases of increasing complexity and effort. The first phase was to develop an inventory of streams crossed by the Road that may contain fish and fish habitat. The inventory was developed in July 2001, from 1:50,000 scale maps with the Road route (as it was then known) supplied by Nishi-Khon/SNC-Lavalin Ltd. (NKSNC). The inventory was a list of stream crossings defined according to their distance along the Road. Kilometre 0 was set at the marine Port. For the sake of convenience, streams were called “km x” with x being the distance from the marine Port.

Attached to each crossing on the list was an estimate of the relative upstream watershed area (small, medium and large, based on visual examination of the maps), and a preliminary assessment of each stream’s fish-bearing status (fish-bearing or potential fish-bearing) based on the size of the watershed. In Nunavut, fish are only found in systems with significant lake overwintering habitat because streams freeze solid during winter, hence the larger a watershed, the more likely it is to contain lakes deep enough to provide overwintering habitat. In addition, crossings that had the potential to be avoided by a re-alignment of the Road were identified. Lakes situated within 100 m of the road were also identified because Rule 1.1 (h) of the draft West Kitikmeot Regional Land Use Plan states that “Unless there is no feasible and prudent alternative, projects must not be

located within 100 metres of the Ordinary High Water Mark of any river, lake or ocean," (Nunavut Planning Commission, 2002). The inventory was used to plan the schedule and logistics of the next two phases.

Reconnaissance Survey

The second phase was a field reconnaissance to ground-truth the inventory of stream crossings. The entire Road route was surveyed from a helicopter by a fisheries biologist from July 23 to 26, 2001. The survey included photographing every stream crossing and occasionally landing to ground-truth observations. Detailed notes were made on each crossing and some sites were videotaped for later reference. Back in the office, the notes, photographs and videotapes were used to modify the original inventory into a final list of stream crossings to be surveyed. Streams with no water or no distinct channel were removed from the final list.

Fish and Fish Habitat Survey

The third phase was a survey of fish and fish habitat in each stream crossing on the final list. The survey was conducted in August 2001. A mid-summer survey time was chosen because it avoided electrofishing streams during the spring spawning run of Arctic grayling, but it allowed sampling when Arctic grayling fry had hatched and were rearing in the streams. All streams used for spawning by Arctic grayling in the spring would be identified in August by the presence of young-of-the-year Arctic grayling. Figure 1.1-1 shows the locations of each of the stream crossings that were surveyed. To complete the survey in a short time, three two-person crews were used. Between three to five stream crossings were surveyed by each crew on each day. The three crews spent the first 2 days together surveying fish and fish habitat at several streams to practice common protocols for describing stream habitat.

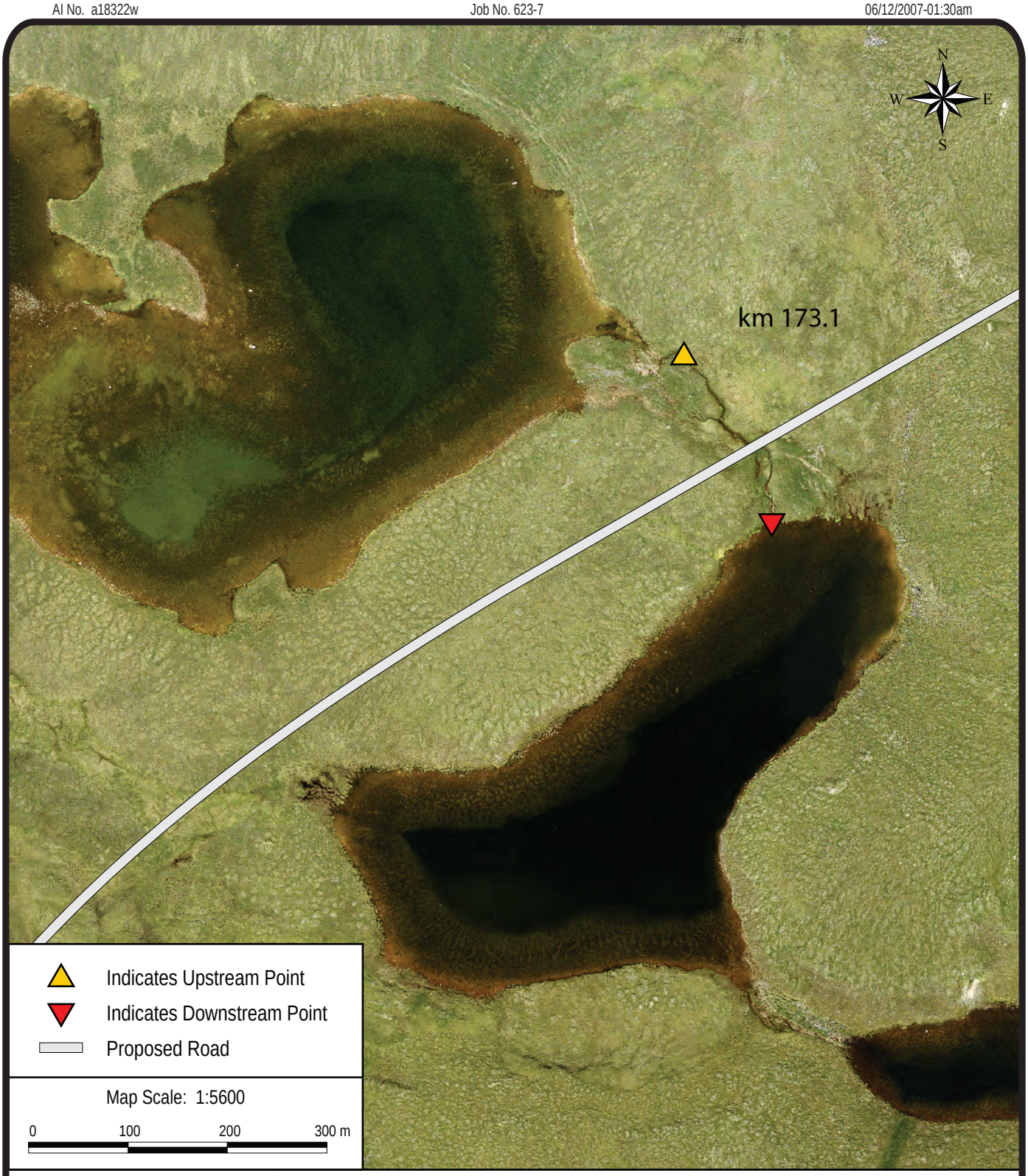
The crews identified the crossings from a helicopter and with the 1:50,000 scale maps with the route drawn on them. Once dropped off from the helicopter, they established a 200 m-long survey distance along the stream (100 m upstream of the road crossing and 100 m downstream of the crossing) using a metre tape. A GPS co-ordinate was taken at each of the upstream and downstream ends of the survey distance. Those co-ordinates were eventually placed into a GIS database. Figure 2.1-1 is an example of a GIS-based map of a portion of the Road showing the upstream and downstream co-ordinates of a survey distance at km 173.1. Fish habitat was usually surveyed first, followed by the electrofishing survey of the fish community. That allowed the crew at least two opportunities to walk the survey distance and search the stream for fish before using the electrofisher. Between one and three photographs were taken along the surveyed reach and an aerial photograph was taken at each crossing.

2.1.2.2 Fish Habitat Assessment

A section of 200 m in each stream was walked to assess fish habitat. Fish habitat assessment techniques were based on those commonly used in British Columbia (Johnston and Slaney, 1996). Habitat units in each stream were first delineated into five types:

1. riffle, an area with turbulent, fast-flowing water and a gradient less than 4%. Riffles are found over a wide range of spatial scales (Plates 2.1-1 to 2.1-3);

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Example of a GIS-Based Map of a Stream (km 173.1) Showing the Downstream and Upstream Coordinates of the Survey Distance

FIGURE 2.1-1

the BATHURST INLET PORT AND ROAD PROJECT

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Plate 2.1-1. Riffle habitat (followed by glide habitat) at the start of the survey distance for a small stream.



Plate 2.1-2. Riffle habitat of a medium-sized stream.



Plate 2.1-3. Riffle habitat of a large stream (km 128.8, *i.e.*, the Mara River).

2. cascade, an area with turbulent, fast-flowing water and a gradient greater than 4% (Plate 2.1-4);
3. glide, an area with smooth, non-turbulent water (Plate 2.1-5). This included boulder glides (or step glides) – a glide interspersed with boulders that create small steps with little downstream turbulence (Plate 2.1-6). It also included boulder fields (also known as boulder gardens or subsurface boulder gardens) – a glide covered by a field of boulders. Plate 2.1-7 shows a glide within an open field of boulders, and Plate 2.1-8 shows a boulder field so thick that water was known to be present only by its sound underneath the boulders. Closed boulder fields were almost always a permanent barrier to fish passage;
4. pool, an area with smooth, non-turbulent flow, a gradient near 0%, deeper water than a glide with a concave bottom and fine sediment (Plate 2.1-9). Pools were classified into three types based on their origin: scoured, dammed or unknown. Maximum depth of a pool was measured at the deepest part, and crest depth was measured at the upstream lip of the pool; and
5. other, areas with undefined channels such as streams that drifted through grassy meadows (Plate 2.1-10).

A suite of 11 physical characteristics were recorded for each habitat unit. Most streams were composed of between 1 to 9 units, but a few streams had so many units that the streams had to be sub-sampled. That is, all types of units were recorded and their lengths measured, but the other 10 physical characteristics were recorded for only every third or fourth unit.



Plate 2.1-4. Cascade habitat located about 1 km downstream of the survey distance on km 115.2. The steep cascades may be a permanent barrier to fish movement.



Plate 2.1-5. Glide habitat in a small stream.



Plate 2.1-6. Step glide in a small stream.



Plate 2.1-7. Glide habitat within an open boulder field in a medium-size stream.



Plate 2.1-8. Glide habitat underneath a closed boulder field at the start of the survey distance of a stream (km 204.3) that connected two lakes.



Plate 2.1-9. Pool habitat in a medium-sized stream (km 72.2). The pool was one of the largest observed in the survey. It is in the background of photograph, with water flowing into glide habitat in the foreground.



Plate 2.1-10. A small, shallow stream (km 197.4) that flows over a grassy meadow. Habitat was classified as "other" because of the undefined channel.

Length of each unit was measured to the nearest 1 m with a metre tape, gradient was measured to the nearest 0.5% with a clinometre, and depths and widths (bankfull and wetted) were measured with a metre stick to the nearest 5 and 10 cm, respectively. Percent composition of substrate (sand, gravel, cobble, boulder and bedrock) was estimated visually to the nearest 5%. Substrate was classified according to average particle size. Sand was defined as silt, clay or fine organic material that was less than 2 mm in average diametre. Gravel was defined as particles 2 to 64 mm in average diametre, cobble was 64 to 256 mm, boulders were 256 to 4,000 mm, and bedrock was greater than 4,000 mm. Percent instream cover was also estimated visually to the nearest 5% and classified as boulder, instream vegetation, overhanging vegetation, undercut banks or pool. There was no woody debris in any of the streams. Barriers to fish passage were classified as boulder fields, dry channel (Plate 2.1-11), no channel, or impassable waterfall (Plate 2.1-12). Each barrier was also classified as temporary or permanent.

Temperature (to the nearest 0.1°C), pH (to the nearest 0.1 logarithmic unit) and conductivity (to the nearest 1 µS/cm) were measured once along the survey distance using electronic metres.

Stream discharge was estimated at one location along the survey length by multiplying the cross-sectional area of the stream by water velocity. Cross-sectional area was the product of wetted width and wetted depth (these measurements were made separately from habitat measurements). Wetted width was measured with a measuring tape or a metre stick. Wetted depth was the average of at least five depth measurements taken at equal intervals across the width of the stream with a metre stick. Velocity was estimated at the same location as wetted width and depth. It was the average of three velocity estimates, each obtained by dropping a twig onto the

water surface (the “floating chip” method), and recording the time required for the twig to float 3 to 10 m downstream (depending on the size of the stream) to a designated end point.



Plate 2.1-11. A braided, dry channel connecting two lakes (km 168.0). It was classified as a permanent barrier to fish migration, although movement may be possible for brief periods under conditions of extremely high freshet flows.



Plate 2.1-12. An impassable waterfall (at least in the upstream direction) 300 m downstream of the survey distance of a medium-sized stream (km 34.8).

Stream visibility was defined as clear, lightly turbid (1.5 m limit of visibility), moderate turbid (barely see bottom) and turbid (a few centimetres of visibility). Almost all streams with water were classified as clear, hence this variable was not used further in classifying habitat.

2.1.2.3 Watershed Area

As part of engineering feasibility studies conducted by Nishi-Khon SNC-Lavalin, watershed area was estimated for 104 streams crossed by the Road using a digitiser pad and 1:50,000 scale maps of the Road route. Those streams included the 55 streams that were surveyed by this study, as well as another 49 streams that were not surveyed because they were assessed as non-fish-bearing during the reconnaissance part of this study. However, the estimates of watershed area were derived for the final Road route as it was known in January 2002, and not the initial Road route as it was known in August 2001. Some of the crossings in the initial route were removed in the final route, and some were moved upstream or downstream of the initial crossings. This meant that watershed areas could not be assigned to each of the 55 streams. Instead, it was assigned only to those streams for which the final Road crossing was less than 400 m upstream or downstream of the initial crossing. For that reason, and because watershed area was not estimated from measurements taken directly within the survey distances of each stream crossing, watershed area was not included in the suite of habitat variables. Instead, it was compared to the results of the habitat analysis, partly to cross-check the conclusions of that analysis.

2.1.2.4 Fish Community Assessment

Fish were sampled from streams and adjacent lakes with Smith-Root backpack electrofishers. The electrofisher produces an electrical field from an anode at the end of a pole that temporarily immobilises fish. Stunned fish are then scooped up with a dipnet and transferred to a water-filled pail. The crew walked the length of the survey distance, fishing any part that appeared to be potential fish habitat and stalking any fish that were seen in the channel.

The electrical field had an effective radius of 1 to 2 m around the anode. Electrofishers were set to a frequency of 60 Hertz, the recommended frequency for the small fish most commonly encountered in Nunavut streams, and a pulse width of 6 milliseconds. Voltage was set to the maximum level possible because of the very low conductivity of most streams along the Road route. At the start of each electrofishing session voltage was increased in increments of 100 V until the overload signal sounded, and then voltage was turned down to a level that allowed good fish catchability but did not overload the machine. Average voltage for the 52 streams that were electrofished was 624 (SD = 218, range = 100 to 900 volts).

Only one pass was made of the entire survey distance, rather than the two or three passes that are usually used to estimate fish density using the depletion method (Bohlin *et al*., 1989: Reynolds, 1996). The one-pass protocol was used for three reasons:

1. the objective of the survey was to describe fish species richness and relative abundance, not to estimate absolute fish density. The only reason for estimating absolute density would be to compare it with other streams, but comparing fish densities of the streams along the Road route with fish densities estimated elsewhere in North America was not an objective of the survey;

2. the depletion method requires blocking off both ends of a stream with nets and waiting at least 1 hour between passes. That level of fishing effort was not necessary for this kind of reconnaissance survey; and
3. the larger streams along the Road route (*e.g.*, the Mara River – km 128.8) were too wide and fast-flowing to allow the use of blocking nets.

Three of the 55 streams could not be electrofished, either because they were dry channels or because they were covered by closed boulder fields. In those cases, electrofishing was conducted along the shorelines of adjacent ponds. Any catches from those adjacent waterbodies were used to calculate fish length frequency plots and weight-length regressions, but were not used to calculate catch-per-unit-effort (CPUE) for a stream survey distance.

Fishing effort was defined as the total number of seconds that the electrofisher was turned on during a stream survey. That was based on the assumption that the duration of electrofishing was directly proportional to survey distance, an assumption that was confirmed by a regression of electrofishing effort on survey distance.

Once the electrofishing pass was completed, biological data were collected on the captured fish. Before handling, they were anaesthetized by dissolving one or more tablets of Alka-Seltzer in a bucket. Fork length (or total length in the case of burbot and slimy sculpin) was measured to the nearest 1 mm, and weight was measured to the nearest 0.1 g with an electronic balance. Notes were made on unusual markings or behaviour. No scales or other aging structures were taken in order to reduce mortality. Fish were then placed in a bucket of water and released after they had recovered from the anaesthetic.

2.1.2.5 Data Analysis

Habitat Data

To simplify analysis of habitat data, average stream dimensions and habitat types were calculated from the dimensions recorded for each habitat unit within a survey distance. Mean length of a habitat unit in a survey distance was the average of all the habitat unit lengths in that distance. Total wetted surface area of a survey distance was the sum of the wetted areas of all of the habitat units in that distance. Wetted surface area of a habitat unit was the wetted length of that unit multiplied by the wetted width of that unit. Percent habitat type (*e.g.*, glide, riffle, cascade and pool) of a survey distance was calculated by multiplying the habitat type by its wetted area, summing those numbers of that particular habitat type over all habitat units in the distance, and then dividing by the total surface area of that survey distance. Wetted depth, bankfull depth, percent substrate type, and percent cover were also calculated in the same way. However, average stream gradient, wetted width and bankfull width were calculated by weighting the dimensions of habitat units by wetted length, rather than wetted area, because they were linear dimensions.

Analysis of habitat data was divided into three steps: description, correlation and factor analysis. Description involved identifying the range of values of a habitat variable, and whether the frequency distribution of the variable was normal or skewed to high or low values. Most habitat variables were not normally distributed because of the wide range of stream sizes and the non-

linear geometry of streams. Since correlation, regression and other parametric statistics require that variables be normally distributed (Zar, 1984), a variety of transformations were applied to normalize skewed frequency distributions. Natural logarithms normalized most variables except those that were intrinsically normally distributed (*e.g.*, temperature), those that were already in logarithmic units (*e.g.*, pH), and percentages, which required the arcsine $(\text{percent}/100)^{0.5}$ transformation. The frequency distributions were examined for evidence of multiple modes which are indicators of sub-classes within a variable.

The second step involved calculating correlation coefficients between each of the habitat variables. The purpose was to identify variables that are not correlated with each other and which play little further part in data analysis, and to assess the overall level of inter-correlation (or redundancy) in the habitat data set. A highly redundant data set means that many of the variables share information. Special statistical procedures such as factor analysis are required to uncover the axes of variation within a highly redundant data set.

Finally, factor analysis was used to extract from the habitat data set a small number of factors that contained most of the variance in the data set, but, unlike the raw variables, were uncorrelated (or orthogonal) with each other. These factors represented the main axes of variation in the data set. Factor analysis extracts the same number of factors as there are raw variables, but most of the variation in the data is contained within the first few factors. The first factor is usually a "size" factor and the following few factors contain variation related to size-independent features of the data set. These factors were assigned meaning based on the strength and direction of their correlations (or "loadings") with raw habitat variables.

Most data analyses were performed using the SYSTAT library of computer programs (SPSS Inc., 1998).

Fish Data

Following standard terminology (*e.g.*, Griffiths, 1997), fish species richness was defined as the total number of fish species in a survey distance of a stream, regardless of the relative abundance of each species.

Weight-length regressions were calculated for each species using the standard formula (Ricker, 1975):

(1) $\ln(W) = \ln(a) + b\ln(L)$

where W = body weight (g), L = fork length (mm), ln(a) is the regression intercept and b is the slope of the regression. Both weight and length were ln-transformed to meet the statistical requirements of linear regression (*i.e.*, a normal distribution and homogeneity of variance). Weights and lengths were pooled across streams for each species to calculate the regressions. That meant they were not population-specific regressions. Their main use was to calculate weights for fish that were measured for length but not weight, and to check for errors in length and weight measurement and data transcription.

Fish biomass for a stream was calculated by summing the weights of all the fish captured in the survey distance of that stream. Weights of fish that were not weighed were estimated from their length with weight-length regressions. Fish for which neither length nor weight had been measured (only a few individuals) were assumed to have the same lengths as the modal length for that species and stream.

Electrofishing catch-per-unit-effort (or CPUE) was defined in two ways:

1. number CPUE – the number of fish captured in one pass of the survey distance divided by the total number of electrofishing seconds expended in that pass; and
2. biomass CPUE – the biomass of fish estimated for a survey distance divided by total electrofishing seconds.

All regressions in this report cite the coefficient of determination (r^2) – an index of the amount of variation in the dependent variable that is explained by the independent variable. The r^2 statistic has a range from 0 to 1. For example, an r^2 of 0.9 indicates that 90% of the variation in the dependent variable has been explained by a regression. All r^2 were adjusted for the number of degrees of freedom of the regression. All regressions also cite the P statistic – an index of the significance of the regression.

2.1.2.6 Maps

Maps of the Road route were prepared by Geowest from aerial photographs supplied by NKSNC. Electronic versions of the maps were imported into ArcView for processing.

2.1.2.7 Quality Assurance/Quality Control

All electronic instruments were calibrated with standards before being used in the survey. Habitat assessment protocols and electrofishing techniques were calibrated among the three survey crews by spending the first 2 days working together on several streams. After data from field forms had been entered into electronic spreadsheets, it was compared between the spreadsheets and the field forms and any transcription errors were corrected. Once the final spreadsheets had been prepared, they were reviewed a second time to ensure that all data cells were filled, and that they were internally consistent (*e.g.*, percent substrates in a habitat unit summed to 100%, all riffles had gradients less than 4%, all cascades had gradients greater than 4% and all pools had gradients of 0%). Weight-length plots were prepared for each species of fish, and outliers were examined to determine if they were the result of data transcription errors or errors that occurred during entry of field data.

2.2 Contwoyto Lake

2.2.1 Aquatic Biology and Chemistry

2.2.1.1 Study Design

Contwoyto Lake is a very large body of water, extending roughly 100 km in a northwest-southeast orientation. It has a surface area of 960 km^2 and drains water from a catchment of approximately 8,000 km^2 (Moore, 1978a). Contwoyto Lake has two outflows. The main

outflow is at the north end of the lake and drains into the Burnside River. The smaller south outflow drains into the Contwoyto River and ultimately into the Back River.

Information on the physical, chemical and biological characteristics of Contwoyto Lake has been reported by CANMET (1996), Reid Crowther (1985) and Moore (1978b). Moore (1978a) was written as part of an environmental assessment for the INCO Gold Property, and was used for comparisons with data from this study. It describes the plankton, benthos, fish and water chemistry of Contwoyto Lake.

An additional station was sampled on Contwoyto Lake at the terminal end of the Road (65º 28.388 N, 110º 10.696 W) between August 17 and 18, 2001. Physical characteristics, surface water quality, sediment quality and aquatic biota were examined to characterize the ecology at this site.

2.2.1.2 Physical Limnology

Secchi depths and dissolved oxygen and temperature profiles were taken in Contwoyto Lake. Secchi depths were taken to estimate light penetration in the water column. A Secchi depth was determined by lowering a standard Secchi disk over the shaded side of the boat, noting the depth at which the disk was no longer visible. The disk was then raised again, noting the depth at which the disk reappeared. Both depths were averaged to obtain an estimate of Secchi depth.

Vertical temperature and dissolved oxygen profiles were taken to determine if there was thermal stratification in the water column and to measure the availability of dissolved oxygen. Vertical profiles were obtained with a YSI temperature-dissolved oxygen metre at 0.5 m depth intervals from the surface to the lake bottom.

2.2.1.3 Water Quality

Water quality samples were collected in duplicate at a depth of 1 m below the water surface using a Teflon-lined 5 L GO-Flo bottle. The only exception was extractable petroleum hydrocarbon samples, which were collected as surface grabs. Samples were preserved in the field when necessary and stored in a dark, cool place until shipment to ALS Environmental in Vancouver. Water samples were analyzed for physical parametres and concentrations of total ions, anions, nutrients, total metals and extractable petroleum hydrocarbons (fractions C_{10} to C_{32}).

2.2.1.4 Sediment Quality

Sediment samples were collected in triplicate using an Ekman grab sampler. Sediment samples were photographed and visually examined for grain size, texture, layering, colour, biological material and debris. Colour descriptions were made using a Munsell Colour Chart. Samples were stored in Whirl-Pak bags. All samples were stored in a cool, dark place until shipment to ALS for metals and grain size analysis. Additional sediment samples stored in small glass jars were collected in triplicate for extractable petroleum hydrocarbons analysis.

2.2.1.5 Primary and Secondary Producers

Samples for phytoplankton biomass and taxonomy were collected in Contwoyto Lake. One litre samples were collected in triplicate at 1 m depth using a GO-Flo bottle. Taxonomic samples

were preserved with Lugol's solution and shipped to a qualified algal taxonomist (Bio-Limno Research and Consulting, Edmonton) for identification and enumeration. Phytoplankton biomass was estimated by chlorophyll *a* concentration. Chlorophyll *a* was determined by filtering 1 L of lake water through a 0.45 µm filter, then wrapping the filter in aluminum foil and freezing the filter until processing at ALS in Vancouver.

Samples for zooplankton taxonomy were collected from Contwoyto Lake. Samples were collected in triplicate using a standard 118 µm mesh zooplankton net fitted with a flowmetre. The collection depth of each sample was recorded and the flowmetre provided an estimate of the quantity of water that passed through the net during the tow. Zooplankton samples were preserved in formalin and sent to a qualified invertebrate taxonomist at Applied Technical Services in Victoria for enumeration and identification. Zooplankton counts were standardized to the volume of water passing through the net from each tow.

Samples for lake benthos taxonomy were collected from Contwoyto Lake. Sediment samples were collected in triplicate using an Ekman grab and filtered through a 595 µm mesh sieve bucket. The collection depth of each sample was recorded. Benthic invertebrate samples were preserved with formalin and sent to Applied Technical Services for enumeration and identification.

2.2.1.6 Data Analysis

Concentrations of water and sediment chemistry parametres are presented as averages of replicate samples. In the case of concentrations below detection limits, half of the detection limit value was used. Only selected chemical parametres are discussed in the Results section due to the large number of chemical variables that were analyzed. Analytical results of all measured variables are provided in the appendices. Particular focus was given to variables that have Canadian guideline concentrations for the protection of aquatic life (CCME, 1999a, 1999b), and those that are widely regarded as indicators of water or sediment quality.

Phytoplankton and zooplankton abundance and benthic invertebrate density are presented as averages of replicate samples. Phytoplankton abundance was standardized to numbers per millilitre of collected water samples. Phytoplankton chlorophyll *a* was standardized to µg per litre. Zooplankton abundance was standardized to numbers per cubic metre of water filtered through the zooplankton net. Benthic invertebrate density was standardized to numbers per square metre of sample surface area obtained by Ekman grab.

Several taxonomic richness and diversity indices were calculated for phytoplankton and zooplankton communities: taxonomic richness (number of taxa), the number of taxa contributing to 90% of community abundance, the Shannon diversity index and the Simpson diversity index. Only richness indices were calculated for benthic invertebrates because benthos taxa were identified to various coarse taxonomic levels. The taxonomic composition of phytoplankton, zooplankton and benthic invertebrate communities were compared among stations on Contwoyto Lake by examining the dominance of major taxonomic groups and individual taxa.

2.2.1.7 Quality Assurance/Quality Control

Quality assurance and quality control (QA/QC) steps were taken to assess and minimize possible contamination of water quality samples collected in Contwoyto Lake. Water was collected using standard protocols and samples were kept cool with ice packs and by refrigeration. Water quality samples were collected in duplicate from separate Go-Flo bottle casts.

Field blanks and travel blanks were analyzed to monitor possible contamination. Travel blanks were filled with distilled deionized water and remained with the samples but unopened over the duration of the field work. These samples were analyzed to detect contamination from shipping and from contamination in the lab. Field blanks were filled with distilled deionized water and handled in the same way as collected samples (*i.e.*, exposed to the same environment and preservative). These blanks were analyzed to detect contamination from sampling techniques and chemical preservatives.

2.2.2 Fish Communities

2.2.2.1 Study Design

The fish communities of Contwoyto Lake were sampled from August 14 to 16, 2001, using a variety of sampling gear (Figure 2.2-1). Fishing effort was concentrated along the shores within a 1 km radius of the terminal end of the Road (Table 2.2-1).

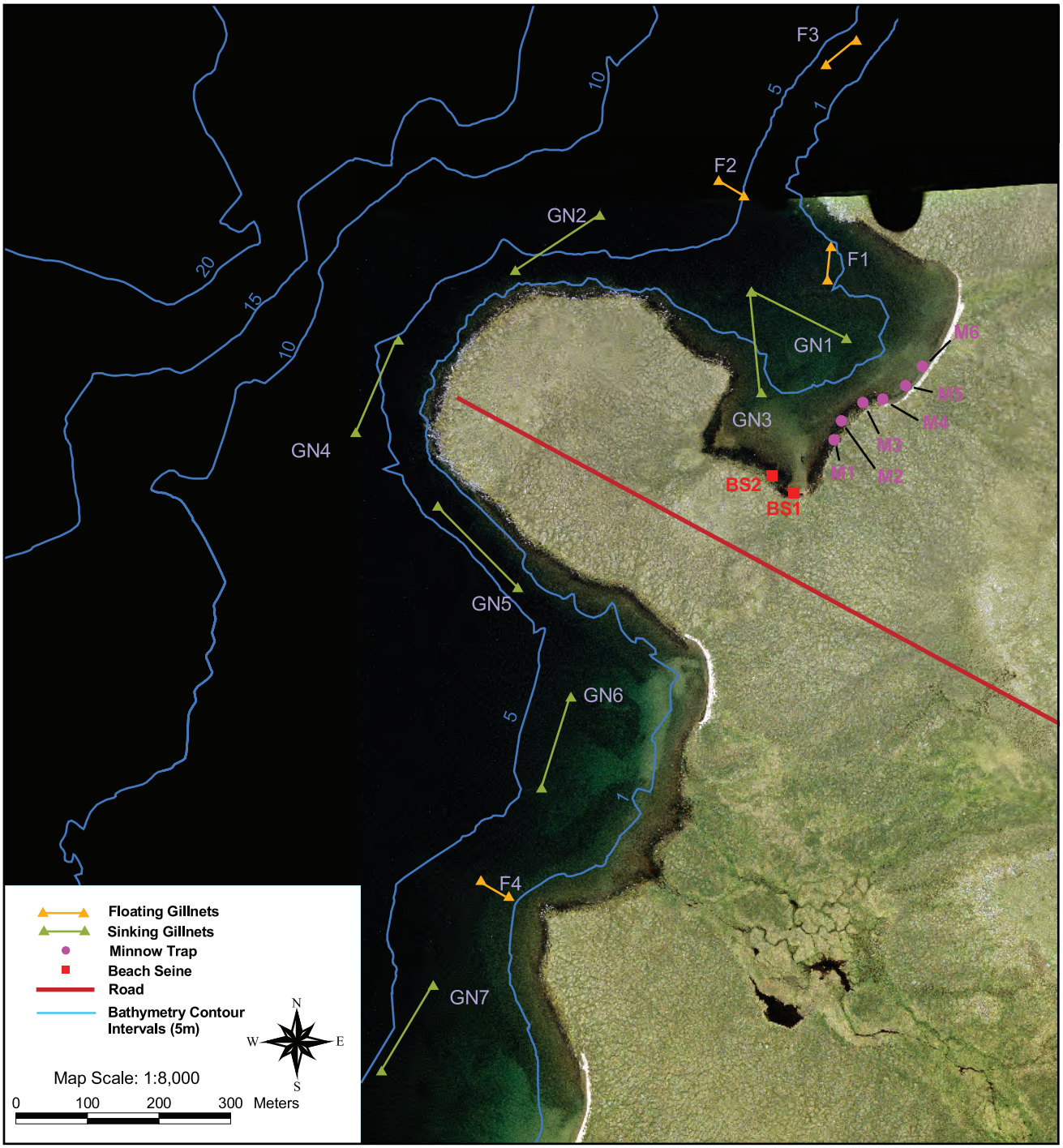
Table 2.2-1
Fish Community Sampling Dates and Methods, Contwoyto Lake, 2001

	Gillnetting			
Dates	# Sinking Nets	# Floating Nets	# Beach Seine Sets	# Minnow Trap Sets
14, 15, 16 August	7	4	2	6

2.2.2.2 Sample Collection and Processing

Four types of sampling gear were used to sample the fish communities: sinking gillnets, floating gillnets, beach seines and minnow traps. Using several methods allowed the sampling of all species and all size classes of fish found in each type of habitat. Sinking nets are designed to catch fish found closer to bottom of lakes and floating nets are designed to catch fish near the surface. The smaller fish species and juveniles of larger species were sampled with beach seines and minnow traps. The beach seines can only be used over sandy bottoms in shallow water but minnow traps can be set anywhere along the shoreline.

Sinking gillnets have a lead line at the bottom of the net and a float line at the top, and lie at the bottom of the lake, whereas the floating nets (which do not have a lead line), are suspended in the water column and float at the surface. The sinking nets measured 137 m (450 ft) long by



the BATHURST INLET PORT AND ROAD PROJECT

Fish Sampling Locations at the Road Terminus, Contwoyto Lake, August 2001

FIGURE 2.2-1

Rescan™

1.83 m (6 ft) deep and were comprised of six panels (each 22.8 m long) with a different mesh size: 38 mm (1.5”), 51 mm (2”), 76 mm (3”), 95 mm (3.75”), 108 mm (4.25”), and 127 mm (5”). The total surface area of each sinking net was 250 m^2.

Floating nets were composed of three panels each 15.2 m (50 ft) by 1.83 m, with mesh sizes of 25 mm (1”), 38 mm (1.5”), and 51 mm (2”). The surface area of the floating nets was 84 m^2. The gillnets were initially set for periods of one hour to minimize fish mortalities. However, due to low catch rates, nets were occassionally set overnight in order to capture more fish.

Smaller fish species and juveniles were sampled along the shorelines with a beach seine where shore conditions allowed sampling. The beach seine used was 1.3 m (4 ft) deep by 15.24 m (50 ft) long and was fabricated with 3 mm (1/8”) knotless mesh. Sampling was conducted by positioning the seine perpendicular to the shore, either from a boat or by wading, and then forming it into an arch, by progressing back towards the shoreline with the distant end. The seine was drawn onto the beach and the captured fish were removed from the bunt of the net on the shore. Locations of the beach seine hauls were recorded and all fish captured were identified to species and measured.

A group of six minnow traps were set for one to two days along the shore at the terminal end of the road in shallow water (0.2 m to 1 m) to capture smaller fish species and juvenile fish. Each conical metal trap measured 40 cm long by 22 cm in diameter with 7 mm mesh. The traps were baited with dog food, and prior to setting them, a plastic buoy and a rope were attached to identify each trap.

For each set of a sampling gear, location, depth (shallow (< 5 m) or deep) and start and finish times were recorded. All fish captured were identified to species, measured (fork length in mm), weighed (in grams) and various aging structures sampled. Live fish were released. Fish that died were dissected to identify sex, maturity, reproductive status and stomach contents. Stomachs of dead fish were opened and the contents were identified to major taxonomic groups (*e.g.*, fish, terrestrial insects, chironomids, *etc*.).

Aging structures were collected from all captured fish. Scales and fin rays were collected from live fish, and otoliths were removed from dead fish. Scales were collected from below the posterior margin of the dorsal fin on the left side of the fish with a knife. Two to three rays of the left pectoral fins were cut with a pair of clippers. The otoliths were retrieved with tweezers after the head was cut with a knife. Aging structures were stored in envelopes labelled with the site, date, species, length and sample number.

Aging analyses were performed by John Tost of North Shore Environmental Services, Thunder Bay, Ontario. Age was estimated by counting the number of annuli (rings) in each structure. Scales were attached to plastic fiches, and annuli were counted with a microfiche reader. Fin rays were air-dried and then mounted in a 50:50 epoxy medium. Microsections were cut using a Beuller Isomet diamond saw and mounted on slides to enable a count of the annuli by using a compound microscope. Otoliths were air-dried, cracked, and burned over a flame to make growth rings more visible. They were subsequently mounted in Plasticine and immersed in oil to

allow the growth rings to be viewed under a microscope. When more than one structure was used for aging, the one with the highest confidence in the count (usually the otolith) was used as the final age estimate.

Muscle tissue samples were collected from lake trout for metal content analysis. Data on metal concentrations will be used for baseline comparison with data obtained after construction of the Road. Lake trout was chosen as the monitoring species because it was the most abundant large species and was available in a wide range of sizes. A minimum of 12 samples from a wide size range of trout were obtained. Tissue samples were cut with a clean stainless steel knife from below the posterior margin of the dorsal fin on the left side of each fish. For all samples, muscle tissue was free of skin and bones. Tissues were placed in Whirl-Pak bags and stored in a freezer at the end of each day. The samples were subsequently sent on ice to ALS in Vancouver for analysis. Samples were kept frozen until ready for analysis. The analytical holding time for tissues is 6 months. Samples were homogenized using stainless steel hand utensils.

Analyses were conducted following procedures adapted from EPA (1995). Detailed procedures are outlined in Section 2.2.2.3. A list of metals analyzed and their respective detection limits are presented in Table 2.2-2.

Table 2.2-2
Metals and Detection Limits for Fish Tissue Analysis

Metal	Detection Limit (mg/dry kg)	Metal	Detection Limit (mg/dry kg)
Aluminum	10	Magnesium	3
Antimony	0.05	Manganese	0.05
Arsenic	0.05	Mercury	0.005
Barium	0.05	Molybdenum	0.05
Beryllium	0.3	Nickel	0.5
Bismuth	0.3	Selenium	1
Cadmium	0.03	Strontium	0.05
Calcium	10	Thallium	0.03
Chromium	0.5	Tin	0.2
Cobalt	0.1	Uranium	0.01
Copper	0.05	Vanadium	0.5
Lead	0.1	Zinc	0.5
Lithium	0.5		

2.2.2.3 Data Analysis

The fish communities were characterized using relative species abundance, catch-per-unit-effort (CPUE), length-frequency distributions, weight-length regressions, age-frequency distributions, length-at-age relationships, sex, maturity, reproductive status, diet, mean length, weight, condition and age. A description of how some of these variables were calculated is presented below.

The exact number of fish within lakes is difficult to determine, however, CPUE is a good index of relative abundance that can be used to compare fish populations among different areas and lakes. CPUE was defined as the number of fish captured per sampling device and can also be presented per unit time and area. For gillnets, CPUE was calculated from the number of fish caught per 100 m^2 of net per 24 hours.

(1) CPUE = number of fish caught per net * (100/total net area) * (24/set time)

For minnow traps, CPUE was calculated as the number of fish captured in one trap in 24 hours. CPUE was not calculated for the beach seine catches because only two fish were caught and the fishing effort of a beach seine is always constant.

Condition is an index of the relative health of fish within a lake. Condition was calculated for all fish for which both individual length and weight data were obtained, and was based on the following formula from Ricker (1975):

(2) Condition = weight (g) x 10^5/length^3 (mm)

Weight-length relationships were calculated for fish species captured in significant numbers. Weight and length were ln-transformed to linearize the weight-length relationship. The regressions can be used to predict the weight of a fish of a given length for a population:

(3) ln(weight) = ln(a) + bln(length)

where weight is in grams, a is a coefficient, b is the slope of the regression and length is in mm.

Length-age relationships were described with the von Bertalanffy growth model (Ricker, 1975):

(4) $L_t = L_\infty(1 - \exp(-K(t - t_0)))$

where L_t = length (mm) at age t (years), L_∞ = asymptotic length (mm) (*i.e.*, length at infinite age), K = growth coefficient (year^{-1}) and t_0 = age (year) at L = 0 mm. The model was fitted with non-linear regression (SPSS, 1998).

A total of 25 metals were analyzed for muscle tissue concentrations. Only metals that were detected in more than 10% of the samples are presented as average concentrations. In calculating the averages, concentrations that were less than the detection limit were replaced with values of half the detection limit. The concentrations are reported as dry weight basis. The Health Canada (2002) guideline for mercury in fish tissue was converted to dry weight concentration for comparison.

2.2.2.4 Quality Assurance and Quality Control

Field notes were transcribed onto electronic spreadsheets once in the office and all transcriptions were checked visually against the field forms and any errors were corrected. The data were also plotted to identify any outliers that may have been a result of transcription errors that occurred in

the field. QA/QC of fish aging was conducted by aging in many cases two to three structures and comparing the results.

QA/QC protocols were followed in the laboratory for metals analyses of muscle tissue. For every 10 samples, one laboratory replicate was performed, sample size permitting. Each analytical batch of up to 25 samples also included up to two method blanks and two certified reference materials (*e.g.* National Research Council of Canada Dogfish Muscle). If results fell outside of the internal data quality objectives required, then corrective action was conducted by the laboratory, including, but not limited to, re-analysis, re-digestion or instrument re-calibration.

2.2.3 Fish Habitat

2.2.3.1 Study Design and Habitat Assessment

Any alteration or destruction of habitat due to project development activities could possibly affect fish populations that use the littoral zone near the terminal end of the Road because local fish populations such as lake trout need certain types of substrate for spawning and cover. Therefore, the objective of the habitat assessment was to classify habitat type along the littoral zone.

Nearshore fish habitat was characterized in August 2001, using a combination of methods. First, the littoral zone was videotaped and photographed from a helicopter at low altitude. An enlarged copy of a 1:50,000 topographic map was used while in the helicopter to delineate transition zones of habitat types along the littoral zone. Once the zones were delineated, substrate composition of each zone was recorded as a percent coverage (*e.g.*, 60% boulder and 40% sand). The habitat types were classified as bedrock, boulder, cobble, gravel, sand-silt, and emergent vegetation. Following the helicopter survey, the data was ground-truthed from a boat. In the office a combination of notes from the field with video and photographic records were used to create the habitat maps and to verify and make any modifications (if needed) of the composition of each zones. The location of each zone were digitized into a GIS system and overlaid onto an aerial photograph.

A survey of bathymetry at the terminal end of the Road was conducted in September 2001. That data was overlaid onto the GIS habitat map to provide a better understanding of habitat complexity.

2.2.3.2 Data Analysis

The surface area of each zone and the perimetre of the shore surveyed were calculated. Percent substrate coverage was converted into surface area. Habitat data collected were compared with fish habitat preference data reported by Richardson *et al.* (2001), which is an extensive literature review of the life history characteristics of all freshwater fish from Canada's north with major emphasis on lake habitat requirements. Four distinct life stages were identified in the report: spawning, young-of-the-year, juveniles and adults. Water depth, substrate type and cover preference for all species and life stages was rated as nil, low, medium or high.

In this report, a summary of the habitat preferences rated high by Richardson *et al.* (2001) is provided as text and in a table format for the eight species captured during this study. Only

preferences rated high (species nearly always associated with specific physical characteristics) were presented in the table rather than the four categories presented in Richardson *et al.* (2001) because it is easier to present and understand the data. This information was used to assess the habitat types at the terminal end of the Road.

3. RESULTS AND DISCUSSION

3. Results and Discussion

3.1 Streams

3.1.1 Aquatic Biology and Chemistry

3.1.1.1 Habitat Characteristics

General stream habitat characteristics were obtained from the fish habitat assessment. Average width, depth, discharge and percent cover of sand and boulders for the nine streams are summarized in Table 3.1-1. The streams varied widely in size with widths ranging from 1 m (km 192.4a) to 37 m (km 134.6). However, despite the range in widths, all streams were shallow with similar riffle and glide depths (≤ 0.5 m). Only three streams had significant amounts of sand as bed material (km 72.2, km 206.9 and km 2.2). The largest streams (km 134.6) were boulder gardens with boulders covering greater than 50% of the streambed.

Table 3.1-1
Average Width, Depth, Discharge and Percent Boulder and Sand Cover of Stream Reaches

Station	Width (m)	Depth (m)[1]	Discharge (m^3/s)	% Sand Cover	% Boulder Cover
km 206.9	4	0.2	0.09	18	12
km 192.4a	1	0.1	0.03	5	29
km 134.6	37	0.1	2.73	0	60
km 84.2	7	0.3	0.49	0	41
km 72.2	8	0.3	0.20	50	23
km 2.2	5	0.5	0.14	100	0

[1] **Depth of riffle and glide sections only. Pool depths were excluded because pool reaches were not sampled.**

3.1.1.2 Water Quality

The chemical composition of stream water has a broad influence on resident aquatic organisms. The amount of nutrients in water strongly affects the productivity of a stream and elevated or scarce levels can impinge on biological processes such as growth and reproduction.

All analytical results for surface water chemistry samples collected in streams during August 2001 are presented in Appendix 3.1-1. Quality assurance and quality control results are described in the water quality section for Contwoyto Lake (Section 3.2.1.2).

Physical Variables and Nutrients

Concentrations of selected physical variables and nutrients measured in stream surface waters are presented in Table 3.1-2. Average pH was similar across all streams with values ranging from 7.2 to 7.9. The majority of stream waters were soft with low concentrations of major variables (Figure 3.1-1). At five of six stream stations, average hardness (as calcium carbonate) was ≤ 25 mg/L. Average total alkalinity ranged from 1 mg/L (km 206.9) to 13 mg/L (km 72.2).

Table 3.1-2
Average Concentrations for Selected Water Quality Variables in Six Streams, August 2001

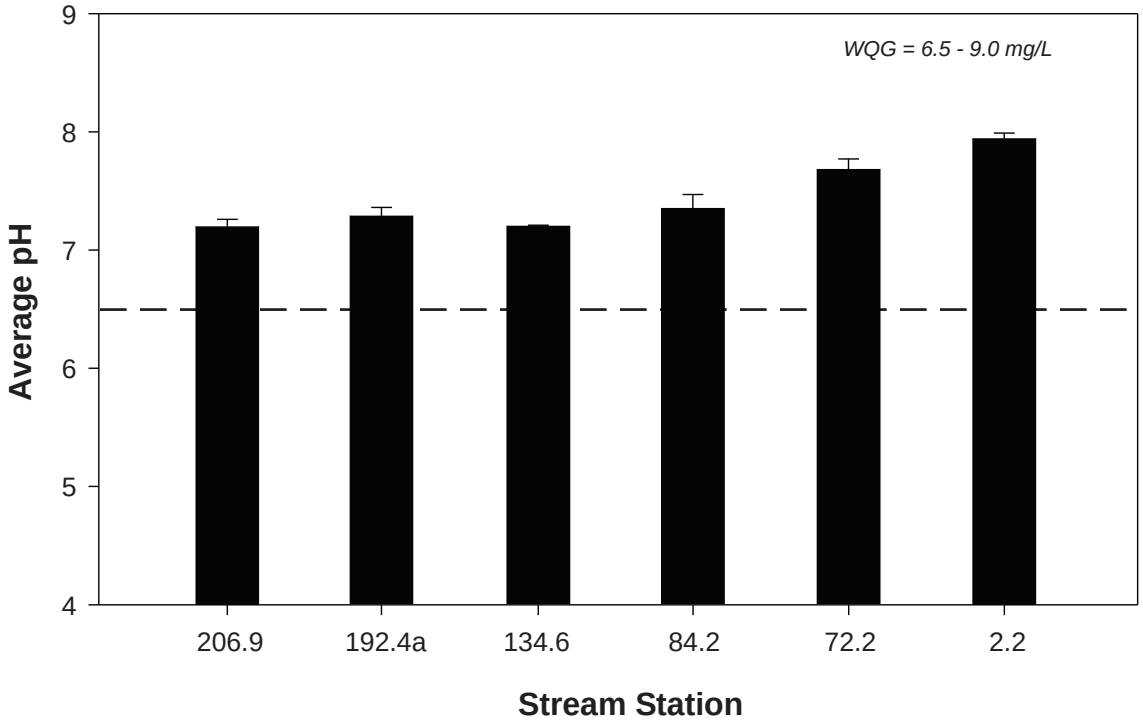
Variable	Units	Km 206.9	Km 192.4a	Km 134.6	Km 84.2	Km 72.2	Km 2.2	CCME Guideline[1]
Physical								
Conductivity	µmhos/cm	10	8	10	21	60	490	-
Total Dissolved Solids	mg/L	<10	<10	<10	<10	36	277	-
Total Suspended Solids	mg/L	<3	<3	<3	<3	<3	3	-
Turbidity	NTU	1.2	0.7	0.9	0.4	0.7	7.5	-
Hardness	mg $CaCO_3$/L	4	4	4	7	25	102	-
PH	pH units	7.20	7.29	7.20	7.35	7.68	7.94	6.5-9.0
Total Alkalinity	mg $CaCO_3$/L	1	3	2	2	13	60	-
Nutrients								
Total Kjeldahl Nitrogen	mg/L	0.19	0.17	0.15	0.13	0.38	0.16	-
Nitrate Nitrogen	mg/L	0.007	0.014	0.015	0.016	0.015	0.028	-
Total Phosphorus	mg/L	0.005	0.007	0.009	0.004	0.004	0.015	-
Total Metals								
Aluminum	mg/L	0.074	0.019	0.033	0.013	0.030	0.298	0.100
Arsenic	mg/L	0.0004	0.0004	0.0002	0.0002	0.0005	0.0008	0.005
Cadmium	mg/L	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	0.000017
Chromium	mg/L	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	0.0006	0.0010 -0.0089[2]
Copper	mg/L	0.0014	0.0007	0.0015	0.0018	0.0032	0.0033	0.002
Iron	mg/L	0.185	0.265	0.150	0.070	0.300	0.345	0.300
Lead	mg/L	0.00007	<0.00005	<0.00005	<0.00005	<0.00005	0.00023	0.001 - 0.002[3]
Mercury	mg/L	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	0.0001
Nickel	mg/L	0.0011	0.0006	0.0012	0.0021	0.0062	0.0009	0.025 - 0.065[4]
Zinc	mg/L	0.0015	<0.001	0.001	0.002	0.004	<0.001	0.030

1 Canadian water quality guidelines for the protection of aquatic life (CCME 1999a).

2 CCME guideline concentration is 0.001 mg/L for hexavalent chromium and 0.0089 mg/L for trivalent chromium. No guideline exists for total chromium.

3 CCME guideline for lead is 0.001 mg/L when [CaCO3] = 0-60 mg/L and the guideline is 0.002 mg/L when [CaCO3] = 60-120 mg/L.

4 CCME guideline for nickel is 0.025 mg/L when [CaCO3] = 0-60 mg/L and the guideline is 0.065 mg/L when [CaCO3] = 60-120 mg/L.



Note: Error bars represent one standard error of the mean.

(Table 3.1-2). Average total ion content was low, as was indicated by a total dissolved solids concentrations close to or below detection limits (< 10-36 mg/L) and average conductivity measurements ranging from 8 µmhos/cm (km 192.4a) to 60 µmhos/cm (km 72.2). Surface waters were very clear with average turbidity readings ranging from 0.4 NTU (km 84.2) to 1.2 NTU (km 206.9).

In contrast, stream km 2.2 had very different water chemistry. This station was located along the eastern section of the road corridor close to Bathurst Inlet. The stream water was hard and high in ions. Hardness was 102 mg/L, total alkalinity was 60 mg/L, total dissolved solids was 277 mg/L (Figure 3.1-2), and conductivity was 490 µmhos/cm (Table 3.1-2). The water was slightly more turbid than in other streams with a reading of 7.5 NTU.

The greater ion content of water at km 2.2 is likely a reflection of different bedrock materials within the drainage basin. There was a large proportion of sedimentary rock in the drainage basin of this stream relative to other basins which were composed of more igneous material. Surface runoff draining sedimentary rock is richer in ions than runoff draining igneous rock because of differences in rock chemical composition and resistance to weathering.

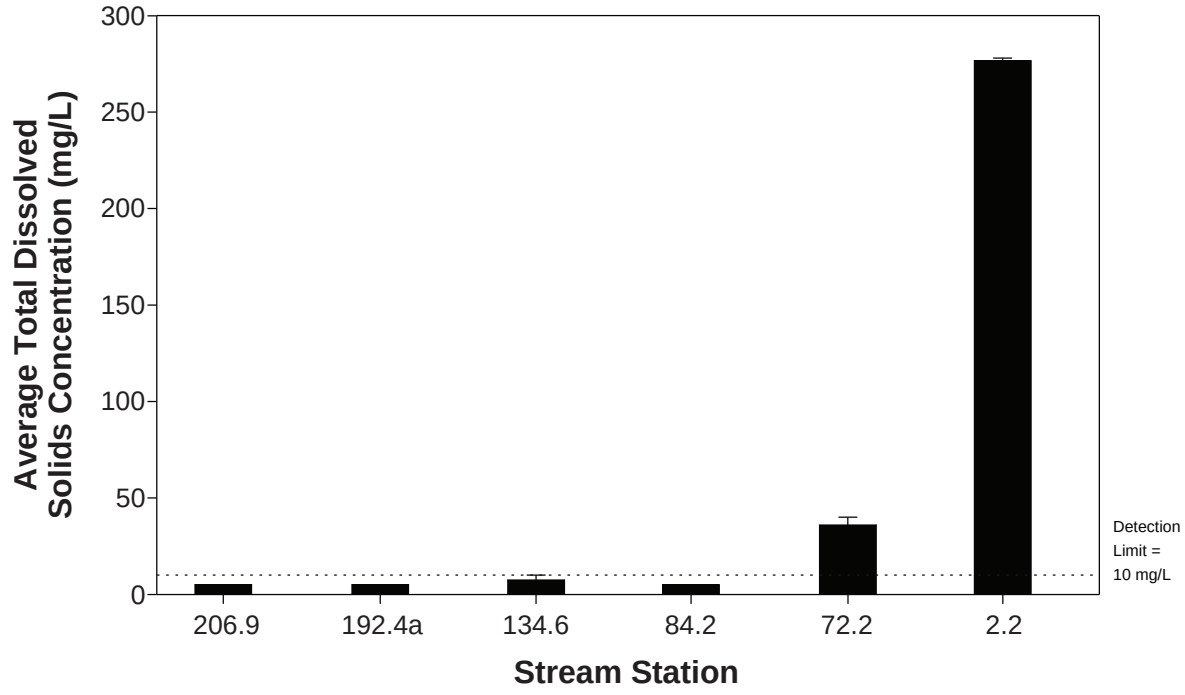
There was little particulate matter suspended in the stream waters. At all stations, total suspended solids concentrations were at or below detection limits (< 3 mg/L) (Table 3.1-2). Total organic carbon concentration ranged from 3.4 mg/L (km 84.2) to 7.0 mg/L (km 72.2).

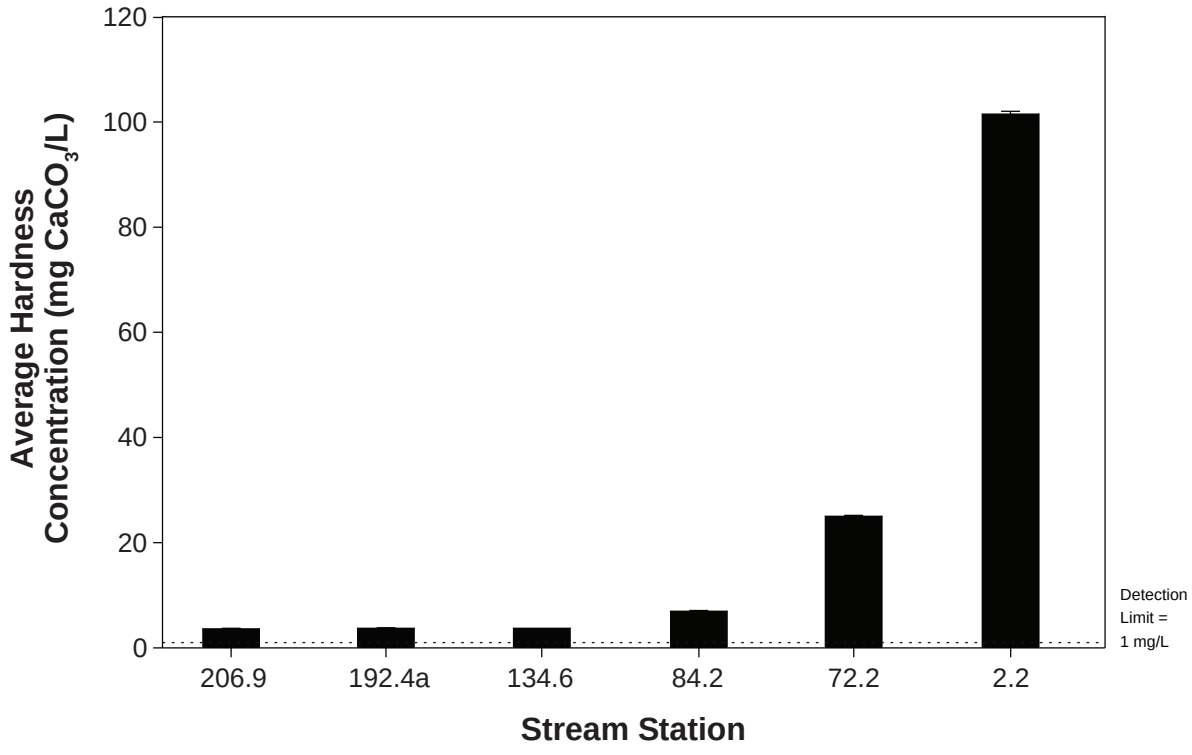
Stream waters were nutrient-poor with nitrate nitrogen ranging from 0.007 mg/L (km 206.9) to 0.028 mg/L (km 2.2) (Figure 3.1-3), total Kjeldahl nitrogen ranging from 0.13 mg/L (km 84.2) to 0.38 mg/L (km 72.2) and total phosphorus ranging from 0.004 (km 72.2) to 0.015 mg/L (km 2.2) (Figure 3.1-3). Total phosphorus concentration was highest at km 2.2, possibly due to more labile phosphorous material or greater phosphorus content within the sedimentary bedrock of its drainage basin. Phosphorus typically limits the growth of attached algae in tundra streams (Peterson *et al*. 1985), and the low phosphorus concentrations observed among streams suggest poor nutrient availability for primary production.

Metals

Concentrations of selected metals measured in stream surface waters are presented in Table 3.1-2. Concentrations of metals were compared with the Canadian water quality guidelines for the protection of aquatic life (CCME 1999a) to identify streams with elevated levels. The guideline concentrations are also presented in Table 3.1-2.

Metal concentrations were generally low in stream surface waters. Many metals, such as cadmium, chromium, lead, mercury and others, were below analytical detection limits at all or most stations. Other metals, such as aluminum, arsenic, copper, iron and nickel, were above analytical detection limits at all stations. There was notable variation in aluminum, copper and iron average concentrations among streams. Aluminum ranged from 0.013 mg/L (km 84.2) to 0.298 mg/L (km 2.2), and arsenic ranged from 0.0002mg/L to 0.0008 mg/L (Figure 3.1-4).





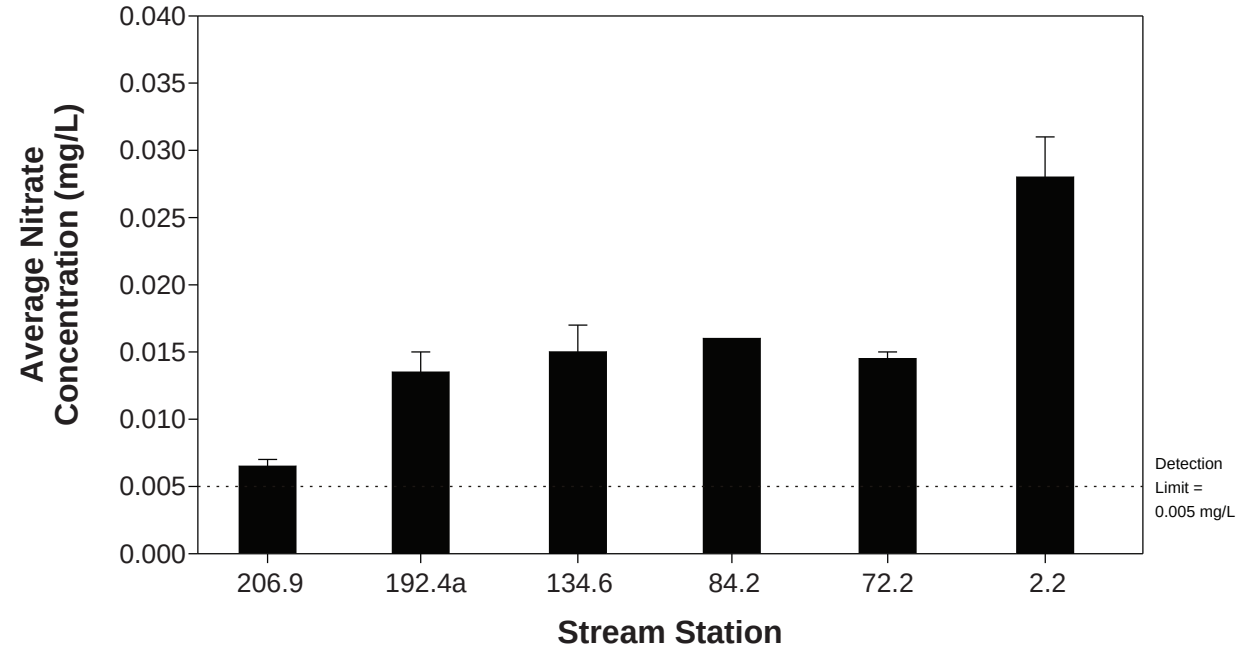
Note: Error bars represent one standard error of the mean.

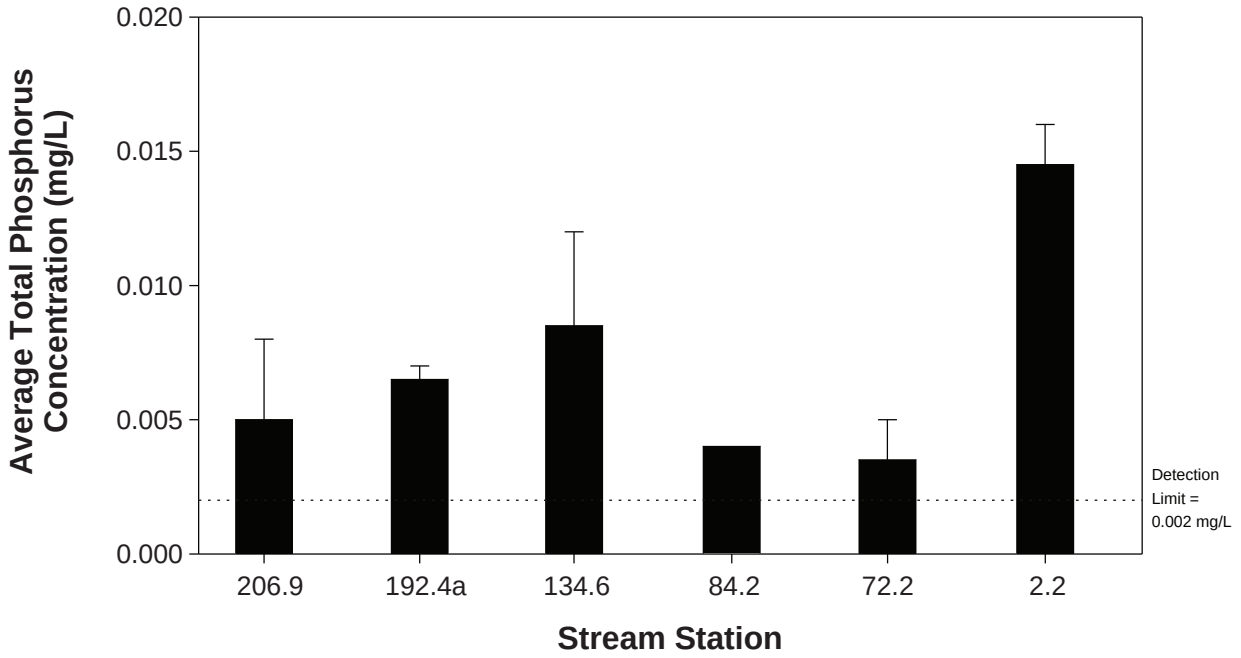
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Average Total Dissolved Solids and Hardness Concentrations, Stream Water, August 2001

FIGURE 3.1-2

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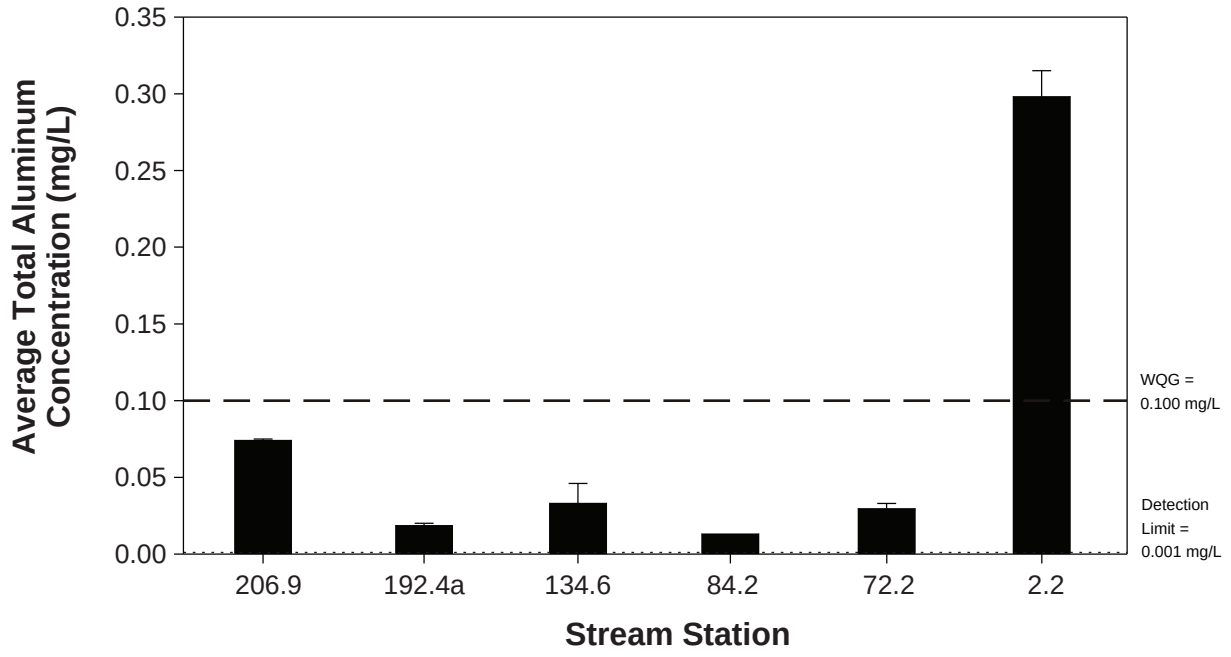
Note: Error bars represent one standard error of the mean.

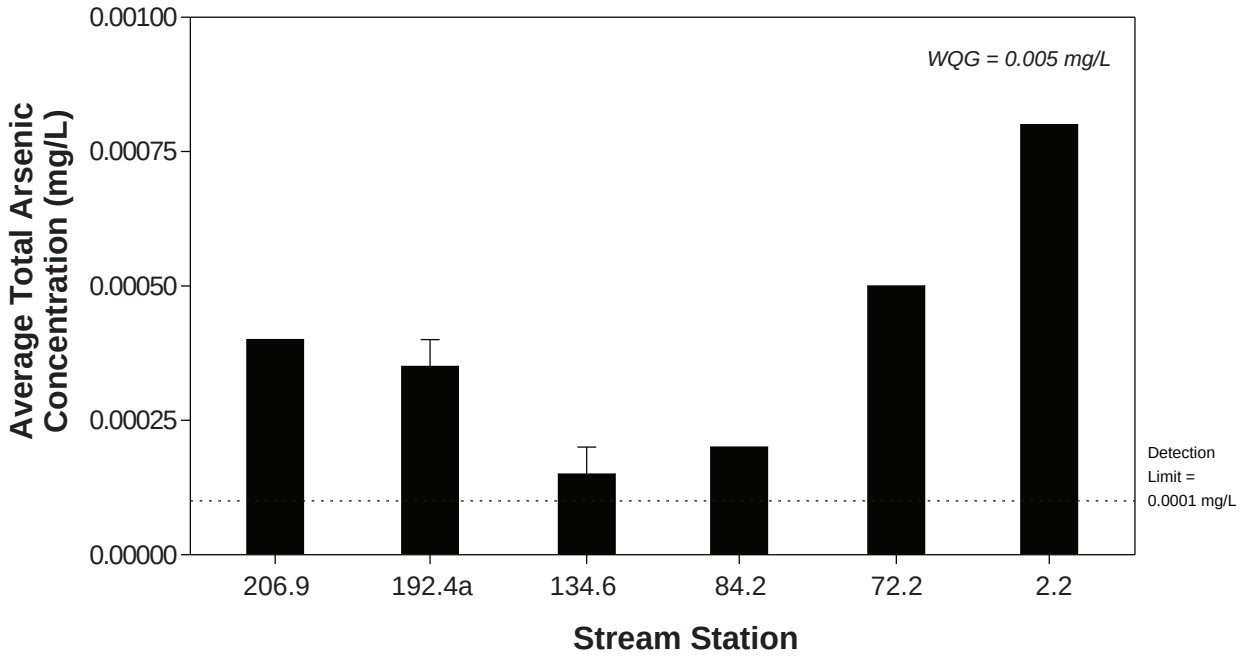
the BATHURST INLET PORT AND ROAD PROJECT

Average Nitrate and Total Phosphorus Concentrations, Stream Water, August 2001

FIGURE 3.1-3

Rescan™





Note: Error bars represent one standard error of the mean.

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Average Total Aluminum and Total Arsenic Concentrations, Stream Water, August 2001

FIGURE 3.1-4

Rescan™

Copper ranged from 0.0007 mg/L (km 192.4a) to 0.0033 mg/L (km 2.2), and iron ranged from 0.070 mg/L (km 84.2) to 0.345 mg/L (km 2.2) (Figure 3.1-5). Km 2.2 tended to have the highest concentrations of metals compared with other sampled streams.

Most stream metal concentrations were below Canadian water quality guidelines for the protection of aquatic life (CCME, 1999a). In contrast, copper, aluminum and iron were above CCME guidelines at km 2.2. Copper was also above guideline levels at km 72.2.

Quality Assurance/Quality Control

Analytical results for water chemistry field blanks and travel blanks are presented in Appendices 3.1-2 and 3.1-3. Field blanks for total organic carbon, total Kjeldahl nitrogen and total metals all had concentrations below detection limits.

3.1.1.3 Sediment Quality

Stream sediments are highly mobile and are subject to continuous erosion by flowing water. Turbulent flow maintains fine particles suspended in the water column, and periodic flooding resuspends more coarse sediment and transports it farther downstream. Sediment deposition in streams is highly variable and largely determined by local hydrological conditions.

Analytical results for all sediment chemistry samples collected in streams during August 2001 are presented in Appendix 3.1-4. Sediment description sheets are presented in Appendix 3.1-5, as well as a photographic record of all collected sediment samples is presented in Appendix 3.1-6.

Sediment Descriptions

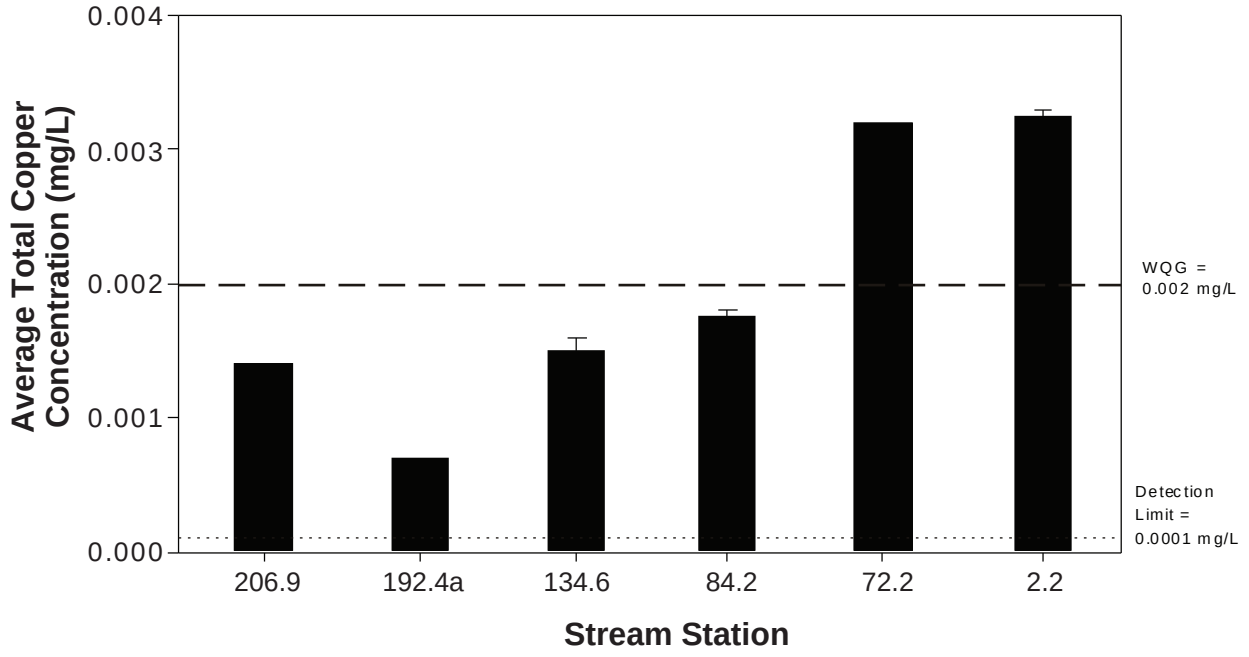
Most stations had streambeds composed primarily of boulders, cobble and gravel. Only three stations had depositional areas with fine gravel and sand where sediment samples could be taken.

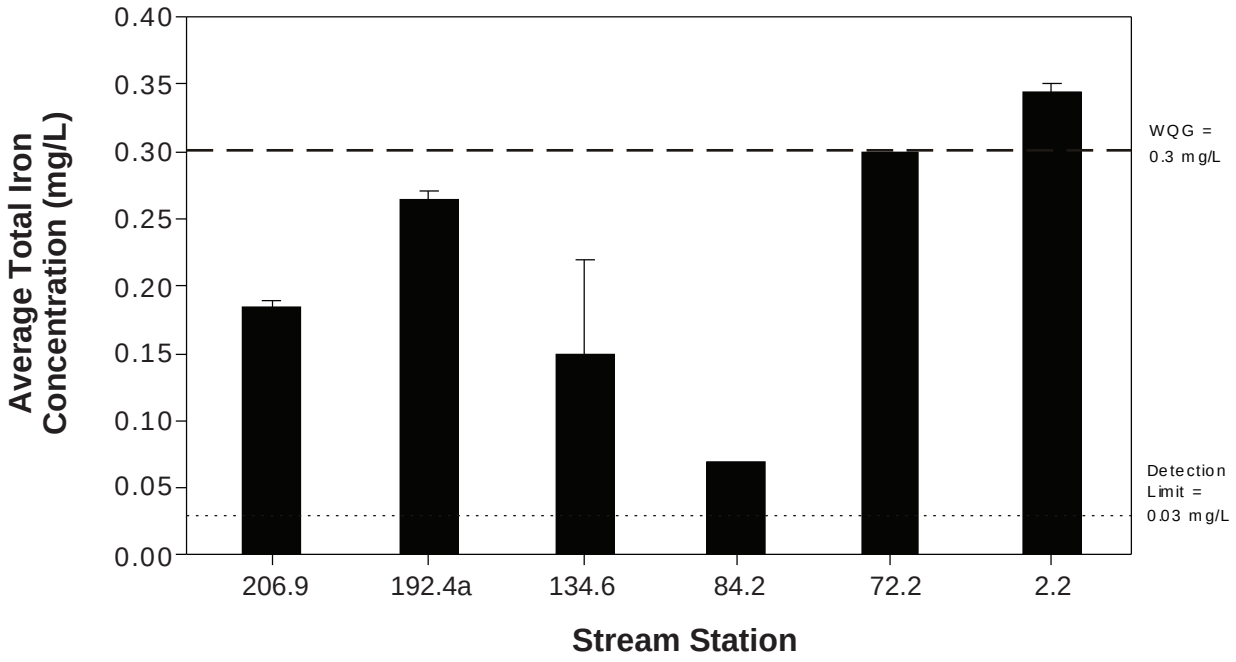
Sediment from km 72.2 and km 206.9 consisted of a heterogeneous mix of coarse sand and gravel. The coarse sand was very dark grey (5Y 3/1) or dark grey (2.5Y 4/1) and the gravel was multi-coloured (Appendices 3.1-5 and 3.1-6). Sediment from km 2.2 was generally a homogenous layer of greyish brown (10YR 5/2) or dark grey (2.5Y 4/1) sand.

Nutrients

Nutrient concentrations measured in stream sediments are presented in Table 3.1-3. Total nitrogen and available phosphorus concentrations are summarized graphically in Figure 3.1-6.

Total organic carbon, available phosphorus, and total nitrogen content of sediment were very low in the streams. Total organic carbon content ranged from < 0.08% (km 2.2) to 0.20% (km 206.9), total nitrogen content ranged from < 0.02% (km 2.2) to 0.06% (km 206.9) and available phosphorus ranged from 4 mg/kg (km 206.9 and 72.2) to 5 mg/kg (km 2.2).





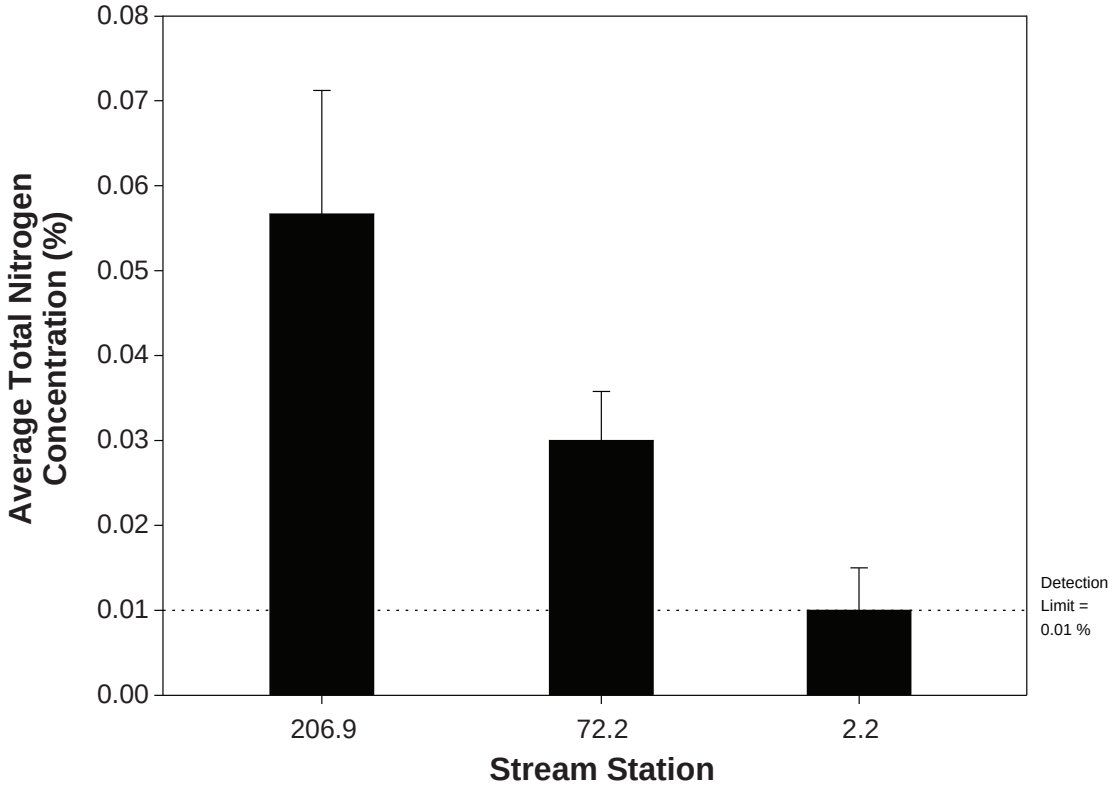
Note: Error bars represent one standard error of the mean.

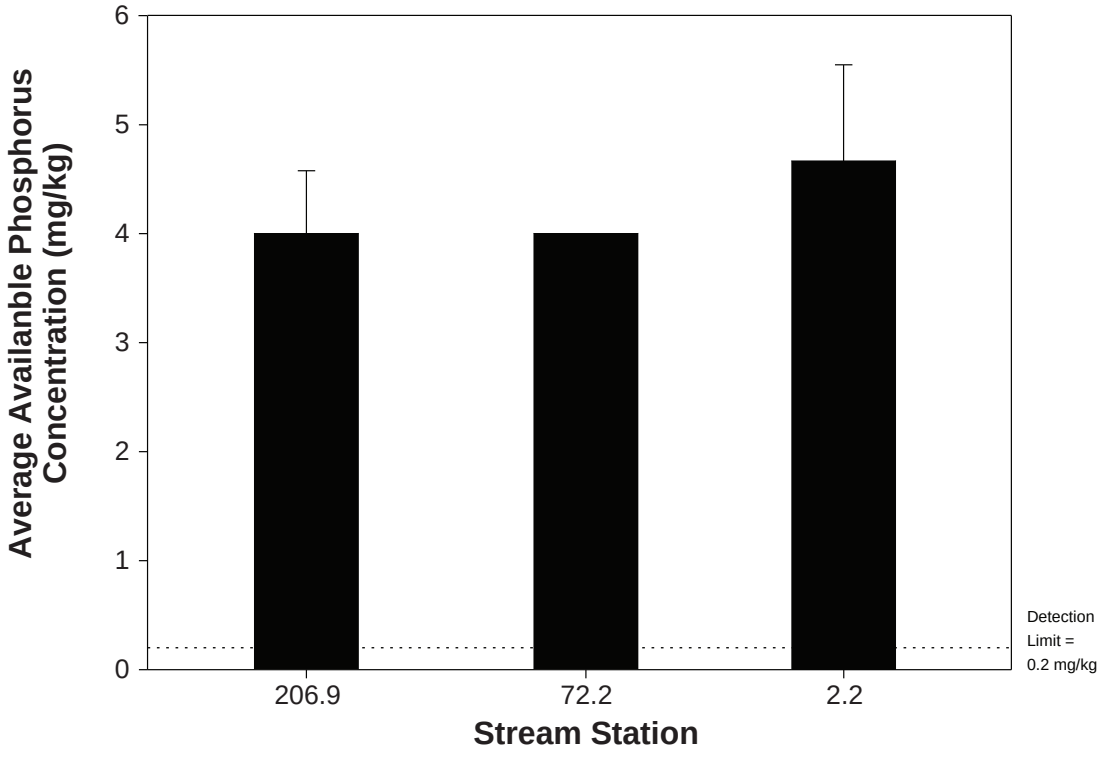
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Average Total Copper and Total Iron Concentrations, Stream Water, August 2001

FIGURE 3.1-5

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Note: Error bars represent one standard error of the mean.

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Average Total Nitrogen and Phosphorus Concentrations, Stream Sediment, August 2001

FIGURE 3.1-6

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Table 3.1-3
Average Concentrations of Selected Sediment Quality Variables Measured in Three Streams, August 2001

Variable	Units	Km 206.9	Km 72.2	Km 2.2	CCME Guideline[1]
Total Organic Carbon	% dry weight	0.20	0.13	0.08	-
Available Phosphorus	mg/kg	4	4	5	-
Total Nitrogen	% dry weight	0.06	0.03	0.02	-
Total Aluminum	mg/kg	8,313	16,267	7,830	-
Total Arsenic	mg/kg	4.0	4.2	2.0	17.0
Total Cadmium	mg/kg	<0.1	<0.1	<0.1	3.5
Total Chromium	mg/kg	25	57	17	90
Total Copper	mg/kg	5	13	8	197
Total Iron	mg/kg	13,933	25,933	10,803	-
Total Lead	mg/kg	<2	<2	3	91.3
Total Mercury	mg/kg	<0.005	<0.005	<0.005	0.486
Total Nickel	mg/kg	11	28	8	-
Total Zinc	mg/kg	25	45	17	315

[1] Probable effect levels (PEL) from the Canadian sediment quality guidelines for the protection of aquatic life (CCME, 1999b).

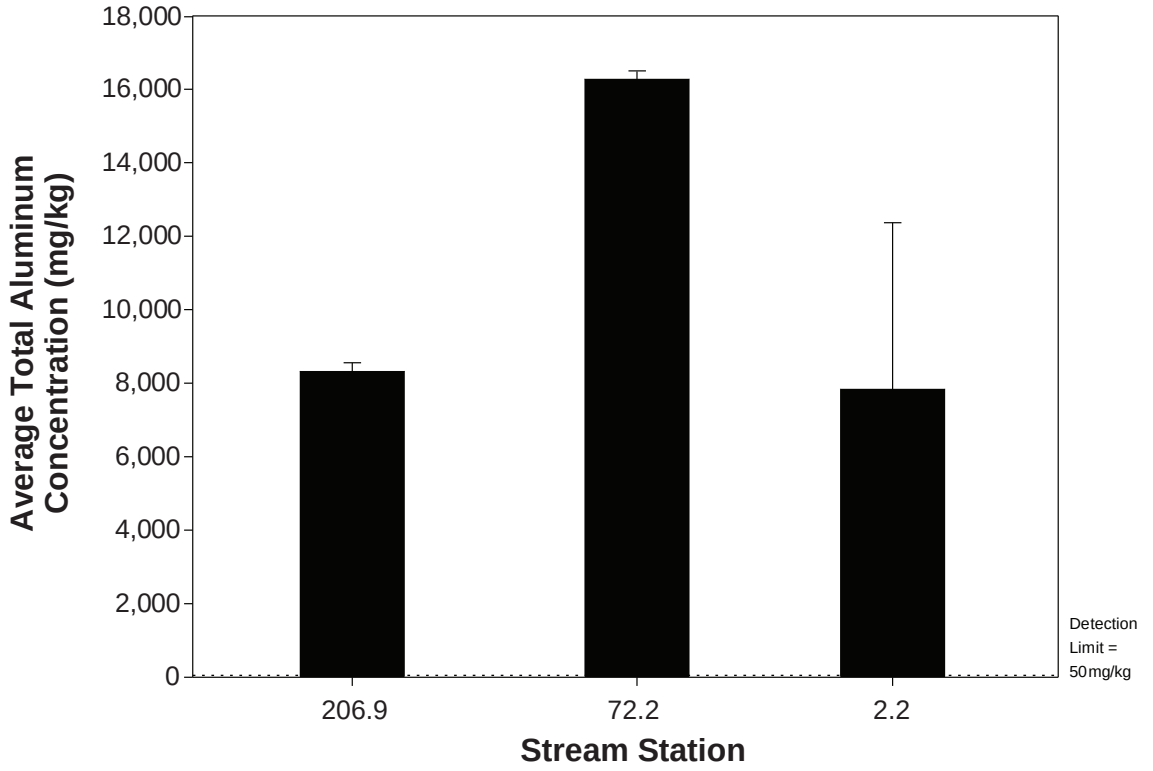
Metals

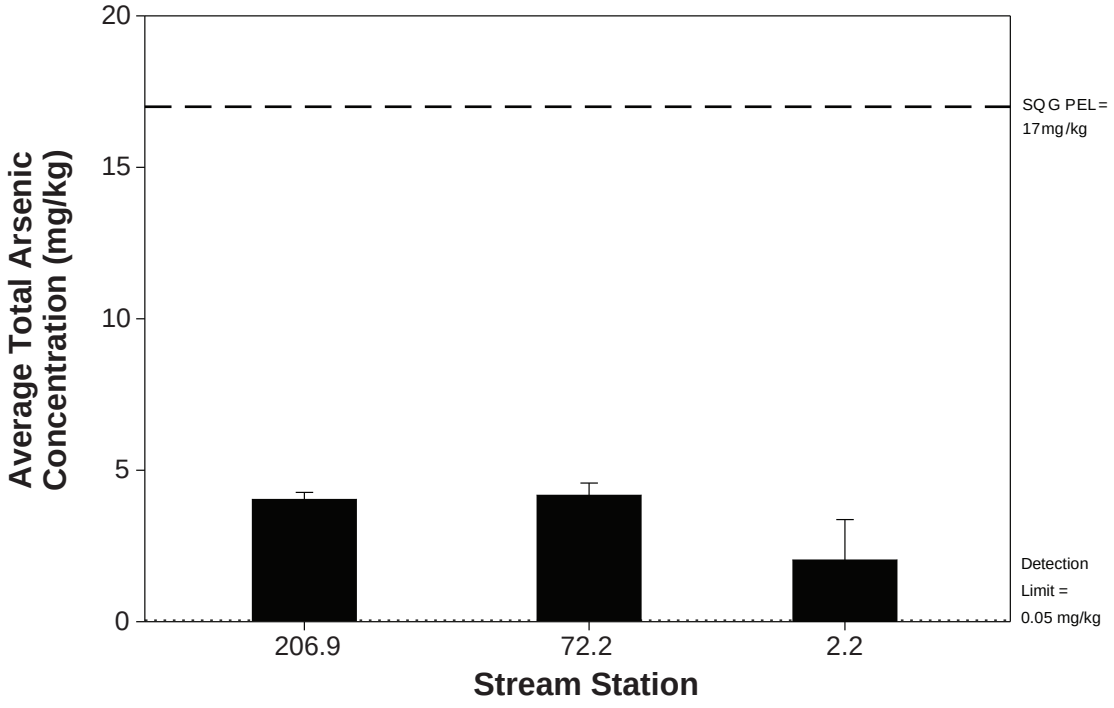
Selected metal concentrations measured in stream sediments are presented in Table 3.1-3. Total concentrations of aluminum, arsenic, chromium and iron are summarized graphically in Figures 3.1-7 and 3.1-8. Concentrations of metals were compared with the Canadian sediment quality guidelines for the protection of aquatic life (CCME, 1999b) to identify streams with elevated levels. The guideline concentrations are also presented in Table 3.1-3.

Sediment metal concentrations measured in streams were low. Some metals such as cadmium, lead and mercury were below analytical detection limits. Total concentrations of aluminum, chromium, copper, iron, nickel and zinc were notably higher at km 72.2 than in other streams. No metals were above probable effects levels as outlined in the Canadian sediment quality guidelines for the protection of aquatic life (CCME, 1999b).

Particle Size

The size distribution of sediment particles differed among streams. Sediment at km 72.2 and km 2.2 was primarily composed of sand particles (80% of total dry weight at both stations) (Figure 3.1-9). In km 206.9, sediment was roughly an even mixture of sand and gravel. The greatest proportion of silt (12%) and sand (7%) was observed in sediment at km 2.2.





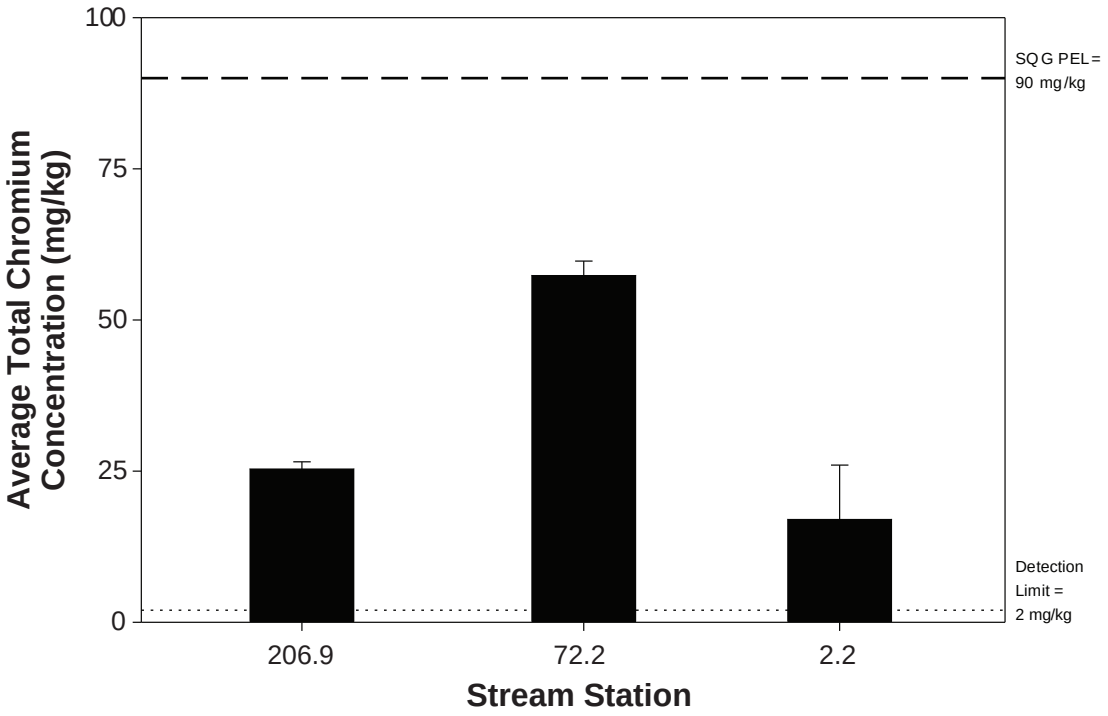
Note: Error bars represent one standard error of the mean.

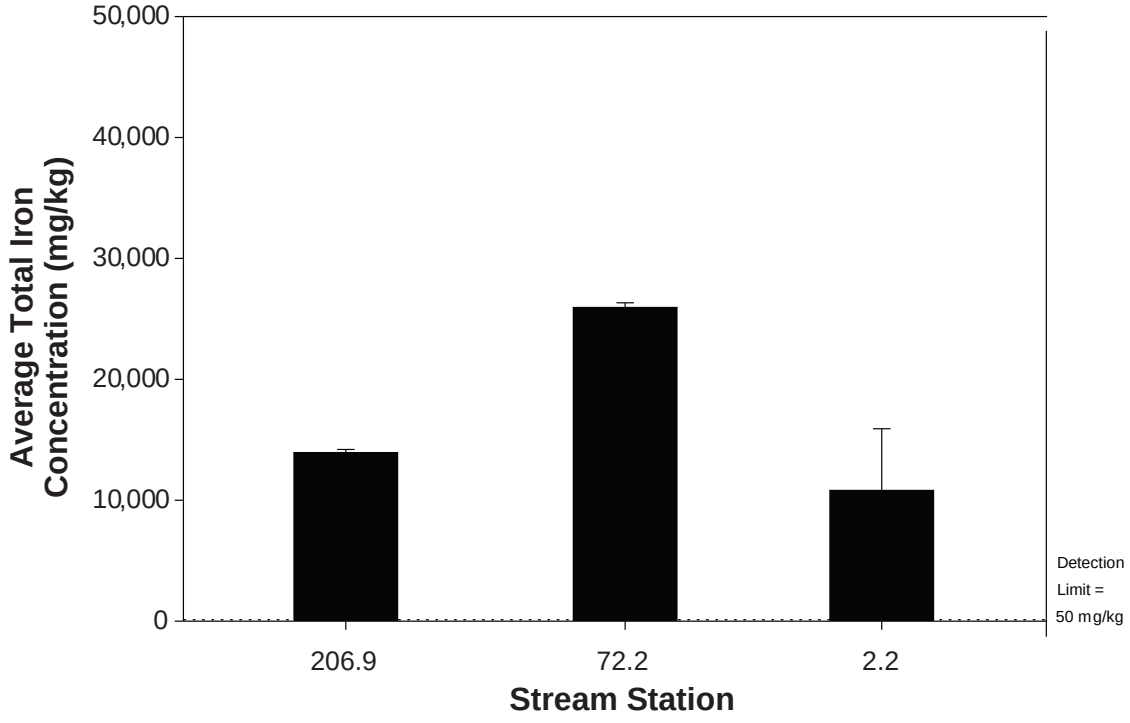
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Average Total Aluminum and Total Arsenic Concentrations, Stream Sediment, August 2001

FIGURE 3.1-7

Rescan™





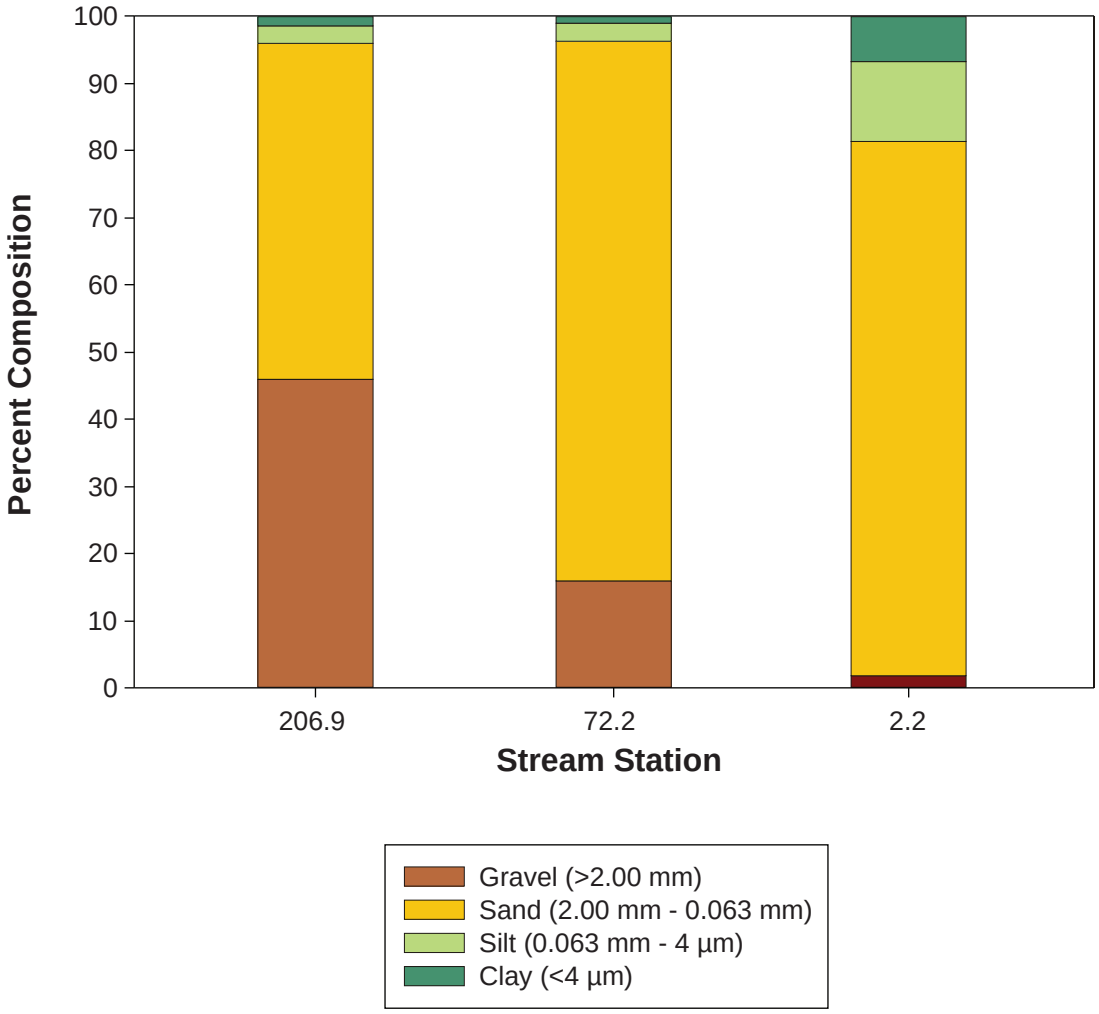
Note: Error bars represent one standard error of the mean.

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Average Total Chromium and Total Iron Concentrations, Stream Sediment, August 2001

FIGURE 3.1-8

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Percent Composition of Grain Sizes, Stream Sediment, August 2001

FIGURE 3.1-9

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3.1.1.4 Primary and Secondary Producers

Periphyton and benthic invertebrates are key communities in stream food webs. In streams, algae usually grow attached to rocks rather than suspended in the water column. Attached algae, often referred to as periphyton, are the dominant primary producers in streams. Benthic invertebrates consume both algae and detrital matter and in turn are a major food source for fish.

Changes in water quality or sediment quality often affect the composition and abundance of primary and secondary producer communities. These shifts in community structure may then impact fish that rely directly or indirectly on primary and secondary producers for food.

Periphyton

Results of the taxonomic enumeration and identification of all periphyton samples are provided in Appendix 3.1-7 and chlorophyll *a* results are provided in Appendix 3.1-8. Periphyton biomass varied widely among streams along the proposed road route. In most streams, cobble stones were covered in thin periphyton films with low chlorophyll *a* (< 100 µg/cm^2). However, at km 134.6 boulders and cobbles were covered in abundant growth of filamentous algae that extended, in some cases, to lengths of more than 30 cm (Plate 3.1-1). At this site, periphyton biomass was an order of magnitude higher, with chlorophyll values at 273 µg/cm^2 (Figure 3.1-10). Abundant filamentous growth was previously observed by Moore (1978a) in streams near Contwoyto Lake.

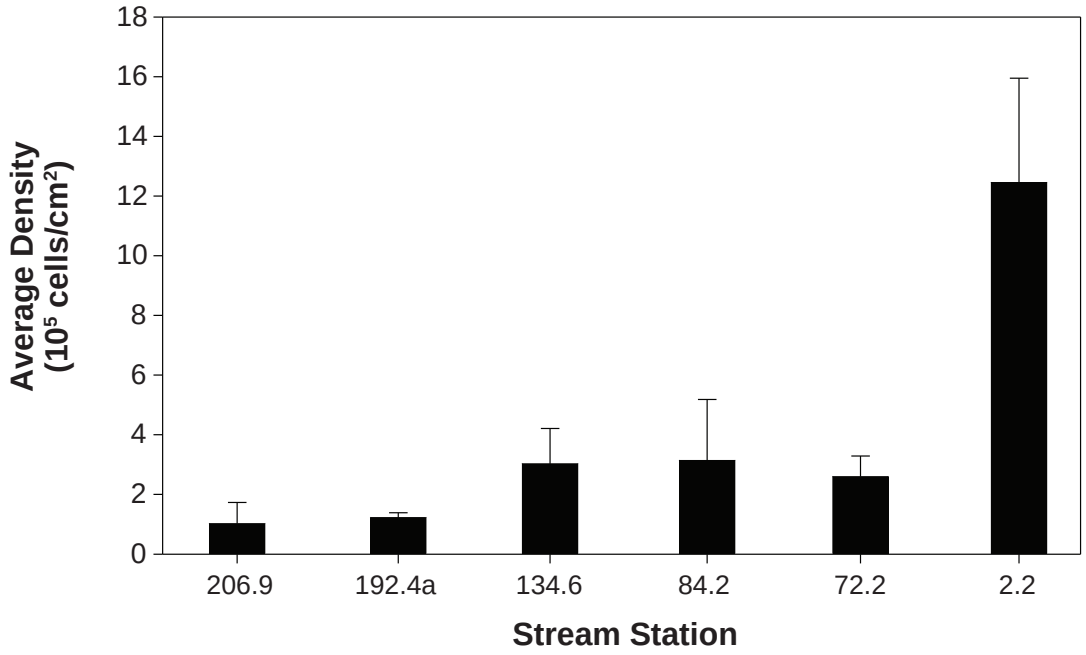
Periphyton density ranged from 102,025 cells/cm^2 (km 206.9) to 1,244,850 cells/cm^2 (km 2.2) (Figure 3.1-10). Although km 2.2 had the highest density, periphyton biomass measured as chlorophyll *a* was low.

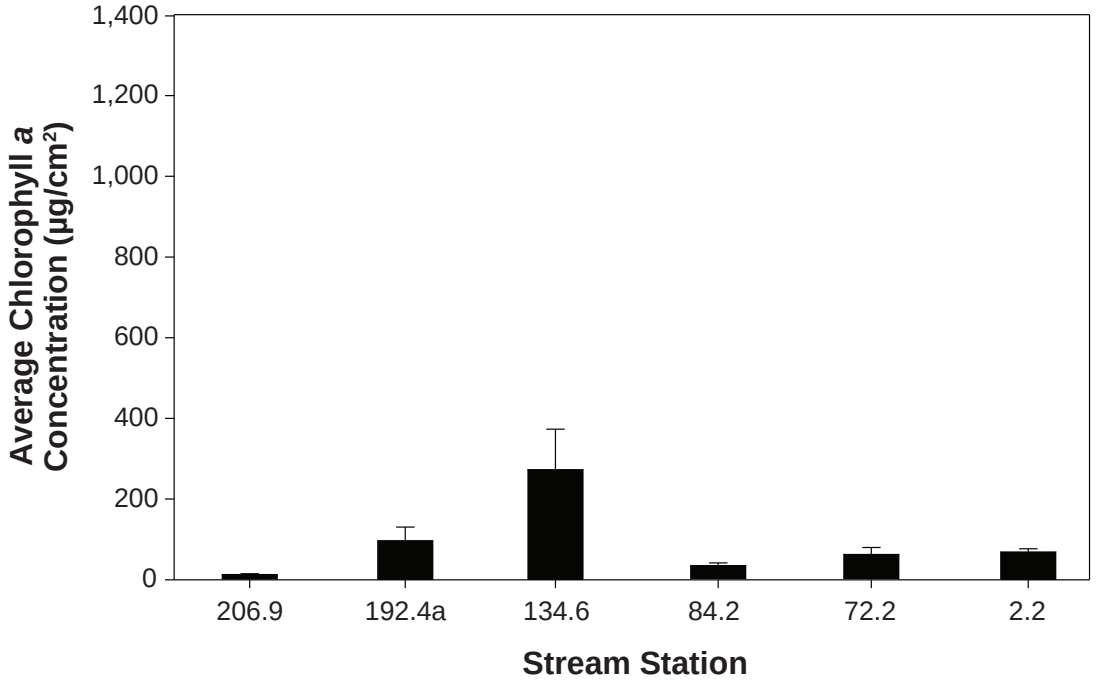
Densities were not very well correlated with chlorophyll *a* estimates probably because average periphyton cell sizes varied widely among streams.

Densities of periphyton cells in this survey were similar to those observed in other undisturbed tundra streams (Rescan, 1995).

The diversity of periphyton communities varied considerably among streams. A total of 62 genera were identified in the samples collected with between 17 genera (km 2.2) to 39 genera (km 134.6) found at individual stations (Table 3.1-4). Periphyton diversity, measured by the Shannon and Simpson diversity indices, ranged widely from 1.55 (km 206.9) to 2.88 (km 192.4a) and 0.57 (km 84.2) to 0.91 (km 192.4a), respectively. The differences in periphyton diversity were for the most part typical compared to other undisturbed tundra streams (Rescan, 1995).

Periphyton communities were composed of algal species from five different taxonomic groups. Overall, cyanobacteria were the most abundant (mean percent density = 63%) followed by diatoms (29%) and green algae (8%). Cyanobacteria were dominant in five of the six streams (Figure 3.1-11), while diatoms were more abundant in one stream (km 2.2). These observations indicate that community composition can vary significantly among undisturbed streams. Cyanobacteria were also found to be the most abundant taxonomic group of periphyton in undisturbed streams in the Lac de Gras watershed (Rescan, 1995).





Note: Error bars represent one standard error of the mean.

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Average Periphyton Density and Chlorophyll *a* Concentrations, Stream Stations, August 2001

FIGURE 3.1-10

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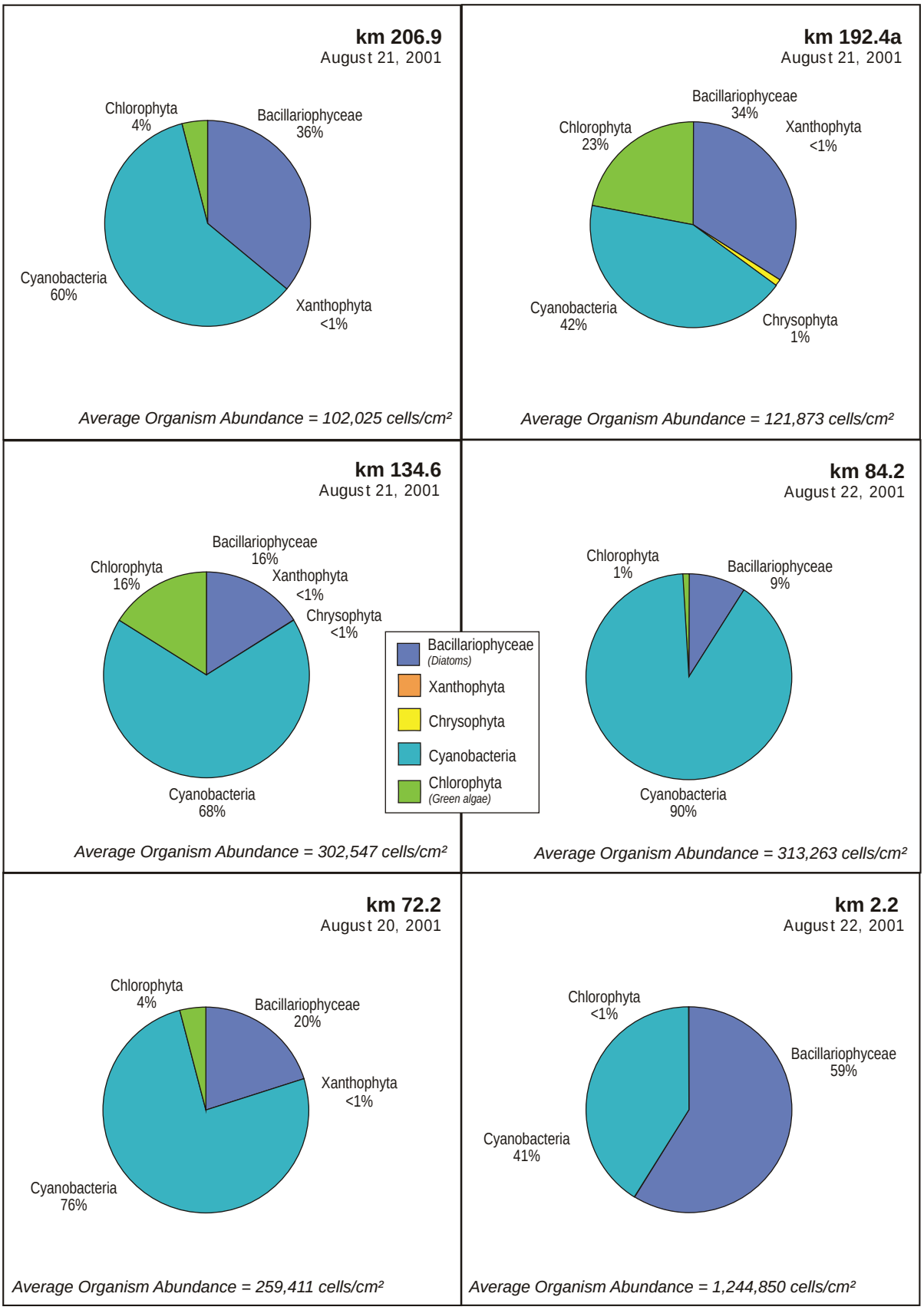


Plate 3.1-1. Filamentous algae growing on stones to lengths in excess of 30 cm (ruler length).

Table 3.1-4
Diversity of Periphyton Communities in Streams, August 2001

Stream	Number of Genera	Genera[1] (90%)	Shannon Diversity Index[2]	Simpson Diversity Index[2]
Km 206.7	23	6	1.55	0.64
Km 192.4a	35	18	2.88	0.91
Km 134.6	39	9	1.64	0.59
Km 84.2	20	7	1.49	0.57
Km 72.2	29	10	2.07	0.77
Km 2.2	17	7	2.13	0.86

[1] **Number of genera contributing to 90% of community density.**
[2] **Diversity indices were calculated based on algal genera.**



Taxonomic Composition of Periphyton Communities by Abundance, Stream Stations, August 2001

the Bathurst Inlet Port and Road Project

FIGURE 3.1-11

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A total of six diatom taxa, eleven cyanobacteria taxa and three green algal taxa dominated periphyton communities, each contributing ≥ 5% to community density. The algal species *Tabellaria flocculosa* and *Planktolyngbya limnetica* were the most widespread, occurring as dominant taxa in three of the streams (Table 3.1-5). Other species such as *Gleotrichia echinulata*, *Phormidium accutissima* and *Zygnema* sp. were very abundant in one or two streams. *Tabellaria flocculosa* is one of the most common periphyton species in the Northwest Territories and parts of Nunavut and is found in virtually every stream (Moore, 1978a, 1978b, 1979; Rescan, 1995).

Table 3.1-5
Percent Abundance of Dominant Periphyton Species in Streams, August 2001

Dominant Species[1]	Km 206.9	Km 192.4a	Km 134.6	Km 84.2	Km 72.2	Km 2.2
Bacillariophycae						
Achnanthes minutissima					7	
Diatoma moniliformis						16
Fragilaria spp.	6					13
Nitzschia perminuta						14
Surirella brebisonii						5
Tabellaria flocculosa	20	16	5			
Cyanobacteria						
Aphanocapsa sp.				5		
Gloeotrichia echinulata				65	43	
Limnothrix redekei		8				
Limnothrix sp.					5	
Merismopedia glauca						9
Phormidium accutissima	54	6				
Phormidium spp.		12				
Planktolyngbya limnetica			62	7		24
Planktothrix agardhii				5	18	
Pseudoanabaena galeata						9
Snowella lacustris					6	
Chlorophyta						
Mougeotia sp.		5				
Stigeoclonium lumbricum		5				
Zygnema sp.			11			

[1] **A periphyton species was considered dominant at a station if it represented ≥5% of total community density.**

Benthic Invertebrates

Results of the taxonomic enumeration and identification of all benthic invertebrate samples are provided in Appendix 3.1-9. Benthic invertebrate densities were typically low (< 5,000 organisms/m^2) in all but one stream (Figure 3.1-12). The lowest observed abundance was 404 organisms/m^2 at km 72.2 and the highest abundance was 7,181 organisms/m^2 at km 134.6.

A total of 90 invertebrate taxa were identified. The number of taxa found in individual streams ranged from 16 (km 2.2) to 48 (km 134.6) and the number of taxa contributing to 90% of community abundance ranged from 6 (km 2.2) to 17 (km 134.6) (Table 3.1-6).

Table 3.1-6
Taxonomic Richness of Benthic Invertebrate Communities in Streams, August 2001

Stream	Number of Taxa	Taxa[1] (90%)
Km 206.9	27	8
Km 192.4a	30	13
Km 134.6	48	17
Km 84.2	43	13
Km 72.2	20	12
Km 2.2	16	6

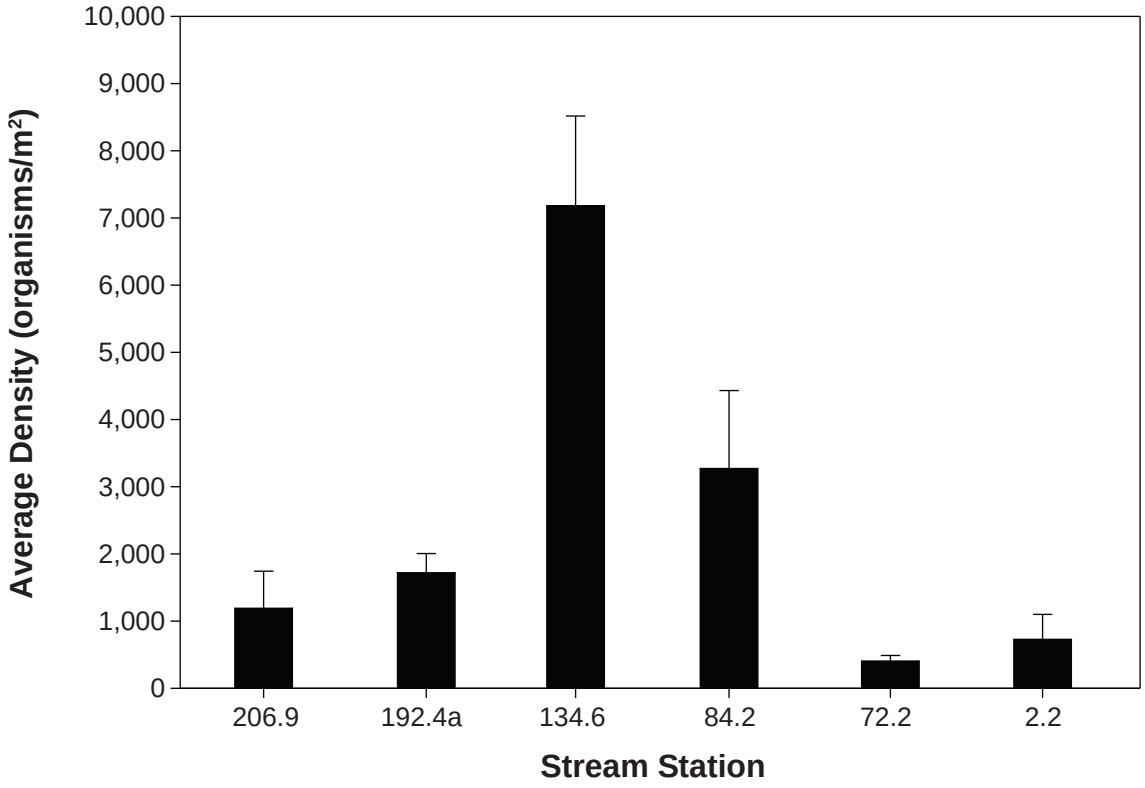
[1] Number of taxa contributing to 90% of community density.

Benthic invertebrate communities contained organisms from 17 different taxonomic groups. Overall, Diptera were the most abundant among streams (mean percent density = 43%) followed by Plecoptera (20%), and Nematoda (10%). Dipterans were dominant in four of the six streams (Figure 3.1-13), while ephemeropterans dominated at km 2.2, and nematodes dominated at km 206.9. These observations indicate that community composition can vary significantly among undisturbed streams and most likely also varies over the summer season, although temporal patterns were not examined in this study.

A total of 17 invertebrate taxa contributed greater than 5% to community abundance in the stream samples. The stonefly *Nemoura* and chironomids were the most widespread, occurring as dominant taxa in at least four of the streams (Table 3.1-7). Chironomids are a common family of aquatic insects and are an important food source for fish. Other taxa such as nematodes, and the mayfly *Pseudocleon,* were very abundant in one of the six streams.

3.1.1.5 Relationships among Streams Biota, Surface Water Chemistry and Habitat Characteristics

Results of the correlation analysis among stream biota, water chemistry and habitat variables are summarized in Table 3.1-8. Relationships between the proportion of streambed covered by boulders and benthic communities (periphyton chlorophyll *a*, periphyton taxonomic richness and benthos taxonomic richness) are presented in Figure 3.1-14.



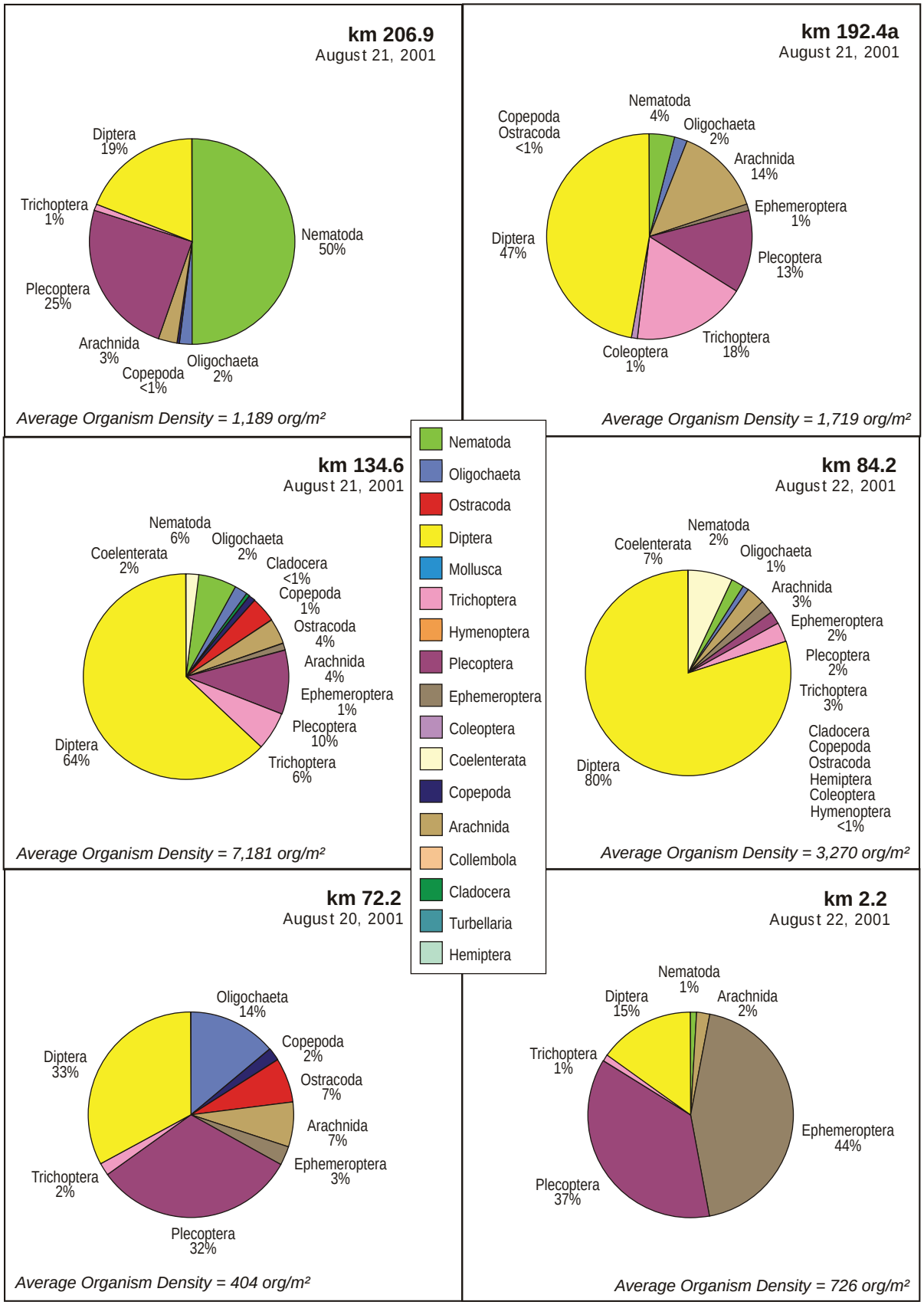
Note: Error bars represent one standard error of the mean.

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Average Benthic Invertebrate Density, Stream Stations, August 2001

FIGURE 3.1-12

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Taxonomic Composition of Benthic Invertebrate Communities, Stream Stations, August 2001

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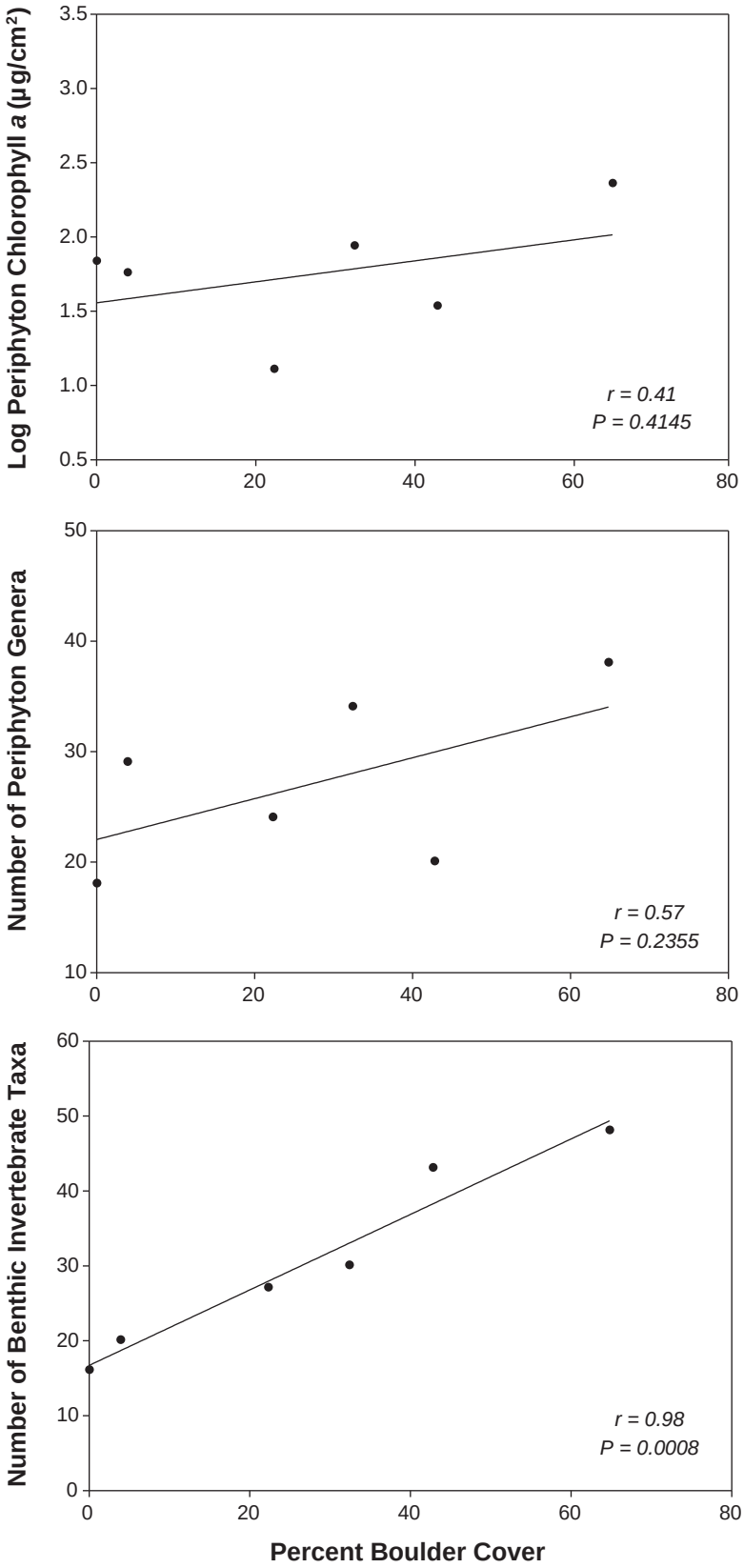
FIGURE 3.1-13

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Table 3.1-7
Percent Density of Dominant Benthic Invertebrate Taxa in Streams, August 2001

Dominant Taxa[1]	Km 206.9	Km 192.4a	Km 134.6	Km 84.2	Km 72.2	Km 2.2
Coelenterata						
Hydra				8		
Nematoda	50		6			
Oligochaeta						
Lumbriculus					14	
Ostrocoda						
Cypria					6	
Arachnida						
Hydracharina		14			7	
Ephemeroptera						
Pseudocleon						39
Plecoptera						
Nemoura	25	13	6		32	36
Trichoptera						
Brachycentrus americana		18	6			
Diptera						
Tipula					7	
Chironomidae		11	16	24	6	
Thiennemannimyia		7			7	
Tanytarsini			22	10		
Rheotanytarsus		9		27		
Stempellinella						
Orthocladiinae			6			
Cricotopus					6	5
Eukiefferiella		5				

[1]**An invertebrate taxon was considered dominant at a station if it represented ≥ 5% of total community density.**



Biomass and Taxonomic Richness of Stream Benthos in Relation to Boulder Cover in the Stream Bed, August 2001

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FIGURE 3.1-14

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Table 3.1-8
Correlations Among Periphyton, Benthic Invertebrate, Fish, Surface Water Chemistry and Stream Habitat Variables

	Periphyton Chlorophyll *a* (mg/cm^2)	Periphyton Density ($cells/cm^2$)	Periphyton Richness (# of genera)	Benthos Density (org/m^2)	Benthos Richness (# of taxa)	Fish Abundance (#/sec)	Fish Biomass (g/sec)	Stream Width (m)	Stream Depth (m)	Percent Boulder Cover (%)	Total Phosphorus (mg/L)
Periphyton Density ($cells/cm^2$)	0.345										
Periphyton Richness (# of genera)	0.648	-0.462									
Benthos Density (org/m2)	0.411	-0.144	0.428								
Benthos Richness (# of taxa)	0.334	-0.251	0.444	**0.951****							
Fish Abundance (#/sec)	-0.055	-0.557	0.54	0.182	0.308						
Fish Biomass (g/sec)	0.73	0.319	0.557	0.31	0.244	0.444					
Stream Width (m)	0.277	0.118	0.312	0.36	0.43	0.724	0.778				
Stream Depth (m)	-0.371	0.239	-0.433	-0.789	-0.608	0.102	-0.104	0.134			
Percent Boulder Cover (%)	0.414	-0.306	0.572	**0.972****	**0.977*****	0.341	0.323	0.407	-0.727		
Total Phosphorus (mg/L)	0.456	0.626	-0.061	0.125	-0.167	-0.434	0.431	-0.037	-0.407	-0.054	
Conductivity (mmhos/cm)	0.044	**0.88***	-0.618	-0.592	-0.668	-0.56	0.081	-0.1	0.55	-0.721	0.472

Notes: Correlation coefficients range from -1 to +1 and estimate the magnitude and direction of relationships between two variables.

Bold values indicate statistically significant correlation coefficients (probability < 0.05). * P<0.05, ** P<0.001, *** P= 0.0008

All variables were logarithmically transformed to meet the assumptions of the parametric statistical test except for the variables Periphyton Richness, Benthos Richness and Percent Boulders.

The correlation analysis did not reveal many relationships between stream biota, water chemistry, and habitat characteristics. Only four significant relationships were observed, two of which were due to percent boulder cover which had a strong positive relationship to benthic invertebrate density and richness (Table 3.1-8). Boulders provide excellent refuge habitat for fish and invertebrates. Boulders also give stability to the streambed during periods of high discharge. Substrate stability is an important habitat characteristic because periphyton and invertebrates are scoured from unstable substrates during high discharge events.

Benthic invertebrate density also had a significant positive correlation to benthic invertebrate richness, indicating that increased densities result in more species, rather than 1 or 2 species dominating the community.

Periphyton biomass, density and taxonomic richness were not related to total phosphorus concentration in the water column. Phosphorus, the primary limiting nutrient for periphyton, was generally very similar in concentration among streams although periphyton communities were different. Periphyton density was, however, positively related to water conductivity. Km 2.2 had the highest periphyton density and also the highest surface water ion content.

The results of the correlation analysis should be interpreted with caution. Probability values for significant correlations were not highly significant ($P < 0.05$ to 0.008) and coefficients were determined with a small sample size (six streams). A greater number of stream samples may be required to support the generality of these findings.

3.1.2 Fish Habitat and Fish Communities

3.1.2.1 Location and Dates of the Survey

A preliminary assessment was conducted on a total of 119 streams and 10 ponds between July 23 and 26. Of those 119 streams, 55 were surveyed between August 10 and 20 for complete fish and fish habitat assessments. Co-ordinates of the 55 stream crossings are presented in Appendix 3.1-10.

3.1.2.2 Fish Habitat Assessment

Appendix 3.1-11 shows results of the preliminary assessment of the 119 stream crossings and the 10 ponds. Of the 119 streams surveyed in July, 64 were identified as non-fish-bearing. These included streams with no flow or minimal flow (referred to as dry), streams with only subsurface flows or streams with no distinct channels that flowed over grassy areas.

Fish and fish habitat assessments were conducted in August on 55 streams. Habitat data sheets for each of the streams are shown in Appendix 3.1-12. Appendix 3.1-13 summarizes the habitat variables for all 55 stream crossings. Table 3.1-9 shows the ranges and averages of habitat variables measured at each of the crossings.

Table 3.1-9
Summary of Habitat Variables Measured at 55 Streams Crossed by the Road

Habitat variable	Units	Geometric Average[1]	Arithmetic Average	Minimum	Maximum
Survey distance	m	-	197	74	405
Number of habitat units	-	4	-	1	33
Average length of a habitat unit	m	46	-	6	203
Water temperature	°C	-	11.3	5.6	15.6
Conductivity	µS/cm	25	-	1	445
pH	-	-	7.1	5.3	9.4
Bankfull width	m	5.8	-	0.2	125.8
Wetted width	m	3.1	-	0.0	113.9
Bankfull depth	m	0.43	-	0.15	2.02
Wetted depth	m	0.21	-	0.05	1.71
Wetted surface area	m^2	562	-	0	23,000
Stream gradient	%	0.8	-	0.1	6.8
Glide habitat type	%	-	71	0	100
Riffle habitat type	%	-	18	0	100
Pool habitat type	%	-	6	0	83
Cascades habitat type	%	-	2	0	69
"Other" habitat type	%	-	3	0	100
Sand substrate	%	-	28	0	100
Gravel substrate	%	-	14	0	68
Cobble substrate	%	-	29	0	90
Boulder substrate	%	-	28	0	100
Bedrock substrate	%	-	2	0	78
Left bank height	m	0.23	-	0.01	3.18
Right bank height	m	0.24	-	0.01	1.57
Boulder cover	%	-	28.7	0.0	99.7
Instream vegetation cover	%	-	13.1	0.0	80.0
Overhanging vegetation cover	%	-	3.2	0.0	84.8
Pool cover	%	-	2.9	0.0	82.7
Undercut bank cover	%	-	0.8	0	5.9
Pool maximum depth	m	-	0.90	0.35	2.00
Pool crest depth	m	-	0.19	0.05	0.50
Temporary barriers to fish movement	-	-	0.22[2]	-	-
Permanent barriers to fish movement	-	-	0.22[2]	-	-
Water velocity	m/sec	0.18	-	0.0	1.1
Stream discharge	m^3/sec	0.04	-	0.00	32.50

[1] for variables with non-normal frequency distributions.
[2] fraction of streams with barriers. The variable used in analysis was presence (1) or absence (0) of barriers.
Dashes indicate no data available.

Survey Distance

The survey distance of the 55 streams ranged from 74 to 405 m, with an average distance of 197 m (Table 3.1-9). Distances less than 200 m only occurred for those streams in which the total length of the channel was less than 200 m (*e.g.*, the stream exited one lake and entered another lake in less than 200 m) or for those streams in which the channel went dry or flowed under a boulder field in less than 200 m. Survey distances greater than 200 m occurred when the reach consisted of a single habitat unit and the survey crew extended the distance in search of a unit break.

Number and Length of Habitat Units

The number of habitat units in each survey distance ranged from 1 to 33 and average length of habitat units ranged from 6 to 203 m (Table 3.1-9). There was a strong inverse and non-linear relationship between the number of units in a survey distance and the average length of a habitat unit (Figure 3.1-15). The relationship was linearized by ln-transformation of both variables. Hence, the appropriate measures of the central tendency of the number and length of habitat units were geometric averages (*i.e.*, the anti-logged averages of ln-transformed variables) rather than arithmetic averages. The geometric average number of habitat units was 4 and the geometric average unit length was 46 m. The average ln(number) was 1.427 and the average ln(length) of a habitat unit was 3.831.

Water Temperature

Water temperature, conductivity and pH were recorded at 53 of the 55 streams. Water quality data were not measured for two streams (km 52.0 and 168.0) because they had no flow.

Temperatures ranged from 5.6 to 15.6°C (Table 3.1-9). They were normally distributed (Figure 3.1-16), as would be expected of a variable that was influenced mainly by air temperature, a variable that varies little over large geographic areas. Hence, the best measure of the central tendency of the data was the arithmetic mean of 11.3°C.

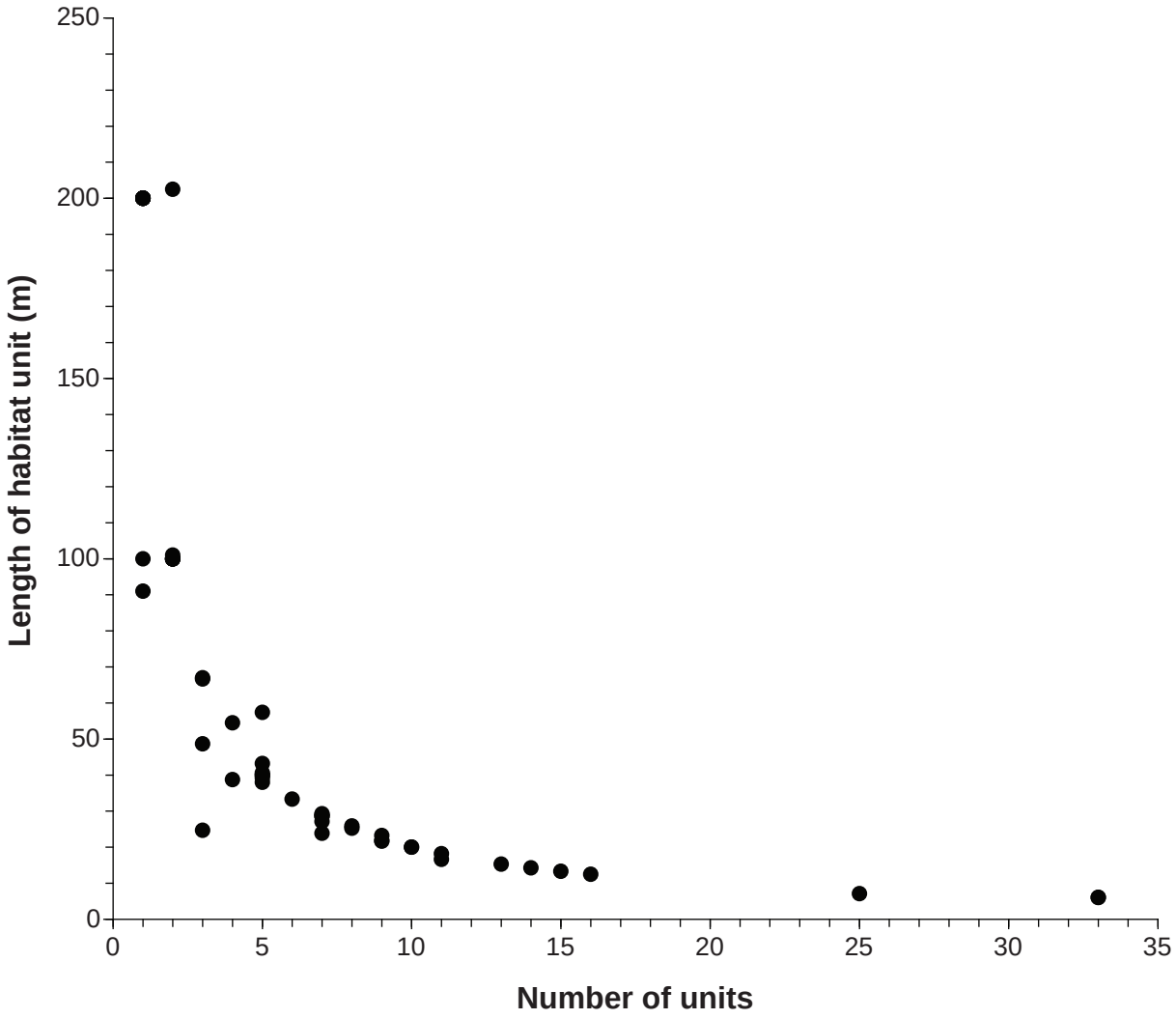
Stream water temperatures followed a dome-shaped relationship with date, rising from a stable range of 8.5 to 9.4°C between August 10 and 11, to a range of 13.0 to 12.4°C from August 12 to 16, and then falling to a low of 8.4°C on August 18 (Figure 3.1-17).

Conductivity

Conductivity of stream water ranged from 1 to 445 µS/cm (Table 3.1-9), and was highly skewed to low values – 72% of values were lower than 50 µS/cm (Figure 3.1-18). Ln-transformation normalized the distribution, hence the geometric mean was the best measure of the central tendency of the data. The geometric average conductivity was 25 µS/cm, and the average ln(conductivity) was 3.202.

pH

pH ranged from 5.3 to 9.4 (Table 3.1-9). It was normally distributed, which was expected of a variable that is already based on logarithmic units (Figure 3.1-19). Arithmetic average pH was 7.1.

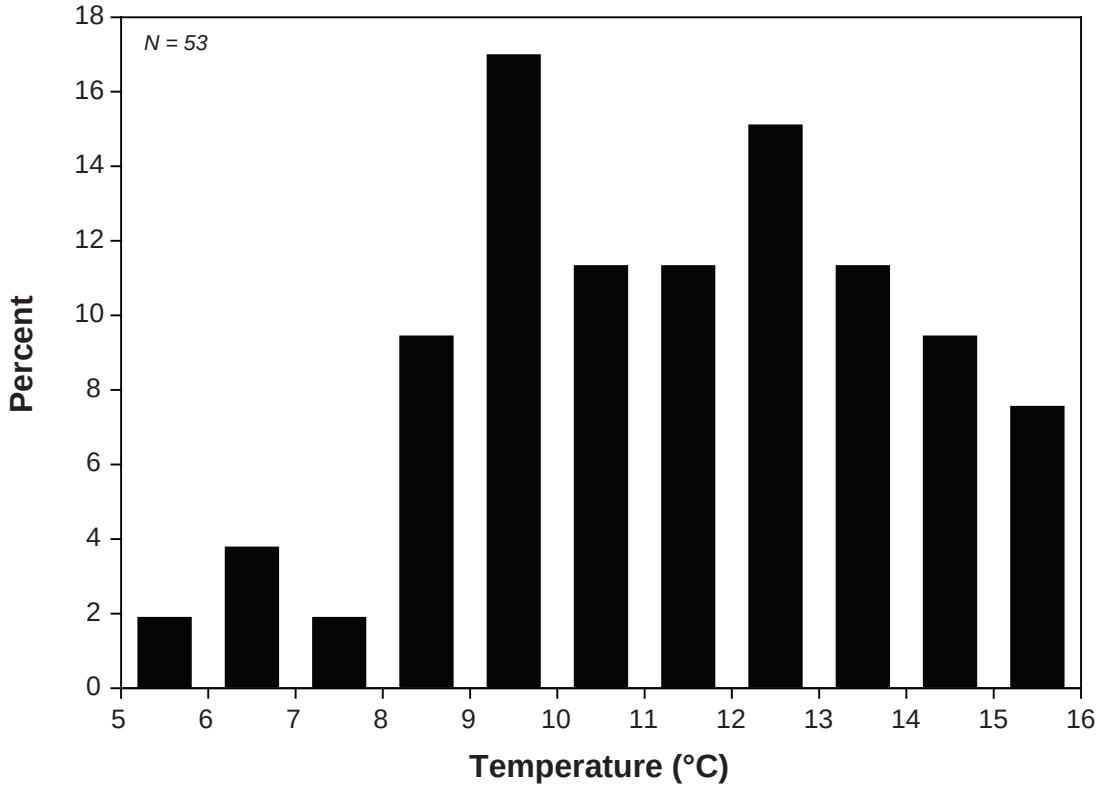


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Plot of the Length of Habitat Units on the Number of Habitat Units Present in the Survey Distance

FIGURE 3.1-15

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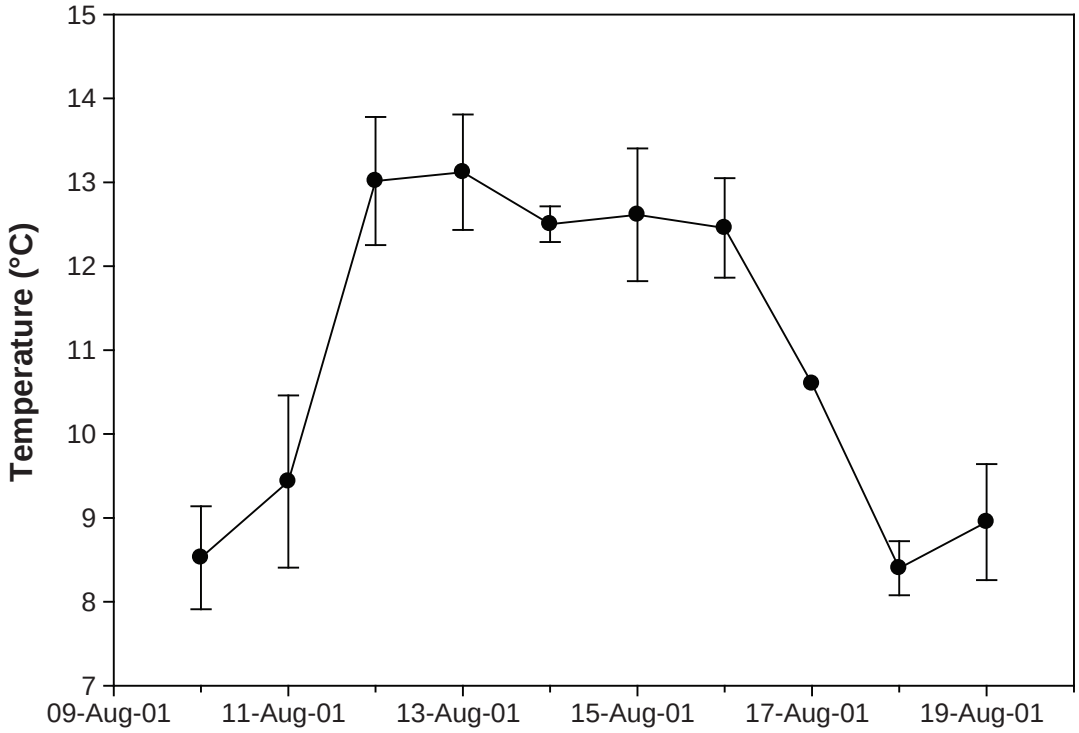


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Frequency Distribution of Stream Temperature

FIGURE 3.1-16

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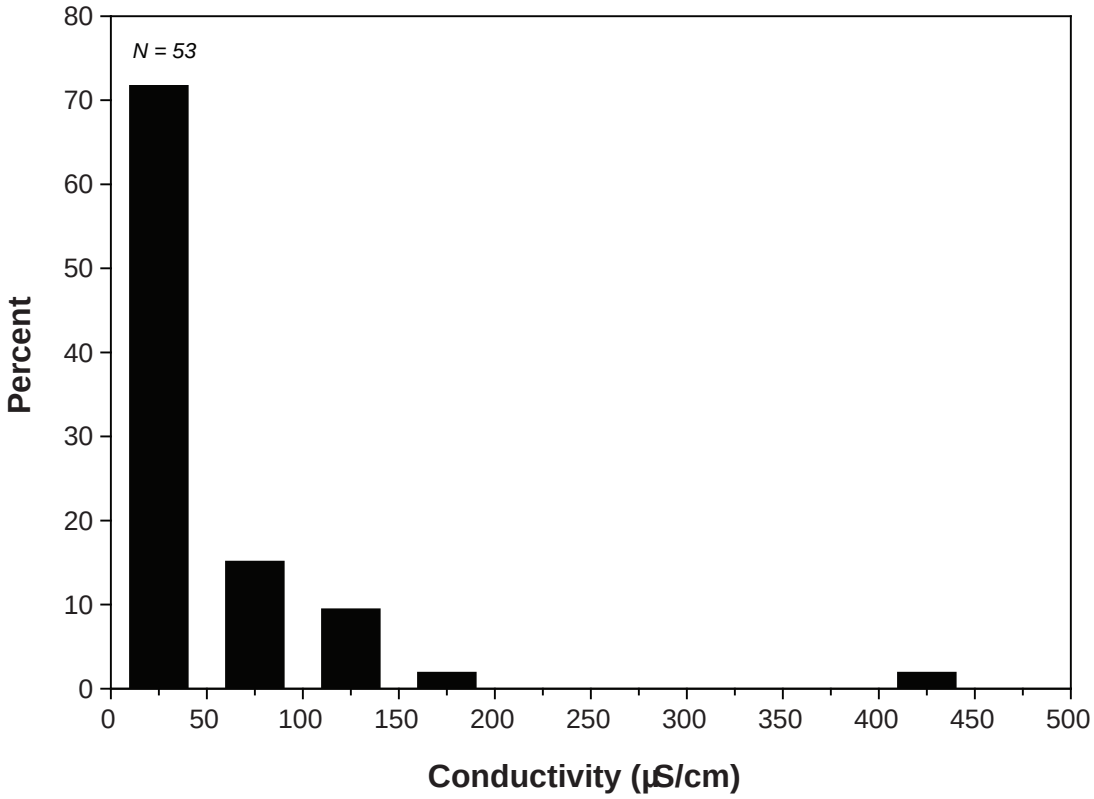


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Average Stream Water Temperatures by Date, Bathurst Road Route, August 2001

FIGURE 3.1-17

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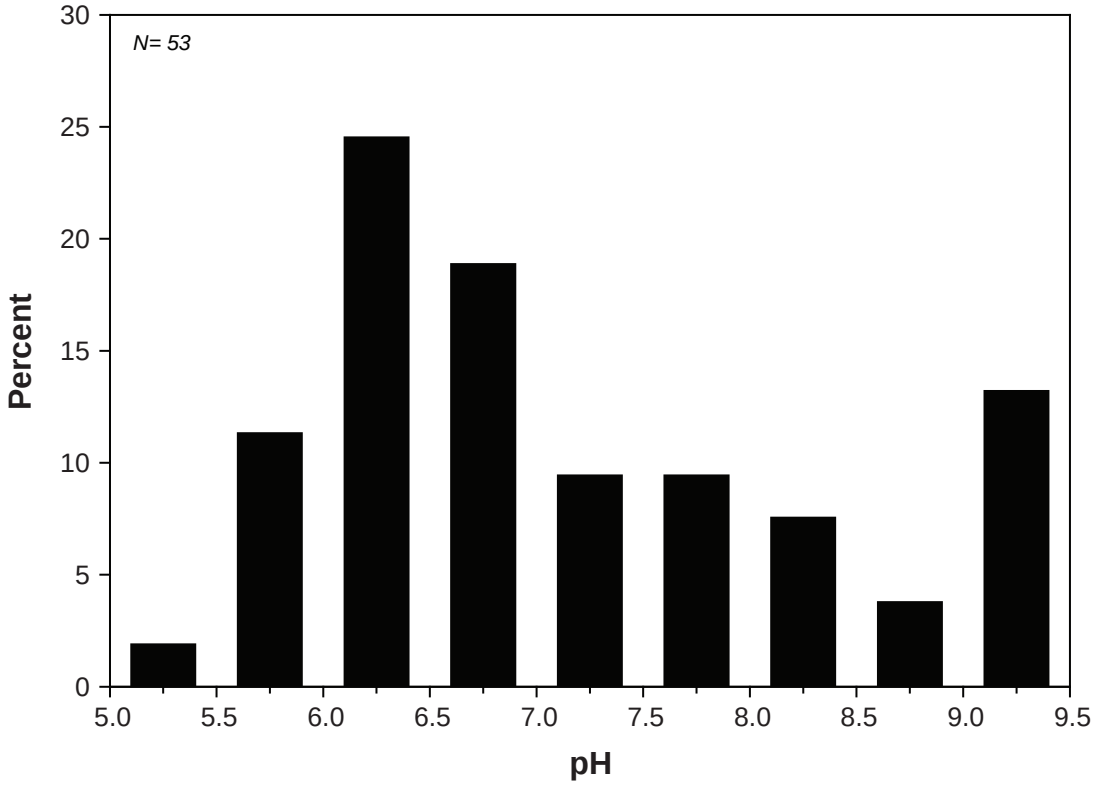


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Frequency Distribution of Stream Conductivity

FIGURE 3.1-18

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Frequency Distribution of Stream pH

FIGURE 3.1-19

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Stream Width

Stream width was measured two ways: from the top edges of the stream banks (bankfull width) and from the wetted edges of the stream (wetted width). The first measure was the expected stream width under maximum freshet conditions, and the second measure was stream width in August 2001.

Bankfull widths of the 55 streams ranged from 0.2 to 125.8 m (Table 3.1-9). The frequency distribution of bankfull width was highly skewed towards low values with 65% having widths less than 10 m (Figure 3.1-20). Logarithmic transformation normalized the frequency distribution, hence the geometric mean was the best measure of the central tendency of the data. Geometric mean bankfull width was 6.5 m, and average ln(bankfull width) was 1.764.

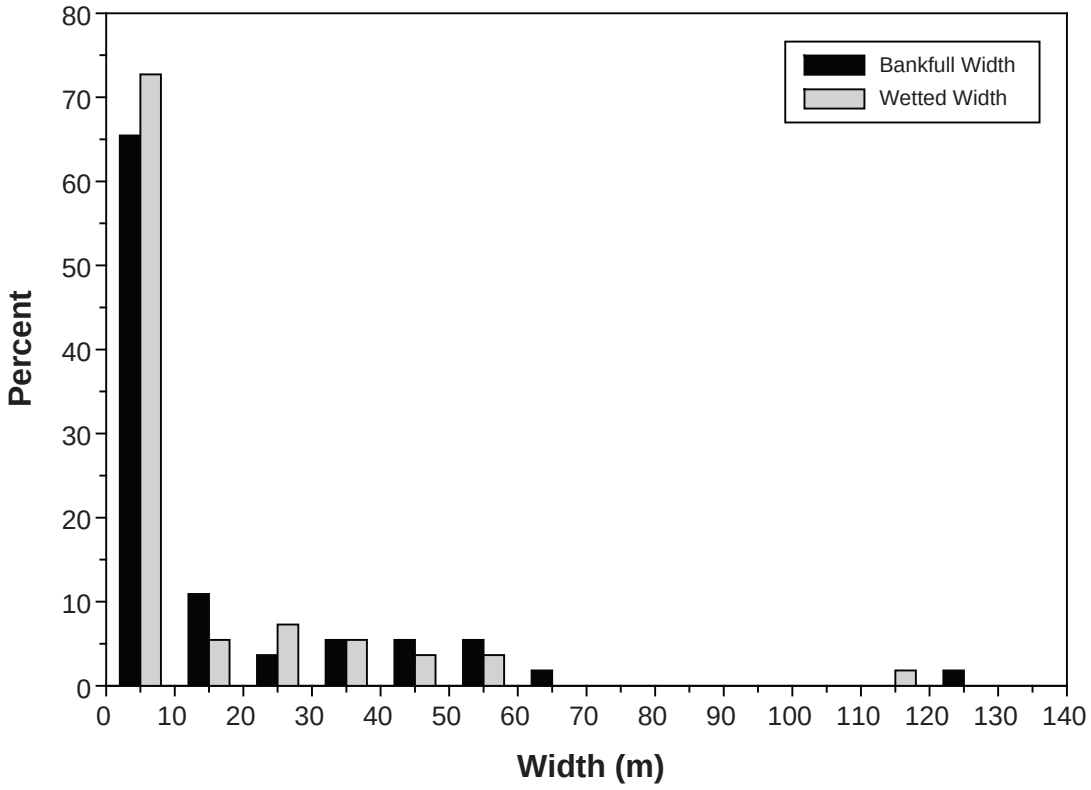
Wetted widths of the 55 streams ranged from 0.0 to 113.9 m (Table 3.1-9). Three streams had zero wetted widths: km 43.3 and 52.0 were boulder fields in which wetted width could not be measured and km 168.0 was a dry channel. The smallest non-zero wetted width was 0.2 m. As with bankfull width, the frequency distribution of wetted widths was highly skewed towards low values (Figure 3.1-20), and required ln-transformation to normalize the distribution. Hence, the geometric mean was the best measure of the central tendency of the data. Geometric mean wetted width was 3.1 m, and average ln(wetted width + 0.1) was 1.178 (the logarithm of zero is undefined, thus a value of 0.1 had to be added to wetted width in order to handle the three streams with zero wetted widths).

The frequency distributions of stream width showed two modes, indicating the presence of two classes of streams. The two modes are most clear when stream widths were plotted as ln-transformed values (Figure 3.1-21). A plot of ln(bankfull width) on ln(wetted width + 0.1) also showed the two classes (Figure 3.1-22). Forty-nine of the 55 streams fall along a straight line, indicating that for those streams wetted width is a constant proportion of bankfull width. The average proportion is 0.77. However, 6 small streams with wetted widths ranging from 0.0 to 0.7 m have bankfull widths that do not follow the proportionality rule but instead range from 2.0 to 50.0 m. Those 6 streams (km 2.8, 36.6, 43.3, 52.0, 168.0 and 183.6) have two characteristics in common: very low stream discharges and boulder fields either in part or in whole. For those streams, the low flows mean that bankfull width has been disconnected from wetted width.

Stream Depth

Stream depth was also measured in two ways: from the top edges of the stream banks (bankfull depth) and from the wetted edges of the stream (wetted depth). Bankfull depth ranged from 0.15 to 2.02 m (Table 3.1-9). The frequency distribution was skewed to shallow depths (Figure 3.1-23), and the distribution was normalized by logarithmic transformation. Hence, the geometric average was the best measure of the central tendency of the data. Geometric average bankfull depth was 0.43 m, and average ln(bankfull depth) was -0.851.

Wetted depth ranged from 0.05 to 1.71 m (Table 3.1-9), and its frequency distribution was also skewed to shallow depths (Figure 3.1-23). Transformation as ln(wetted depth + 0.01) normalized the distribution. The geometric average wetted depth was 0.22 m, and average ln(wetted depth + 0.1) was -1.557.

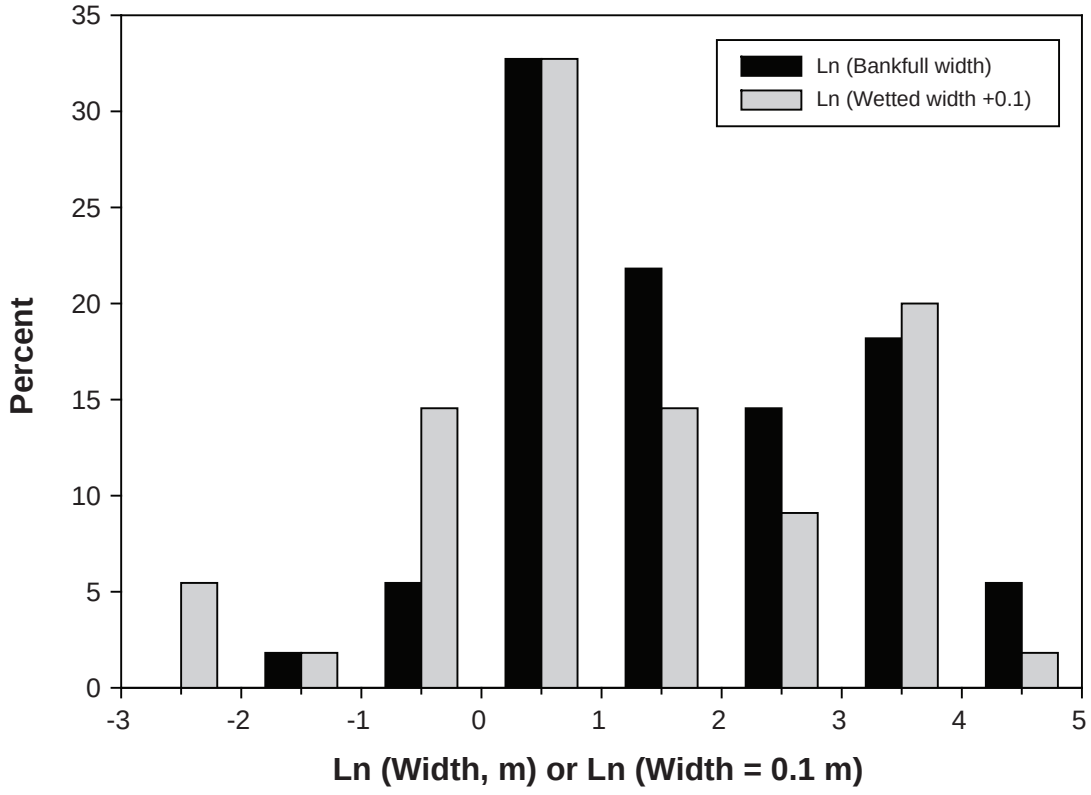


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Frequency Distribution of Stream Width for 55 Streams

FIGURE 3.1-20

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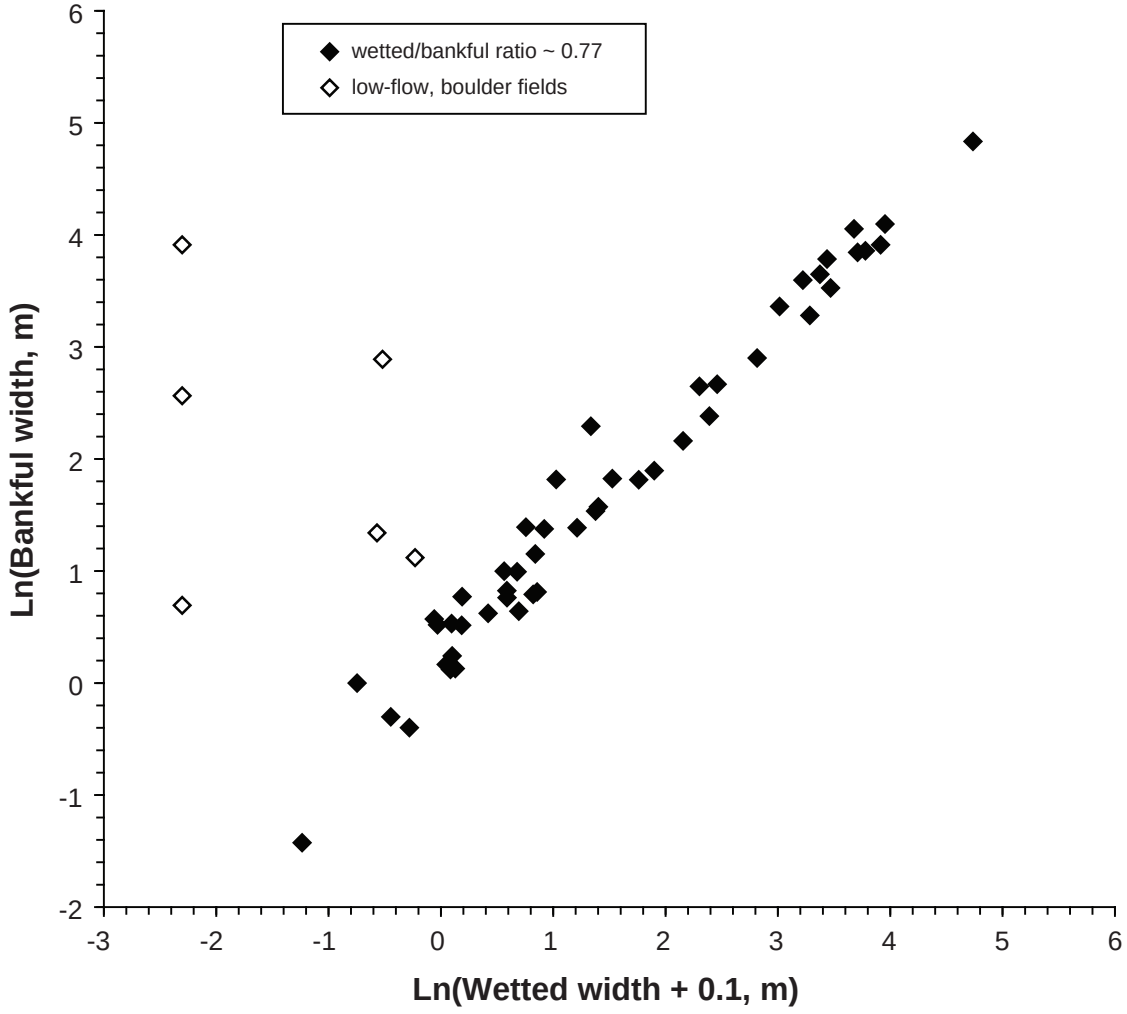


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Frequency Distribution of Ln-Transformed Stream Width for 55 Streams

FIGURE 3.1-21

Rescan™

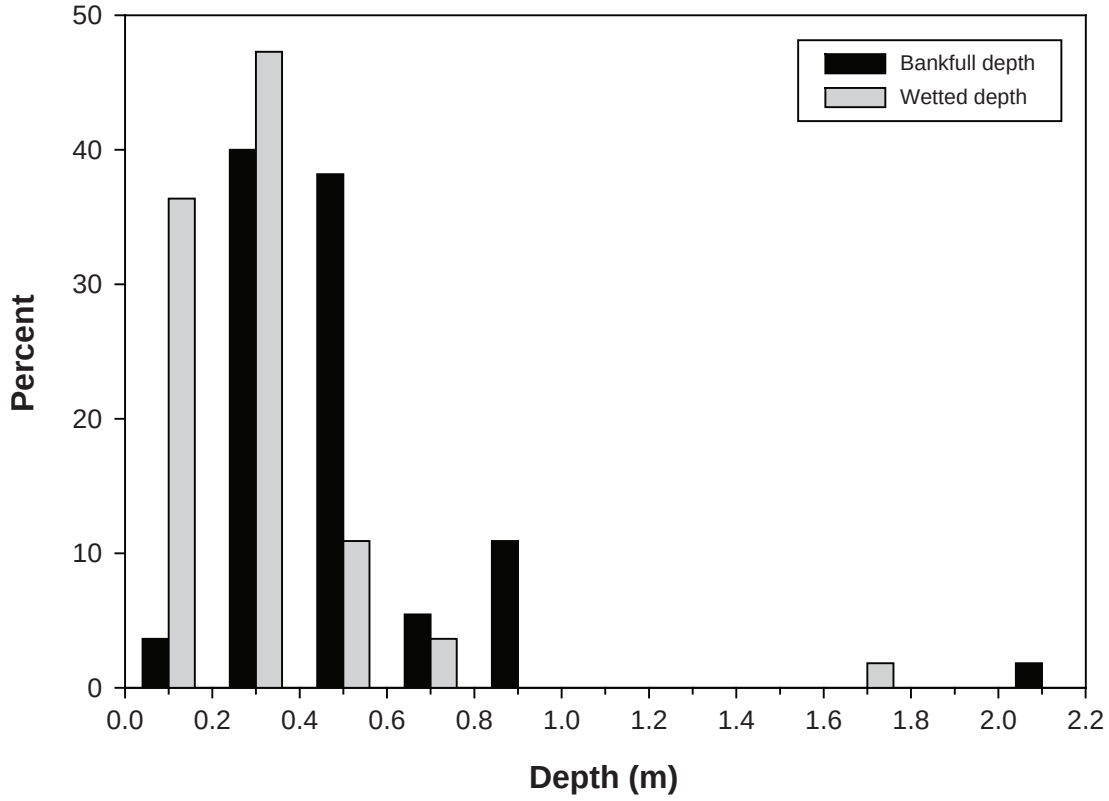


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Plot of Bankfull Width on Wetted Width for 55 Streams, Showing Two Classes of Streams

FIGURE 3.1-22

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FIGURE 3.1-23

Frequency Distribution of Stream Depth

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A plot of ln(bankfull depth) on ln(wetted depth + 0.01) showed that 52 of the 55 streams fell along a straight line indicating that they shared a common proportionality (Figure 3.1-24). For those streams, wetted depth was, on average, 57% of bankfull depth. The other three streams (km 43.3, 52.0 and 168.0, the same dry streams discussed above with regard to stream width) did not fall along that line of proportionality because they had bankfull depths of 0.3 to 0.4 m, but wetted depths of zero.

Wetted Surface Area

Wetted surface area of the survey distance ranged from 0.0 to 23,000 m^2 (Table 3.1-9). Three streams had zero wetted area because they had zero wetted width. Stream crossings km 43.3 and 52.0 were boulder fields in which wetted width could not be measured and km 168.0 was a dry channel. The frequency distribution of wetted surface area was highly skewed to low areas (Figure 3.1-25), but transformation of wetted area as ln(area + 10) successfully normalized the frequency distribution. Hence the geometric mean was the best measure of the central tendency of the surface area data. The geometric average wetted area was 562 m^2, and the average ln(area + 10) was 6.332.

Stream Gradient

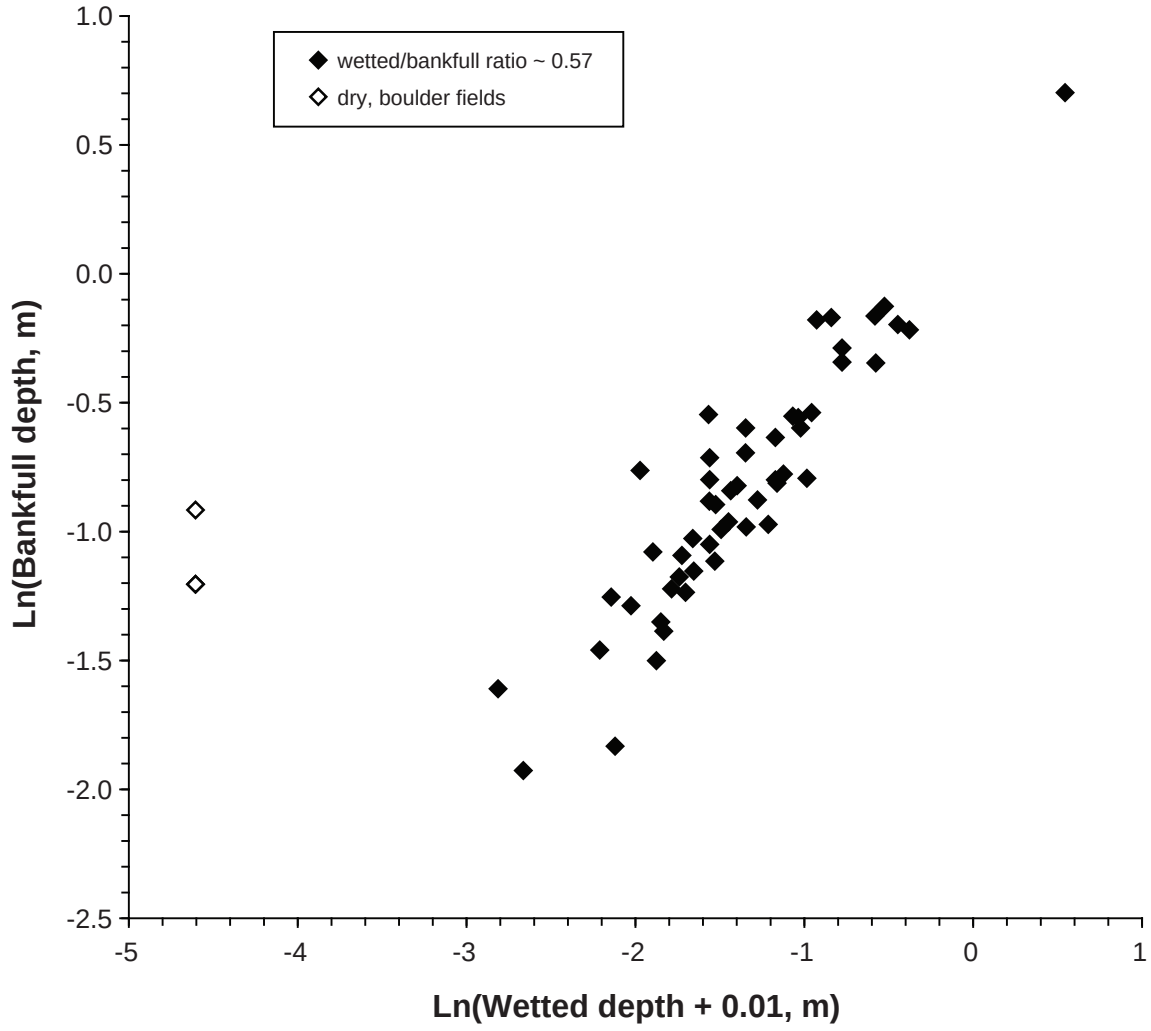
Gradient ranged from 0.1 to 6.8% (Table 3.1-9). The frequency distribution of percent gradient was highly skewed to low values with 65% of streams having gradients lower than 1.0% (Figure 3.1-26). The standard transformation for percentages, $\arcsin(\text{percent}/100)^{0.5}$ (Zar, 1984), successfully normalized the distribution. Average transformed gradient was 5.713°, which was equivalent to an average gradient of 1.2%.

Habitat Type

Habitat types were not assigned to 3 of the 55 streams because they consisted of boulder fields (km 43.3 and 52.0) or were a dry channel (km 168.0). For the other 52 streams, glide habitat was the most common type, making up an average of 71% of wetted surface area (range = 0 to 100%) (Figure 3.1-27). Riffles were the next most common habitat type, making up an average of 18% of wetted surface area (range = 0 to 100%). Pools made up an average of 6% of wetted surface area (range = 0 to 83%), and cascades (range = 0 to 69%) and "other" (range = 0 to 100%) each made up an average of 2% and 3% of the wetted surface area, respectively.

Substrate Composition

Substrate composition was available for all 55 streams, even if they did not all have water at the time of survey. Cobbles were the most common type of substrate, making up an average of 29% of wetted surface area (range: 0 to 90%) (Figure 3.1-28). Sand (range: 0 to 100%) and boulder (range: 0 to 100%) each made up an average of 28%, gravel made up an average of 14% (range: 0 to 68%), and bedrock made up only 2% (range: 0 to 78%). Of the 25 possible combinations of substrate types, only 10 combinations were observed and only a few of those were commonly observed. The most common combination was sand-gravel-cobble-boulder, observed in 24 streams or 44% of the 55 streams.

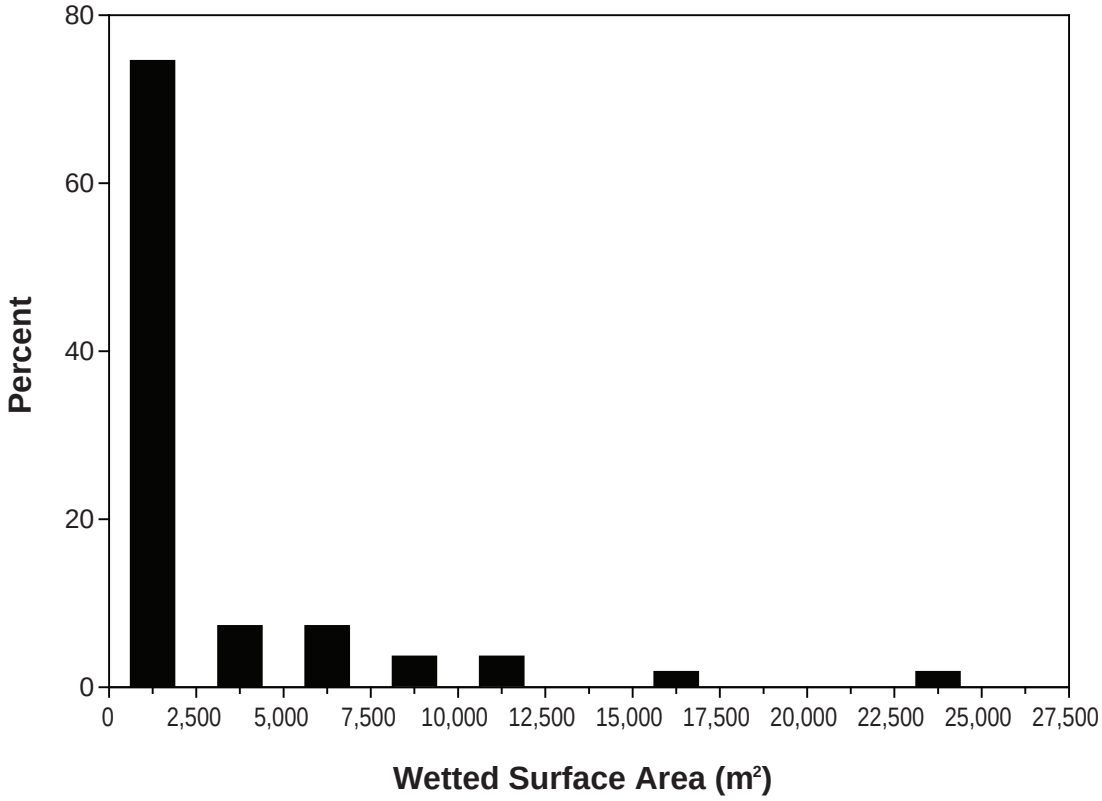


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Plot of Bankfull Depth on Wetted Depth for 55 Streams

FIGURE 3.1-24

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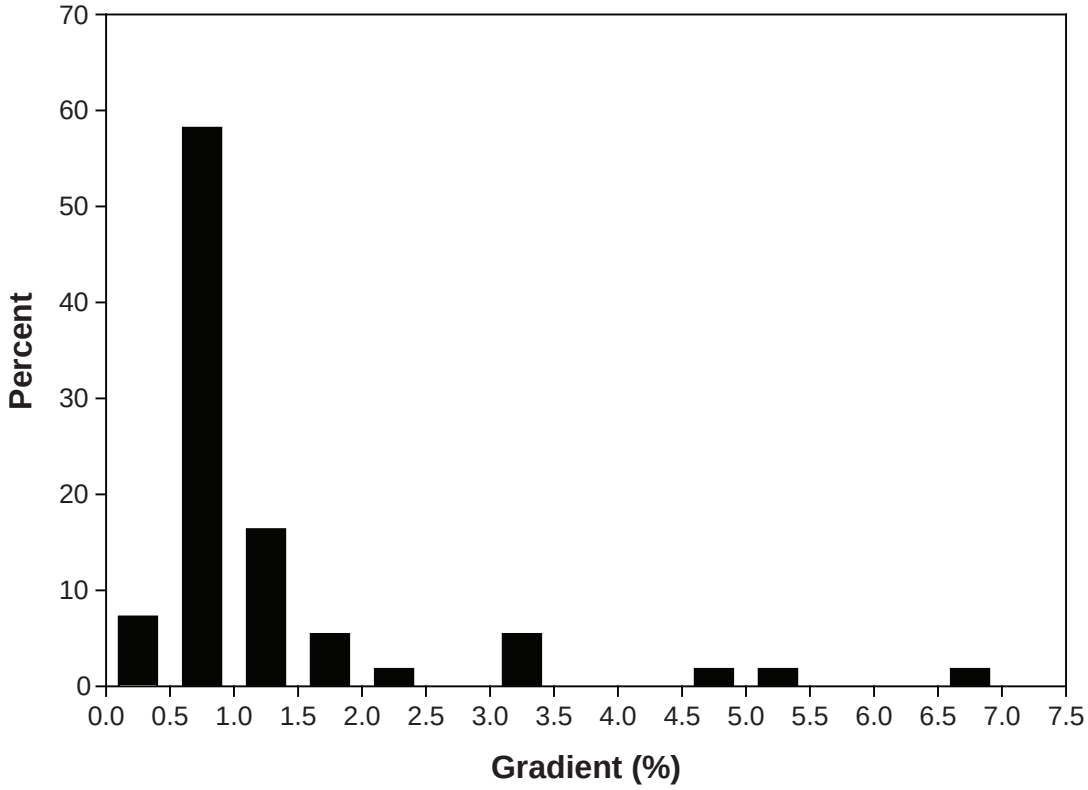


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Frequency Distribution of Wetted Surface Area of the Survey Distance of 55 Streams

FIGURE 3.1-25

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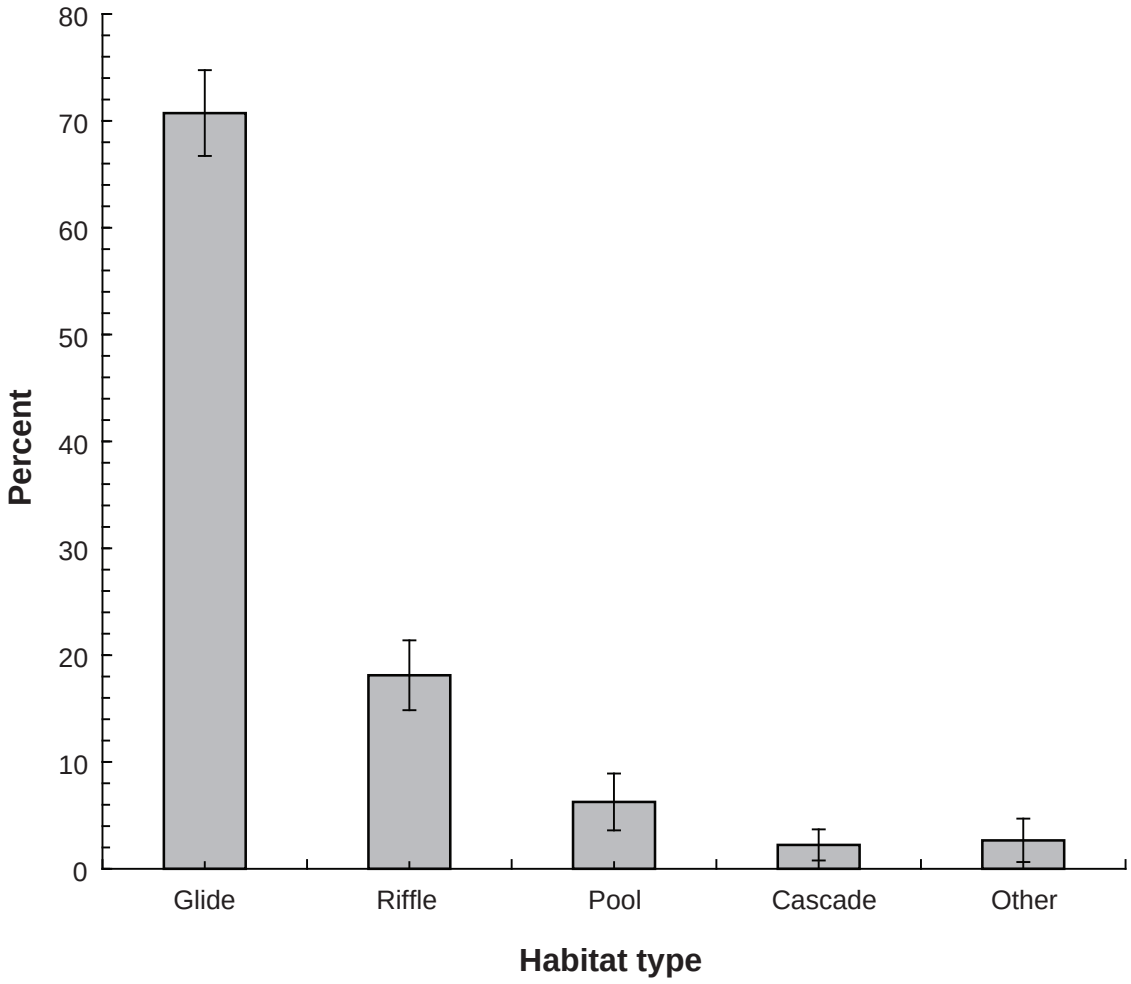


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Frequency Distribution of Gradient for 55 Streams

FIGURE 3.1-26

Rescan™

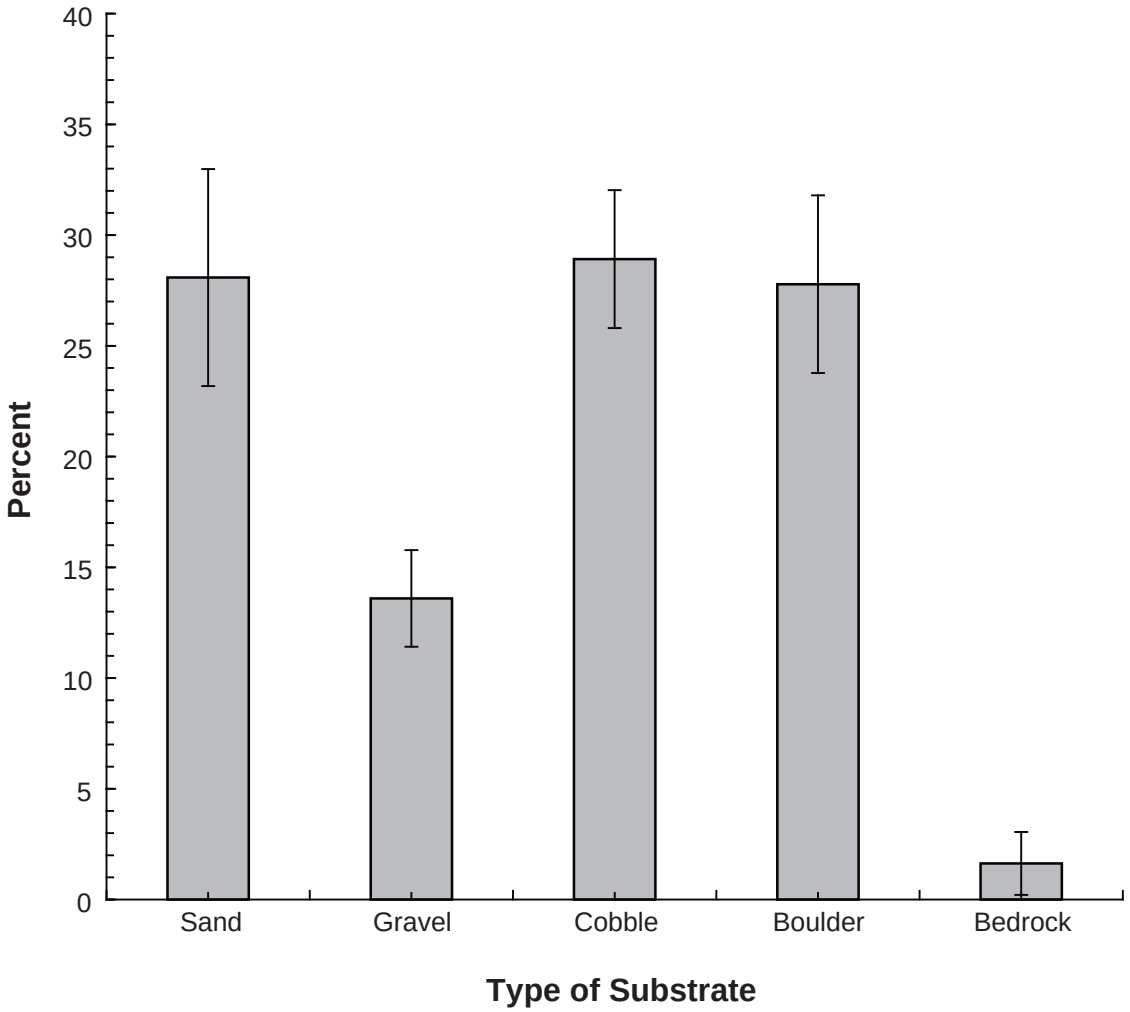


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Average Percent of the Wetted Surface Area of a Survey Distance made up of Five Habitat Types

FIGURE 3.1-27

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Average Percent of Substrate in Five Types for 55 Streams

FIGURE 3.1-28

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Bank Height

Stream bank height was measured from the water surface to the upper edge of the bank for both left and right banks. It ranged over three orders of magnitude (from 0.01 to 3.18 m) (Table 3.1-9 and Figure 3.1-29), and ln-transformation was required to normalize its frequency distribution. That meant that the geometric average was the best measure of the central tendency of the data. Geometric average bank height (pooled over left and right banks) was 0.24 m. Average ln(bank height) (also pooled over left and right banks) was -1.443.

Cover

Boulders were the most common source of cover for fish in the 55 streams, covering an average of 28.7% of the wetted surface area of the survey distance of a stream (Figure 3.1-30). Boulder cover was found in 45 of the 55 streams, and covered between 0 to 99.7% of the wetted surface area of those 45 streams. Instream vegetation (mainly submerged grasses) was the next most common source of cover (13.1%). It was found in 34 streams and accounted for 0 to 80.0% of the wetted surface area of those streams. Overhanging vegetation was third (3.2%). Most of it consisted of grass and willow shrubs that grew along the stream banks. It was found in 18 streams and covered between 0 and 84.8% of the surface area of those streams. Pool cover was fourth in importance (2.9%). It was found in 11 streams and accounted for 0 to 82.7% of surface area of those streams. Maximum depth of pools (averaged over the survey distance of each stream) ranged from 0.35 to 2.00 m and averaged 0.90 m. The crest depth of pools (the depth at the lip of the pool where the stream entered) ranged from 0.05 to 0.50 m and averaged 0.19 m. Undercut banks was the least common source of cover (0.8%). It was found in 22 streams and ranged from 0 to 5.9%.

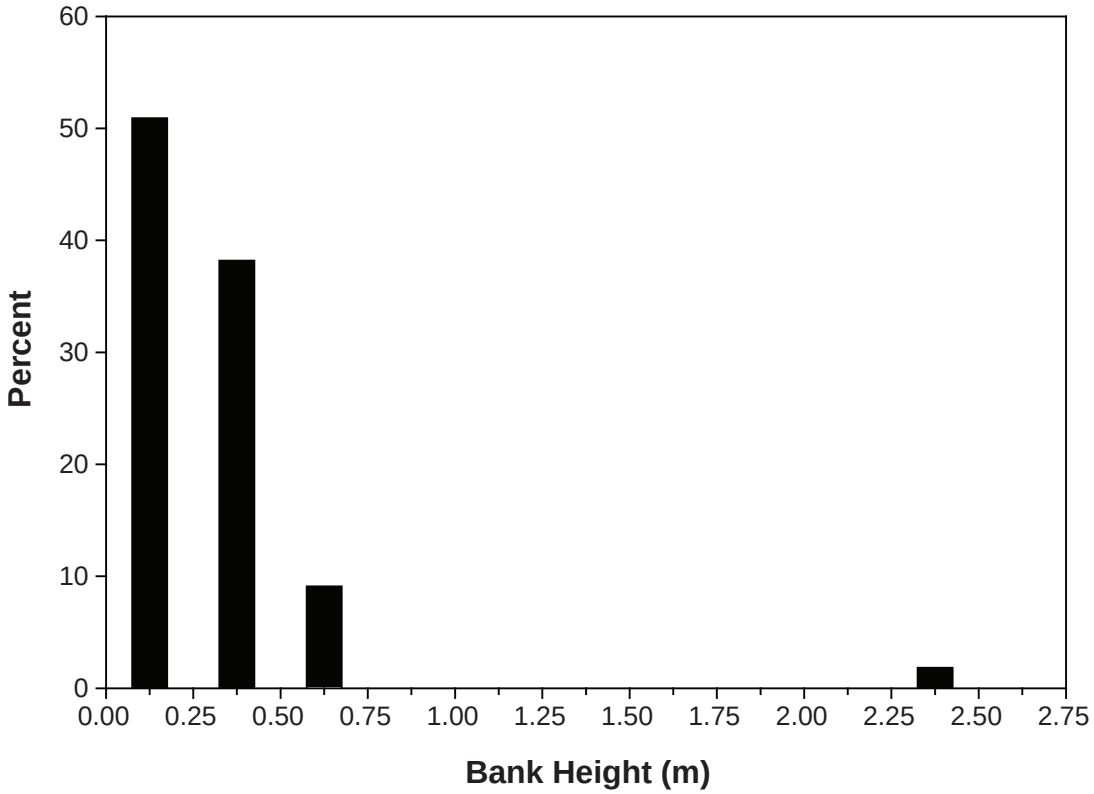
Barriers to Fish Migration

Barriers to fish migration were observed in 24 of the 55 streams (Table 3.1-10). Boulder fields were the most common type, being found in 7 of the 24 streams. In 6 of those 7 streams the boulder field was a permanent barrier that was not expected to be surmounted during spring freshet. The boulder field in the other stream was expected to be submerged during spring freshet, thereby allowing fish migration at that time.

The second most common barrier was a dry channel, which was found in 6 of the 24 streams. With one exception, dry channels were classified as temporary barriers because they were expected to be flooded during freshet. The exception was the dry channel of km 168.0, which was classified as a permanent barrier.

The third most common barrier was “no channel,” which was observed in 5 streams.

These were small streams with reaches that disappeared into wet, grassy meadows or boulder fields, leaving no discernible channel. With one exception, all were classified as temporary barriers because freshet flows would create a channel even if one did not exist during summer. The exception was km 186.5, which narrowed into a caribou trail and then flowed under a thick boulder field.

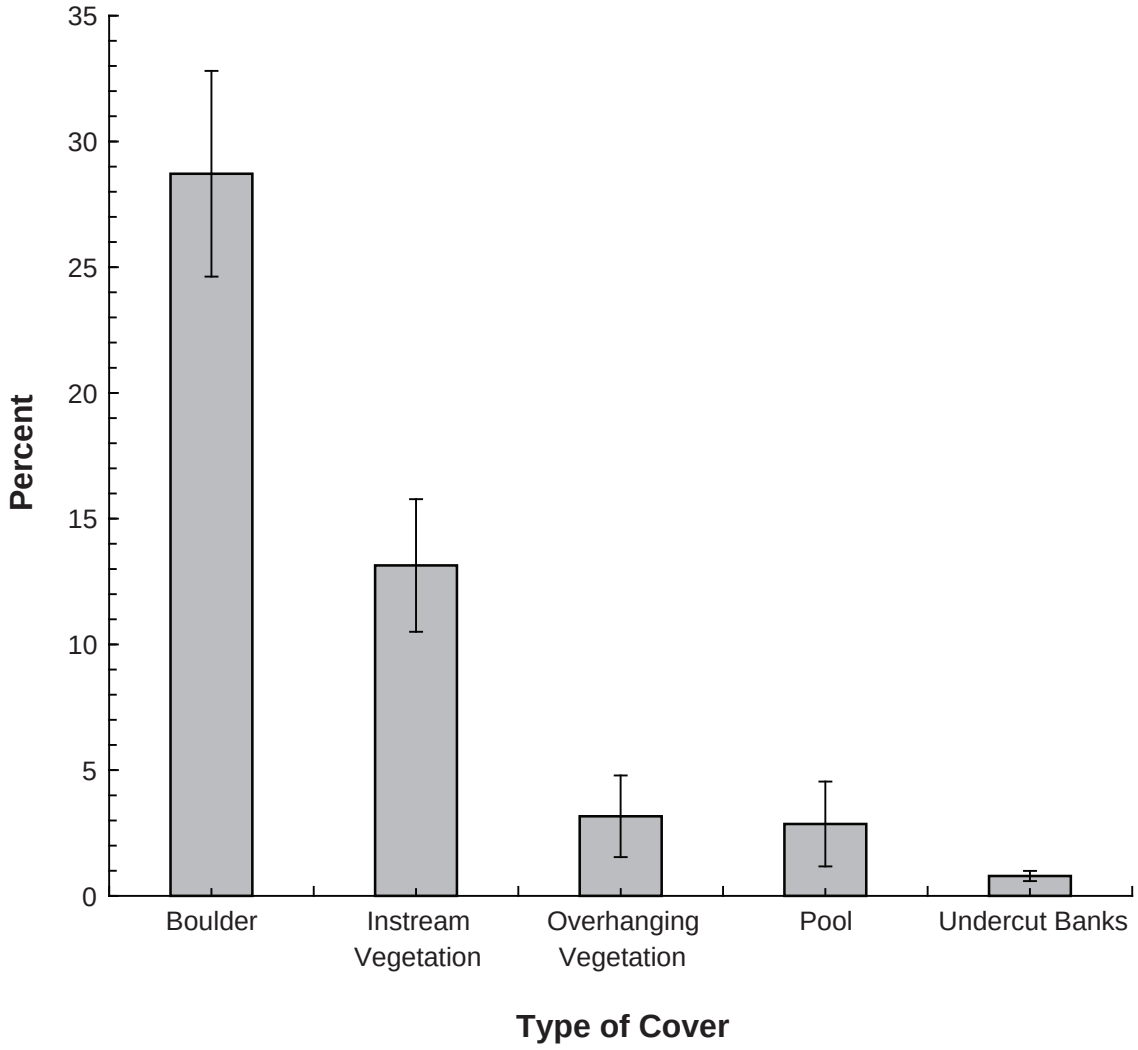


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Frequency Distribution of Left and Right Bank Height for 55 Streams

FIGURE 3.1-29

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Average Percent Cover for Fish, Pooled Over 55 Streams

FIGURE 3.1-30

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Table 3.1-10
Streams with Barriers to Fish Migration

Stream:	Boulder	Dry	No	Impassable	Significance	
km	field	channel	channel	waterfall	Temporary	Permanent
33.8		X			X	
36.6		X			X	
42.3	X				X	
43.3		X			X	
49.7	X					X
52.0		X			X	
58.7	X					X
70.1				X		X
85.0	X					X
90.3				X		X
103.3	X					X
134.6	X					X
168.0		X				X
170.8	X					X
183.6		X			X	
186.5			X			X
189.6				X	X	
192.4	X					X
196.7	X		X		X	
197.0			X		X	
197.4			X		X	
204.3	X					X
208.2			X		X	
Total	10	6	5	3	11	12

Impassable waterfalls were observed in three streams, of which two were classified as permanent barriers and one (km 189.6) was classified as temporary because the waterfall was only 0.35 m high.

Water Velocity

Water velocity was estimated at 47 streams. Velocity could not be estimated at five streams (km 36.6, 43.3, 52.0, 196.7 and 197.0) because there was no flow or it was too low to estimate. It could not be estimated at another three streams (km 49.7, 90.3 and 103.3) because water flowed beneath boulder fields.

Water velocity ranged from 0.0 to 1.1 m/sec, and was skewed to low velocities (Figure 3.1-31). Its frequency distribution was normalized by ln-transformation (after adding 0.01 to account for streams with zero velocity), hence the geometric average velocity was the best measure of the

central tendency of the data. Geometric average velocity was 0.18 m/sec, and average ln(velocity + 0.01) was -1.7027.

Stream Discharge

Discharge estimates were calculated for 51 streams. Discharge could not be calculated for three streams (km 49.7, 90.3 and 103.3) because water flowed under boulder fields making it impossible to measure water depth and velocity. Discharge was assumed to be zero for streams with zero velocity.

Discharge of the 51 streams ranged over five orders of magnitude from 0.0 to 32.5 m^3/sec (Table 3.1-9). The 12 streams with zero estimates had either no flow or the water moved so slowly that velocity (and hence discharge) could not be estimated with the floating chip method. The smallest discharge that could be estimated was 0.002 m^3/sec.

The frequency distribution of discharge was highly skewed towards low flows – over 92% of the estimates were less than 5.0 m^3/sec. Transformation of discharge by ln(discharge + 0.001) normalized the distribution, hence the geometric average discharge was the best measure of the central tendency of the data. The geometric average discharge was 0.037 m^3/sec, and the average transformed discharge was -3.286.

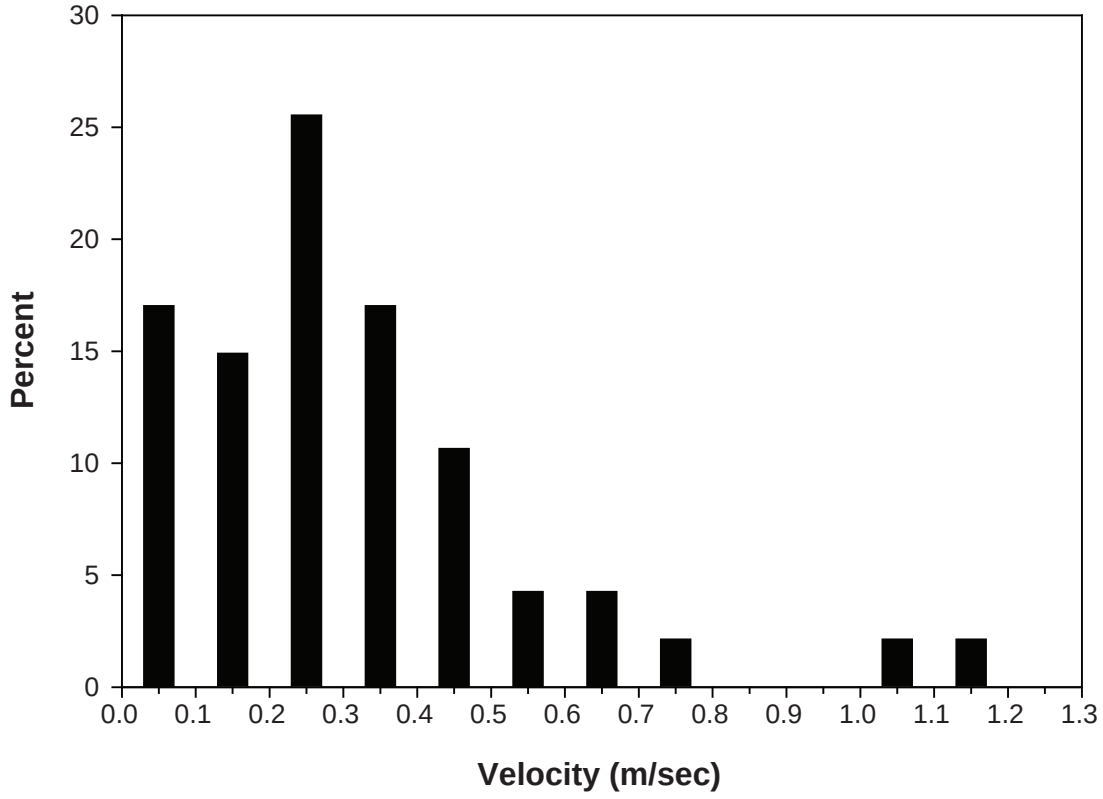
3.1.2.3 Fish Habitat Analysis

This section of the report calculated correlations among the habitat variables (thereby assessing the degree of redundancy within the habitat data set), and used factor analysis to reduce the data set to four un-correlated factors that represented the major axes of variation in stream habitat. This section also includes a description of watershed area for each stream. Watershed area was not included in the suite of habitat variables measured in the survey distances part of the stream crossing survey. Instead, it was estimated from 1:50,000 maps of the Road route.

Correlations Among Habitat Variables

The purpose of calculating correlations among the 34 habitat variables was to assess the overall level of redundancy in the habitat data set. Redundancy means that many variables share information. The greater the level of redundancy in a data set, the greater is the need to use a data reduction technique such as factor analysis to identify the major axes of variation in the data.

Correlation coefficients were calculated between all 34 habitat variables (Appendix 3.1-14). Barriers to fish migration were included by creating two variables: temporary barriers and permanent barriers. Both variables had values of 0 (no barrier) or 1 (barrier) for each stream. The other 32 variables were transformed, if necessary, to satisfy the requirement for a normal distribution. The only variables that were not transformed were those that were already normally distributed (temperature, pH, maximum depth of pools, and crest depth of pools). Sixteen of the 28 remaining variables were percentages, and their distributions were normalized with the $\text{arcsine}(X/100)^{0.5}$ transformation, where X was the percentage. The other 12 variables were normalized with the ln(X + Y) transformation, where X was the variable and Y was a number added to the variable to handle zero values. Y was zero for the number of habitat units, average



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Frequency Distribution of Stream Velocity for 47 Streams

FIGURE 3.1-31

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length of a habitat unit, conductivity, bankfull width, bankfull depth, left bank height, and right bank height. Temperatures, conductivities and pH values were not available for 2 of the 55 streams. Those six empty cells were filled with averages for each variable over the 53 streams. That is considered statistically acceptable because the percentage of cells filled with averages (2 cells out of 55 cells or 4% of the total) for each correlation coefficient was much less than the commonly-accepted limit of 10% (Zar, 1984).

Of the 561 correlation coefficients, only 40 (or 7% of the total) were significant at the $P < 0.05$ level. Eight variables: stream temperature, percent bedrock substrate, percent overhanging and undercut cover, and glide, riffle, cascade and other percent habitat types were not significantly correlated with any other variable. The other 26 variables were significantly correlated with between 1 and 7 other variables. Eight variables had 4 or more significant correlations: bankfull width (7), wetted width (4) and wetted area (5), wetted depths (5), sand substrate (5), pool cover (4), instream cover (4) and velocity (4). Five variables measured an aspect of stream size (including velocity).

Many of the correlations make intuitive sense because they flow directly from the geometry of streams and from the classification systems used in this study. The strongest correlations were between variables that were directly linked either through measurement or calculation, *e.g.*, wetted width and wetted area ($r = 0.99$), percent boulder substrate and percent boulder cover ($r = 0.99$), number of habitat units and average length of a habitat unit ($r = -0.97$), left bank height and right bank height ($r = 0.98$), water velocity and stream discharge ($r = 0.82$), maximum pool depth and crest pool depth ($r = 0.83$), and wetted width and bankfull width ($r = 0.73$).

Correlations with absolute strengths between 0.37 and 0.75 were between variables that were less directly linked, *e.g.*, wetted area and bankfull width ($r = 0.70$), wetted area and stream discharge ($r = 0.75$), percent sand substrate and percent boulder substrate ($r = -0.67$), pH and conductivity ($r = 0.65$), the presence of temporary barriers and water velocity ($r = -0.59$), the presence of permanent barriers and stream gradient ($r = 0.48$), and percent cascade habitat and stream gradient ($r = 0.42$).

In summary, the habitat data for stream crossings along the Road route are highly redundant because many variables were correlated with each other. This meant that factor analysis was required to identify the major axes of variation in the data set.

Factor Analysis of Habitat Variables

The most effective means of reducing the habitat data set to a manageable core of key variables was to use factor analysis to extract from the data several artificial variables (called factors) that contain most of the variance in fish habitat. Variables used in the factor analysis that did not follow a normal distribution curve were ln-transformed. All proportional data was transformed using arcsine $(\text{percent}/100)^{0.5}$. The first run of factor analysis with all 34 habitat variables showed that there were at least three significant factors and perhaps as many as four factors. The other 29 to 31 factors were assumed to represent axes of variation that were essentially statistical noise (factor analysis extracts as many factors as there are input variables, but only the first few factors represent meaningful axes of variation). Together, the first four factors explained 41% of

the total variance in the data set. Nineteen of the 34 variables were significantly correlated with the four factors.

To enhance comprehension of the data, the 15 variables not correlated with the first four factors were excluded from the second run of factor analysis. Four factors were extracted in that second run and they explained 69% of the total variance of the reduced data set. The loadings (correlation coefficients between variables and factors) of the 19 variables on each of the four factors are shown in Table 3.1-11.

Table 3.1-11
Loadings of Habitat Variables on Factors Extracted from the Reduced Habitat Data Set in the Second Run of Factor Analysis

	Loadings on Factor			
Habitat Variable	**1**	**2**	**3**	**4**
Discharge	0.914			
Wetted Area	0.906			
Wetted Width	0.901			
Velocity	0.785			
Wetted Depth	0.671			
Temporary Barriers	-0.643			
Bankfull Depth	0.564			
Maximum Pool Depth		0.949		
Crest Pool Depth		0.868		
% Pool Cover		0.858		
% Pool Habitat		0.808		
Habitat Length			0.819	
Number of Habitat Units			-0.817	
% Gravel Substrate			-0.783	
% Riffle Habitat			-0.696	
% Cascade Habitat				-0.713
Permanent Barriers				-0.659
% Bedrock Substrate				-0.649
% variance explained	**23%**	**22%**	**15%**	**9%**

Habitat variables are either ln-transformed, or arcsince(percent/100)0.5 with the exception of maximum pool depth, crest pool depth, temporary and permanent barriers.
Loadings are correlation coefficients of habitat variables with factors.
Only the significant loadings are shown.

The loading pattern showed that the first factor is an index of stream size. It is dominated by variables such as discharge, wetted area, wetted width, velocity, wetted depth, and bankfull depth that are clearly an aspect of stream size. For these 6 variables all loadings are positive, indicating that they all increase together. One variable, temporary barrier, was the only negative loading of factor 1, which reveals that as stream sizes increase the frequency of temporary barriers decreases. This makes sense because barriers are classified as temporary when low water levels restrict access to fish movement up or downstream.

Factor 2 is an index of maximum pool depth, with all four loadings (maximum pool depth, crest pool depth, percent pool cover, percent pool habitat) positively related and increasing together. This makes intuitive sense; as maximum pool depth increases so does the percent pool cover and habitat for fish, along with the crest pool depth.

The third factor is an index of riffle habitat. The pattern of loadings shows that as the average length of a habitat unit increases, the percent of substrate made of gravel, the percent of riffle habitat, and the number of habitat units all decrease. This means that in short habitat units, gravel substrate and riffle habitat are linked variables. In other words, the longer a habitat unit is, the less likely it is to contain gravel substrate and the more likely it is to be something other than riffle habitat.

The fourth factor is an inverse index of percent cascade habitat, with permanent barriers to fish movement and percent gradient of a stream increasing with increasing percent cascade habitat.

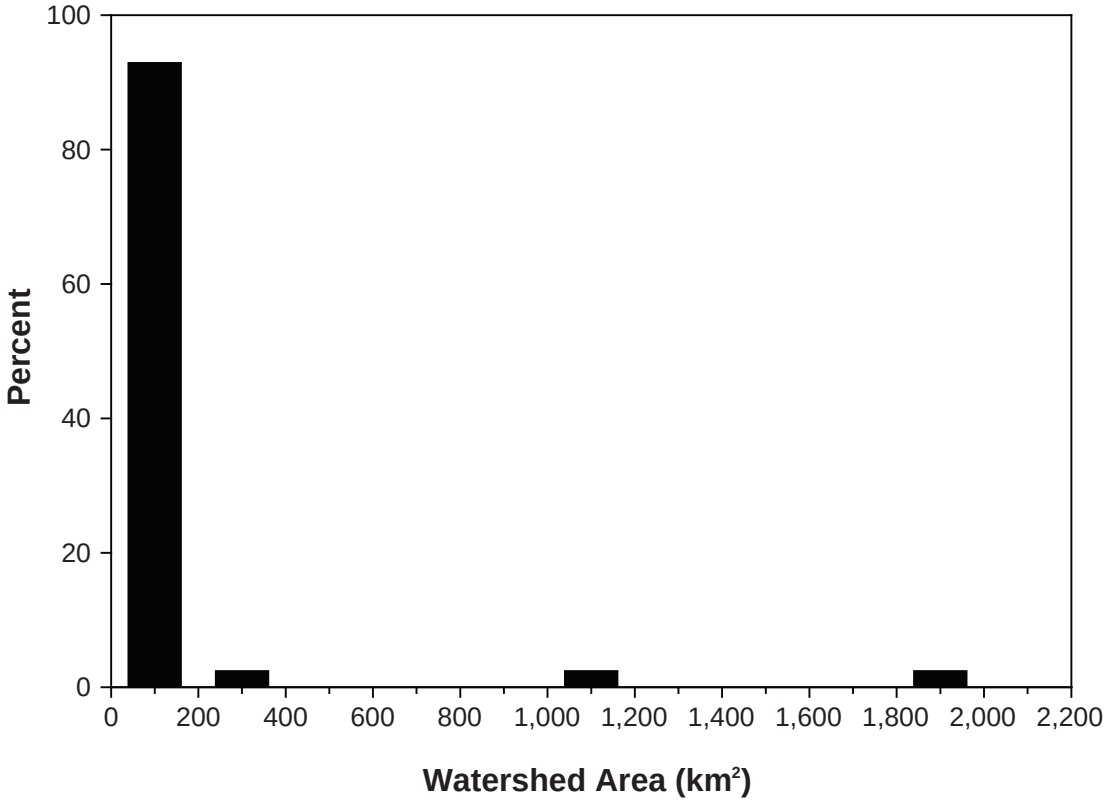
In summary, factor analysis showed that nearly half of the variance in stream habitat data can be summarized by only four factors: stream size, maximum pool depth, amount of riffle habitat and percent cascade habitat. The rest of the variance is primarily statistical noise.

Rather than use those four factors in subsequent analyses, it was intuitively simpler and more convenient to use habitat variables that were highly correlated with the factors. Hence, stream width is the best index of the stream size factor because it is highly correlated ($r = 0.90$) with the stream size factor and easier to measure or calculate than discharge or wetted area. In the same way, maximum pool depth, percent riffle habitat, and percent cascade habitat are the best indices of the percent pool habitat and cover, percent gravel substrate and habitat length, and percent bedrock substrate and frequency of permanent barriers.

Watershed Area

Watershed areas were available for only 42 of the 55 streams surveyed in this study. They ranged from 0.6 km^2 (km 186.5) to 1,825.6 km^2 (for km 128.8, *i.e.*, the Mara River), and were highly skewed to low values (Figure 3.1-32). Ln-transformation normalized the distribution, hence the geometric mean was the best measure of the central tendency of the distribution. The geometric average watershed area was 11.5 km^2, and the average ln(area) was 2.446.

Indices of stream size such as stream discharge in August, wetted width and wetted depth were positively correlated with watershed area (Figures 3.1-33 to 3.1-35; the streams km 43.3 and 52.0



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Frequency Distribution of Watershed Area for 42 Streams

FIGURE 3.1-32

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were excluded from analysis because their discharges and wetted widths could not be measured because they were both covered by boulder fields, and km 168.0, a dry channel, was excluded from the depth-area regression because it was an obvious outlier). In contrast, percent riffle habitat, percent gradient and conductivity were not significantly correlated with watershed area. This confirms that the three variables were independent of stream size.

3.1.2.4 Fish Communities Assessment

A total of 311 fish from seven species were captured during the survey. Arctic grayling was the most common species (121 fish or 38.9% of total number), and lake trout, round whitefish, Arctic char and Arctic cisco were the least common species (3, 2 and 1 fish respectively, or 1, 0.6 and 0.3%) (Figure 3.1-36). Table 3.1-12 lists the life history characteristics of each species. Appendices 3.1-15 and 3.1-16 show the fish data sheets, a summary of fish CPUE data, and fish length and weight data, respectively. Plates 3.1-2 to 3.1-5 show photographs of four of the seven species captured.

Fish Communities

A maximum of four species were found in a single stream. The frequency distribution of fish species richness was skewed to low values (Figure 3.1-37). Of the 52 streams that were fished (3 had no water), 23 or 44% had no fish, 12 (23%) had only one species, 8 (15%) had two species, 6 (12%) had three species and 3 (6%) had four species. A plot of the percent of the total numbers of each species caught in each of these stream types (one species streams, two species streams, three species streams, and four species streams) showed that Arctic grayling and slimy sculpin together constitute 58 to 93% of all fish captured (Figure 3.1-38). The plot also showed that ninespine stickleback constitute between 0.8 and 35.3% of the number of fish, and that there is no consistent trend in percentage with the number of species. However, the percent of numbers made up of burbot is greatest for communities of three species and least for a community of one species, suggesting that burbot prefer to reside in fish communities with two or more species. That would be consistent with the piscivorous diet of burbot.

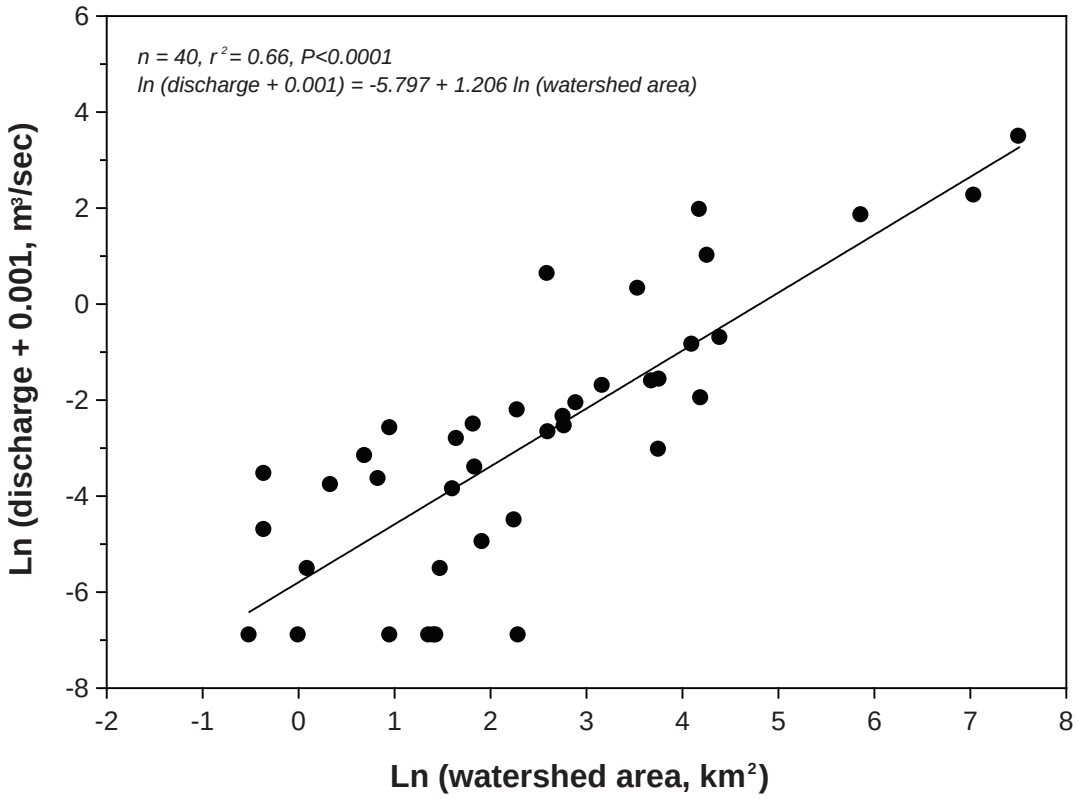
Fish Length and Weight

Table 3.1-13 shows average lengths and weights of the seven species captured during the stream survey.

Length-Frequency Distributions

Length-frequency distributions were calculated for each fish species by pooling length data over all streams. The purpose was to identify age-classes and life history stages.

At least two modes are obvious in the length-frequency distribution of Arctic grayling (Figure 3.1-39). The first and largest mode occurred at lengths from 25 to 74 mm. It corresponds to 0+ (young-of-the-year) that hatched in July of 2001 and were rearing in their natal stream in August. The second mode is in the 100 to 124 mm length interval and may represent the average length of 1+ juveniles that spent at least one winter in lakes and then returned to spend a second summer in streams. For those fish, streams may provide more shelter

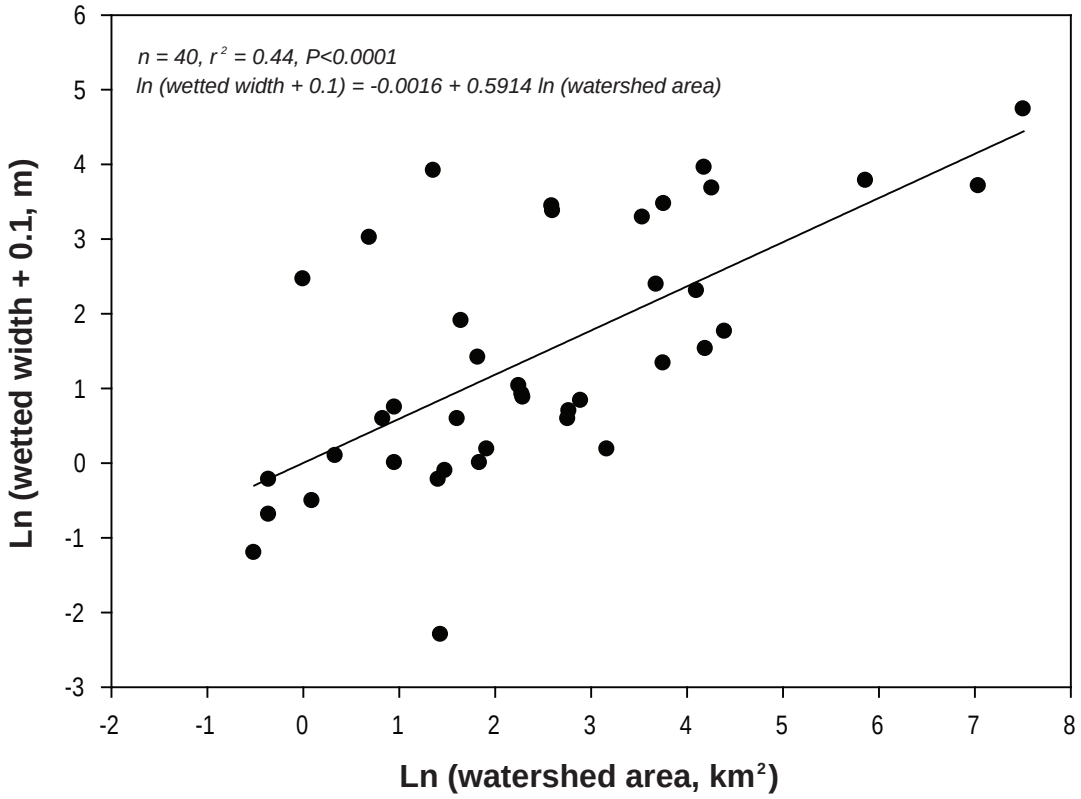


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Regression of Stream Discharge on Watershed Area, August 2001

FIGURE 3.1-33

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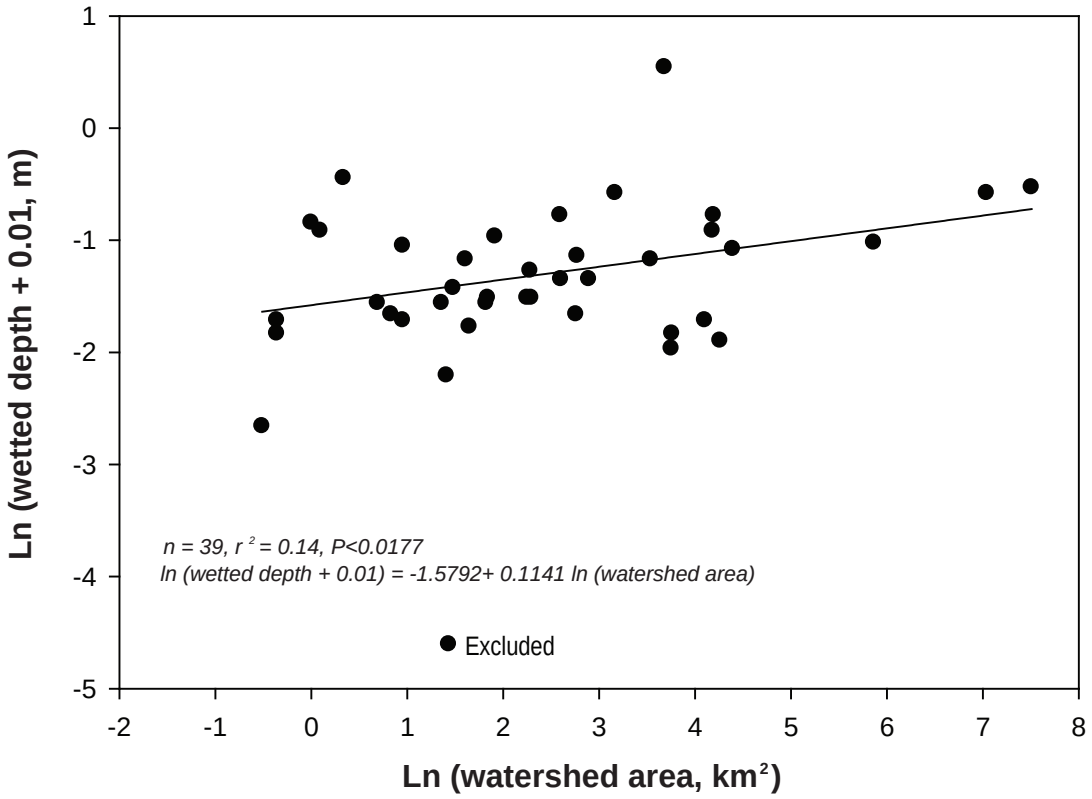


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Regression of Wetted Width on Watershed Area

FIGURE 3.1-34

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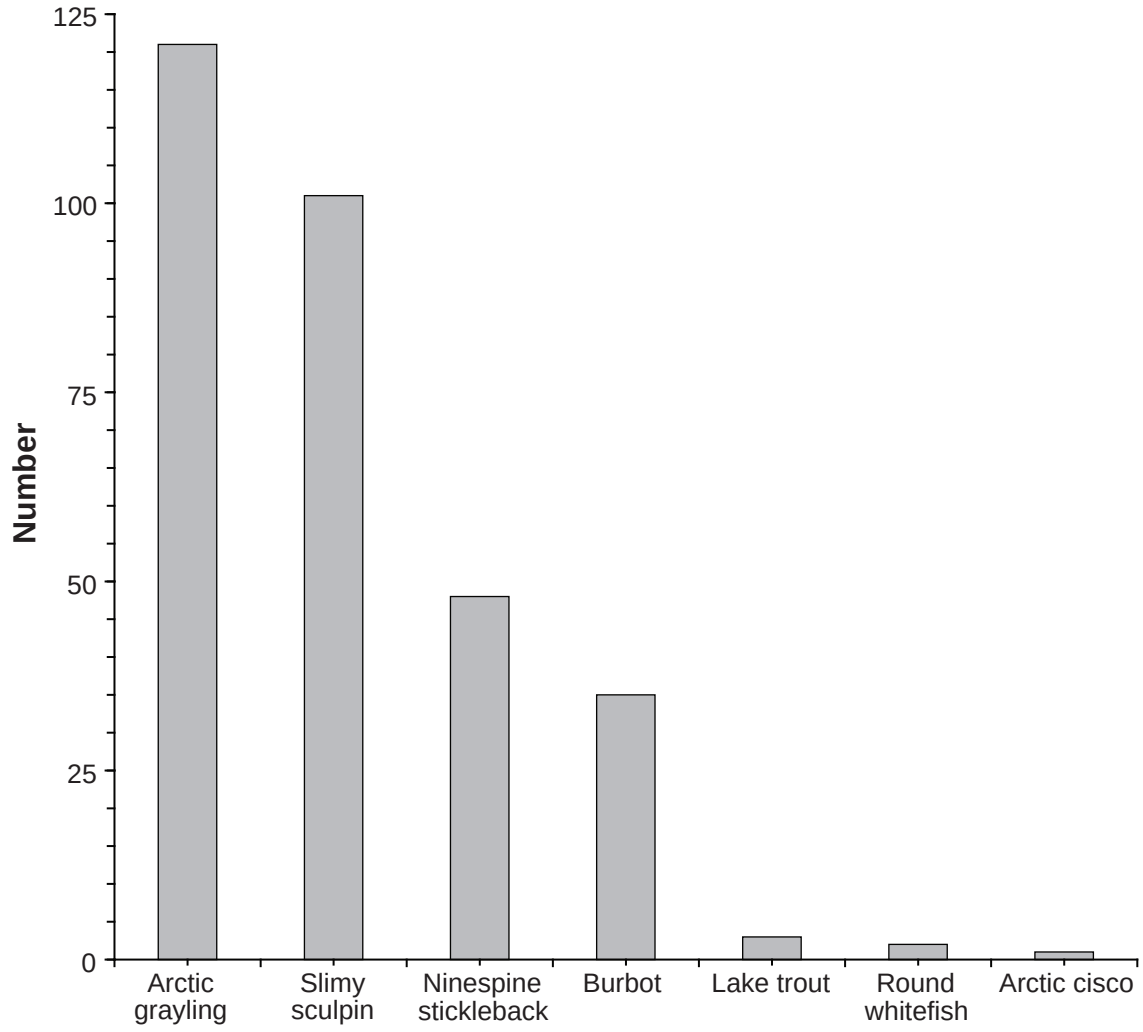


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Regression of Wetted Depth on Watershed Area

FIGURE 3.1-35

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Number by Species of the Fish Captured in Stream Crossings

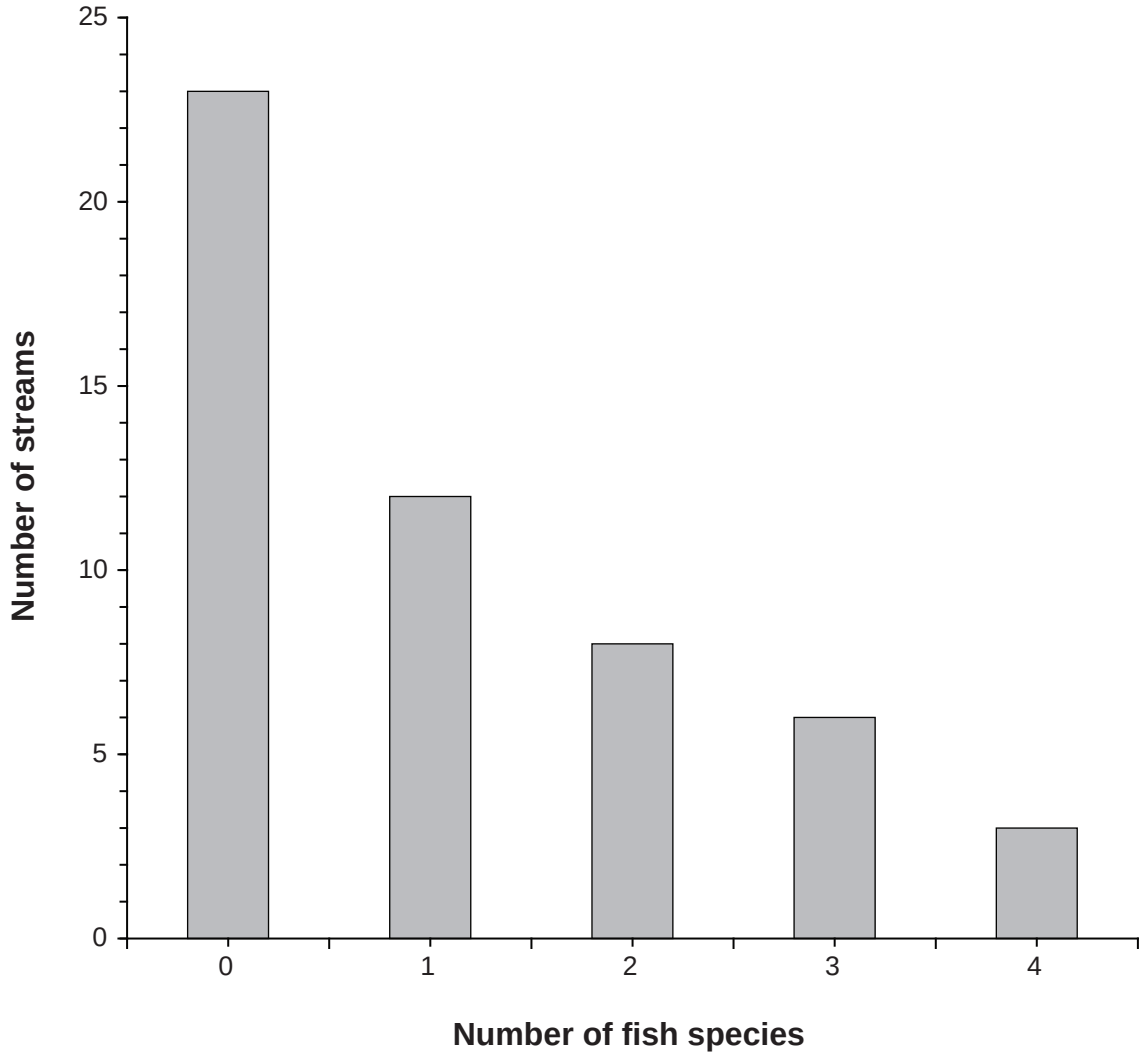
FIGURE 3.1-36

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Table 3.1-12
Life Histories of Fish Species Captured in Streams along the Road Route

Common name	Scientific name	Habitat	Body size	Diet	Spawning		
					Time	Location	Substrate
Arctic grayling	*Thymallus arcticus*	lakes/rivers	medium	zooplankton/insects	Apr-Jun	streams	gravel/cobble
Slimy sculpin	*Cottus cognatus*	lakes/streams	small	benthic invertebrates/insects	May-Jun	lakes/streams	rock
Burbot	*Lota lota*	lakes/streams	medium	invertebrates/fish	Jan-Mar	lakes/streams	sand/gravel
Arctic char	*Salvelinus alpinus*	lakes/rivers/coastal marine	large	invertebrates/fish	Sep-Oct	lakes/streams	gravel/cobble
Longnose sucker	*Catostomus catostomus*	streams/lakes	medium	benthic invertebrates	Apr-May	streams/lakes	gravel
Ninespine stickleback	*Pungitius pungitius*	lakes/streams	small	zooplankton/insects	Jun-Aug	lakes/streams	weeds
Lake trout	*Salvelinus namaycush*	lakes/rivers	large	invertebrates/fish	Sep-Oct	lakes	boulder
Arctic cisco	*Coregonus autumnalis*	lakes/coastal marine	medium	zooplankton/fish	July	rivers	gravel
Round whitefish	*Prosopium cylindraceum*	lakes	medium	benthic invertebrates	Jul-Aug	lakes	gravel

Species characteristics taken from Scott and Crossman (1973). Spawning times in Nunavut may be later than those reported by Scott and Crossman (1973).

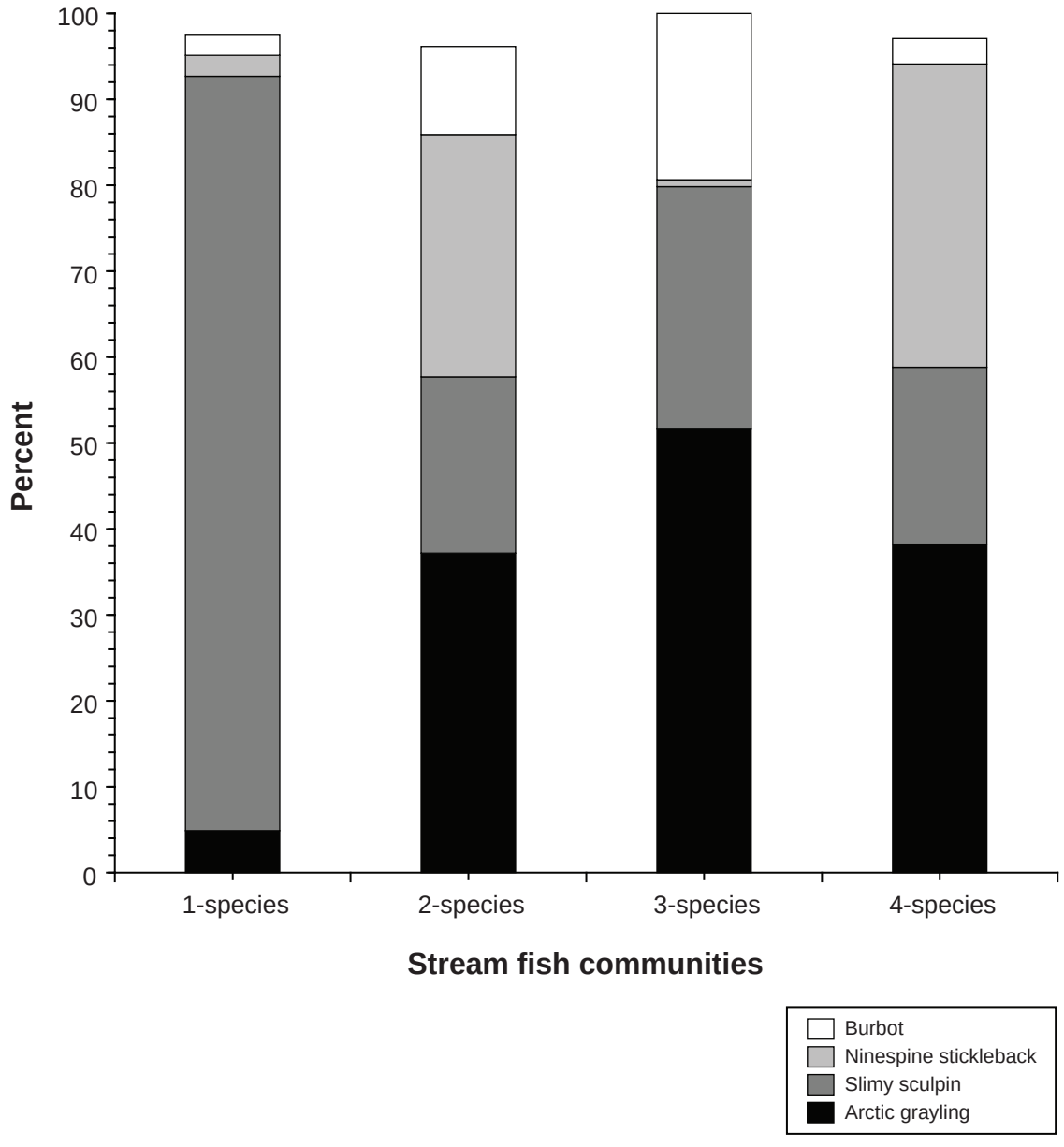


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Frequency Distribution of Fish Species Richness for the 52 Streams that were Fished

FIGURE 3.1-37

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Percent by Species of the Total Number of Fish in Stream Fish Communities

FIGURE 3.1-38

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Plate 3.1-2. Adult or subadult Arctic grayling captured at one of the sites.

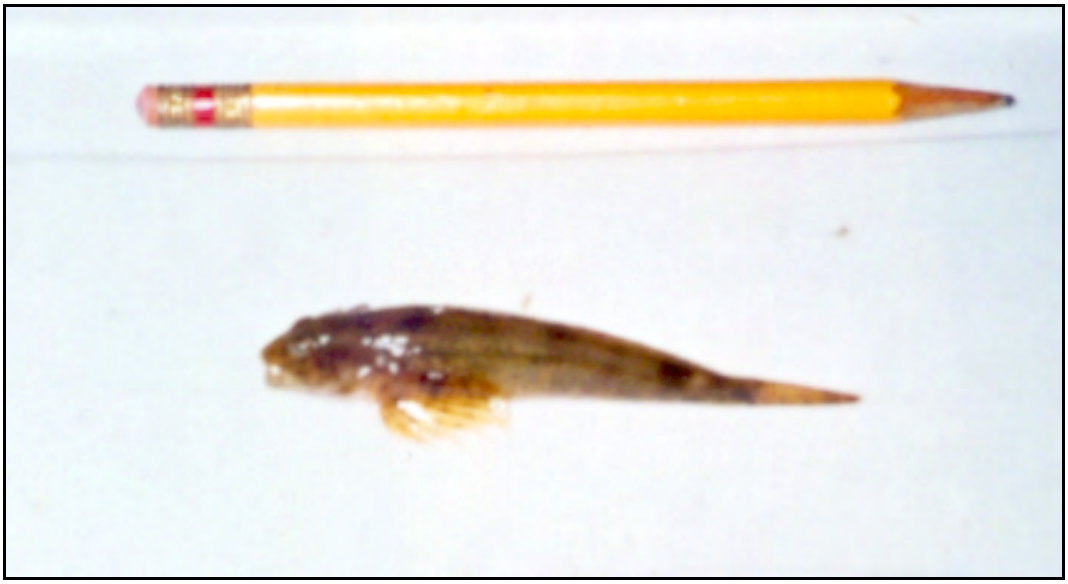


Plate 3.1-3. Slimy sculpin captured at one of the sites.



Plate 3.1-4. Juvenile burbot captured at one of the sites.

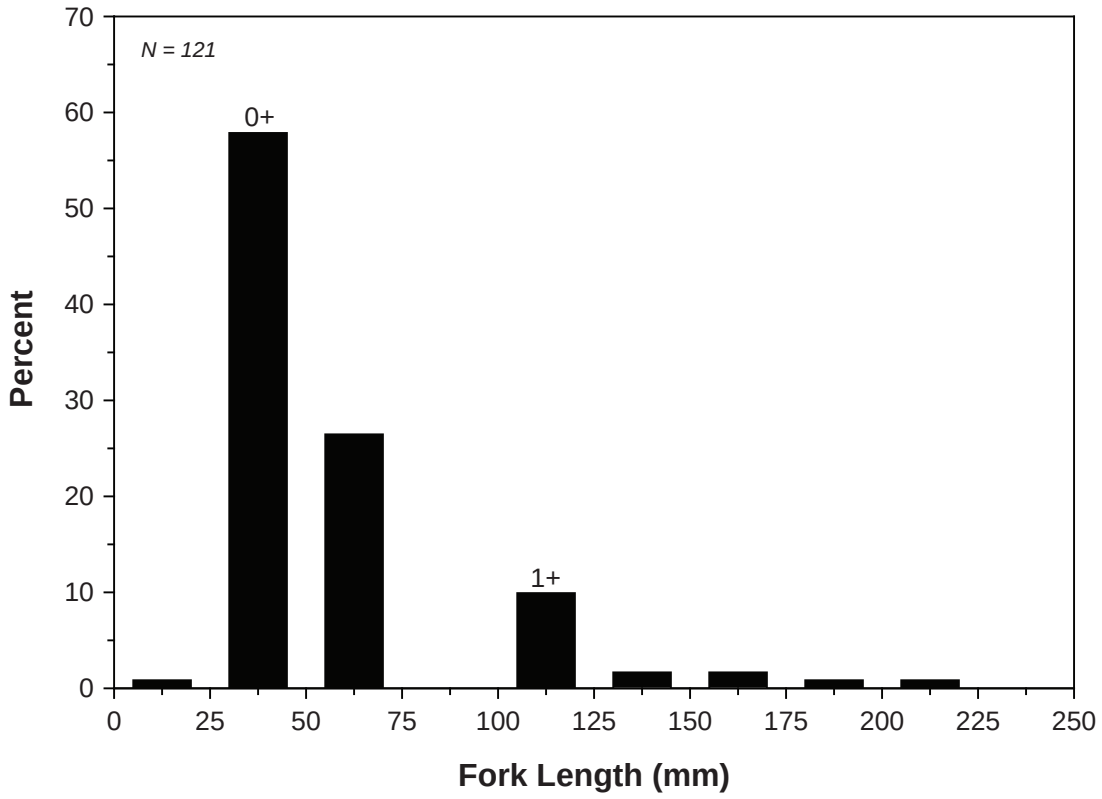


Plate 3.1-5. Juvenile lake trout captured at one of the sites.

Table 3.1-13
Average Lengths and Weights of Fish Captured during Stream Surveys

	Fork length (mm)					Body weight (g)				
Species	**n**	**mean**	**SD**	**min**	**max**	**n**	**mean**	**SD**	**min**	**max**
Arctic grayling	121	58	33	24	210	53	10.9	20.0	0.3	95.1
Slimy sculpin	101	60	16	25	97	80	2.8	2.3	0.1	10.5
Ninespine stickleback	48	42	11	25	61	37	0.7	0.6	0.1	2.1
Burbot	35	74	54	25	235	24	12.6	25.8	0.1	121.3
Lake trout	3	116	42	72	155	3	26.0	23.1	4.0	50.0
Round whitefish	2	118	18	105	131	2	16.8	9.8	9.9	23.7
Arctic cisco	1	135	-	135	135	1	32.0	-	32.0	32.0

SD = standard deviation and n = sample size.
Note: all fish were measured for length but only a subset was measured for body weight.



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Length Frequency Distribution of Arctic Grayling, August 2001

FIGURE 3.1-39

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from predators than lakes. Other potential modes in longer length intervals probably represent subadult and adult grayling, but the numbers of those fish were too low to make definitive conclusions. Adult grayling are lake residents and enter streams in spring to spawn.

Only one mode was observed in the length-frequency distribution of slimy sculpin (Figure 3.1-40). It likely represents a combination of subadults and adults because only a few obviously juvenile sculpins (< 30 mm long) were caught during the survey. Scott and Crossman (1973) cited studies of slimy sculpin in Great Bear Lake (Northwest Territories) and northern Saskatchewan that reported sexual maturity over a length range of 60 to 120 mm. That range corresponds to the descending right-hand limb of the length-frequency distribution, and it indicates that subadults (30 to 60 mm) made up most of the ascending left-hand limb. Adults use stream habitat for spawning as well as feeding

Only one mode was observed in the length-frequency distribution of ninespine stickleback (Figure 3.1-41). It likely represented a combination of subadult and adult sticklebacks because no juvenile sticklebacks (< 20 mm) were caught during the survey. Scott and Crossman (1973) cited reports from English rivers and the Atlantic coast of Canada that indicated that juveniles reach a length of 15 mm within 2 weeks of leaving their natal nest, and that maximum length after the first year of life was 38 to 46 mm. These records are not directly applicable to ninespine stickleback in Nunavut waters because the lower temperatures and shorter growing seasons would cause lower lengths-at-age. However, those reports suggest that most of the fish on the descending right-hand limb of the length-frequency distribution were adults and that most of the fish on the ascending left-hand limb were subadults. As with slimy sculpins, sticklebacks use stream habitat for spawning as well as feeding.

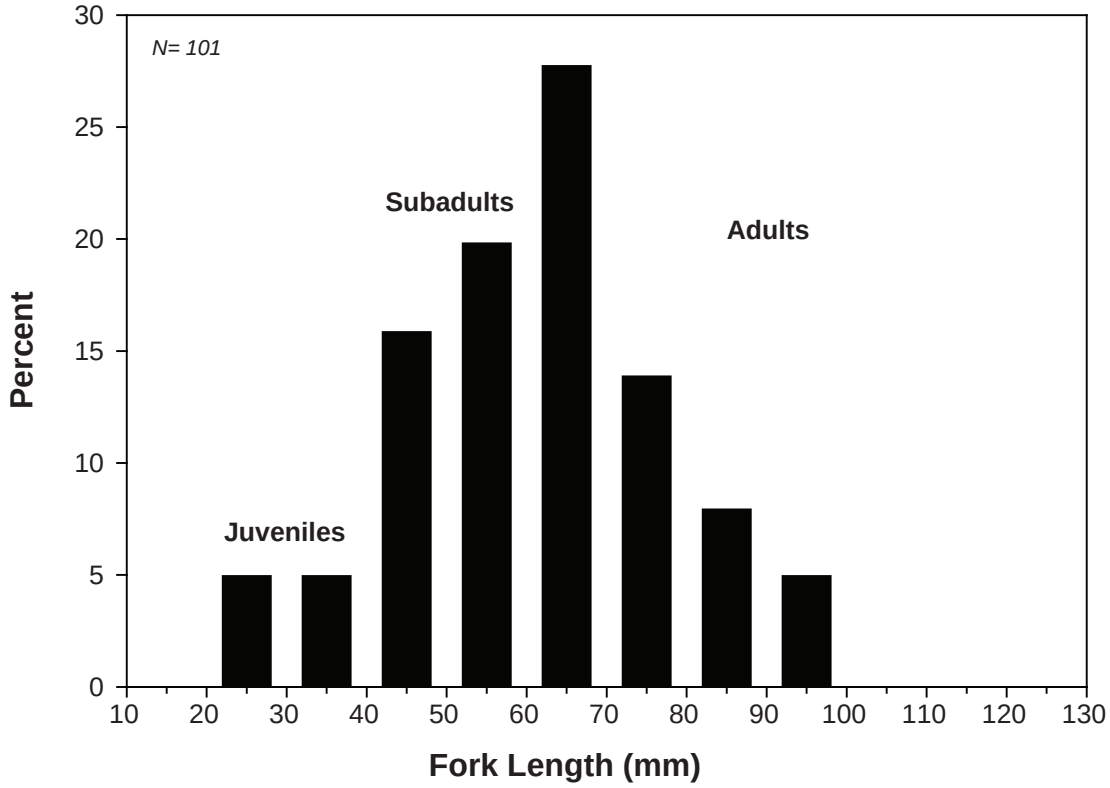
At least two modes were present in the length-frequency distribution of burbot (Figure 3.1-42). The first and largest mode was in the 25 to 49 mm length interval and corresponds to 0+ fish that hatched in early spring of 2001 from eggs laid during mid-winter in shallow inshore areas of lakes and large rivers. Juveniles then swam up into streams in search of rearing habitat.

Weight-Length Relationships

Sample sizes were sufficient to calculate regressions of ln(weight) on ln(fork length) for Arctic grayling, slimy sculpin, ninespine stickleback and burbot (Figures 3.1-43 to 3.1-46). All regressions were highly significant ($P < 0.0001$) and explained between 85 and 99% of the variation in ln(weight). Weight-length exponents ranged between 2.775 and 3.287, bracketing the expected value of 3.0. These regressions were used to predict weight from length for fish that were not weighed in the field.

Fishing Effort and CPUE

Three of the 55 streams (km 43.3, 52.0 and 208.2) were not electrofished because there was not enough water to allow fishing. Fishing effort for the other 52 streams ranged from 102 to 787 electrofishing seconds with an average of 408 sec. Fishing effort was directly proportional to stream survey distance, as was shown by a regression of fishing effort on distance (Figure 3.1-47). The regression was significant and explained 11% of the variation in fishing effort.

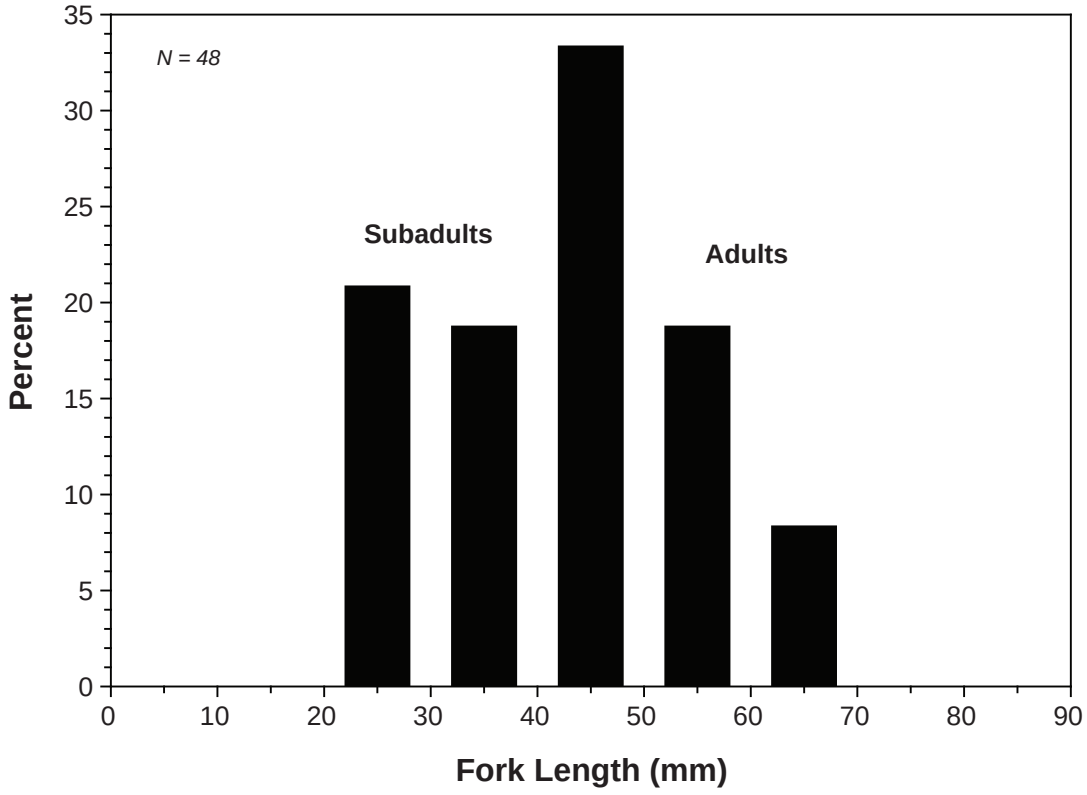


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Length Frequency Distribution of Slimy Sculpin, August 2001

FIGURE 3.1-40

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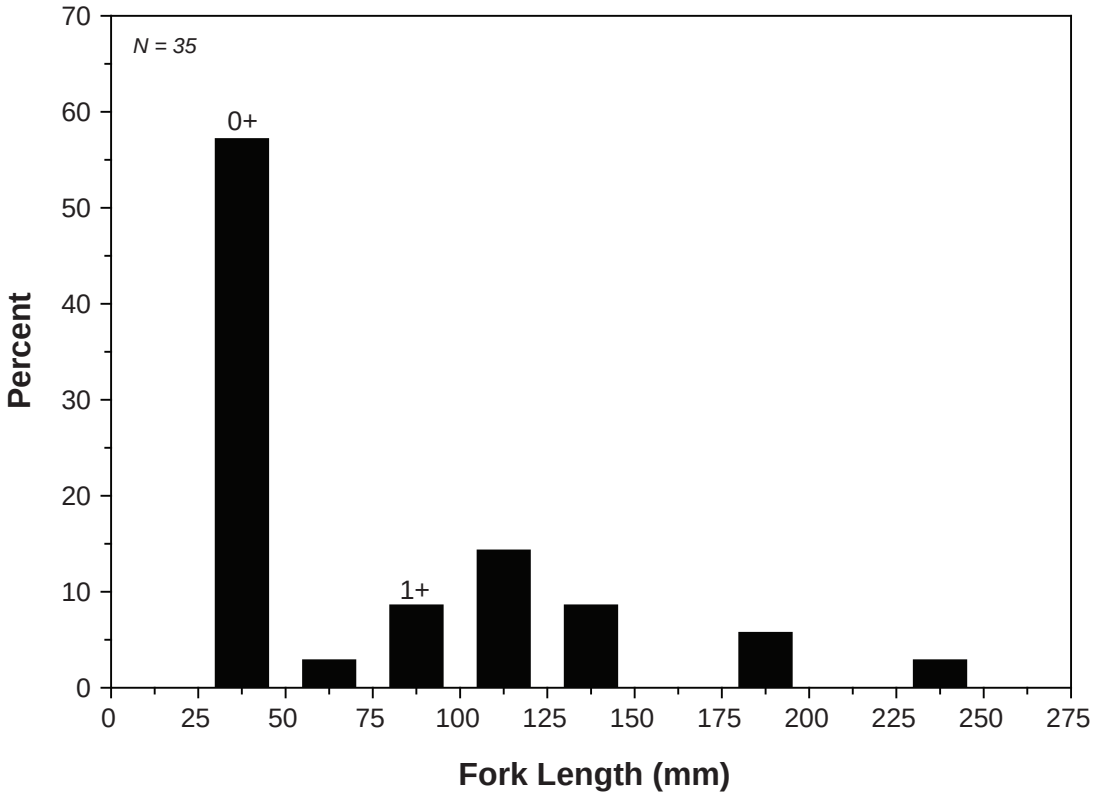


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Length Frequency Distribution of Ninespine Stickleback, August 2001

FIGURE 3.1-41

Rescan™

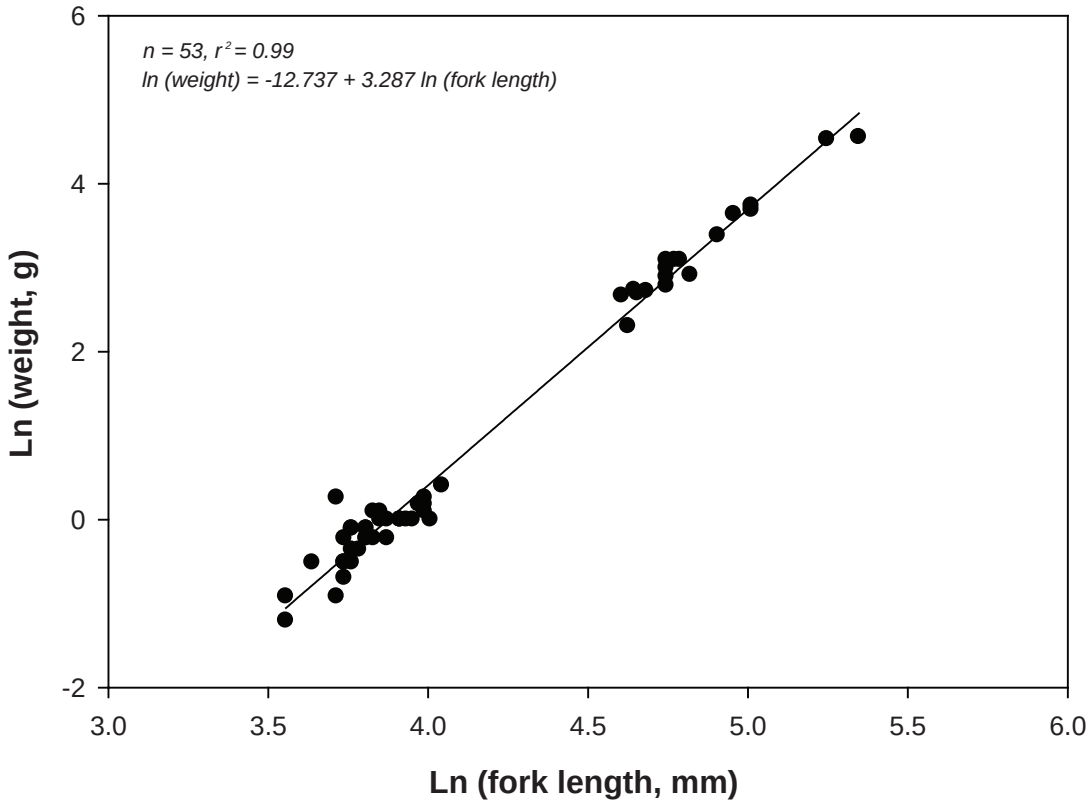


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Length Frequency Distribution of Burbot, August 2001

FIGURE 3.1-42

Rescan™

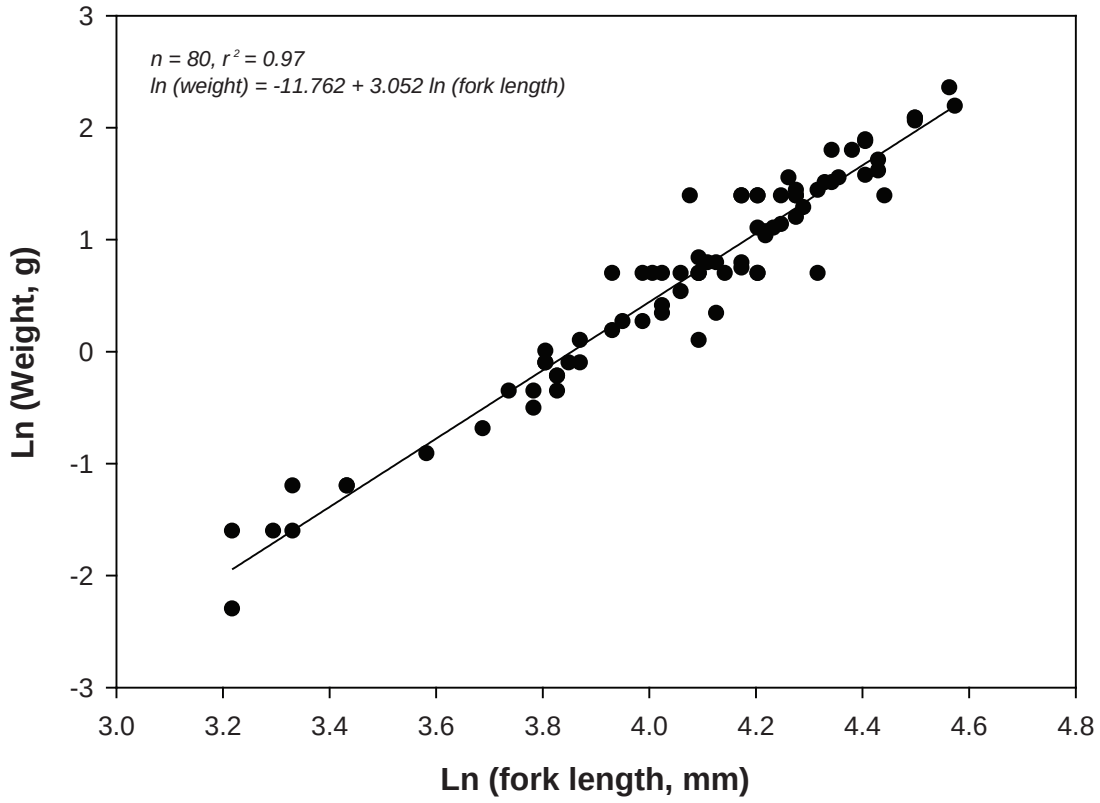


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Weight-Length Relationship of Arctic Grayling, August 2001

FIGURE 3.1-43

Rescan™

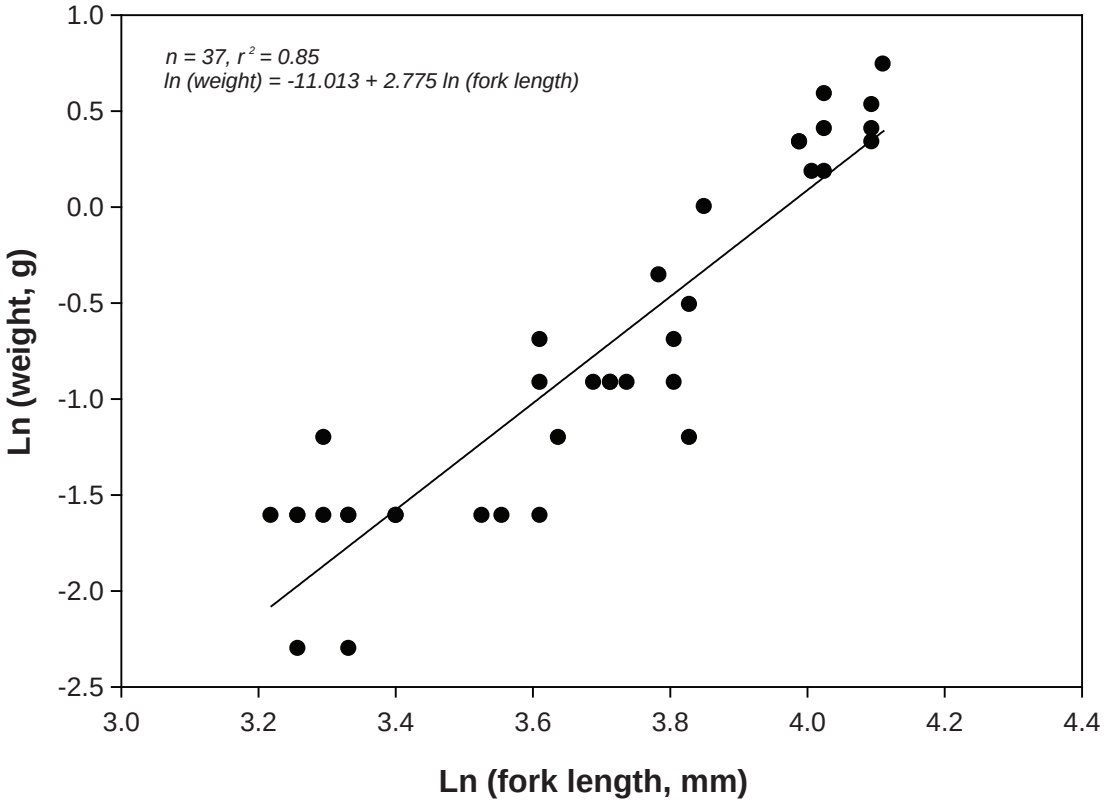


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Weight-Length Relationship of Slimy Sculpin, August 2001

FIGURE 3.1-44

Rescan™

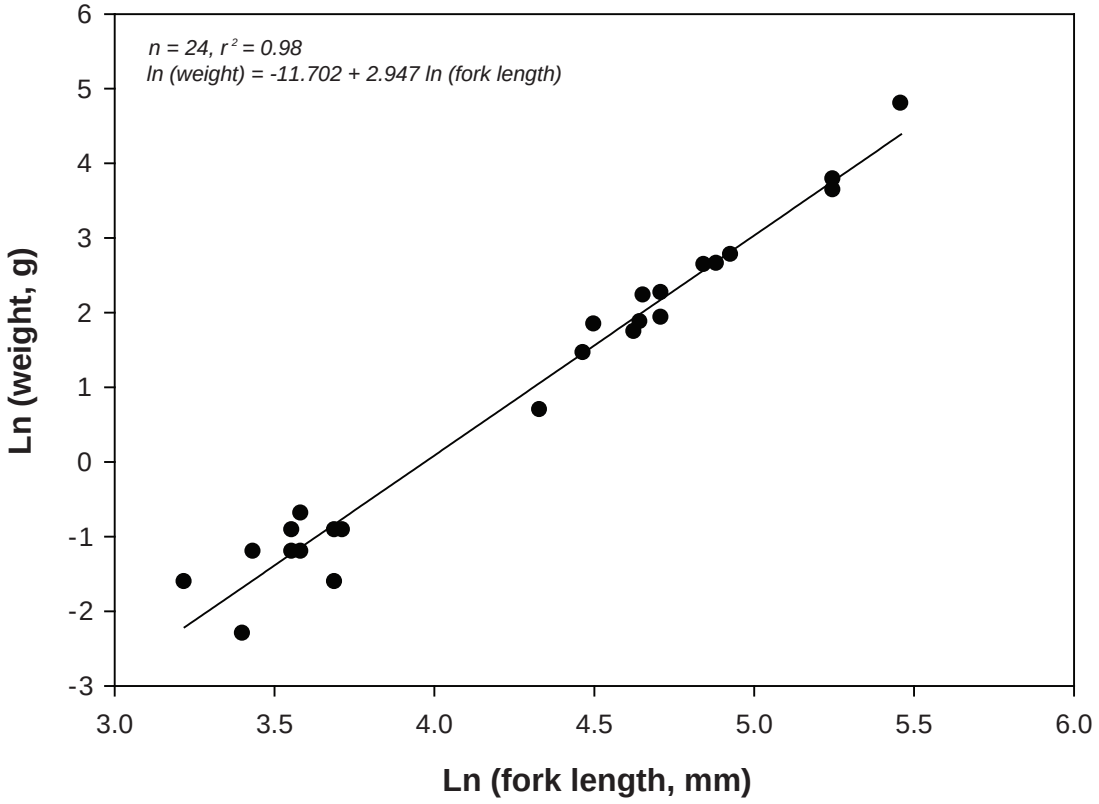


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Weight-Length Relationship of Ninespine Stickleback, August 2001

FIGURE 3.1-45

Rescan™

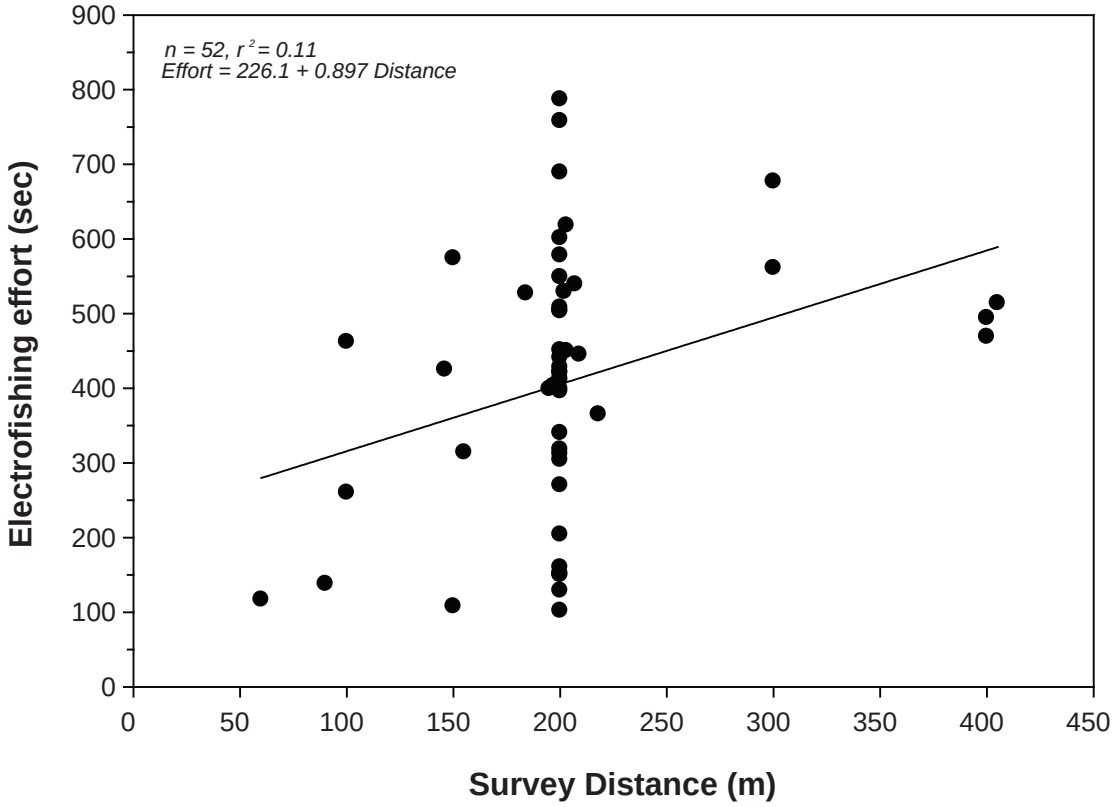


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Weight-Length Relationship of Burbot, August 2001

FIGURE 3.1-46

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Regression of Electrofishing Effort on Stream Survey Distance

FIGURE 3.1-47

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The frequency distribution of the number of fish caught per unit effort (or number CPUE) ranged from 0.000 to 0.077 fish/sec, and was highly skewed to low values, partly because no fish were caught in 23 of the 52 streams that were fished. Skewness was reduced by including in the frequency distribution only those 29 streams in which fish were caught (Figure 3.1-48). Two modes were present: the first and largest mode represented streams with a few fish (CPUE < 0.009), and the second mode represented streams with high densities of juvenile Arctic grayling (modal CPUE = 0.055 fish/sec).

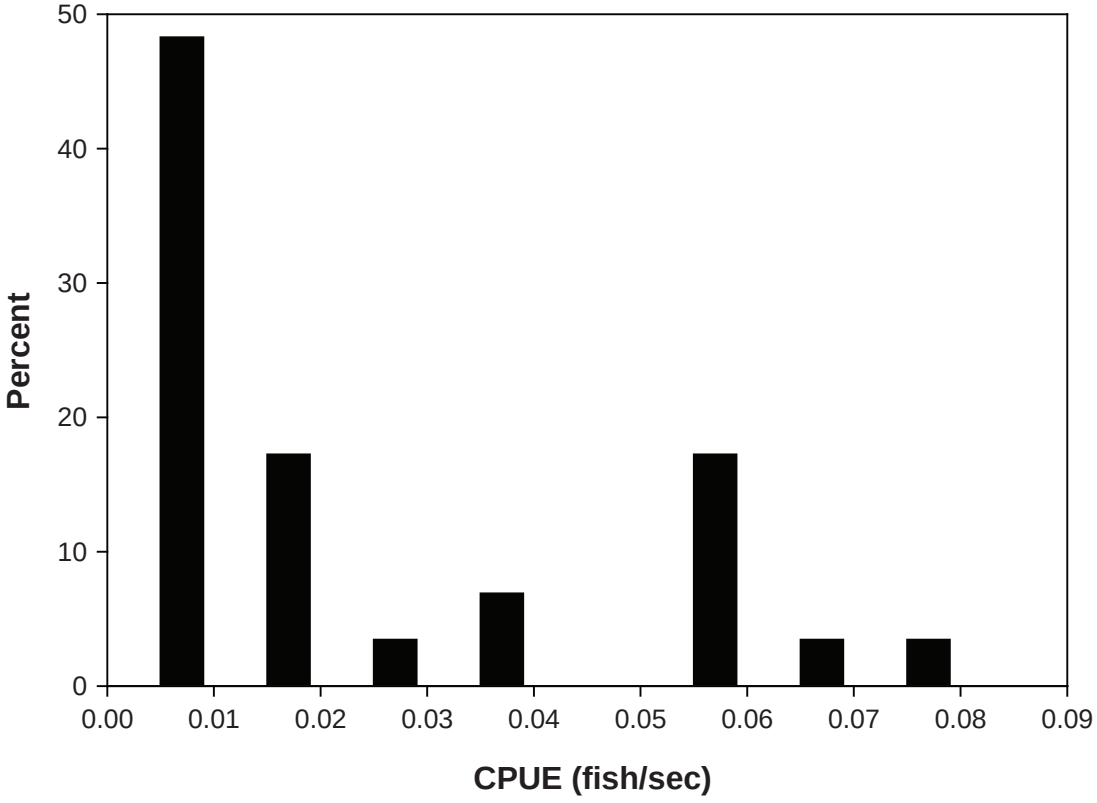
The frequency distribution of the weight of fish caught per unit effort (or biomass CPUE) ranged from 0.00 to 0.63 g/sec, and was even more highly skewed to low values than the frequency distribution of number CPUE. Skewness was partially reduced by including in the frequency distribution only those 29 streams in which fish were caught (Figure 3.1-49). There was only one mode in the distribution; it was located in the 0.00-0.19 g/sec interval and represented all streams with fish. The long descending right-hand limb of the frequency distribution showed that it was not normally distributed. Ln-transformation normalized the distribution, hence the geometric average biomass CPUE was the best measure of the central tendency of the data. The geometric average biomass CPUE was 0.0066 g/sec, and the average ln(biomass CPUE + 0.001) was -5.013.

3.1.2.5 Stream Rank by Fisheries Value

Streams were assigned a fisheries value based primarily on the electrofishing catch of the August survey. Habitat characteristics measured during the August survey were not used to assign a fisheries value because of the lack of strong relationships between fish abundance and habitat and because there are no independent habitat criteria for assessing the fisheries value of Nunavut streams. The three categories of fisheries value were:

1. ***Low***: streams that were assessed as non-fish-bearing during the July reconnaissance because their flows were too low to support fish, and streams surveyed in August in which no fish were caught.
2. ***Medium***: streams that were surveyed in August and contained fish, but only small-bodied species with little commercial, food or cultural value, *i.e.*, slimy sculpin and ninespine stickleback.
3. ***High***: streams that were surveyed in August and contained either Arctic grayling, juvenile burbot, or a large, migratory species (*i.e.*, Arctic cisco, Arctic char, round whitefish, lake trout or longnose sucker). These species were assigned greater fisheries values than other species because they are food and sport fish. Also, as stream spawners, the presence of Arctic grayling indicated the presence of stream spawning substrate. The presence of large, migratory species indicated that the stream may be a migration corridor. The Mara River and Amagok Creek were assigned high fisheries values despite their zero catch. These waterbodies are known to contain large or migratory fish because of their size.

A total of 119 streams were surveyed in either July for reconnaissance or in August for the full survey. They were divided into the following three groups:

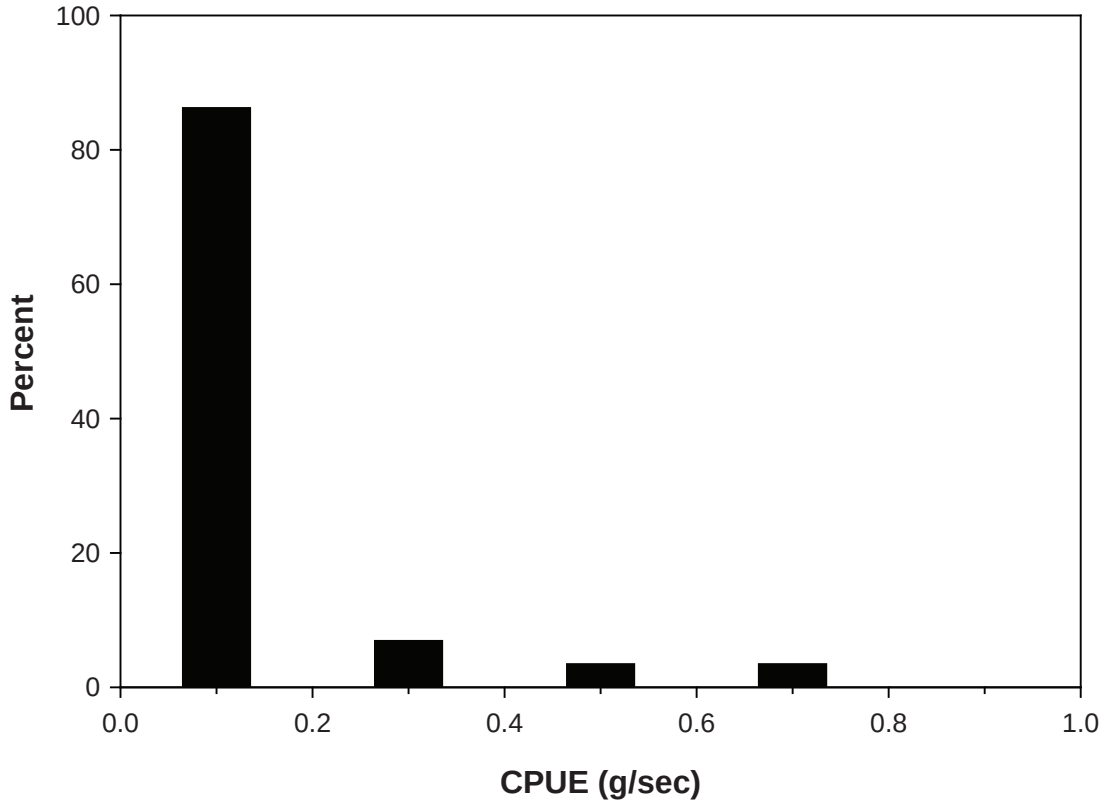


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Frequency Distribution of Fish Number CPUE in 29 Streams in Which Fish Were Caught

FIGURE 3.1-48

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Frequency Distribution of Fish Biomass CPUE in 29 Streams in Which Fish Were Caught

FIGURE 3.1-49

Rescan™

1. 64 streams assessed as non-fish-bearing during the July reconnaissance survey and not surveyed for fish and fish habitat in August 2001 (Table 3.1-15). All were assigned a low fisheries value due to very low flows.
2. 12 streams surveyed for fish and fish habitat in August 2001, but which were subsequently removed from the list of stream crossings after the revised Road route by-passed those crossings (Table 3.1-16). Nine were assigned a low fisheries value because no fish were caught, 1 was assigned a medium fisheries value because slimy sculpin and/or ninespine stickleback were caught and 2 were assigned a high fisheries value because Arctic grayling, juvenile burbot, or a large, migratory species were caught.
3. 43 streams that were surveyed for fish and fish habitat in August 2001, and which remained on the list of stream crossings after the Road route was revised (Table 3.1-17). On the basis of their electrofishing catch, and on the basis of watershed size (for Amagok Creek and Mara River) 21 streams were assigned a low fisheries value, 10 were assigned a medium value and 12 were assigned a high value.

Table 3.1-15
Streams Assessed as Non-fish-Bearing in July, 2001, and Not Surveyed for Fish and Fish Habitat in August 2001

Stream Crossing (km)	Fisheries value	Expected crossing	Stream Crossing (km)	Fisheries value	Expected crossing
11.1	Low		98.8	Low	F
14.1		B	100.3	Low	F
18.3	Low	F	117.4	Low	F
25.7	Low	F	119.4	Low	F
27.4	Low	F	123.3	Low	F
27.8	Low		123.8	Low	F
28.9	Low		125.3	Low	F
30.4	Low	F	136.6	Low	F
32.1	Low		144.6	Low	F
33.4	Low	F	145.7	Low	
38.1		F	146.6	Low	F
39.0	Low	F	147.5	Low	F
39.5	Low		149.7	Low	F
40.6	Low	F	151.6	Low	B
41.4	Low		152.4	Low	
42.3	Low		155.7	Low	F
47.5	Low	F	158.2	Low	F
54.3	Low	F	158.8	Low	
56.9	Low	F	159.2	Low	
62.3		F	159.7	Low	F
63.5		F	160.7	Low	
66.5		F	167.6	Low	
66.4	Low		168.0	Low	B

(continued)

Table 3.1-15
Streams Assessed as Non-fish-Bearing in July, 2001, and Not Surveyed for Fish and Fish Habitat in August 2001 (completed)

Stream Crossing (km)	Fisheries value	Expected crossing	Stream Crossing (km)	Fisheries value	Expected crossing
73.9	Low	F	169.2	Low	
74.1	Low		169.4	Low	F
74.9	Low	F	177.2	Low	F
78.5	Low		182.9	Low	
78.6	Low		192.4		C
78.9	Low	F	193.8	Low	F
80.4	Low	F	195.9	Low	
81.5	Low		196.7		F
83.7	Low	F	198.2	Low	F
91.1	Low	F	206.9		B
91.4	Low	F	208.2		C
92.3	Low	F	211.0		F
94.1	Low	F	212.5	Low	
95.3	Low		212.8	Low	
97.2		F			

Crossing type: F = rock-filled ford, C = arch culvert, and B = bridge.
na : no assessments were conducted.

Table 3.1-16
Streams Surveyed in August 2001, but Removed from the List of Stream Crossing of the Revised Road Route

Stream Crossing (km)	Fisheries value	Comments
11.7	Low	No catch
36.6	Low	No catch
67.9	Low	No catch
68.3	Low	No catch
69.4	Low	No catch
192.4	Medium	2 slimy sculpin (CPUE = 0.006 fish/sec)
192.4a	High	1 Arctic grayling, 1 slimy sculpin and 1 burbot (CPUE = 0.002, 0.002 and 0.002 fish/sec)
196.7	Low	No catch
197.0	Low	No catch
197.4	Low	All fish caught were taken from an adjacent lake, not the stream
206.9	High	21 Arctic grayling and 9 burbot (CPUE = 0.040 and 0.017 fish/sec)
208.2	Low	No catch

Streams have no revised chainage values.
Fisheries value: L = low (no fish captured), M = medium (contains slimy sculpin, ninespine stickleback, burbot or other species, but not Arctic grayling), and H = high (contains Arctic grayling).

Table 3.1-17
Streams Surveyed in August 2001 that Remain Stream Crossings of the Revised Road Route

Stream Crossing (km)	Fisheries value	Expected crossing	Crossing length (m)	Comments
2.2	High	B	20	1 ARCS (CPUE = 0.003 fish/sec)
2.8	Low	F	-	No catch
7.8	Low	F	-	No catch
22.9	Low	B	50	No catch
33.7	Medium	-	-	1 NNST
33.8	Low	B	30	No catch
34.8	Medium	B	30	1 SLSC
35.9	Low	B	30	No catch
42.3	Medium	B	20	3 SLSC
43.3	Low	F	-	No catch
44.5	Medium	B	20	3 SLSC
49.7	Medium	F	-	21 SLSC
52.0	Low	B	20	No catch
58.7	Medium	F	-	2 SLSC
68.6	High	F	-	5 SLSC and 1 RDWH
70.1	Low	F	-	No catch
72.2	High	B	20	16 ARGR, 1 SLSC and 4 BURB
76.0	Low	B	10	No catch
77.0	Low	F	-	No catch
84.2	High	B	30	3 ARGR and 1 RDWH
85.0	Low	F	-	No catch
90.3	Low	F	-	No catch
103.3	Low	F	-	No catch in stream. 3 ARGR and 1 LKTR from adjacent lake
103.3a	High	F	-	11 ARGR, 13 SLSC and 1 BURB
106.7	Low	B	30	No catch
113.2	Low	B	20	No catch
113.8	High	F	-	2 ARGR
115.2	Medium	B	20	3 SLSC
128.8	Low	B	70	No catch
134.6	High	B	30	22 ARGR, 1 SLSC, 1 BURB and 1 LKTR
159.5	Low	F	-	No catch. 2 SLSC and 2 NNST from an adjacent lake
160.7	High	B	10	3 ARGR, 11 SLSC, 1 BURB and 19 NNST
168.0	Low	F	-	No catch
169.6	Medium	F	-	4 SLSC and 18 NNST

(continued)

Table 3.1-17
Streams Surveyed in August 2001 that Remain Stream Crossings of the Revised Road Route (completed)

Stream Crossing (km)	Fisheries value	Expected crossing	Crossing length (m)	Comments
170.8	Medium	F	-	1 BURB
173.1	High	F	-	12 ARGR, 11 SLSC and 17 BURB
181.4	High	B	30	8 ARGR, 8 SLSC and 1 NNST
183.6	Low	F	-	No catch
186.5	Low	F	-	No catch in stream. 2 SLSC captured in adjacent lake
189.6	Low	C	3	No catch
201.9	High	B	20	1 ARGR and 4 SLSC
202.8	High	B	20	1 ARGR, 1 SLSC and 1 BURB
204.3	Medium	F	-	1 SLSC and 2 NNST

Fisheries value: L = low (not fish-bearing or no fish captured), M = medium (contains SLSC, NNST, BURB or other species, but not ARGR or large, migratory species, and H = high (contains ARGR or species of large, migratory fish).
Crossing type: F = rock-filled ford, C = arch culvert and B = bridge.
Dashes indicate no data are available.
ARGR = Arctic grayling, SLSC = slimy sculpin, BURB = burbot, NNST = ninespine stickleback, LKTR = lake trout, RDWH = round whitefish, ARCS = Arctic cisco and LNSU = longnose sucker.

3.2 Contwoyto Lake

3.2.1 Aquatic Biology and Chemistry

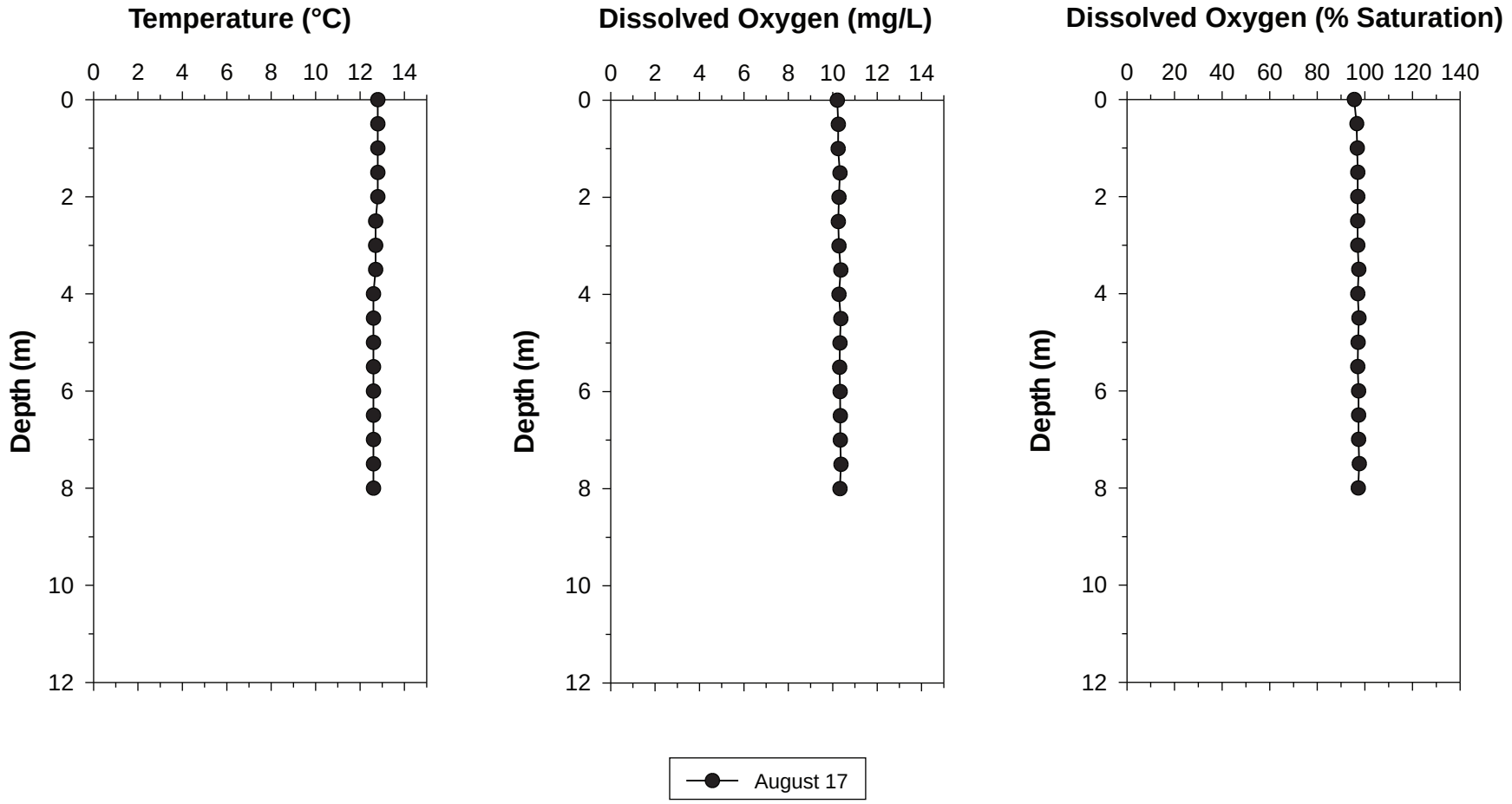
3.2.1.1 Physical Limnology

Physical characteristics such as light penetration, vertical mixing, water temperature and dissolved oxygen concentration can strongly affect biological and chemical processes occurring within a lake. The degree of light penetration in the water column determines light availability for algal growth. Thermal stratification commonly occurs in larger lakes during the summer and prevents the mixing and exchange of dissolved ions and oxygen between bottom and surface waters.

All physical limnology data collected from Contwoyto Lake during August 2001 are provided in Appendix 3.2-1. Vertical profiles of dissolved oxygen and temperature are presented in Figure 3.2-1.

Surface water temperature was 12.8ºC. Water depth near the terminal end of the Road was 8.5 m, although the lake is considerably deeper in other areas. Moore (1978a) observed a maximum depth of 30 m during his study of the lake.

The water column was not thermally stratified near the terminal end of the Road. A second temperature and dissolved oxygen profile was taken in deeper waters in the middle of the lake to



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Vertical Depth Profiles of Dissolved Oxygen and Temperature, Contwoyto Lake, August 2001

FIGURE 3.2-1

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determine if there was stratification farther away from shore. Water temperature decreased by only 1.4 °C over a 30 m depth indicating no stratification (Appendix 3.2-1). These results contrast with those of Moore (1978a) who observed well-defined stratification during summer in the north section of Contwoyto Lake. Summer weather conditions such as air temperature and wind speed may determine if thermal stratification occurs in the lake.

Dissolved oxygen concentrations were high, and ranged from 10.2 to 10.4 mg/L. No significant vertical changes in dissolved oxygen were observed, and concentrations were close to complete saturation at all depths.

Contwoyto Lake had very clear water allowing for high light penetration. A lowered Secchi disk was visible to the lake bottom indicating there was sufficient light for photosynthesis over the entire water column depth. A maximum Secchi depth of 8.5 m was measured.

3.2.1.2 Water Quality

The chemical composition of lake water has a broad influence on resident aquatic organisms. The amount of nutrients in water strongly affects the productivity of a lake, and elevated or scarce levels of metals can impinge on biological processes such as growth and reproduction. From a human perspective, water quality is a critical resource issue because of its effect on drinking water supplies and fisheries.

All analytical results for physical parameters, nutrients and metals in surface water samples collected on Contwoyto Lake during August 2001 are presented in Appendix 3.1-2. Extractable petroleum hydrocarbon results are presented in Appendix 3.1-3.

Physical Variables and Nutrients

Analytical results for selected physical variables and nutrients measured in Contwoyto Lake surface waters are presented in Table 3.2-1.

The surface waters of Contwoyto Lake were very soft, clear, and dilute. Calcium carbonate, a measure of hardness, had an average concentration of 3.3 mg/L. Total alkalinity was low, indicating a weak acid buffering capacity of the lake. Total dissolved solids concentration was below detection limits, and conductivity measured 10 µmhos/cm, reflecting the extremely low ion content. Surface waters were very clear with average turbidity at 1.4 NTU.

Nutrient concentrations were also low. Average concentration of nitrate nitrogen was 0.009 mg/L, total Kjeldahl nitrogen was 0.36 mg/L, and total phosphorus was 0.004 mg/L. The low nutrient concentrations suggest poor nutrient availability for primary production at the terminal end of the Road. Phosphorus is the primary limiting nutrient for algal growth in northern Canadian lakes (Schindler, 1977), and it was particularly low in surface waters, even in comparison to other arctic tundra lakes (Pienitz *et al*., 1997).

The water quality measured is typical of undisturbed northern lakes whose underlying bedrock is predominately granite. Granite is highly resistant to chemical weathering, and surface run-off in granite drainage basins is generally low in particulate and dissolved material.

Table 3.2-1
Average Concentrations for Selected Water Quality Variables, Contwoyto Lake

Variable	Units	Contwoyto Lake	CCME Guideline[1]
Physical			
Conductivity	µmhos/cm	10	-
Total Dissolved Solids	mg/L	<10	-
Total Suspended Solids	mg/L	<3	-
Turbidity	NTU	1.4	-
Hardness	Mg $CaCO_3$/L	3.3	-
PH	pH units	6.93	6.5-9.0
Total Alkalinity	Mg $CaCO_3$/L	3	-
Nutrients			
Total Kjeldahl Nitrogen	mg/L	0.36	-
Nitrate Nitrogen	mg/L	0.009	-
Total Phosphorus	mg/L	0.004	-
Extractable Petroleum Hydrocarbons			
C_{10}-C_{19}	mg/L	<0.1	-
C_{19}-C_{32}	mg/L	<0.1	-
Total Metals			
Aluminum	mg/L	0.011	0.100
Arsenic	mg/L	0.0003	0.005
Cadmium	mg/L	<0.00005	0.000017
Chromium	mg/L	<0.0005	0.001-0.0089[2]
Copper	mg/L	0.0006	0.002
Iron	mg/L	<0.03	0.300
Lead	mg/L	<0.00005	0.001
Mercury	mg/L	<0.00001	0.0001
Nickel	mg/L	0.0006	0.025
Zinc	mg/L	<0.001	0.030

[1] Canadian water quality guidelines for the protection of aquatic life (CCME, 1999a).
[2] CCME guideline concentration is 0.001 mg/L for hexavalent chromium and 0.0089 mg/L for trivalent chromium. No guideline exists for total chromium.

Metals

Analytical results for selected metals are presented in Table 3.2-1. Concentrations of metals were compared with the Canadian water quality guidelines for the protection of aquatic life (CCME, 1999a) to identify stations with elevated levels. The guideline concentrations are presented in Table 3.2-1.

All metal concentrations were below Canadian water quality guidelines for the protection of aquatic life (CCME, 1999a). Many metals such as cadmium, chromium, iron, lead, mercury, and zinc were below analytical detection limits (Table 3.2-1). Total concentrations of aluminum, arsenic, copper and nickel were above analytical detection limits. Copper concentration was 0.0006 mg/L, arsenic concentration was 0.0003 mg/L, aluminum concentration was 0.011 mg/L, and nickel concentration was <0.0006 mg/L.

Petroleum Hydrocarbons

Extractable petroleum hydrocarbon concentrations (C_{10}-C_{32}) were below detection limits in all surface water samples (Table 3.2-1).

Quality Assurance/Quality Control

Analytical results for water chemistry field blanks and travel blanks are presented in Appendices 3.1-2 and 3.1-3. Field blanks for total organic carbon, total Kjeldahl nitrogen and total metals all had concentrations below detection limits. A travel blank for extractable petroleum hydrocarbons also had concentrations below detection limits.

3.2.1.3 Sediment Quality

Lake sediments are both a source and a sink for particulate and dissolved material in the water column. Trace metals, nutrients, and contaminants can accumulate in sediments and can also be released to overlying water through various biogeochemical processes. Changes in chemistry, organic matter, and inorganic particle composition of surface waters are commonly reflected in sediment composition.

Analytical results for nutrients, metals and particle size in sediment samples collected in August 2001 are presented in Appendix 3.2-2. Petroleum hydrocarbon results are presented in Appendix 3.2-3. Sediment description sheets are presented in Appendix 3.2-4, and a photographic record of all collected sediment samples is presented in Appendix 3.2-5.

Sediment Descriptions

Sediment was difficult to collect near the terminal end of the Road because large boulders covered much of the lake bottom. Sediment consisted of a thin top layer of very dark brown sand (Munsell colour code: 10YR 2/2) and a dark yellowish brown (10YR 4/4) bottom layer of clay sand (Appendices 3.2-4 and 3.2-5). Biological material observed in the sediment samples was limited to a single worm.

Nutrients

Average nutrient concentrations are presented in Table 3.2-2. Total organic carbon, available phosphorus, and total nitrogen content of sediment were low. Total organic carbon (TOC) content was 0.44%, total nitrogen content was 0.04% and available phosphorus was 6 mg/kg.

Metals

Average concentrations for selected metals in sediments are presented in Table 3.2-2. Concentrations of metals were compared with the Canadian sediment quality guidelines for the

protection of aquatic life (CCME, 1999b) to identify stations with elevated levels. The guideline concentrations are also presented in Table 3.2-2.

Table 3.2-2
Average Concentrations for Selected Sediment Quality Variables, Contwoyto Lake

Variable	Units	Contwoyto Lake	CCME Guideline[1]
Total Organic Carbon	%	0.44	-
Available Phosphorus	mg/kg	6	-
Total Nitrogen	%	0.04	-
Extractable Petroleum Hydrocarbons C_{10}-C_{19}	mg/kg	<200	-
Extractable Petroleum Hydrocarbons C_{19}-C_{32}	mg/kg	<200	-
Total Aluminum	mg/kg	5,967	-
Total Arsenic	mg/kg	3.8	17.0
Total Cadmium	mg/kg	<0.1	3.5
Total Chromium	mg/kg	15	90
Total Copper	mg/kg	6	197
Total Iron	mg/kg	9,427	-
Total Lead	mg/kg	<2	91.3
Total Mercury	mg/kg	<0.005	0.486
Total Nickel	mg/kg	13	-
Total Zinc	mg/kg	21	315

[1] Probable effect levels (PEL) from the Canadian sediment quality guidelines for the protection of aquatic life (CCME, 1999b).

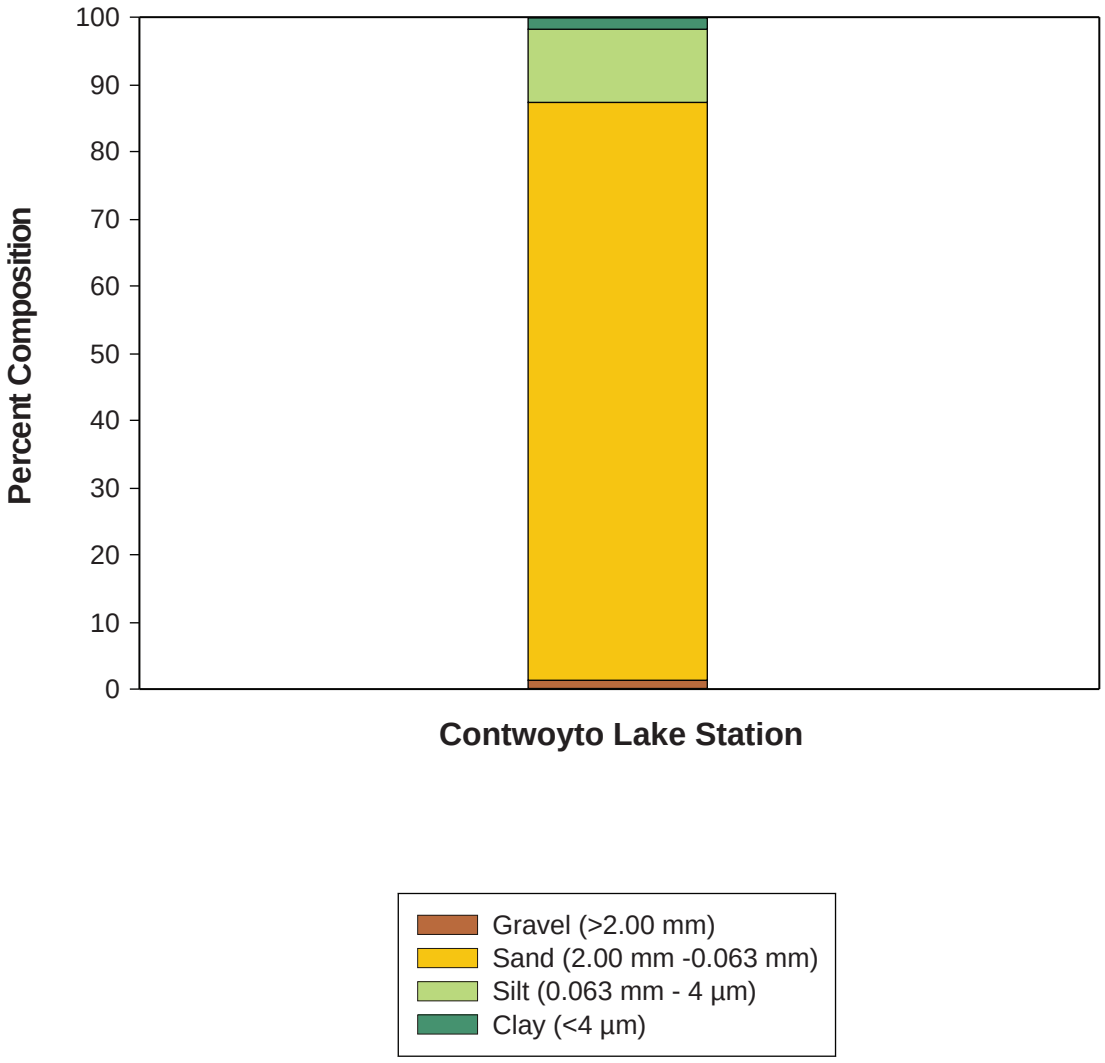
Sediment metal concentrations were generally low. Total concentrations of arsenic, cadmium, chromium, copper, lead, mercury, nickel and zinc were below probable effects levels as outlined in the Canadian sediment quality guidelines for the protection of aquatic life (CCME, 1999b).

Petroleum Hydrocarbons

Extractable petroleum hydrocarbon concentrations (C_{10}-C_{32}) in sediment were below detection limits at the terminal end of the Road.

Particle Size

The results of the sediment particle size analysis are presented in Figure 3.2-2. Sediment was primarily composed of sand particles (86% of total dry weight).



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Percent Composition of Grain Sizes, Contwoyto Lake Sediment, August 2001

FIGURE 3.2-2

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3.2.1.4 Primary and Secondary Producers

Phytoplankton, zooplankton, and benthic invertebrates are key communities in lake food webs. Phytoplankton are microscopic algae suspended in the open waters of a lake, using energy from the sun to grow. They are the dominant primary producers in lake surface waters and are a principal source of food for zooplankton. Zooplankton are microscopic invertebrates drifting suspended in the water column. By consuming phytoplankton, they provide an energy link between phytoplankton and larger zooplanktivorous invertebrates and fish. Benthic invertebrates consume algae, bacteria and detrital matter on the lake bottom and can be an important source of food for fish, especially in Arctic lakes where zooplankton communities are often small.

Phytoplankton

Results of the taxonomic enumeration and identification of all phytoplankton samples are provided in Appendix 3.2-6 and chlorophyll *a* results are provided in Appendix 3.2-7. Phytoplankton biomass and abundance were low. Phytoplankton average abundance was 124 cells/mL and chlorophyll *a* was 0.20 µg/L. Similarly low phytoplankton abundance was observed in Contwoyto Lake and neighbouring lakes by Moore (1978a), with abundances ranging from 110 to 490 cells/mL.

Phytoplankton communities were relatively diverse. A total of 32 genera were identified, with 14 genera contributing 90% of the abundance. Phytoplankton diversity, measured by the Shannon and Simpson diversity indices, was 2.55 and 0.87 respectively. The diversity in Contwoyto Lake was relatively high compared with other undisturbed Arctic lakes such as those in the Lac de Gras watershed where Shannon and Simpson diversity indices ranged from 1.3 to 2.1 and from 0.5 to 0.8, respectively (Rescan, 2000). The phytoplankton species, *Rodomonas minuta* (a dinoflagellate) and *Monoraphidium komerkovae* (green algae), were dominant at all stations on Contwoyto Lake (Table 3.2-3). In a survey completed by Moore (1978c) of 153 lakes, rivers and pools in the Northwest Territories, two *Cyclotella* species were the most common diatoms, and *Dinobryon bavaricum* was the most abundant and widespread of all species.

Table 3.2-3
Percent Abundance of Dominant Phytoplankton Species in Contwoyto Lake

Dominant Species[1]	Contwoyto Lake
Bacillariophyceae	
Cyclotella spp.	5
Chlorophyta	
Elaktothrix gelatinosa	8
Monoraphidium komarkovae	17
Ulothrix sp.	8
Pyrrophyta	
Rhodomonas minuta	24

[1] A phytoplankton species was considered dominant at a station if it represented ≥ 5% of total community abundance.

Phytoplankton communities were composed of algal species from seven different taxonomic groups. Green algae were the most abundant (mean percent abundance = 45%), followed by dinoflagellates (31%), chrysophytes (12%) and diatoms (10%) (Figure 3.2-3). Phytoplankton were only sampled once in August and these observations do not include changes in taxonomic composition that likely occurred over the summer season.

Zooplankton

Results of the taxonomic enumeration and identification of zooplankton samples are presented in Appendix 3.2-8. Zooplankton abundance was low, totalling 23,323 organisms/m^3. Zooplankton communities were relatively diverse with 14 species identified. Zooplankton diversity, measured by the Shannon and Simpson diversity indices were 1.77 and 0.76, respectively. In comparison, only five to seven zooplankton species were observed in forest-tundra lakes surveyed in the Northwest Territories by Swadling *et al*. (2000). A total of five zooplankton taxonomic groups were identified. Rotifera were the most abundant (mean percent abundance = 53%), followed by cladocerans (21%) and cyclopoid copepods (15%) (Figure 3.2-4).

The zooplankton species *Kellicottia longispina* (a rotifer) was the most dominant species (Table 3.2-4). Moore (1978a) also found that the rotifer *Kellicottia longispina* and the copepod *Cyclops scutifer* were important zooplankton species in Contwoyto Lake.

Table 3.2-4
Percent Abundance of Dominant Zooplankton Species, Contwoyto Lake

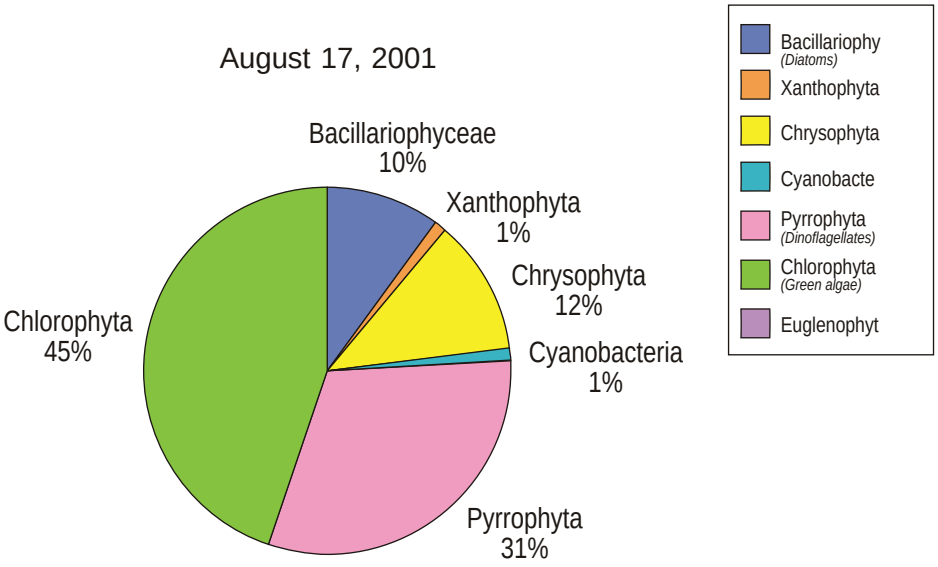
Dominant Species[1]	Contwoyto Lake
Rotifera	
Kellicottia longispina	42
Conochilus sp.	11
Cladocera	
Holopedium gibberum	10
Bosmina longirostris	9
Copepoda, Calanoida	
Leptodiaptomus sp.	7
Copepoda, Cyclopoida	
Cyclops sp.	13

[1]A zooplankton species was considered dominant at a station if it represented ≥ 5% of total community abundance.

Benthic Invertebrates

Results of the taxonomic enumeration and identification of all benthic invertebrate samples are provided in Appendix 3.2-9. Lake benthos densities were low, totalling 1,689 organisms/m^2. Moore (1978a) observed similar benthos densities (approximately 2,000 organisms/m^2) in Contwoyto Lake.

Contwoyto Lake

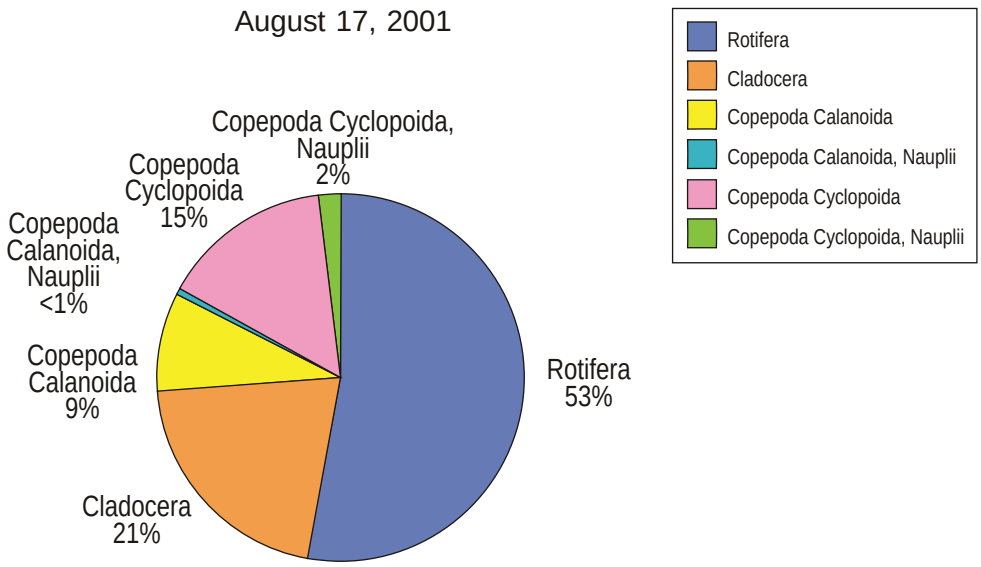


Average Organism Abundance = 124 cells/mL

Taxonomic Composition of Phytoplankton Communities by Abundance, Contwoyto Lake, August 2001

FIGURE 3.2-3

Contwoyto Lake



Average Organism Abundance = 23,323 org/m³

Taxonomic Composition of Zooplankton Communities by Abundance, Contwoyto Lake, August 2001

FIGURE 3.2-4

A total of 24 benthic invertebrate taxa were identified, with 12 taxa contributing 90% of community abundance.

Benthos communities were composed of organisms from 11 different invertebrate taxonomic groups. Dipterans were the most abundant group (mean percent density = 53%) followed by molluscs (22%) and nematodes (11%) (Figure 3.2-5). A total of 8 invertebrate taxa contributed more than 5% to community density (Table 3.2-5).

Table 3.2-5
Percent Density of Dominant Benthic Invertebrate Taxa in Contwoyto Lake

Dominant Taxa[1]	Contwoyto Lake
Nematoda	11
Diptera	
Chironomidae	5
Paratanytarsus	8
Rheotanytarsus	12
Tanytarsus	6
Orthocladius	15
Mollusca	
Sphaeriidae	8
Sphaerium	14

[1] **An invertebrate taxon was considered dominant at a station if it represented ≥ 5% of total community density.**

Moore (1978a) observed that *Heterotrissocladius* was the dominant chironomid in Contwoyto Lake benthos communities.

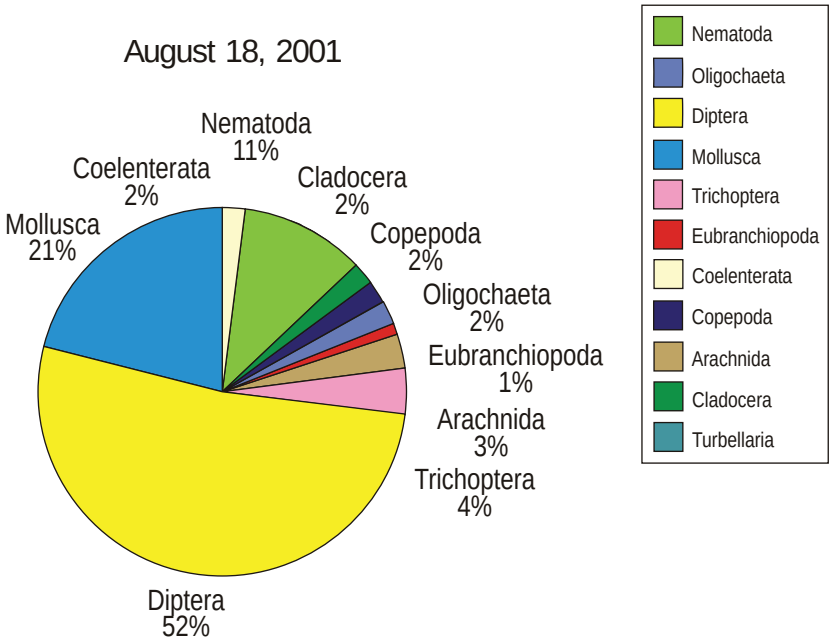
3.2.2 Fish Communities

3.2.2.1 Community Composition and Catch-Per-Unit-Effort

A total of 145 fish were captured during the fish community survey conducted in August 2001, at the terminal end of the Road. All information collected from the captured fish are listed in Appendix 3.2-10, which displays the date when the fish were caught, the sampling method used, the species, length, weight, sex, maturity, reproductive status, aging structures and tissue collected and stomach contents.

Fish were collected with a variety of equipment to enable sampling of all habitats and to capture all species and size classes present. Sampling sites were spread out around the peninsula and covered large areas (Figure 2.2-1). An aerial photo of the area was available and was overlaid on Figure 2.2-1. Co-ordinates of the locations of the sampling gear are presented in Appendix 3.2-11, with two point locations given for gillnets (one for each end) and one location for minnow traps and beach seines.

Contwoyto Lake



Average Organism Density = 1,689 org/m²

Taxonomic Composition of Benthic Invertebrate Communities by Abundance, Contwoyto Lake, August 2001

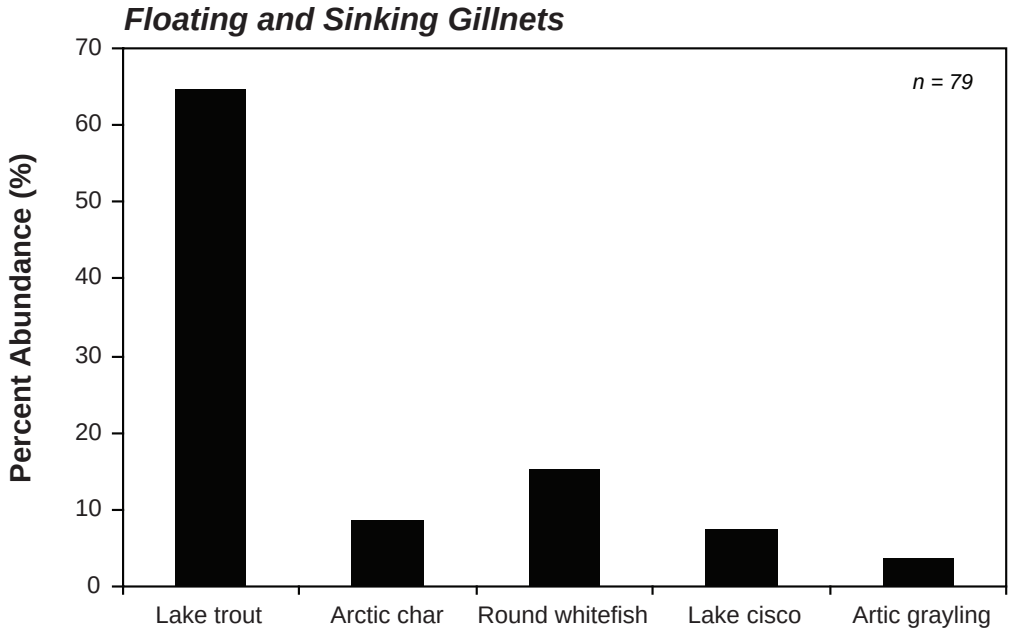
FIGURE 3.2-5

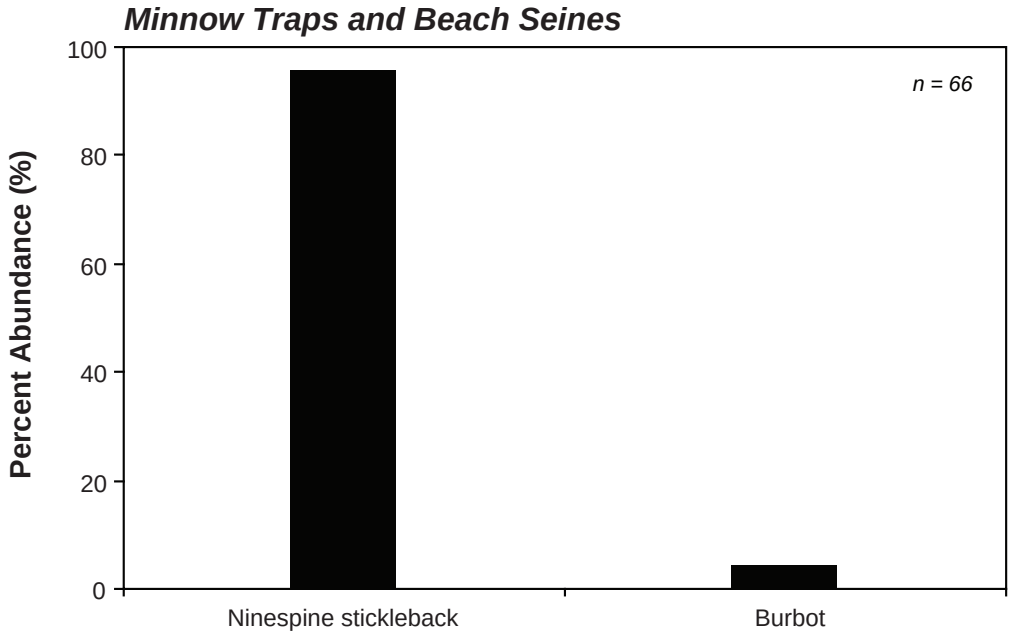
The majority of the fish caught in gillnets were lake trout. They comprised about 65% of the total catch (Figure 3.2-6). This result was expected as lake trout are one of the most abundant species found in Arctic lakes and are widely distributed throughout the study region. Other studies in northern areas of Contwoyto Lake report lake trout abundances from gillnet catches of between 43% and 52% (CANMET, 1996; Reid Crowther, 1985). The second most abundant species captured was round whitefish. Arctic char, lake cisco and Arctic grayling were the other three large species captured in 2001. Gillnetting studies conducted in 1983 and 1984 on the north-east shore of Contwoyto Lake reported that 57% of the catch was Arctic char (Reid Crowther, 1985). Lake trout is the dominant species in Arctic lakes and is an important food source for local people. It is a cold-water species, preferring temperatures between 4 and 12^{o}C (Martin and Olver, 1976). It is a slow growing fish, reaching maturity at 6 to 11 years in the northern part of its range (McPhail and Lindsey, 1970). They spawn in the autumn over cobble and gravel areas along lakeshores at depth of 0.3 m to 4 m (Martin and Olver, 1976). Embryo development takes place over winter with hatching occurring the following spring during ice break up. Lake trout are primarily piscivorous and feed on lake cisco, round whitefish, ninespine sticklebacks, benthic organisms, terrestrial insects and zooplankton (McPhail and Lindsey, 1970).

Minnow traps and beach seines are usually used to capture fish of small body size. They were less effective than gillnets in this study, except for two instances where 20 and 32 ninespine sticklebacks were caught in minnow traps. The two large numbers of sticklebacks were captured in vegetated areas (Plate 3.2-1), whereas the other traps were placed in areas of cobble and boulders with no vegetation (Plate 3.2-2). The third species sampled in the minnow traps were juvenile burbot (Plate 3.2-3).



Plate 3.2-1. Minnow trap with a high catch rate in vegetated area in the littoral zone, Contwoyto Lake, August 2001.





Relative Abundance of Fish Species Caught with Different Methods, Contwoyto Lake, August 2001

FIGURE 3.2-6

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Plate 3.2-2. Minnow trap that was set over cobble and boulders in the littoral zone, had a catch of zero fish.



Plate 3.2-3. Burbot (larger fish) and ninespine stickleback captured in a minnow trap set in the littoral zone of Contwoyto Lake, August 2001.

The seven species captured during the 2001 study was one species short (slimy sculpin) of the eight species captured between 1981 and 1994 by R.L.&L and Reid Crowther (R.L.&L., 1996). A total of 1,152 fish were captured in Contwoyto Lake during those years, using a variety of sampling gear. The four most abundant fish were lake trout, lake cisco, round whitefish and Arctic char.

Since floating and sinking gillnets were used to sample different habitats (surface versus bottom), species composition would be expected to be different. This was the case for fish caught near the terminal end of the Road. The majority of fish captured in floating nets were Arctic char, followed by lake trout and lake cisco (Figure 3.2-7). Lake trout made up 40% of the catch in the floating nets, whereas in the sinking nets they formed the majority comprising 69% of the catch. Arctic grayling and round whitefish were only captured in the sinking nets. (Figure 3.2-7).

Seventy-nine fish were captured in 11 gillnet sets (Table 3.2-6). The beach seine was also used at two locations along with six minnow traps set in the littoral zone. Set times and retrieval times of the gear are provided for all sets in Appendix 3.2-12.

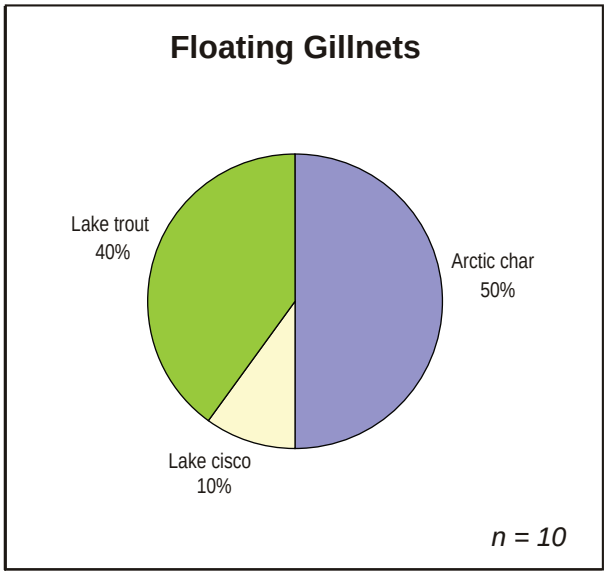
Individual CPUE values for each set and the number of each species caught per set are provided in Appendix 3.2-12. Average CPUE values were 6.74 and 23.45 fish per 100 m^2 for sinking nets and floating nets, respectively (Figure 3.2-8). The high variance observed with the floating nets is due to the low sample size and the few fish captured.

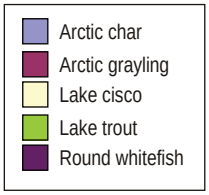
Approximate floating gillnet CPUE values for another study conducted in the north part of Contwoyto Lake were 3.7 and 7 fish per 100 m^2 of net per 24 hours (CANMET, 1996). Reid Crowther (1985) reported a CPUE of 4.8 fish for a site in north Contwoyto Lake.

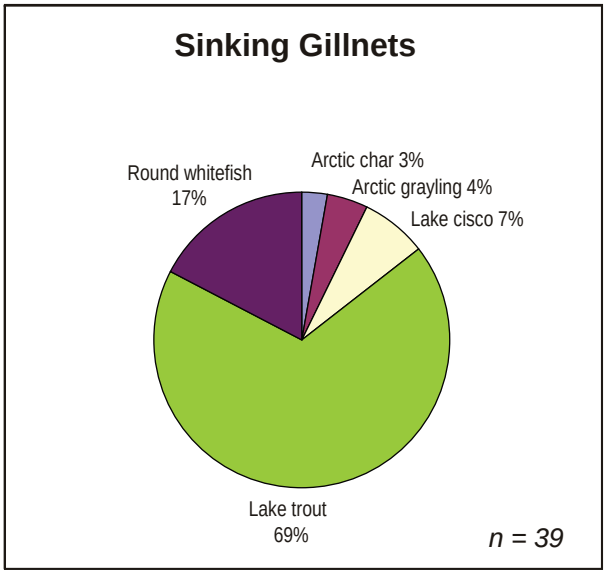
The approximate depth where both types of gillnets were set was recorded during the survey as either shallow or deep to identify any depth preference by fish species. Shallow was approximately less than 5 m and deep greater than 5 m. Average CPUE for sinking nets were not different between deep and shallow nets, whereas average CPUE for floating nets were much higher in shallow water than deep water (Figure 3.2-9). This suggests that fish captured in sinking nets (swimming near the bottom) do not have depth preferences and, therefore, were caught in similar numbers in both areas. Results from the floating nets, however, suggest that when fish swim at the surface they are more often found nearshore than offshore. This may be due to the greater amount of prey found nearshore (*e.g.*, terrestrial insects that float on the water's surface). The majority of the fish captured in shallow floating nets were Arctic char and lake trout.

3.2.2.2 Length, Weight and Condition

The most abundant species caught was lake trout with 51 individuals captured (Plate 3.2-4). The trout were mostly large and had a mean fork length of 509 mm and a mean weight of 2,272 g (Table 3.2-6). From 1981 to 1994, a total of 600 lake trout were sampled from Contwoyto Lake using a variety of techniques as part of fisheries investigations of the Lupin Mine (R.L.&L., 1996). Seventy percent of the fish were captured with gillnets in July and August. Average fork length for the 600 lake trout was 539 mm, slightly higher than the average length measured in this study.





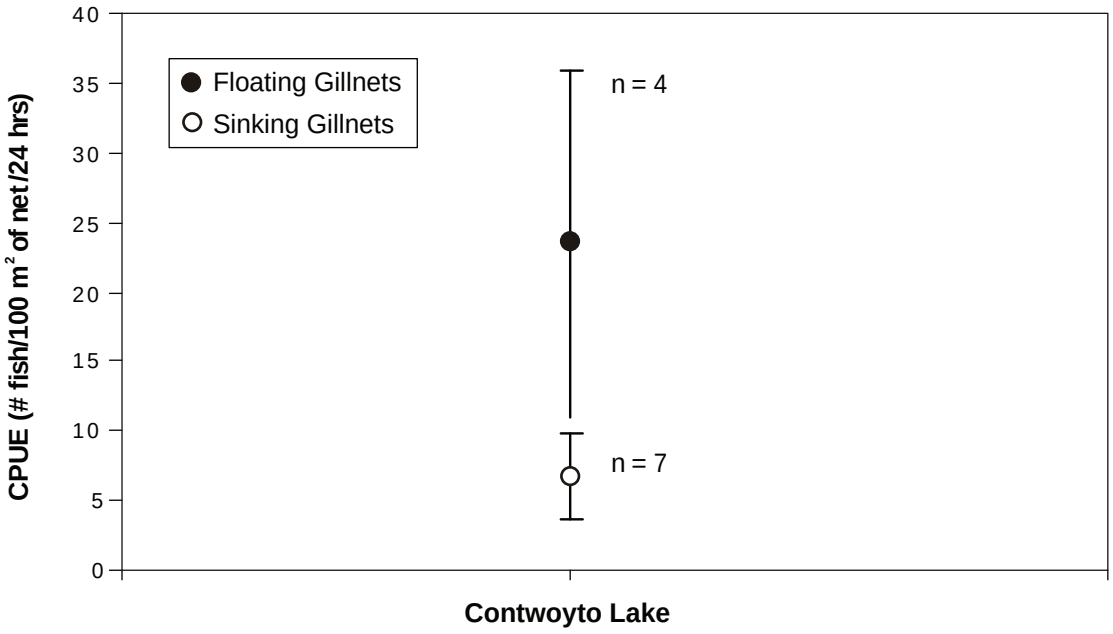


Species Composition from Two Different Sampling Devices, Contwoyto Lake, August 2001

FIGURE 3.2-7

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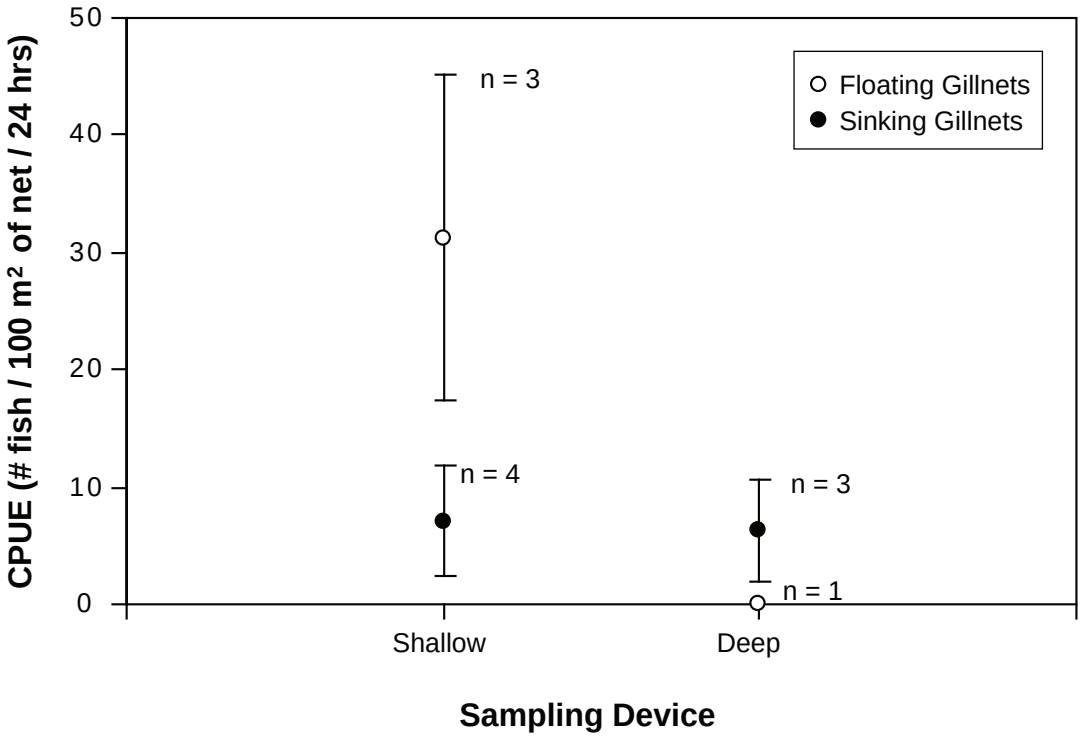
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Note: Error bars represent one standard error.
n = sample size

Average Catch-per-Unit-Effort for both Floating and Sinking Gillnet Sets, Contwoyto Lake, August 2001

FIGURE 3.2-8



Average Catch-per-Unit-Effort for Shallow and Deep Water Gillnet Sets, Contwoyto Lake, August 2001

FIGURE 3.2-9

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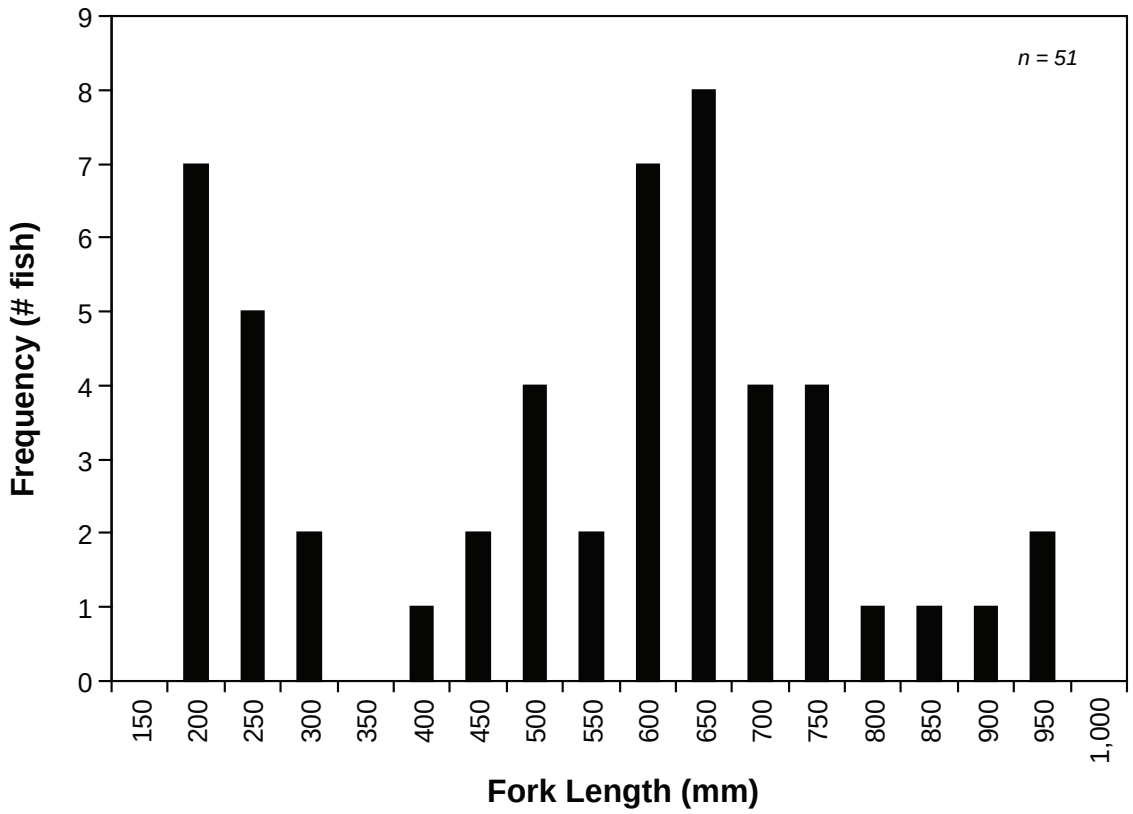
Plate 3.2-4. Lake trout captured in Contwoyto Lake (fork length = 766 mm and weight = 4,300 g), on August 15, 2001.

Table 3.2-6
Summary of Fish Lengths and Weights from Fish Captured in Contwoyto Lake

		Fork Length (mm)			Weight (g)		
	n	Mean	Range	SE	Mean	Range	SE
Lake trout	51	509	165-943	31	2272	46-10,775	314
Arctic char	7	429	211-620	51	1020	92-2,700	345
Round whitefish	12	300	240-363	9	285	100-525	30
Lake cisco	6	273	235-326	14	247	138-450	47
Arctic grayling	3	416	399-425	9	833	800-850	17
Ninespine stickleback	63	51	45-62	0.4	nd	nd	nd
Burbot	3	102	96-113	6	nd	nd	nd
Slimy sculpin	nf	nf	nf	nf	nf	nf	nf

SE = standard error of the mean.
nf = no fish captured.
nd = no data available.
"-" = no SE calculated due to sample size of 1.

The length-frequency distribution was bimodal with one mode between 150 mm and 200 mm and the second between 600 and 650 mm (Figure 3.2-10). The length-frequency distribution for the 600 lake trout captured between 1981 and 1994 was unimodal with the model length class interval between 575 and 600 mm (R.L. & L., 1996).



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Length Frequency Distributions for Lake Trout, Contwoyto Lake, August 2001

FIGURE 3.2-10

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A total of 7 Arctic char were caught near the terminal end of the Road. Average fork length was 429 mm and weight was 1,020 g (Table 3.2-6). Twelve round whitefish were captured and measured and weighed, on average, 300 mm and 285 g (Plate 3.2-5). Length-frequency distributions for Arctic char and round whitefish are presented in Figure 3.2-11.

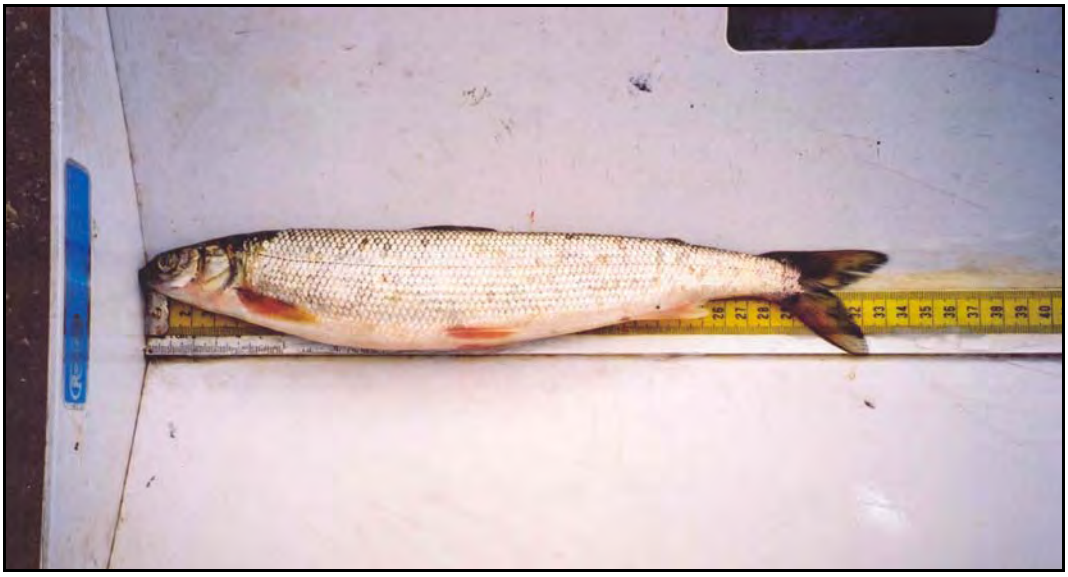


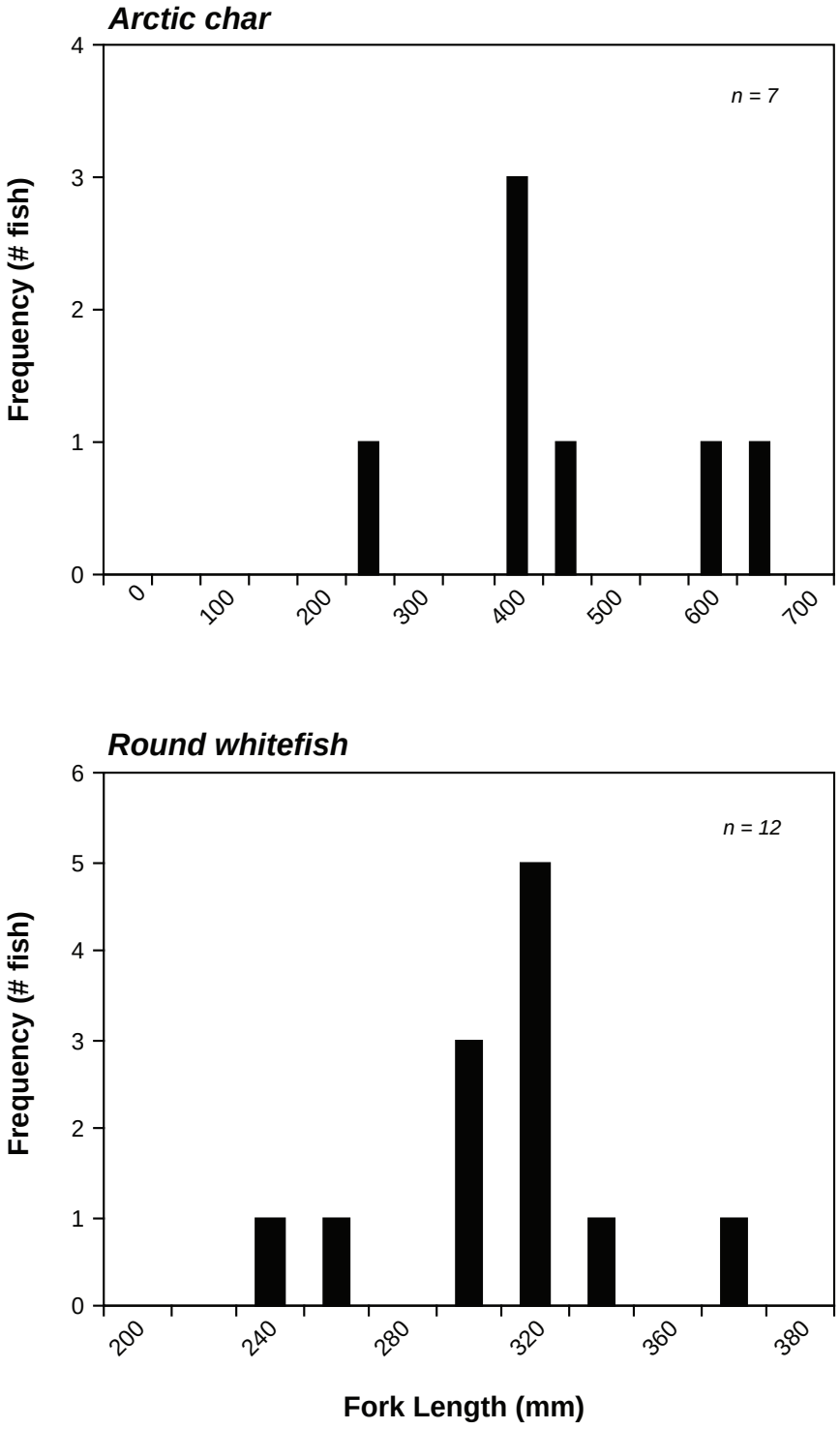
Plate 3.2-5. Round whitefish captured in Contwoyto Lake, August 2001 (fork length = 305 mm and weight = 300 g).

Length-frequency distributions for other species are not presented because too few fish were captured. However, means and ranges of lengths and weights for these species are reported in Table 3.2-6. Lake cisco captured averaged 273 mm and 247 g (Plate 3.2-6). The Arctic grayling captured were large, weighing on average 833 g and measuring 416 mm (Plate 3.2-7). Average length of ninespine sticklebacks was 51 mm. The three juvenile burbot caught measured, on average, 102 mm.

Weight-length relationships for lake trout and Arctic char are presented in Figure 3.2-12. Data are presented for these two species only because sufficient numbers of fish were caught. Regressions for lake trout and Arctic char explained the same amount of variation (r^2= 0.99).

Condition factor, the ratio of weight (g) to length (mm) cubed, is used as an indicator of the relative health of a fish. Mean condition for lake trout was 1.09 g/mm^3(Table 3.2-7). These values are similar to those from previous studies on lake trout from Contwoyto Lake where condition ranged from 1.06 to 1.12 g/mm^3 between 1981 to 1994, and averaged 1.09 g/mm^3 for all years (R.L.&L., 1996).

Condition was not calculated for the smaller species (ninespine stickleback and burbot) because no weight measurements were taken. Mean condition for Arctic char and round whitefish were 1.00 g/mm^3 (Table 3.2-7). Lake cisco and Arctic grayling mean condition was 1.15 and 1.16 g/mm^3, respectively.



Length Frequency Distributions for Arctic Char and Round Whitefish, Contwoyto Lake, August 2001

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FIGURE 3.2-11

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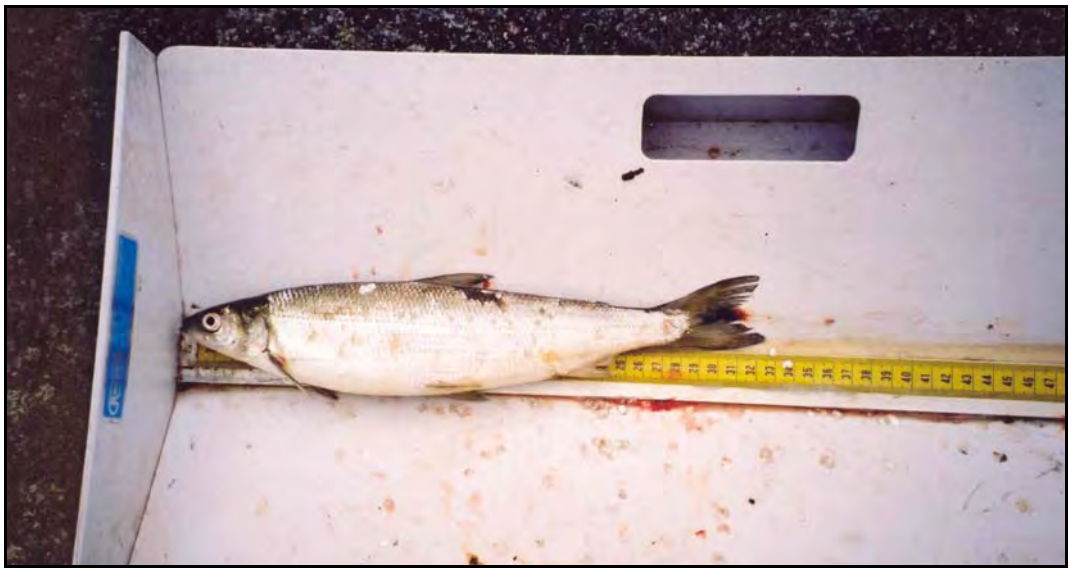
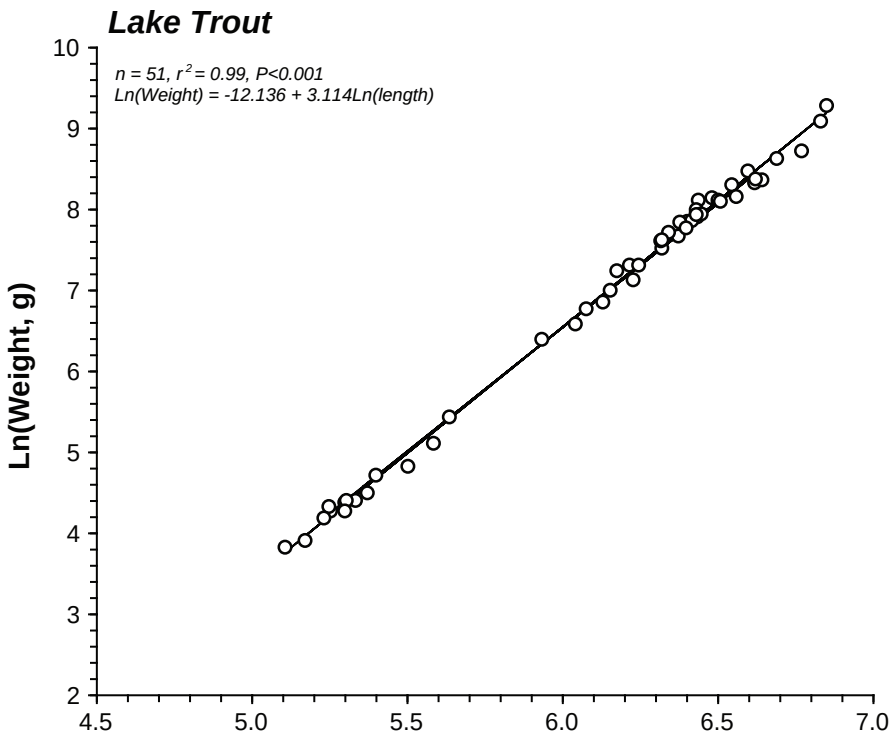
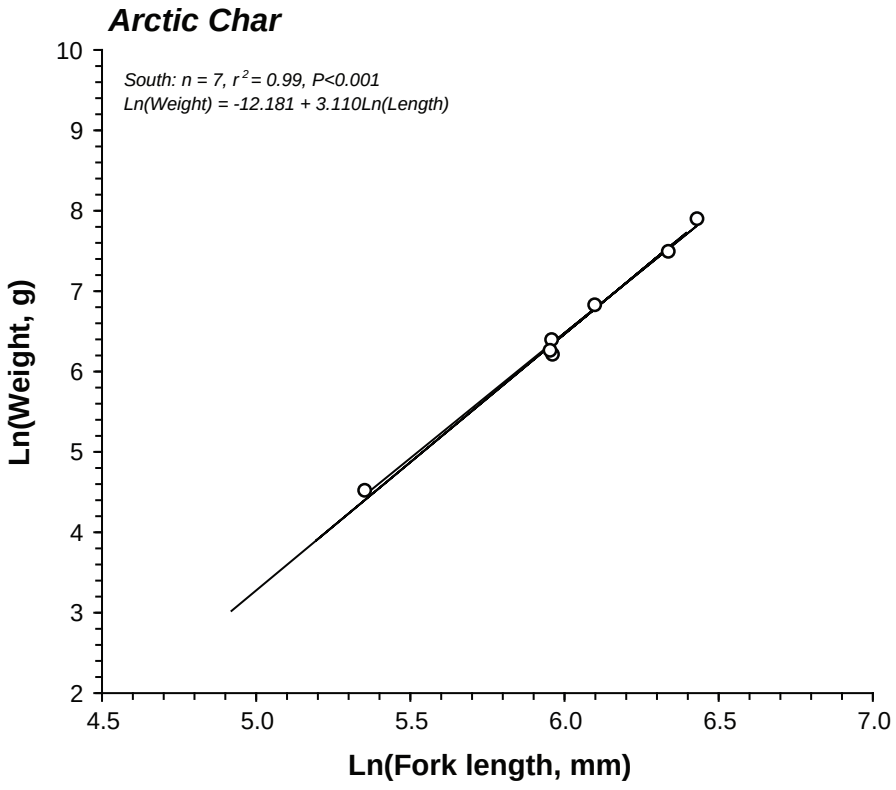


Plate 3.2-6. Lake cisco captured in Contwoyto Lake, August 2001 (fork length = 290 mm and weight = 250 g).



Plate 3.2-7. Arctic grayling captured in Contwoyto Lake, August 2001 (fork length = 450 mm and weight = 850 g).





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Weight-Length Relationships for Lake Trout and Arctic Char, Contwoyto Lake, August 2001

FIGURE 3.2-12

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Table 3.2-7
Summary of Fish Condition in Contwoyto Lake

Species	n	Mean	Range	SE
Lake trout	51	1.09	0.85 - 1.38	0.02
Arctic char	7	1.00	0.86 - 1.13	0.03
Round whitefish	12	1.00	0.72 - 1.20	0.04
Lake cisco	6	1.15	1.03 - 1.30	0.05
Arctic grayling	3	1.16	1.11 - 1.26	0.05
Ninespine stickleback	nd	nd	nd	nd
Burbot	nd	nd	nd	nd

nd = no data available.

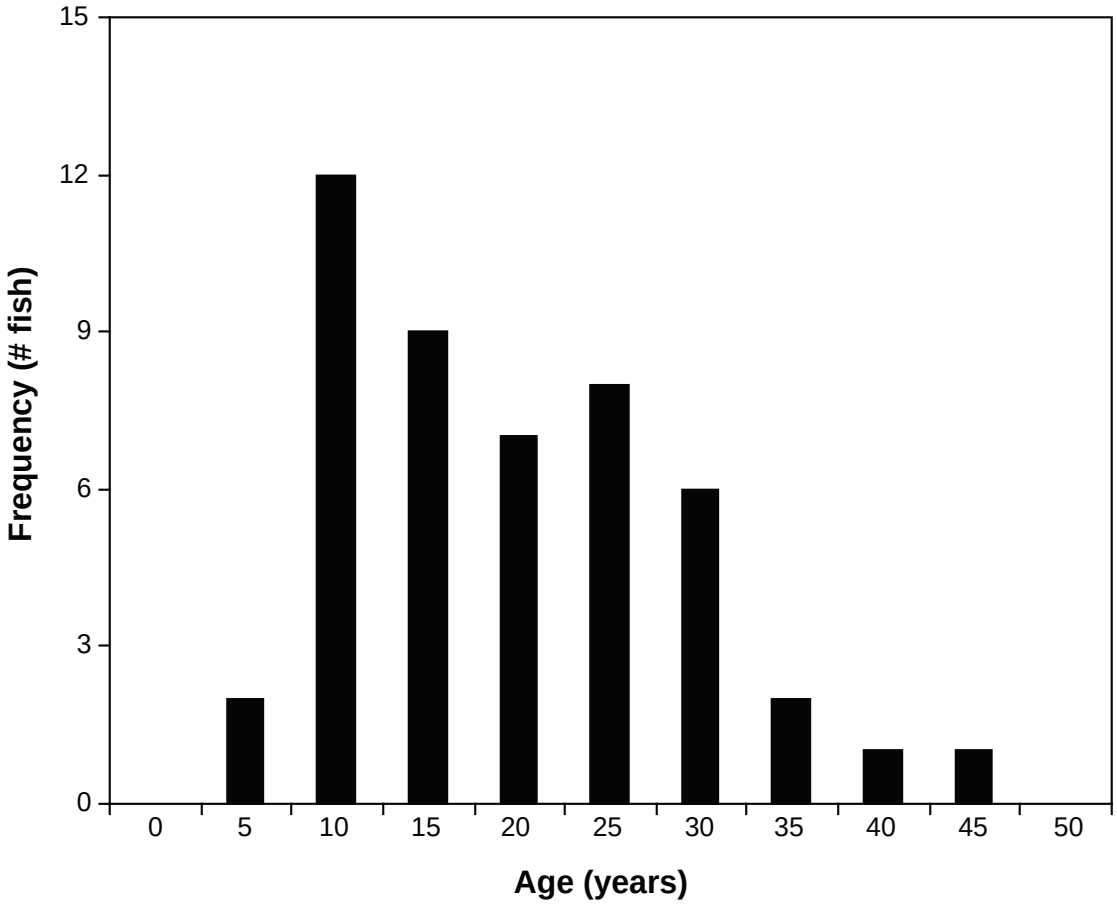
3.2.2.3 Age

Age of fish was determined from a combination of structures: fin rays, otoliths and scales. The lake trout captured consisted of a high number of old fish. The crystallisation observed in older lake trout otoliths yielded lower confidence on overall age assessment. Interestingly, some of the younger lake trout (*i.e.,* 6 to 12 years old) showed very little growth in 2001 (Jon Tost, North Shore Environmental Services, Thunder Bay, pers. comm.). It was either a slow-growth year, or these fish may have more of their growth in the fall (late August to October) than other populations. The individuals who aged the fish were fairly confident of their age estimates for round whitefish, lake cisco and Arctic char.

The mean age of lake trout was 17 years with an age range of 4 to 42 years (Table 3.2-8). Lake trout populations in the Arctic are typically older than in temperate lakes due to slower growth rates. The age-frequency distribution of lake trout was skewed towards younger ages, with the most abundant age class being 5 to 10 years (Figure 3.2-13). The average age of lake trout captured in Contwoyto Lake from 1981 to 1984 and from 1990 and 1993 ranged from 19 to 22 years (R.L.&L., 1996).

Table 3.2-8
Summary of Fish Age Data in Contwoyto Lake

Species	n	Mean	Range	SE
Lake trout	48	17	4 - 42	1
Arctic char	7	9	4 - 12	1
Round whitefish	12	7	4 - 9	0.4
Lake cisco	6	7	5 - 11	1
Arctic grayling	3	13	9 - 18	3



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Length Frequency Distributions for Lake Trout, Contwoyto Lake, August 2001

FIGURE 3.2-13

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Arctic char had an average of 9 years, and the age-frequency distribution ranged from 3 to 15 years (Figure 3.2-14). Round whitefish and lake cisco both averaged 7 years of age, while Arctic grayling were much older, averaging 13 years of age.

Length-age relationships of lake trout were described with the von Bertalanffy growth model (Figure 3.2-15). Percent variation explained by the model was 89%, with a growth coefficient of 0.083 per year.

3.2.2.4 Sex, Maturity, and Reproductive Status

Sex, maturity, and reproductive status are presented only for lake trout because only sufficient numbers of lake trout were captured to present averages (Figure 3.2-16). All raw data for other species are reported in Appendix 3.2-10. A total of 30 lake trout were sexed and their reproductive status and maturity were assessed. Males were more abundant and represented 53% of the fish caught. Forty-three percent of the lake trout captured were immature, with the high percentage of mature fish captured leading to a great number of imminent spawners observed. Lake trout usually spawn in September and early October in Canada's north.

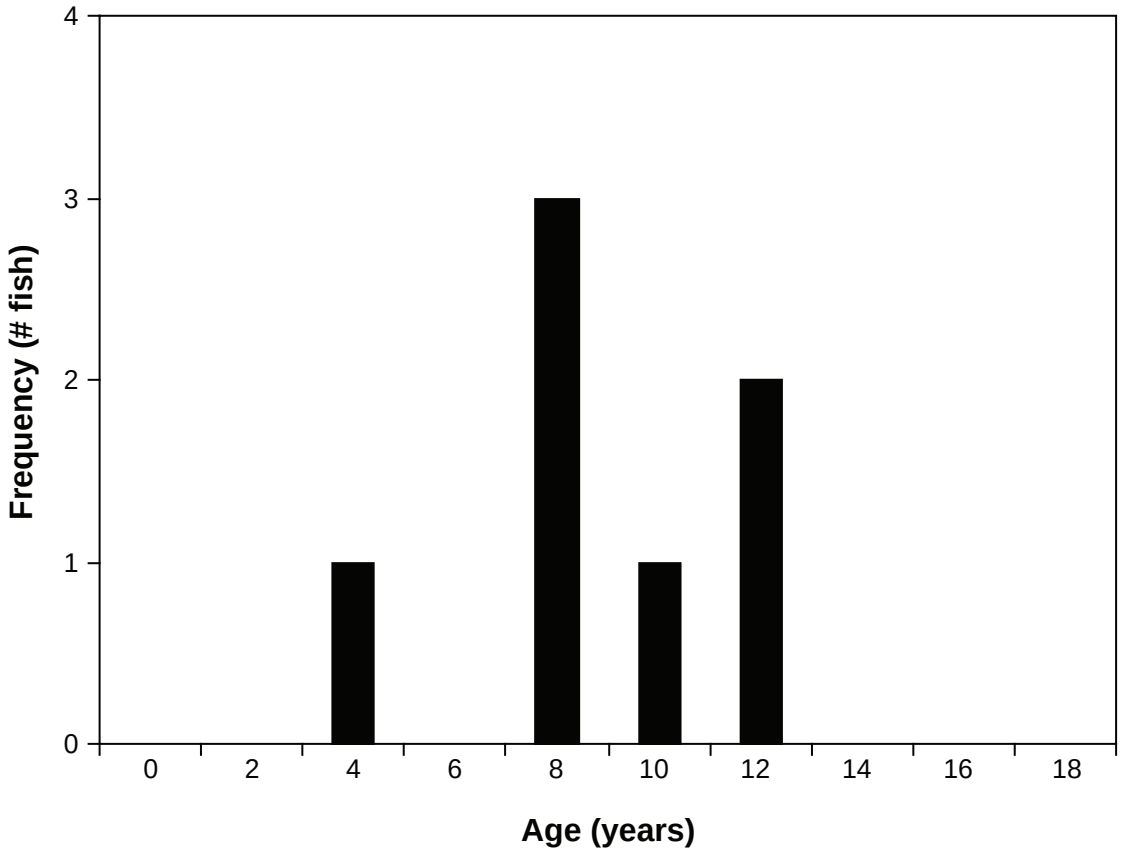
3.2.2.5 Diet

Stomach contents of dead fish were identified in the field. A summary of the diet of the lake trout captured is presented in Figure 3.2-17, and data from the other species are shown in Appendix 3.2-10. Lake trout are predaceous and feed on a broad range of organisms (Scott and Crossman, 1973) as observed near the terminal end of the Road. Approximately 30% of the trout had consumed only fish. After lake trout fed on fish, they sometimes fast for a few days, and so may have empty stomachs when captured, as observed. The data demonstrate that trout are mainly pelagic feeders and only a small portion of their diet is composed of benthic invertebrates (chironomids and molluscs). Terrestrial insects were the most abundant (36%) in the lake trout diet.

3.2.2.6 Metal Concentrations in Fish Tissue

Appendix 3.2-13 shows the total concentrations of 25 metals in muscle tissue of 10 lake trout sampled from Contwoyto Lake. Table 3.2-9 shows the average concentrations of 12 of these metals. Those 12 metals had more than 10% of their values above detection limits, whereas the other 13 metals had less than 10% of their values above detection limits. Concentrations of those 13 metals are shown in Appendix 3.2-13, but are not analyzed here.

To calculate average concentrations, values of the 12 key metals that were below detection limits were replaced with one-half of the detection limit, which is the standard practice for analysis of metals residues. Of the 120 concentrations (*i.e.*, 12 metals x 10 fish), 19 or 16% were replaced with one-half the detection limit, mostly concentrations for selenium (5), barium (8) and cobalt (6).

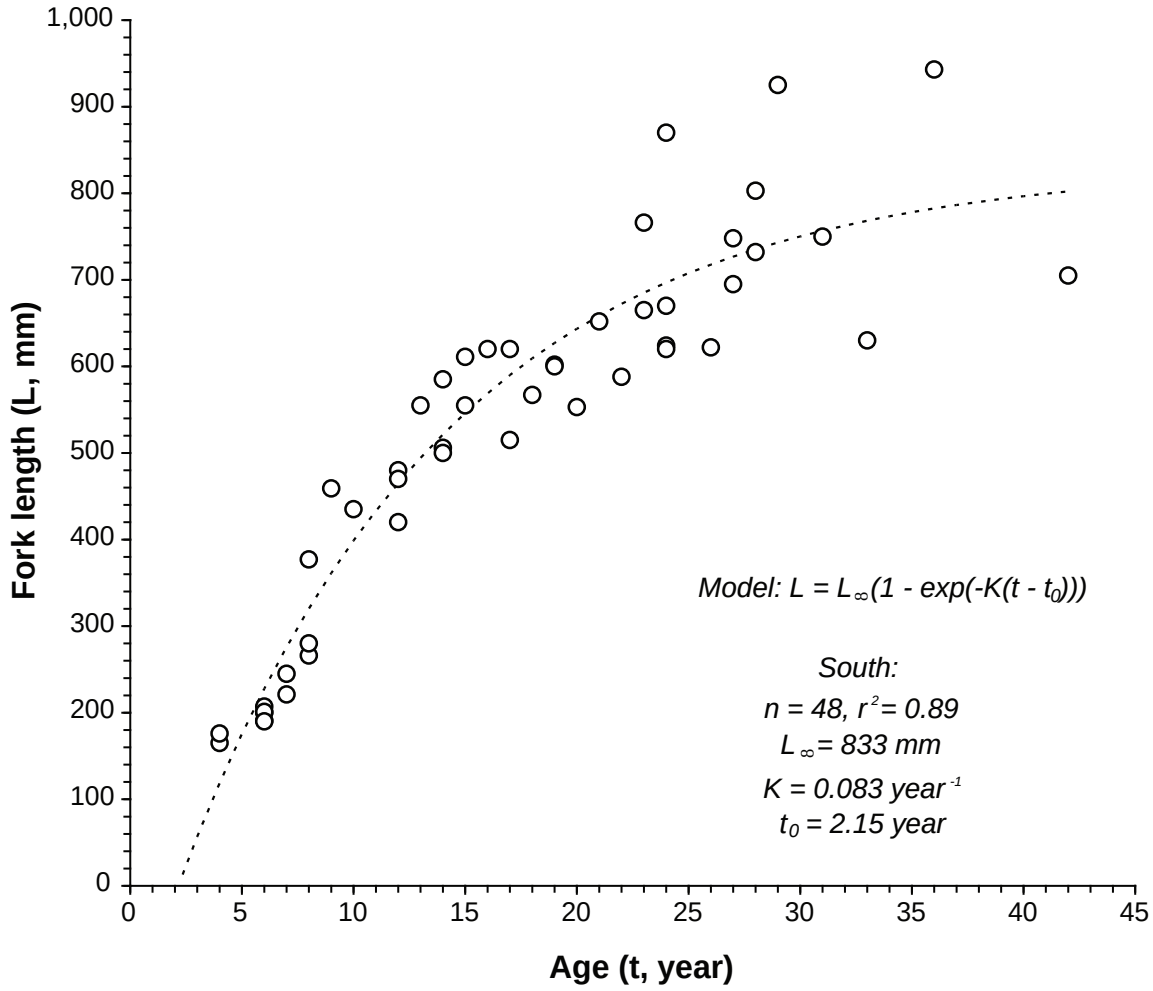


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Age Frequency Distributions for Arctic Char, Contwoyto Lake, August 2001

FIGURE 3.2-14

Rescan™

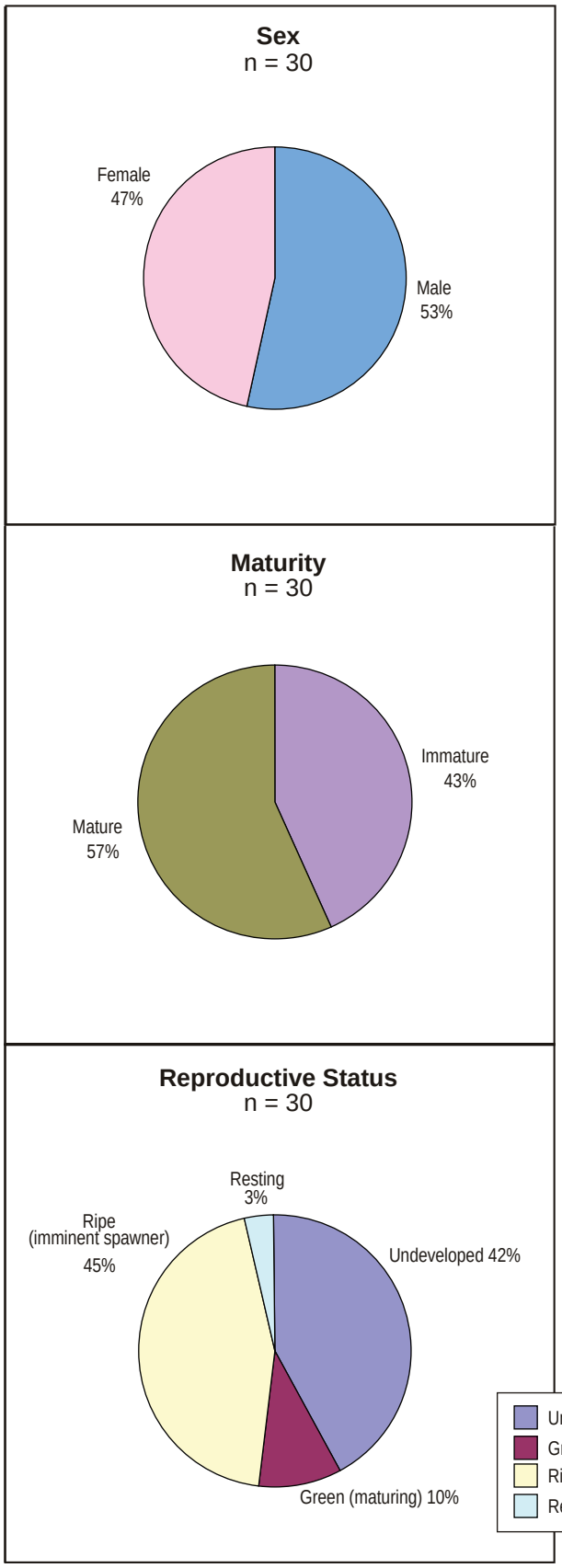


the BATHURST INLET PORT AND ROAD PROJECT

von Bertalanffy Growth Models for Lake Trout from Contwoyto Lake

FIGURE 3.2-15

Rescan™

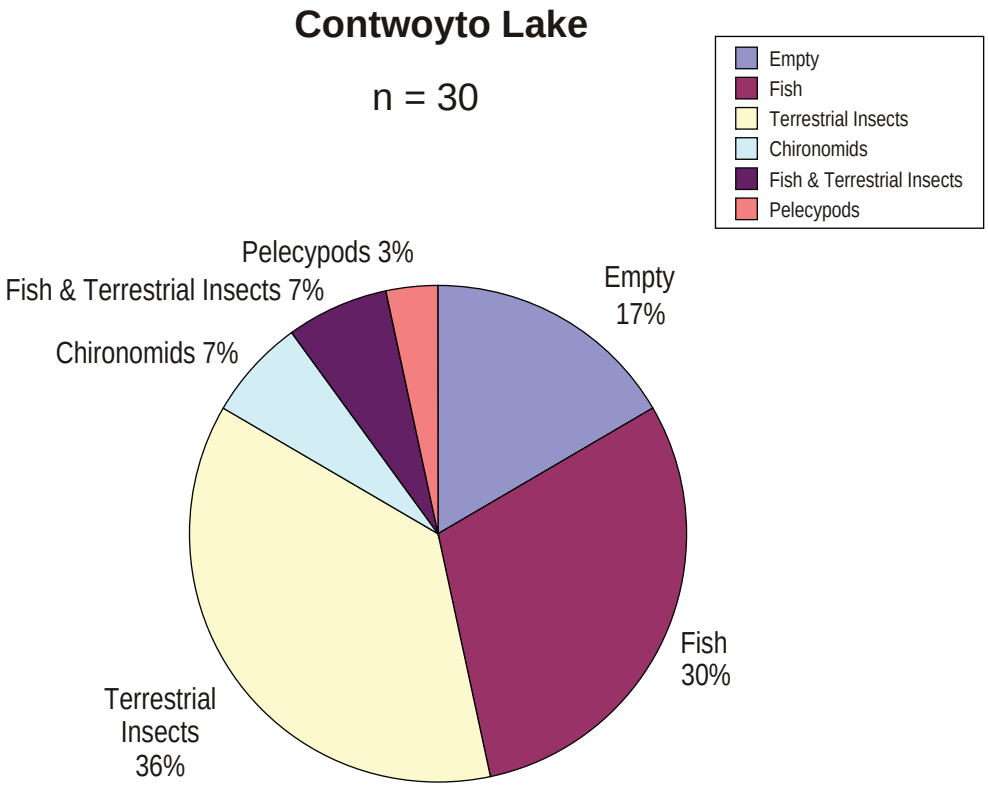


Sex, Maturity, and Reproductive Status of Lake Trout, Contwoyto Lake, August 2001

FIGURE 3.2-16

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Summary of Stomach Contents for Lake Trout, Contwoyto Lake, August 2001

FIGURE 3.2-17

Table 3.2-9
Concentrations of Metals in Muscle Tissue of Lake Trout, Contwoyto Lake

		Concentration (mg/kg DW):		
Metal	**n**	**mean**	**SE**	**range**
Thallium	10	0.06	0.01	0.04-0.11
Barium	10	0.04	0.01	0.03-0.15
Cobalt	10	0.1	0.0	0.1-0.4
Arsenic	10	0.21	0.02	0.09-0.28
Strontium	10	0.28	0.04	0.15-0.55
Manganese	10	0.43	0.05	0.30-0.91
Mercury	10	1.491	1.385	0.590-5.250
Selenium	10	1	0	1-1
Copper	10	1.60	0.17	0.97-2.82
Zinc	10	15.3	1.5	11.2-27.5
Calcium	10	235	19	162-371
Magnesium	10	1181	40	982-1350

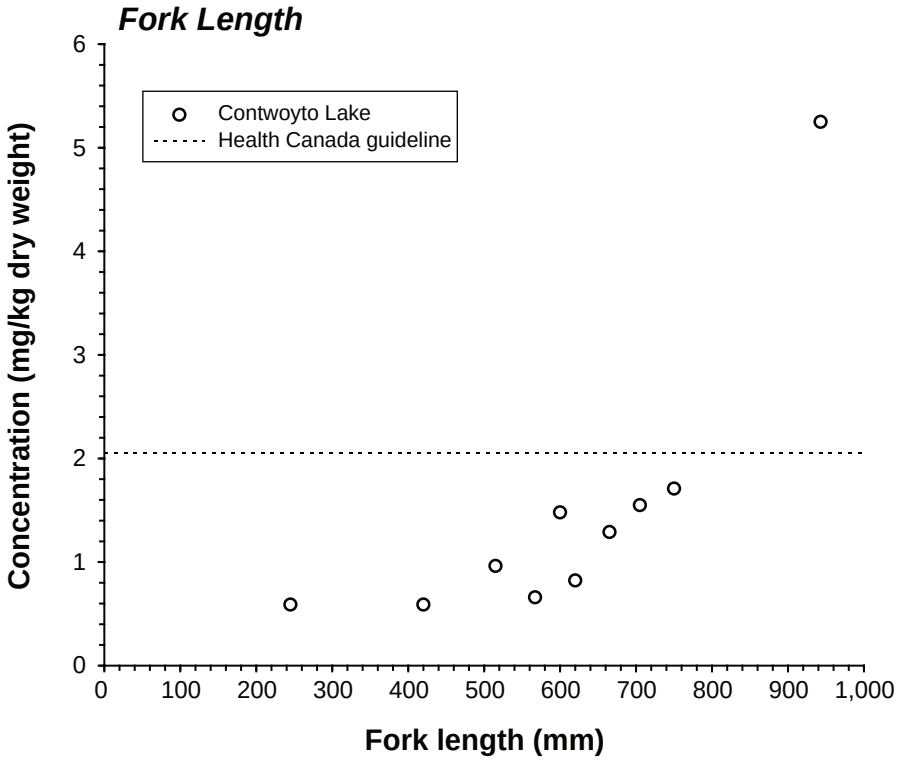
n = number of fish used to calculate means.
DW = dry weight, and SE = standard error of a mean.

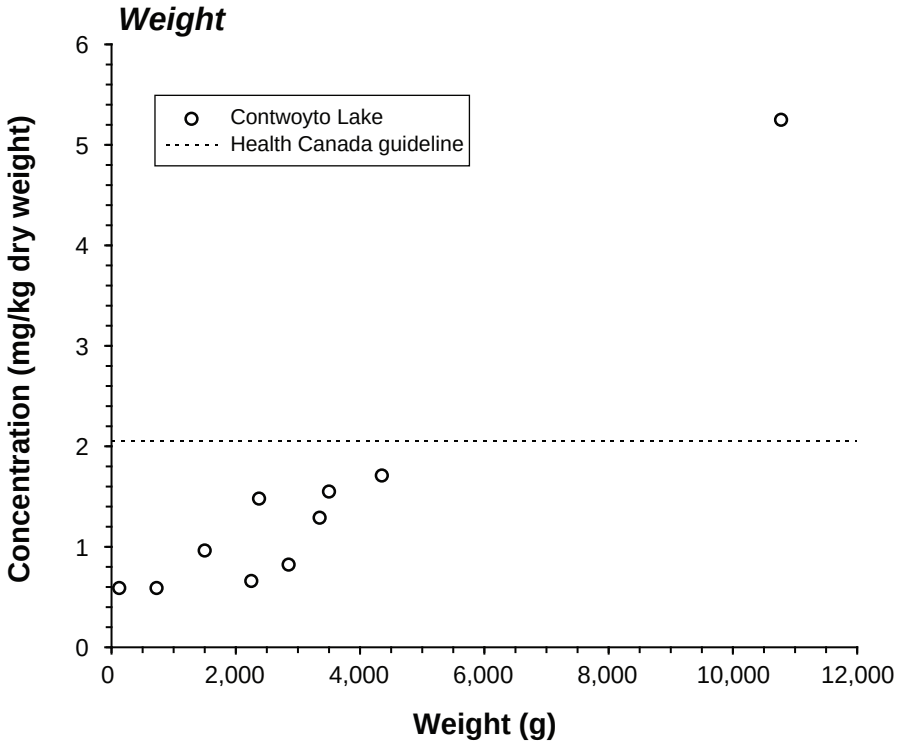
Concentrations are expressed as mg/kg dry weight. Percent moisture of each sample is shown in Appendix 3.2-13. It ranged from 72.0 to 80.1% and averaged 76.4%.

Thallium and barium had the lowest average concentrations of the 12 metals and calcium and magnesium had the highest average concentrations (Table 3.2-9).

Mercury is the only metal of the 12 for which the Canadian government has set guidelines for protection of human health (Health Canada, 2002). The guideline is 0.5 ppm (or mg/kg) of total mercury in edible fish tissue. Since total mercury concentrations of lake trout in Contwoyto Lake were expressed as mg/kg dry weight, that guideline was converted to a dry weight basis by multiplying it by $1/(1 – (x/100))$ where "x" was the average percent moisture of all 10 lake trout samples from Contwoyto Lake (76.4%). In other words, the wet weight guideline of 0.5 mg/kg was multiplied by a factor of 4.24 to obtain a dry weight guideline of 2.12 mg/kg.

One of the 10 lake trout exceeded that guideline – sample number 74 had a muscle mercury concentration of 5.250 mg/kg DW, which was 2.5 times above the guideline. Fish number 74 was the largest fish caught during the Contwoyto Lake study, having a fork length of 943 mm and weight of 10,775 g. Mercury is well known to increase with increasing fish body size because fish lack the metabolic machinery to excrete mercury. That was shown for this study by plots of mercury concentration on fork length and body weight (Figure 3.2-18).





Plots of Mercury Concentration on Fork Length and Weight for Lake Trout Captured, Contwoyto Lake, August 2001

FIGURE 3.2-18

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The plots show that the relationship is curvilinear – the rate of increase in mercury concentration with increasing body size is not constant but increases with increasing body size. The inflexion point occurs at about 500 mm in length or 1,000 g in weight. That curvilinear pattern is common for such plots and it is usually linearized by transforming both variables with logarithms. However, the August 2001, Contwoyto Lake data are unusual in that log-transformation did not linearize the concentration-size plots (those plots are not shown here). Instead, they retained curvilinearity. That finding suggests that mercury concentration in lake trout of Contwoyto Lake may be influenced by size-dependent changes in diet. That is, lake trout longer than about 500 mm or 1,000 g in body weight may prefer prey (or are capable of catching prey) that are higher in the trophic scale (*e.g.*, fish) and that have higher body burdens of mercury.

Comparison of the average mercury concentration in lake trout from Contwoyto Lake measured in August 2001, with average concentrations measured in 1982-1984, 1985, 1988, 1990 and 1993 and reported by R.L.&L. (1995) showed that the 2001 data fell within the range observed over the last 20 years (Figure 3.2-19).

3.2.3 Fish Habitat

3.2.3.1 Fish Habitat Assessment

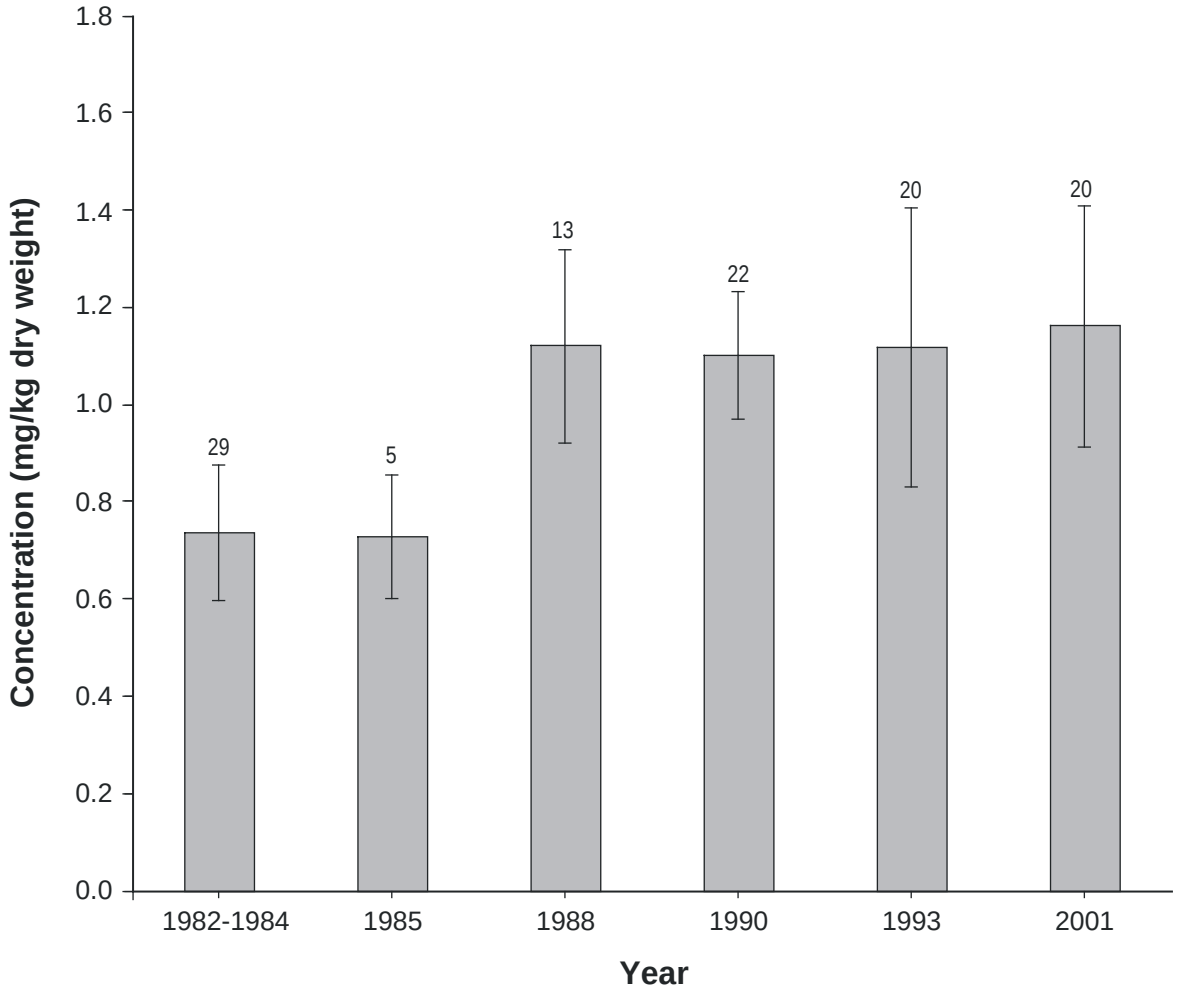
Habitat assessments were conducted on August 17, 2001, with sixteen habitat zones being delineated. Substrate composition of each zone is presented in Figure 3.2-20 along with an overlay of the bathymetric contours (in 1-m intervals) onto aerial photographs.

At the proposed terminal end of the Road, 2,380 m of shoreline and its associated habitat were surveyed. More than 45% of the area's substrate was composed of sand (Table 3.2-10). The second most dominant substrate (34.1%) was boulder. Cobble (11.6%) was next, followed by emergent vegetation (4.7%) and bedrock (2.0%).

The littoral zone that surrounded the peninsula was dominated by boulder and bedrock (Figure 3.2-20). In contrast, sand, silt, and cobble dominated the sheltered bay areas. The bay east of the peninsula harboured significant amounts of emergent vegetation (Plate 3.2-8). The substrate composition observed at this site is typical of large waterbodies. Exposed areas such as peninsulas, generally have substrates composed of larger diametre rock and bedrock whereas sheltered areas have substrates consisting of fine sands and silts. The slope at this site was steep (Plate 3.2-9).

3.2.3.2 Fish Habitat Preferences

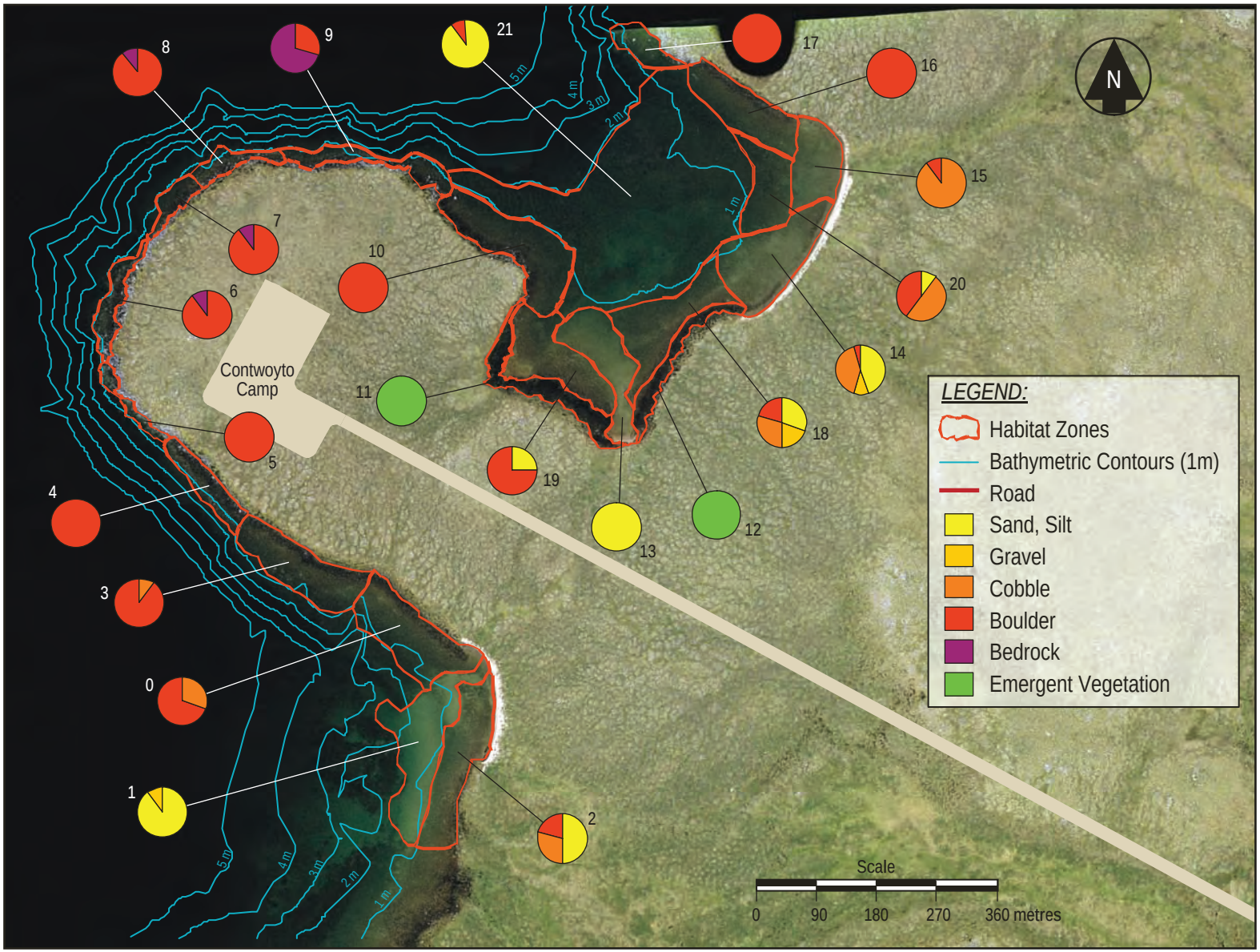
Lake trout was the most abundant species captured during the Contwoyto Lake survey. Approximately 65% of fish captured were lake trout. To link habitat types with species preferences, a summary of habitat preferences that were rated high by Richardson *et al.* (2001) for the seven species captured during this study is provided in Table 3.2-11. A written summary of those habitat preferences is also presented below. The areas of abundant cobble and boulder present at the terminal end of the Road are highly preferred areas by all life stages of lake trout and several life stages of other species captured such as Arctic char and burbot.



Error bars are one SE of the average.
Data for 1982-1984 to 1993 from R.L.&L. (1995).
Numbers are sample sizes for each average.

Average Concentrations of Total Mercury in Muscle Tissue of Lake Trout from Contwoyto Lake for the Years 1982-1984 to 2001

FIGURE 3-2-19



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Fish Habitat Assessment, Contwoyto Lake, August 2001

FIGURE 3.2-20

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Table 3.2-10
Substrate Composition of the Littoral Zone at the Terminal End of the Road, Contwoyto Lake

Zone No.	Area (m^2)	Sand (%)	Gravel (%)	Cobble (%)	Boulder (%)	Emerg. Veg. (%)	Bedrock (%)	Sand (m^2)	Gravel (m^2)	Cobble (m^2)	Boulder (m^2)	Emerg. Veg. (m^2)	Bedrock (m^2)
0	6,378			30	70			0	0	1,913	4,465	0	0
1	7,349	90	10					6,614	735	0	0	0	0
2	5,994	50		30	20			2,997	0	1,798	1,199	0	0
3	5,656			10	90			0	0	566	5,091	0	0
4	2,417				100			0	0	0	2,418	0	0
5	962				100			0	0	0	962	0	0
6	1,929				90		10	0	0	0	1,737	0	193
7	1,220				90		10	0	0	0	1,098	0	122
8	1,448				90		10	0	0	0	1,303	0	145
9	2,681				30		70	0	0	0	805	0	1,877
10	6,922				100			0	0	0	6,923	0	0
11	3,403					100		0	0	0	0	3,404	0
12	2,151					100		0	0	0	0	2,152	0
13	4,696	100						4,696	0	0	0	0	0
14	6,540	45	10	40	5			2,943	654	2,616	327	0	0
15	3,722			90	10			0	0	3,350	372	0	0
16	4,799				100			0	0	0	4,800	0	0
17	1,673				100			0	0	0	1,673	0	0
18	5,786	30	20	30	20			1,736	1,157	1,736	1,157	0	0
19	5,478	75			25			4,109	0	0	1,370	0	0
20	3,743	10		50	40			374	0	1,872	1,497	0	0
21	33,992	90			10			30,593	0	0	3,399	0	0
Total	**118,949**						**Total**	**54,063**	**2,546**	**13,851**	**40,597**	**5,555**	**2,337**
							%	**45.5**	**2.1**	**11.6**	**34.1**	**4.7**	**2.0**

Note: Emerg. Veg. = Emergent Vegetation.



Plate 3.2-8. Emergent vegetation located in habitat zone 11 at the terminal end of the Road.



Plate 3.2-9. Steep slope of the peninsula at the terminal end of the road. The photograph is taken from the west and shows habitat zones 6 and 7.

Table 3.2-11
Habitat Preference for Species Captured during the August 2001 Survey

	Substrate Preference					Cover					Depth Preference			
Species	**Sand-Silt**	**Gravel**	**Cobble**	**Boulder**	**Bedrock**	**None**	**Submergent Vegetation**	**Emergent vegetation**	**Overhead**	**In situ**	**S**	**Y**	**J**	**A**
Lake trout		S	S-Y-J-A	S-Y-J-A		S-A				Y-J	0-10+ m	2-10+ m	2-10+ m	10+ m
Arctic char		S	S-Y-J-A	Y-J-A			J	J		Y-J	2-10 m	10+ m	5-10+ m	0-10+ m
Round whitefish		S-Y	Y								0-1 m	0-2 m	0-2 m	0-2, 5-10+m
Lake cisco	S	S									0-5 m			10+ m
Arctic grayling	S	S-A	S-A				S	S			0-1 m	0-1 m		0-5 m
Ninespine stickleback	S-Y		S-A								0-1 m	0-5 m		0-5 m
Burbot	S	S-Y-J-A	S-Y-J-A	Y-J-A	A						0-2 m	0-5 m	0-5 m	10+ m
Slimy sculpin	S-Y	S-Y-J-A	S-Y-J-A	S-Y						S	0-2 m	0-10+ m	0-10+ m	0-10+ m

Source : Richardson et al. , 2001

Categories are S-spawning, Y- young-of-the-year, J-juveniles, and A-adults

Cover

Submergent vegetation: aquatic plants that grow wholly under the water's surface

Emergent vegetation: aquatic plants that grow on water-saturated or submerged soils and extend their stems and leaves above the surface of the water

Overhead: riparian cover overhanging the littoral zone and undercut banks

In situ: rocks and boulders on sand/gravel substrates

Substrate

Sand-Silt: <2 mm diameter

Gravel: 2-64 mm diameter

Cobble: 64-256 mm diameter

Boulder: 256-4000 mm diameter

Bedrock: >4000 mm diameter

Boulder and cobble are used as spawning substrate and cover for lake trout and Arctic char. The peninsula at the terminal end of the Road is almost entirely composed of boulder and some areas in the east bay are mainly composed of cobble. Exposed areas observed are also abundant with boulders and cobble. The sheltered bay areas are mainly composed of sand and silt and therefore are preferred habitat for spawning of lake cisco, ninespine stickleback and burbot. Bedrock habitat is only associated with adult burbot and therefore areas of abundant bedrock may be inhabited by burbot. Although no cover ratings are available for ninespine stickleback, adults are often found in densely vegetated areas, as observed at the terminal end of the Road, due to the abundance of emergent vegetation.

Lake trout

Lake trout are found throughout the Northwest Territories and Nunavut mostly in deep-water lakes (McPhail and Lindsey, 1970; Lee *et al.*, 1980). Lake trout spawning grounds are nearly always associated with cobble, boulder and gravel substrates (Scott and Crossman, 1973; Lawrence and Davies, 1978; Martin and Olver, 1980), in areas of no vegetative cover and at depths ranging from 0 to greater than 10 m. Young-of-the-year remain in spawning areas from several weeks to several months (Peck, 1982; Goodyear *et al*., 1982) moving into deeper areas as water temperatures rise to greater than 15º C (Peck, 1982). Young-of–the-year and juveniles both prefer areas of cobble and boulder substrate for cover and inhabit waters with a depth range of 2 to greater than 10 m (Ford *et al.*, 1995; Davis *et al.*, 1997). Adult lake trout disperse into deeper water habitats, greater than 10 m in depth (Scott and Crossman, 1973; Machniak, 1975; Goodyear *et al*., 1982), and are most commonly found over cobble and boulder substrates with no vegetative cover.

Arctic char

Spawning habitat preferences for Arctic char are over gravel and cobble substrates at depths ranging from 2 to 10 metres (Rubin and Buttiker, 1992; Sandlund *et al.*, 1988). Young-of-the-year are most often found nearshore in shallow water (Johnson, 1989; Riget *et al.*, 1986) and are also found in open water (Sandlund *et al.*, 1988). Both young-of-the-year and juvenile char use cobble and boulders as cover (Lawrence and Davies, 1978; L'Abée-Lund *et al.*, 1992). Juveniles are most often found in deeper habitats from 5 to 10 metres deep (Johnson, 1980; Naesje, 1995) and in areas of submergent to emergent vegetation (Halvorsen *et al.*, 1997; L'Abée-Lund *et al.*, 1993). Adult Arctic char usually occupy a variety of depths and habitats over boulder substrate.

Round whitefish

Round whitefish are most commonly found in shallow areas of lakes, ponds, slow flowing rivers and streams as well as brackish waters (McPhail and Lindsey, 1970; Scott and Crossman, 1973). Preferred spawning grounds are waters less than 1 m in depth over a gravel substrate (Morrow, 1980; Bryan and Kato, 1975). Young-of-the-year are most often found over gravel and cobble substrates in shallow water (Normandeau, 1969; Goodyear *et al.*, 1982). Adults are found in both shallow and deeper water habitats.

Lake cisco

Spawning of lake cisco usually takes place in shallow waters of less than 5 m, (Goodyear *et al.*, 1982; Scott and Crossman, 1973) over sand and gravel substrates (Cucin and Faber, 1985; Lawrence and Davies, 1978). Not much is known of preferred habitats for young and juvenile lake cisco, however, adults occur in both shallow and deep waters (McPhail and Lindsey, 1970; Scott and Crossman, 1973).

Arctic grayling

Arctic grayling are commonly found in clear water of large cold rivers, streams and lakes throughout the north (McPhail and Lindsey, 1970; Ford *et al.*, 1995). They prefer spawning grounds over sand, gravel, and cobble in shallow stream waters of 0 to 1 m depth (Lawrence and Davies, 1978; Falk *et al.*, 1982) and within submergent and emergent vegetation. Young-of-the-year and juvenile Arctic grayling remain in shallow waters of streams up to 1 m deep in the summer months (Krueger, 1981), while adults are found in lake waters of up to 5 m.

Ninespine stickleback

Spawning of ninespine sticklebacks occurs in relatively shallow waters of less than 1 m deep (Scott and Crossman, 1973; Wootton, 1976), over silt, sand and cobble, with the males building their nests amongst weeds in densely vegetated areas located 10 to 15 cm off the bottom (Scott and Scott, 1988; Morrow, 1980). When the young become free-swimming they disperse into shallow water areas up to 5 m deep (Becker, 1983; Goodyear *et al.*, 1982). Adults are found in both densely vegetated habitats and in open water areas over sand and gravel with sparse vegetation (Scott and Crossman, 1973).

Burbot

Burbot spawn over sand gravel or cobble at depths of up to 2 m (Ford *et al.*, 1995; Mansfield *et al.*, 1983). Young-of-the-year seek shelter in shallow waters under boulders and cobble or within submergent vegetation (Ford *et al.*, 1995; Ryder and Pisendorfer, 1992). Juveniles prefer boulder, cobble and gravel substrates and water depths up to 5 m. Adult burbot range into deeper waters with depths greater than 10 m, over substrates of bedrock, boulder, cobble or gravel.

4. SUMMARY

4. Summary

4.1 Streams

4.1.1 Aquatic Biology and Chemistry

The majority of stream waters sampled along the Road route were soft, clear and dilute. In contrast, one stream (km 2.2) draining into Bathurst Inlet had hard water with high ion content, probably reflecting differences in drainage basin bedrock. Nutrient and metal concentrations were typically low although they were slightly higher in the km 2.2 stream. Copper, aluminum and iron were above CCME guidelines for the protection of aquatic life in that stream. Copper was also above guideline levels at km 72.2.

In streams where fine sediments were collected, samples were composed primarily of sand and/or gravel. The nutrient and metal content of sediments was low. All metal concentrations were below CCME guidelines for the protection of aquatic life.

Periphyton biomass varied widely between locations, and in one stream (km 134.6), filamentous algae were observed growing on stones to lengths in excess of 30 cm. Cyanobacteria were the most abundant taxonomic group followed by diatoms and green algae.

Benthic invertebrate abundance was generally low and similar among streams. Invertebrate communities were dominated by Diptera taxa, particularly chironomids, as well as the stonefly *Nemoura* (Plecoptera). The largest streams, which were predominately covered by boulders, had more productive and taxonomically rich benthic communities.

The stream at km 2.2 had very different benthic invertebrate communities compared to other streams sampled in this survey as observed with water chemistry. This may be partly due to the different bedrock geology of the drainage basin. Also, unlike other streams, the streambed was covered predominately by sand.

4.1.2 Fish Habitat and Fish Communities

4.1.2.1 Fish Habitat Assessment

In general, most streams that will be crossed by the Road are narrow and shallow with low gradient, low water velocity and low August discharge. Their water is clear with near-neutral pH and very low conductivity (compared to streams of southern Canada). Since biological productivity tends to increase with increasing conductivity, the streams along the Road route likely have low productivity. As would be expected from the low gradient, most habitat units are glides, followed by riffles and pools. Cascades are rare. Cobbles were the most common type of substrate, followed by boulder, sand and gravel. Bedrock substrates are rare. Boulders provide most of the cover for fish, followed by instream grassy vegetation, overhanging grasses and shrubs, pools and undercut banks. Streams are generally too shallow to have significant numbers of pools, and the few pools that exist are usually shallow. Stream flows are typically low (at least during summer) and bank heights are also low, hence undercut banks are rare.

One consequence of the dominance of boulder cover is that streams support mainly small fish that can fit into the crevices underneath boulders. That includes juveniles of fish species with medium to large adult body stages (*e.g.*, Arctic grayling and burbot), and adults of species with small adult body sizes (*e.g.*, slimy sculpin and ninespine stickleback).

Twenty-four of the 55 streams had barriers to fish migration, of which 12 were permanent and 12 were temporary. The consequence of barriers to the presence or absence of fish is uncertain because some barriers may stop fish movement in both upstream and downstream directions (*e.g.*, dry channels), while others may prevent only upstream migration (*e.g.*, impassable waterfalls). Also, there is little information on the presence or absence of barriers outside of the survey distance.

4.1.2.2 Fish Habitat Analysis

Correlation analysis showed that the 34 habitat variables measured for each of the 55 stream crossings were highly inter-correlated. Factor analysis was used to remove redundancies in the habitat data set. It identified four major uncorrelated axes of variation in the data set that explained 44% of the variation in habitat data (*i.e.*, stream size, maximum pool depth, the frequency of riffle habitat, and lastly the percent of cascade habitat, in descending order of importance).

The results of the factor analysis were more or less intuitive. The first result showed that six variables of stream size (discharge, wetted area, wetted width, velocity, wetted depth and bankfull depth) were all positively related to one another and increase together. Temporary barriers were negatively related to stream size which indicates that the frequency of temporary barriers decreases with stream size. Barriers are classified as temporary when lack of water restricts fish movements up or downstream. Therefore, larger streams have more water to provide access passed these barriers. The second result showed that as maximum pool depths increase, crest pool depth, percent pool cover and percent pool habitat for fish also increase. The third result was less intuitive and showed that the frequency of riffle habitat (and of gravel substrate) is inversely dependent on the length of a habitat unit (independent of stream size). That is, riffle habitat occurs most often in streams with complex geometries that contain a large number of different habitat types. Lastly, an inverse relationship between percent cascade habitat, permanent barriers, and percent gradient was observed. Comparison of habitat variables with estimates of watershed area showed that indices of stream size (discharge, wetted width and wetted depth) were positively correlated with watershed area, but that percent riffle habitat, percent stream gradient and conductivity were not.

4.1.2.3 Fish Communities Assessment

Of the 55 stream crossings surveyed in August 2001, 52 had enough water to be fished. A total of 311 fish from seven species were caught in those streams. Arctic grayling was the dominant species by number (38.9%), followed by slimy sculpin (32.5%), ninespine stickleback (15.4%) and burbot (11.3%). Three other species (Arctic cisco, lake trout and round whitefish) represented 1.9% of the total catch. Twenty-three of the 55 streams contained no fish, and the other 43 streams contained between one and four species each. Length-frequency distributions showed that the streams were used mainly as rearing habitat for juvenile Arctic grayling, slimy sculpin, ninespine

stickleback and burbot, and as feeding and spawning habitat for adult sculpin and ninespine stickleback. The other three species were likely migrants or temporary residents. Electrofishing CPUE ranged from 0.000 to 0.077 fish/sec, and its frequency distribution was bimodal. Most streams contained few fish (CPUE < 0.009 fish/sec), but a few had high densities of juvenile Arctic grayling (modal CPUE = 0.055 fish/sec). That second mode disappeared when CPUE was expressed in units of fish weight. The geometric average biomass CPUE was 0.0066 g/sec.

4.1.2.4 Stream Rank by Fisheries Value

Streams along the Road were assigned a fisheries value based primarily on electrofishing catch during a survey in August 2001. The three categories of fisheries value were:

1. ***Low***: streams that were assessed as non-fish-bearing during the July reconnaissance because their flows were too low to support fish, and streams surveyed in August in which no fish were caught;
2. ***Medium***: streams that contained fish, but only small-bodied species with little commercial, food or cultural value, *i.e.*, slimy sculpin and ninespine stickleback.
3. ***High***: streams that were surveyed in August and contained either Arctic grayling, juvenile burbot or a large or migratory species (*i.e.*, Arctic cisco, Arctic char, round whitefish, lake trout or longnose sucker). These species were assigned greater fisheries values than other species because they are food and sport fish.

Of the 119 streams surveyed in July 2001 for reconnaissance, 64 streams were assessed as non-fish-bearing. The remaining 55 streams were surveyed in August 2001, and of those, 43 remained on the list of stream crossings after the Road route was revised and 12 were by-passed. Of the 43 crossings, 21 were assigned a low fisheries value, 10 were assigned a medium value and 12 were assigned a high value.

4.2 Contwoyto Lake

4.2.1 Aquatic Biology and Chemistry

Contwoyto Lake at the terminal end of the Road had very clear water allowing light to penetrate deep into the water column. The lake was not thermally stratified during the sampling period in August 2001, and dissolved oxygen concentrations were close to 100% saturation.

The surface waters of Contwoyto Lake were soft and very dilute. Nutrient and metal concentrations were low, as is typical of undisturbed northern lakes. The low nutrient concentrations suggest poor nutrient availability for primary production in Contwoyto Lake. All metal concentrations were below CCME guidelines for the protection of aquatic life.

Lake-bottom sediments were composed predominately of sand. Sediments were low in concentrations of metals and nutrients.

Phytoplankton communities were high in diversity but low in total abundance. Green algae were the most abundant taxonomic group followed by dinoflagellates, chrysophytes and diatoms.

Zooplankton communities were also high in diversity but low in total abundance. Rotifers were the most abundant taxonomic group followed by cladocerans and cyclopoid copepods. Benthic invertebrate density was low at all stations. Dipterans were the most abundant taxonomic group followed by molluscs and nematodes.

4.2.2 Fish Communities

A total of 145 fish were captured during the fish community survey conducted in August 2001. Fish were caught using gillnets, beach seines and minnow traps. Lake trout was the most abundant species, representing approximately 65% of the gillnet catches. Other species captured included Arctic char, round whitefish, lake cisco, Arctic grayling, ninespine stickleback and burbot. Arctic char were more abundant in floating gillnets than in sinking nets, whereas the opposite was observed for lake trout.

The lake trout captured were large on average, with a mean length of 509 mm and mean weight of 2,272 g. The average length of Arctic char was 429 mm.

Juvenile burbot and a large number of ninespine stickleback were captured using minnow traps. The high abundance of emergent vegetation is the likely cause of the numbers of juveniles and small-bodied fish.

Weight-length regressions calculated for lake trout and Arctic char explained 99% of the variation in body weight. Average condition was similar between lake trout and Arctic char with a mean condition of 1.09 g/mm^3 and 1.00 g/mm^3, respectively.

Mean age of lake trout was 17 years, with the oldest trout being 42 years old. Arctic char had a mean age of 9 years. Round whitefish and lake cisco both averaged 7 years, and Arctic grayling captured ranged from 9 to 18 years.

Sex ratios for lake trout were skewed towards males. Forty-five percent of the lake trout were imminent spawners.

Stomach content analyses of lake trout demonstrated a diverse diet. Fish and terrestrial insects were the two most important items and benthic invertebrates comprised only a small portion of the diet.

4.2.3 Fish Habitat

A habitat assessment delineated sixteen habitat zones over 2,380 m of shoreline. The habitat was dominated by sand, followed by boulder, cobble, and gravel. However, the littoral zone also had a measurable amount of bedrock and emergent vegetation.

The areas where cobble and boulder are abundant are highly preferred areas by all life stages of lake trout and several life stages of other species captured such as Arctic char and burbot. Boulder and cobble are used as spawning substrate and cover for lake trout and Arctic char. The peninsula at the terminal end of the Road is almost entirely composed of boulder and some areas in its east bay are mainly composed of cobble. Areas composed of sand and silt are preferred habitat for

spawning of lake cisco, ninespine stickleback and burbot. Adult burbot and adult ninespine stickleback are often found in densely vegetated areas, as observed in this study.

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APPENDIX 3.1-1
ANALYTICAL RESULTS FOR PHYSICAL VARIABLES, DISSOLVED ANIONS, NUTRIENTS AND METALS IN STREAM SURFACE WATERS, AUGUST 2001

Appendix 3.1-1
Analytical Results for Physical Variables, Dissolved Anions, Nutrients and Metals in Stream Surface Waters, August 2001

Variable	Units	km 206.9 Rep A 8/21/2001	km 206.9 Rep B 8/21/2001	km 192.4a Rep A 8/21/2001	km 192.4a Rep B 8/21/2001	km 134.6 Rep A 8/21/2001	km 134.6 Rep B 8/21/2001	km 84.2 Rep A 8/22/2001	km 84.2 Rep B 8/22/2001	km 72.2 Rep A 8/20/2001	km 72.2 Rep B 8/20/2001	km 2.2 Rep A 8/22/2001	km 2.2 Rep B 8/22/2001
Physical Tests													
Conductivity	µmhos/cm	10	9	8	8	10	10	21	20	59	61	491	489
Total Dissolved Solids	mg/L	<10	<10	<10	<10	10	<10	<10	<10	32	40	275	278.0
Hardness	mg $CaCO_3$/L	3.5	3.7	3.8	3.6	3.7	3.7	6.8	7.1	25.2	24.8	102.0	101.0
pH	pH units	7.26	7.13	7.36	7.21	7.21	7.19	7.47	7.23	7.77	7.59	7.99	7.89
Total Suspended Solids	mg/L	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	3	<3
Turbidity	NTU	1.2	1.2	0.7	0.6	0.8	0.9	0.3	0.4	0.6	0.7	7.5	7.4
Total Organic Carbon	mg/L	5.9	5.8	3.6	3.7	3.8	3.8	3.4	3.3	6.9	7.1	5.7	6.3
Dissolved Anions													
Acidity (to pH 8.3) ($CaCO_3$)	mg/L	2	2	2	2	2	2	2	2	2	2	2	2
Alkalinity-Total ($CaCO_3$)	mg/L	1	1	3	3	2	2	2	2	13	13	57	63
Bromide	mg/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Chloride	mg/L	<0.5	<0.5	<0.5	<0.5	0.5	<0.5	<0.5	<0.5	1.0	1.0	104.0	103.0
Fluoride	mg/L	0.02	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.04	0.04
Silicate	mg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	3	3
Sulphate	mg/L	2	1	1	1	2	2	5	5	11	10	16	16
Nutrients	mg/L												
Ammonia Nitrogen	mg/L	0.011	0.013	0.015	0.016	0.018	0.015	<0.005	0.009	0.010	0.007	0.006	<0.005
Total Kjeldahl Nitrogen	mg/L	0.19	0.19	0.17	0.17	0.15	0.15	0.13	0.12	0.38	0.38	0.16	0.15
Nitrate Nitrogen	mg/L	0.007	0.006	0.012	0.015	0.017	0.013	0.016	0.016	0.015	0.014	0.025	0.031
Nitrite Nitrogen	mg/L	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Dissolved Ortho-Phosphate	mg/L	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	0.002	<0.001	0.002	0.002
Total Phosphorous	mg/L	0.002	0.008	0.007	0.006	0.005	0.012	0.004	0.004	0.002	0.005	0.013	0.016
Total Metals													
Aluminum	mg/L	0.073	0.075	0.017	0.02	0.02	0.046	0.013	0.013	0.026	0.033	0.281	0.315
Antimony	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Arsenic	mg/L	0.0004	0.0004	0.0003	0.0004	0.0001	0.0002	0.0002	0.0002	0.0005	0.0005	0.0008	0.0008
Barium	mg/L	0.00282	0.00287	0.0022	0.0022	0.00195	0.00265	0.00254	0.00249	0.00453	0.00479	0.0298	0.0305
Beryllium	mg/L	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Bismuth	mg/L	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Boron	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.03	0.03
Cadmium	mg/L	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Calcium	mg/L	0.8	0.69	0.73	0.74	0.59	0.66	1.11	1.09	4.72	4.81	17.6	17.5
Chromium	mg/L	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	0.0005	0.0006
Cobalt	mg/L	0.0001	0.0001	0.0002	0.0002	0.0002	0.001	0.0001	0.0001	0.0004	0.0004	0.0002	0.0002
Copper	mg/L	0.0014	0.0014	0.0007	0.0007	0.0014	0.0016	0.0018	0.0017	0.0032	0.0032	0.0032	0.0033
Iron	mg/L	0.19	0.18	0.26	0.27	0.08	0.22	0.07	0.07	0.3	0.3	0.35	0.34
Lead	mg/L	0.00007	0.00006	<0.00005	0.00006	<0.00005	0.00006	<0.00005	<0.00005	<0.00005	0.00007	0.00023	0.00022
Lithium	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Magnesium	mg/L	0.4	0.4	0.4	0.4	0.5	0.6	1	1	3.1	3.1	12.9	12.8
Manganese	mg/L	0.00218	0.0022	0.00623	0.00598	0.00973	0.0428	0.00301	0.00274	0.00432	0.00442	0.022	0.0226
Mercury	mg/L	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Molybdenum	mg/L	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	0.00006	<0.00005	0.0003	0.0003
Nickel	mg/L	0.0011	0.0011	0.0006	0.0006	0.0009	0.0014	0.0021	0.002	0.0061	0.0062	0.0009	0.0009
Phosphorus	mg/L	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
Potassium	mg/L	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	3	2
Selenium	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.002
Silicon	mg/L	0.11	0.11	0.18	0.18	0.13	0.13	0.11	0.1	0.15	0.16	2.04	1.84
Silver	mg/L	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Sodium	mg/L	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	53	53
Strontium	mg/L	0.0052	0.0052	0.0052	0.0052	0.004	0.0042	0.0049	0.0048	0.0137	0.0139	0.071	0.0727
Thallium	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Tin	mg/L	<0.002	<0.0007	<0.002	<0.0001	<0.002	<0.0005	<0.0001	<0.002	<0.0001	<0.0001	<0.002	<0.0006
Titanium	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01
Uranium	mg/L	0.00003	0.00003	<0.00001	<0.00001	0.00001	0.00002	0.00001	0.00001	0.00002	0.00002	0.00066	0.00067
Vanadium	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc	mg/L	0.001	0.002	<0.001	<0.001	<0.001	0.002	0.002	0.002	0.003	0.004	<0.001	0.001

APPENDIX 3.1-2
ANALYTICAL RESULTS FOR PHYSICAL VARIABLES, DISSOLVED ANIONS, NUTRIENTS, AND METALS IN CONTWOYTO LAKE SURFACE WATERS, AUGUST 2001

Appendix 3.1-2
Analytical Results for Physical Variables, Dissolved Anions, Nutrients, and Metals in Contwoyto Lake Surface Waters, August 2001

Parameter	Units	Contwoyto Lake Rep A 8/17/2001	Contwoyto Lake Rep B 8/17/2001	Field Blank 8/24/2001
Physical Tests				
Conductivity	µmhos/cm	11	10	
Total Dissolved Solids	mg/L	<10	<10	
Hardness	mg $CaCO_3$/L	3.3	3.3	
pH	pH units	6.69	7.16	
Total Suspended Solids	mg/L	<3	<3	
Turbidity	NTU	1.4	1.4	
Total Organic Carbon	mg/L	3.1	2.5	<0.5
Dissolved Anions				
Acidity (to pH 8.3) ($CaCO_3$)	mg/L	2	2	
Alkalinity-Total ($CaCO_3$)	mg/L	3	3	
Bromide	mg/L	<0.5	<0.5	
Chloride	mg/L	<0.5	<0.5	
Fluoride	mg/L	<0.02	<0.02	
Silicate	mg/L	0.1	0.1	
Sulphate	mg/L	2	2	
Nutrients	mg/L			
Ammonia Nitrogen	mg/L	0.011	0.011	
Total Kjeldahl Nitrogen	mg/L	0.42	0.3	<0.05
Nitrate Nitrogen	mg/L	0.009	0.008	
Nitrite Nitrogen	mg/L	<0.001	<0.001	
Dissolved Ortho-Phosphate	mg/L	<0.001	<0.001	
Total Phosphorous	mg/L	0.004	0.004	
Total Metals				
Aluminum	mg/L	0.011	0.011	<0.001
Antimony	mg/L	<0.0001	<0.0001	<0.0001
Arsenic	mg/L	0.0003	0.0003	<0.0001
Barium	mg/L	0.0019	0.00198	<0.00005
Beryllium	mg/L	<0.0005	<0.0005	<0.0005
Bismuth	mg/L	<0.0005	<0.0005	<0.0005
Boron	mg/L	<0.01	<0.01	<0.01
Cadmium	mg/L	<0.00005	<0.00005	<0.00005
Calcium	mg/L	0.71	0.7	<0.05
Chromium	mg/L	<0.0005	<0.0005	<0.0005
Cobalt	mg/L	<0.0001	<0.0001	<0.0001
Copper	mg/L	0.0006	0.0006	<0.0001
Iron	mg/L	<0.03	<0.03	<0.01
Lead	mg/L	<0.00005	0.00006	<0.00005
Lithium	mg/L	<0.005	<0.005	<0.005
Magnesium	mg/L	0.4	0.4	<0.1
Manganese	mg/L	0.00251	0.00265	<0.00005
Mercury	mg/L	<0.00001	<0.00001	<0.00001
Molybdenum	mg/L	<0.00005	<0.00005	<0.00005
Nickel	mg/L	0.0005	0.0006	<0.0005
Phosphorus	mg/L	<0.3	<0.3	<0.3
Potassium	mg/L	<2	<2	<2
Selenium	mg/L	<0.001	<0.001	<0.001
Silicon	mg/L	0.05	0.05	<0.05
Silver	mg/L	0.00003	0.00002	<0.00001
Sodium	mg/L	<2	<2	<2
Strontium	mg/L	0.0045	0.0046	<0.0001
Thallium	mg/L	<0.0001	<0.0001	<0.0001
Tin	mg/L	0.0008	0.0004	<0.0001
Titanium	mg/L	<0.01	<0.01	<0.01
Uranium	mg/L	0.00001	0.00001	<0.00001
Vanadium	mg/L	<0.001	<0.001	<0.001
Zinc	mg/L	<0.001	0.001	<0.001

APPENDIX 3.1-3
ANALYTICAL RESULTS FOR EXTRACTABLE PETROLEUM HYDROCARBONS IN CONTWOYTO LAKE SURFACE WATERS, AUGUST 2001

Appendix 3.1-3
Analytical Results for Extractable Petroleum Hydrocarbons at the South Barge Terminal, Contwoyto Lake Surface Waters, August 2001

Extractable Hydrocarbons	Units	Contwoyto Lake Rep A 9/19/2001	Contwoyto Lake Rep B 9/19/2001	Travel Blank 9/19/2001
C_{10}-C_{19}	mg/L	<0.1	<0.1	<0.1
C_{19}-C_{32}	mg/L	<0.1	<0.1	<0.1

APPENDIX 3.1-4
ANALYTICAL RESULTS FOR PHYSICAL VARIABLES, NUTRIENTS, METALS AND PARTICLE SIZE OF SEDIMENTS IN STREAMS, AUGUST 2001

Appendix 3.1-4
Analytical Results for Physical Variables, Nutrients, Metals and Particle size of Sediments in Streams, August 2001

Variable	Units[1]	km 206.9 Rep A 8/21/2001	km 206.9 Rep B 8/21/2001	km 206.9 Rep C 8/21/2001	km 72.2 Rep A 8/20/2001	km 72.2 Rep B 8/20/2001	km 72.2 Rep C 8/20/2001	km 2.2 Rep A 8/22/2001	km 2.2 Rep B 8/22/2001	km 2.2 Rep C 8/22/2001
Physical Variables										
Moisture	%	16.8	15.7	13.3	13.7	15.5	12.7	22	21.3	21.3
Nutrients										
Available Phosphorus	mg/kg	5	4	3	4	4	4	5	3	6
Total Nitrogen	% dry weight	0.08	0.06	0.03	0.03	0.04	0.02	0.02	<0.01	<0.01
Inorganic Variables										
Total Sulphur	% dry weight	<0.01	<0.01	0.02	0.02	0.01	0.02	0.03	0.03	0.01
Organic Variables										
Total Organic Carbon	% dry weight	0.21	0.25	0.15	<0.05	0.17	0.2	0.2	<0.05	<0.05
Particle Size										
Gravel (>2.00mm)	% dry weight	47.5	60.5	29.6	15.3	27	5.3	<0.1	<0.1	5.4
Sand (2.00mm - 0.063mm)	% dry weight	46.5	36.1	67.5	82.2	68	90.8	48.4	98.8	91.3
Silt (0.063mm - 4um)	% dry weight	3.6	2.4	1.9	1.7	3.5	2.8	33.7	0.5	1.4
Clay (<4um)	% dry weight	2.4	1	1	0.8	1.5	1.1	17.9	0.7	1.9
Total Metals										
Aluminum	mg/kg	8,090	8,050	8,800	16,100	16,000	16,700	16,900	3,460	3,130
Antimony	mg/kg	<20	<20	<20	<20	<20	<20	<20	<20	<20
Arsenic	mg/kg	3.8	3.8	4.5	4.3	3.4	4.8	4.7	0.7	0.7
Barium	mg/kg	37	35	31	41	36	36	80	16	15
Beryllium	mg/kg	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.6	<0.5	<0.5
Bismuth	mg/kg	<20	<20	<20	<20	<20	<20	<20	<20	<20
Cadmium	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Calcium	mg/kg	1,700	1,920	2,110	2,050	2,560	1,780	4,770	1,330	1,280
Chromium	mg/kg	26	27	23	56	54	62	35	8	8
Cobalt	mg/kg	4	4	4	12	10	10	7	<2	<2
Copper	mg/kg	5	5	5	12	12	16	17	4	4
Iron	mg/kg	13,500	13,900	14,400	25,600	25,500	26,700	21,000	5,590	5,820
Lead	mg/kg	<2	<2	<2	<2	<2	<2	6	<2	<2
Lithium	mg/kg	18	19	25	32	32	30	25	6	6
Magnesium	mg/kg	5,000	5,220	5,590	10,900	11,100	10,800	8,930	2,220	2,270
Manganese	mg/kg	121	127	156	254	253	244	187	56	58
Mercury	mg/kg	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.005	<0.005	<0.005
Molybdenum	mg/kg	<4	<4	<4	<4	<4	<4	<4	<4	<4
Nickel	mg/kg	11	12	11	27	28	30	18	<5	<5
Phosphorus	mg/kg	290	336	326	425	437	410	577	166	177
Potassium	mg/kg	1,550	1,720	1,890	1,410	1,200	1,430	4,520	867	679
Selenium	mg/kg	<50	<50	<50	<50	<50	<50	<50	<50	<50
Silver	mg/kg	<2	<2	<2	<2	<2	<2	<2	<2	<2
Strontium	mg/kg	10.3	11	11.3	8.9	11.7	7.5	43.9	12.4	11.4
Thallium	mg/kg	<50	<50	<50	<50	<50	<50	<50	<50	<50
Tin	mg/kg	<10	<10	<10	<10	<10	<10	<10	<10	<10
Titanium	mg/kg	489	549	541	495	626	430	829	232	218
Vanadium	mg/kg	25	26	27	39	40	40	43	11	11
Zinc	mg/kg	26	24	26	47	46	43	36	8	8

[1] **Results expressed as mg/kg were measured as dry weight.**

APPENDIX 3.1-5
SEDIMENT DESCRIPTION SHEETS FOR STREAMS, AUGUST 2001

Appendix 3.1-5
Sediment Description Sheets for Streams, August 2001

Station:	**Bathurst km 206.9**		
Replicate:	**Rep A**	**Rep B**	**Rep C**
Date:	**21 August, 2001**	**21 August, 2001**	**21 August, 2001**
Core Thickness (mm)	**70**	**155**	**85**
Physical Description:	Coarse sand and gravel, heterogeneous, loosely bound, thin detrital layer on surface	*Top layer*: Coarse sand and gravel ~125 mm *Bottom layer*: ~ 30 mm soil clay with roots, abrupt horizon	*Top layer*: Coarse sand and gravel ~75 mm *Bottom layer*: ~ 10 mm fine loose clay
Munsell Color Classification:	Dark gray 2.5Y 4/1	*Top layer*: Dark gray 2.5Y 4/1 *Bottom layer*: Dark brown 10YR 3/3	*Top layer*: Dark gray 2.5Y 4/1
Biological Material:	Strong organic smell	Organic smell, small pieces of plant	No organic smell, small pieces of plants
Debris Material:			
Notes:			
Photograph (Y/N):	Yes	Yes	Yes

Station:	**Bathurst km 72.2**		
Replicate:	**Rep A**	**Rep B**	**Rep C**
Date:	**20 August, 2001**	**20 August, 2001**	**20 August, 2001**
Core Thickness (mm)	**125**	**95**	**100**
Physical Description:	Coarse sand and gravel, heterogeneous, no layers	Coarse sand and gravel, heterogeneous, no layers	Coarse sand and gravel, heterogeneous, no layers
Munsell Color Classification:	*Sand*: Very dark gray 5Y 3/1 *Gravel*: multicolored	*Sand*: Very dark gray 5Y 3/1 *Gravel*: multicolored	*Sand*: Very dark gray 5Y 3/1 *Gravel*: multicolored
Biological Material:	None	Plant	None
Debris Material:			
Notes:	Sample taken from behind rock, no current		
Photograph (Y/N):	Yes	Yes	Yes

Station:	**Bathurst km 2.2**		
Replicate:	**Rep A**	**Rep B**	**Rep C**
Date:	**22 August, 2001**	**22 August, 2001**	**22 August, 2001**
Core Thickness (mm)	**90**	**85**	**145**
Physical Description:	Homogeneous clay sand (grit to touch) with thin layer of coarse sand underneath ~10 mm	Coarse sand	*Top layer*: Coarse sand *Bottom layer*: Last ~20 m clay sand with organic matter, abrupt horizon
Munsell Color Classification:	*Top layer*: Grayish brown 10YR 5/2 *Bottom layer*: Dark gray 2.5Y 4/1	**Dark gray 2.5Y 4/1**	*Top layer*: Dark gray 2.5Y 4/1 *Bottom layer*: Black 1 For Gley 2.5/
Biological Material:	No organic smell		Roots in bottom 20 mm
Debris Material:			Pebbles
Notes:	Most of streambed is a layer of coarse sand covering clay, Rep A taken ~30 cm from bank where sand washed away		
Photograph (Y/N):	Yes	Yes	Yes

APPENDIX 3.1-6
PHOTOGRAPHIC RECORD OF STREAM SEDIMENTS, AUGUST 2001

APPENDIX 3.1-6
PHOTOGRAPHIC RECORD OF STREAM SEDIMENTS, AUGUST 2001



Plate 1: Stream Bathurst km 206.9, Rep. A (August 21, 2001)



Plate 2: Stream Bathurst km 206.9, Rep. B (August 21, 2001)



Plate 3: Stream Bathurst km 206.9, Rep. C (August 21, 2001).



Plate 4: Stream Bathurst km 72.2, Rep. A (August 20, 2001)



Plate 5: Stream Bathurst km 72.2, Rep. B (August 20, 2001).



Plate 6: Stream Bathurst km 72.2, Rep. C (August 20, 2001).



Plate 7: Stream Bathurst km 2.2, Rep. A (August 22, 2001).



Plate 8: Stream Bathurst km 2.2, Rep. B (August 22, 2001).



Plate 9: Stream Bathurst km 2.2, Rep. C (August 22, 2001)

APPENDIX 3.1-7
DENSITIES OF STREAM PERIPHYTON TAXA, AUGUST 2001

Appendix 3.1-7
Densities of Stream Periphyton Taxa, August 2001

		km 206.9 Rep A 21/08/2001	km 206.9 Rep B 21/08/2001	km 206.9 Rep C 21/08/2001	Mean	Std. Error	%
BACILLARIOPHYCEAE (DIATOMS)							
BACILLARIOPHYCEAE	*Achnanthes biasolettiana* Grunow						
PENNALES	*Achnanthes flexella* (Kuetzing) Braun						
	Achnanthes minutissima Kuetzing	2,902	1,642	923			
	Achnanthes ploenensis Husdtedt			615			
	Amphora spp.						
	Anomoeoneis brachysira (Brebisson) Grunow			307			
	Anomoeoneis brachysira var zellensis (Grunow) Krammer						
	Asterionella formosa Hansall						
	Cymbella affinis Kuetzing						
	Cymbella cessatii (Rabenhorst) Grunow	2,488	2,052				
	Cymbella descripta (Hustedt) Lange-Bertalot			307			
	Cymbella microcephala Grunow						
	Cymbella minuta Hilse						
	Cymbella silesiaca Bleisch ex. Rabenhorst	622	205	1,539			
	Cymbella sinuata Gregory						
	Denticula subtilis Grunow						
	Diatoma moniliformis Kuetzing						
	Diatoma tenuis Agardh						
	Diatoma vulgaris Bory						
	Diploneis sp						
	Eunotia arcus Ehrenberg			307			
	Eunotia bilunaris (Ehrenberg) Mills		1,231	2,155			
	Eunotia diodon Ehrenberg						
	Eunotia exigua Brebisson (Rabenhorst)						
	Eunotia faba Ehrenberg						
	Eunotia incisa Gregory						
	Eunotia paludosa Grunow						
	Eunotia tenella (Grunow) Hustedt						
	Fragilaria capucina Desmazieres	622	1,642	3,386			
	Fragilaria construens (Ehrenberg) Grunow						
	Fragilaria crotonensis Kitton						
	Fragilaria spp.	4,560	4,310	8,313			
	Fragilaria ulna (Nitzsch) Lange-Bertalot						
	Frustulia rhomboides (Ehrenberg) de Toni			923			
	Gomphonema angustatum (Kuetzing) Rabenhorst						
	G*omphonema parvulum* Kuetzing		205	2,463			
	Gomphonema pumilum (Grunow) Reichardt & Lange-Bertalot						
	Hannaea arcus (Ehrenberg) Patrick						
	Meridion circulare (Greville) Agardh						
	Navicula cryptocephala Kuetzing	207		307			
	Navicula cryptotenella Lange-Bertalot						
	Navicula decussis Ostrup						
	Navicula pupula Kuetzing	207	205				
	Navicula spp			1,847			
	Neidium spp		205	307			
	Nitzschia acicularis (Kuetzing) W. Smith						
	Nitzschia clausii Hantzsch						
	Nitzschia inconspicua Grunow						
	Nitzschia linearis (Agardh) W. Smith						
	Nitzschia palea (Kuetzing) W. Smith						
	Nitzschia perminuta Lange-Bertalot						
	Ntzschia spp	207	410	1,231			
	Tabellaria flocculosa (Roth) Kuetzing	5,598	19,090	36,024			
	Surirella brebisonii Krammer & Lange-Bertalot						
CENTRALES	*Aulacoseira granulata (Ehrenberg) Simonsen*						
	Aulacoseira spp.	1,036					
	Cyclotella ocellata Pantocsek						
	Cyclotella pseudostelligera Hustedt						
	Cyclotella spp						
	TOTAL DIATOMS	**18,449**	**31,197**	**60,954**	**36,867**	**12,593**	**36**
CYANOBACTERIA							
CYANOBACTERIA							
NOSTOCALES	*Anabaena aequalis Borge*			6,158			
	Anabaena circinalis Rabenhorst						
	Anabaena flos-aquae Brebisson						
	Anabaena solitaria Klebahn						
	Anabaena spiroides Klebahn						
	Anabaena sp			4,618			
	Gloeotrichia echinulata (J.E. Smith) Richter						
CHROOCOCCALES	*Chroococcus minutus* (Kuetz.) Naegeli						
	Aphanocapsa sp						
	Gloeocapsa sp						
	Merismopedia glauca (Ehrenberg) Naegeli						
	Snowella lacustris (Chodat) Komarek et Hindak						
	Rhabdoderma lineare Woloszynska						
OSCILLATORIALES	*Borzia* sp Cohn ex Gormont						
	Heteroleibleinia sp						
	Hormoscilla sp						
	Limnothrix redekei (Van Goor) Meffert						
	Limnothrix-like sp						
	Oscillatoria princeps Vaucher						
	Phormidium accutissima Kefferath			166,268			
	Phormidium spp	6,220					
	Planktothrix agardhii Gomont						
	Planktolyngya limnetica Lemmermann						
	Pesudanabaena galeata Bocher						
	TOTAL CYANOBACTERIA	**6,220**	**0**	**177,044**	**61,088**	**58,006**	**60**

(continued)

Appendix 3.1-7
Densities of Stream Periphyton Taxa, August 2001 (continued)

		192.4a Rep A 21/08/2001	192.4a Rep B 21/08/2001	192.4a Rep C 21/08/2001	Mean	Std. Error	%
BACILLARIOPHYCEAE (DIATOMS)							
BACILLARIOPHYCEAE	*Achnanthes biasolettiana* Grunow	481	307	366			
PENNALES	*Achnanthes flexella* (Kuetzing) Braun						
	Achnanthes minutissima Kuetzing	6,735	1,539	366			
	Achnanthes ploenensis Husdtedt						
	Amphora spp.		307				
	Anomoeoneis brachysira (Brebisson) Grunow						
	Anomoeoneis brachysira var zellensis (Grunow) Krammer						
	Asterionella formosa Hansall						
	Cymbella affinis Kuetzing						
	Cymbella cessatii (Rabenhorst) Grunow	12,027	615	1,099			
	Cymbella descripta (Hustedt) Lange-Bertalot	481	307				
	Cymbella microcephala Grunow			366			
	Cymbella minuta Hilse						
	Cymbella silesiaca Bleisch ex. Rabenhorst	481					
	Cymbella sinuata Gregory						
	Denticula subtilis Grunow						
	Diatoma moniliformis Kuetzing			733			
	Diatoma tenuis Agardh		1,847				
	Diatoma vulgaris Bory						
	Diploneis sp						
	Eunotia arcus Ehrenberg		1,231	1,832			
	Eunotia bilunaris (Ehrenberg) Mills		1,847	366			
	Eunotia diodon Ehrenberg						
	Eunotia exigua Brebisson (Rabenhorst)		307				
	Eunotia faba Ehrenberg		615				
	Eunotia incisa Gregory						
	Eunotia paludosa Grunow		307				
	Eunotia tenella (Grunow) Hustedt						
	Fragilaria capucina Desmazieres	7,697		733			
	Fragilaria construens (Ehrenberg) Grunow						
	Fragilaria crotonensis Kitton						
	Fragilaria spp.	6,734	615	2,932			
	Fragilaria ulna (Nitzsch) Lange-Bertalot						
	Frustulia rhomboides (Ehrenberg) de Toni	962					
	Gomphonema angustatum (Kuetzing) Rabenhorst						
	Gomphonema parvulum Kuetzing	962	923				
	Gomphonema pumilum (Grunow) Reichardt & Lange-Bertalot						
	Hannaea arcus (Ehrenberg) Patrick						
	Meridion circulare (Greville) Agardh						
	Navicula cryptocephala Kuetzing	2,405					
	Navicula cryptotenella Lange-Bertalot						
	Navicula decussis Ostrup						
	Navicula pupula Kuetzing	481	615	366			
	Navicula spp	481		366			
	Neidium spp						
	Nitzschia acicularis (Kuetzing) W. Smith						
	Nitzschia clausii Hantzsch						
	Nitzschia inconspicua Grunow						
	Nitzschia linearis (Agardh) W. Smith						
	Nitzschia palea (Kuetzing) W. Smith						
	Nitzschia perminuta Lange-Bertalot			366			
	Ntzschia spp	0	1,847	0			
	Tabellaria flocculosa (Roth) Kuetzing	25,017	7,697	27,491			
	Surirella brebisonii Krammer & Lange-Bertalot						
CENTRALES	*Aulacoseira granulata (Ehrenberg) Simonsen*						
	Aulacoseira spp.						
	Cyclotella ocellata Pantocsek						
	Cyclotella pseudostelligera Hustedt						
	Cyclotella spp	481	307	366			
	TOTAL DIATOMS	**65,425**	**21,233**	**37,748**	**41,469**	**12,892**	**30**
CYANOBACTERIA							
CYANOBACTERIA							
NOSTOCALES	*Anabaena aequalis Borge*						
	Anabaena circinalis Rabenhorst						
	Anabaena flos-aquae Brebisson			7,331			
	Anabaena solitaria Klebahn						
	Anabaena spiroides Klebahn		6,158				
	Anabaena sp						
	Gloeotrichia echinulata (J.E. Smith) Richter			3,665			
CHROOCOCCALES	*Chroococcus minutus* (Kuetz.) Naegeli						
	Aphanocapsa sp						
	Gloeocapsa sp						
	Merismopedia glauca (Ehrenberg) Naegeli						
	Snowella lacustris (Chodat) Komarek et Hindak						
	Rhabdoderma lineare Woloszynska						
OSCILLATORIALES	*Borzia* sp Cohn ex Gormont						
	Heteroleibleinia sp						
	Hormoscilla sp		9,237	3,665			
	Limnothrix redekei (Van Goor) Meffert		15,395	12,829			
	Limnothrix-like sp						
	Oscillatoria princeps Vaucher						
	Phormidium accutissima Kefferath	14,433	9,237				
	Phormidium spp		30,790	14,662			
	Planktothrix agardhii Gomont		12,316				
	Planktolyngya limnetica Lemmermann	9,622					
	Pesudanabaena galeata Bocher		6,158				
	TOTAL CYANOBACTERIA	**24,055**	**89,291**	**42,152**	**51,833**	**19,444**	**37**

(continued)

Appendix 3.1-7
Densities of Stream Periphyton Taxa, August 2001 (continued)

		km 134.6 Rep A 21/08/2001	km 134.6 Rep B 21/08/2001	km 134.6 Rep C 21/08/2001	Mean	Std. Error	%
BACILLARIOPHYCEAE (DIATOMS)							
BACILLARIOPHYCEAE	*Achnanthes biasolettiana* Grunow	307		461			
PENNALES	*Achnanthes flexella* (Kuetzing) Braun						
	Achnanthes minutissima Kuetzing	3,386	11,084	5,080			
	Achnanthes ploenensis Husdtedt						
	Amphora spp.	307					
	Anomoeoneis brachysira (Brebisson) Grunow		923				
	Anomoeoneis brachysira var zellensis (Grunow) Krammer						
	Asterionella formosa Hansall						
	Cymbella affinis Kuetzing						
	Cymbella cessatii (Rabenhorst) Grunow		2,771	461			
	Cymbella descripta (Hustedt) Lange-Bertalot		461				
	Cymbella microcephala Grunow						
	Cymbella minuta Hilse						
	Cymbella silesiaca Bleisch ex. Rabenhorst		461	923			
	Cymbella sinuata Gregory						
	Denticula subtilis Grunow	1,231					
	Diatoma moniliformis Kuetzing						
	Diatoma tenuis Agardh	307					
	Diatoma vulgaris Bory	923					
	Diploneis sp			461			
	Eunotia arcus Ehrenberg	923	1,385	1,385			
	Eunotia bilunaris (Ehrenberg) Mills		461				
	Eunotia diodon Ehrenberg		1,385	461			
	Eunotia exigua Brebisson (Rabenhorst)						
	Eunotia faba Ehrenberg			923			
	Eunotia incisa Gregory		461	461			
	Eunotia paludosa Grunow	307					
	Eunotia tenella (Grunow) Hustedt						
	Fragilaria capucina Desmazieres		1,847				
	Fragilaria construens (Ehrenberg) Grunow						
	Fragilaria crotonensis Kitton						
	Fragilaria spp.	4,309	3,693	16,164			
	Fragilaria ulna (Nitzsch) Lange-Bertalot						
	Frustulia rhomboides (Ehrenberg) de Toni	615	923	1,385			
	Gomphonema angustatum (Kuetzing) Rabenhorst						
	G*omphonema parvulum* Kuetzing						
	Gomphonema pumilum (Grunow) Reichardt & Lange-Bertalot						
	Hannaea arcus (Ehrenberg) Patrick						
	Meridion circulare (Greville) Agardh						
	Navicula cryptocephala Kuetzing	615	8,313	1,847			
	Navicula cryptotenella Lange-Bertalot		461				
	Navicula decussis Ostrup						
	Navicula pupula Kuetzing	615					
	Navicula spp						
	Neidium spp						
	Nitzschia acicularis (Kuetzing) W. Smith						
	Nitzschia clausii Hantzsch						
	Nitzschia inconspicua Grunow		461				
	Nitzschia linearis (Agardh) W. Smith						
	Nitzschia palea (Kuetzing) W. Smith						
	Nitzschia perminuta Lange-Bertalot		923	6,927			
	Ntzschia spp	5,234	3,694	0			
	Tabellaria flocculosa (Roth) Kuetzing	12,316	13,393	21,245			
	Surirella brebisonii Krammer & Lange-Bertalot						
CENTRALES	*Aulacoseira granulata (Ehrenberg) Simonsen*						
	Aulacoseira spp.	923					
	Cyclotella ocellata Pantocsek						
	Cyclotella pseudostelligera Hustedt			461			
	Cyclotella spp	2,155					
	TOTAL DIATOMS	**34,473**	**53,100**	**58,645**	**48,739**	**7,311**	**15**
CYANOBACTERIA							
CYANOBACTERIA							
NOSTOCALES	*Anabaena aequalis Borge*						
	Anabaena circinalis Rabenhorst		6,927				
	Anabaena flos-aquae Brebisson	1,539					
	Anabaena solitaria Klebahn						
	Anabaena spiroides Klebahn						
	Anabaena sp						
	Gloeotrichia echinulata (J.E. Smith) Richter		11,546				
CHROOCOCCALES	*Chroococcus minutus* (Kuetz.) Naegeli			3,694			
	Aphanocapsa sp						
	Gloeocapsa sp						
	Merismopedia glauca (Ehrenberg) Naegeli						
	Snowella lacustris (Chodat) Komarek et Hindak						
	Rhabdoderma lineare Woloszynska			923			
OSCILLATORIALES	*Borzia* sp Cohn ex Gormont						
	Heteroleibleinia sp						
	Hormoscilla sp						
	Limnothrix redekei (Van Goor) Meffert						
	Limnothrix-like sp						
	Oscillatoria princeps Vaucher						
	Phormidium accutissima Kefferath						
	Phormidium spp	6,158	18,474				
	Planktothrix agardhii Gomont						
	Planktolyngya limnetica Lemmermann	147,794	50,804	367,176			
	Pesudanabaena galeata Bocher						
	TOTAL CYANOBACTERIA	**155,491**	**87,751**	**371,793**	**205,012**	**85,653**	**64**

(continued)

Appendix 3.1-7
Densities of Stream Periphyton Taxa, August 2001 (continued)

		km 84.2 Rep A 22/08/2001	km 84.2 Rep B 22/08/2001	km 84.2 Rep C 22/08/2001	Mean	Std. Error	%
BACILLARIOPHYCEAE (DIATOMS)							
BACILLARIOPHYCEAE	*Achnanthes biasolettiana* Grunow		481				
PENNALES	*Achnanthes flexella* (Kuetzing) Braun						
	Achnanthes minutissima Kuetzing	1,847	8,659	4,105			
	Achnanthes ploenensis Husdtedt						
	Amphora spp.						
	Anomoeoneis brachysira (Brebisson) Grunow						
	Anomoeoneis brachysira var zellensis (Grunow) Krammer						
	Asterionella formosa Hansall						
	Cymbella affinis Kuetzing						
	Cymbella cessatii (Rabenhorst) Grunow						
	Cymbella descripta (Hustedt) Lange-Bertalot						
	Cymbella microcephala Grunow						
	Cymbella minuta Hilse	461	481				
	Cymbella silesiaca Bleisch ex. Rabenhorst						
	Cymbella sinuata Gregory						
	Denticula subtilis Grunow						
	Diatoma moniliformis Kuetzing		8,659				
	Diatoma tenuis Agardh						
	Diatoma vulgaris Bory						
	Diploneis sp						
	Eunotia arcus Ehrenberg	461	3,848				
	Eunotia bilunaris (Ehrenberg) Mills						
	Eunotia diodon Ehrenberg						
	Eunotia exigua Brebisson (Rabenhorst)						
	Eunotia faba Ehrenberg						
	Eunotia incisa Gregory		2,405				
	Eunotia paludosa Grunow						
	Eunotia tenella (Grunow) Hustedt						
	Fragilaria capucina Desmazieres	4,156	6,735				
	Fragilaria construens (Ehrenberg) Grunow		2,886				
	Fragilaria crotonensis Kitton						
	Fragilaria spp.	3,233	0	1,026			
	Fragilaria ulna (Nitzsch) Lange-Bertalot						
	Frustulia rhomboides (Ehrenberg) de Toni	5,542	11,065	1,026			
	Gomphonema angustatum (Kuetzing) Rabenhorst						
	Gomphonema parvulum Kuetzing						
	Gomphonema pumilum (Grunow) Reichardt & Lange-Bertalot						
	Hannaea arcus (Ehrenberg) Patrick		481				
	Meridion circulare (Greville) Agardh						
	Navicula cryptocephala Kuetzing						
	Navicula cryptotenella Lange-Bertalot						
	Navicula decussis Ostrup						
	Navicula pupula Kuetzing	461					
	Navicula spp		481				
	Neidium spp						
	Nitzschia acicularis (Kuetzing) W. Smith						
	Nitzschia clausii Hantzsch						
	Nitzschia inconspicua Grunow						
	Nitzschia linearis (Agardh) W. Smith						
	Nitzschia palea (Kuetzing) W. Smith						
	Nitzschia perminuta Lange-Bertalot	923	1,924	2,052			
	Ntzschia spp	0	0	0			
	Tabellaria flocculosa (Roth) Kuetzing	1,385	7,216	2,052			
	Surirella brebisonii Krammer & Lange-Bertalot						
CENTRALES	*Aulacoseira granulata (Ehrenberg) Simonsen*						
	Aulacoseira spp.						
	Cyclotella ocellata Pantocsek						
	Cyclotella pseudostelligera Hustedt						
	Cyclotella spp						
	TOTAL DIATOMS	**18,469**	**55,321**	**10,261**	**28,017**	**13,856**	**8**
CYANOBACTERIA							
CYANOBACTERIA							
NOSTOCALES	*Anabaena aequalis Borge*						
	Anabaena circinalis Rabenhorst						
	Anabaena flos-aquae Brebisson						
	Anabaena solitaria Klebahn						
	Anabaena spiroides Klebahn						
	Anabaena sp						
	Gloeotrichia echinulata (J.E. Smith) Richter	2,309	606,187				
CHROOCOCCALES	*Chroococcus minutus* (Kuetz.) Naegeli						
	Aphanocapsa sp			51,317			
	Gloeocapsa sp						
	Merismopedia glauca (Ehrenberg) Naegeli						
	Snowella lacustris (Chodat) Komarek et Hindak						
	Rhabdoderma lineare Woloszynska						
OSCILLATORIALES	*Borzia* sp Cohn ex Gormont	6,466					
	Heteroleibleinia sp						
	Hormoscilla sp		7,216	25,658			
	Limnothrix redekei (Van Goor) Meffert						
	Limnothrix-like sp						
	Oscillatoria princeps Vaucher						
	Phormidium accutissima Kefferath						
	Phormidium spp		33,677				
	Planktothrix agardhii Gomont	27,711	19,244				
	Planktolyngya limnetica Lemmermann	69,278					
	Pesudanabaena galeata Bocher						
	TOTAL CYANOBACTERIA	**105,764**	**666,324**	**76,975**	**283,021**	**191,832**	**85**

(continued)

Appendix 3.1-7
Densities of Stream Periphyton Taxa, August 2001 (continued)

		km 72.2 Rep A 20/08/2001	km 72.2 Rep B 20/08/2001	km 72.2 Rep C 20/08/2001	Mean	Std. Error	%
BACILLARIOPHYCEAE (DIATOMS)							
BACILLARIOPHYCEAE	*Achnanthes biasolettiana* Grunow	1,847					
PENNALES	*Achnanthes flexella* (Kuetzing) Braun	2,078		615			
	Achnanthes minutissima Kuetzing	42,721	3,848	9,442			
	Achnanthes ploenensis Husdtedt						
	Amphora spp.						
	Anomoeoneis brachysira (Brebisson) Grunow						
	Anomoeoneis brachysira var zellensis (Grunow) Krammer						
	Asterionella formosa Hansall			410			
	Cymbella affinis Kuetzing						
	Cymbella cessatii (Rabenhorst) Grunow	1,154	461	3,900			
	Cymbella descripta (Hustedt) Lange-Bertalot	1,385					
	Cymbella microcephala Grunow						
	Cymbella minuta Hilse			205			
	Cymbella silesiaca Bleisch ex. Rabenhorst						
	Cymbella sinuata Gregory						
	Denticula subtilis Grunow						
	Diatoma moniliformis Kuetzing	5,080					
	Diatoma tenuis Agardh	2,771					
	Diatoma vulgaris Bory						
	Diploneis sp						
	Eunotia arcus Ehrenberg	3,463	153				
	Eunotia bilunaris (Ehrenberg) Mills						
	Eunotia diodon Ehrenberg						
	Eunotia exigua Brebisson (Rabenhorst)						
	Eunotia faba Ehrenberg						
	Eunotia incisa Gregory						
	Eunotia paludosa Grunow						
	Eunotia tenella (Grunow) Hustedt						
	Fragilaria capucina Desmazieres	4,156	2,001				
	Fragilaria construens (Ehrenberg) Grunow						
	Fragilaria crotonensis Kitton	1,154					
	Fragilaria spp.	6,465	7,389	5,541			
	Fragilaria ulna (Nitzsch) Lange-Bertalot						
	Frustulia rhomboides (Ehrenberg) de Toni						
	Gomphonema angustatum (Kuetzing) Rabenhorst						
	Gomphonema parvulum Kuetzing	1,154		410			
	Gomphonema pumilum (Grunow) Reichardt & Lange-Bertalot						
	Hannaea arcus (Ehrenberg) Patrick						
	Meridion circulare (Greville) Agardh						
	Navicula cryptocephala Kuetzing	4,156		9,237			
	Navicula cryptotenella Lange-Bertalot	1,385	461				
	Navicula decussis Ostrup						
	Navicula pupula Kuetzing	692		821			
	Navicula spp						
	Neidium spp						
	Nitzschia acicularis (Kuetzing) W. Smith						
	Nitzschia clausii Hantzsch						
	Nitzschia inconspicua Grunow		615				
	Nitzschia linearis (Agardh) W. Smith						
	Nitzschia palea (Kuetzing) W. Smith	461					
	Nitzschia perminuta Lange-Bertalot	1,154	2,155				
	Ntzschia spp	0	461	11,699			
	Tabellaria flocculosa (Roth) Kuetzing	4,618	2,463	2,257			
	Surirella brebisonii Krammer & Lange-Bertalot						
CENTRALES	*Aulacoseira granulata (Ehrenberg) Simonsen*						
	Aulacoseira spp.		6,158				
	Cyclotella ocellata Pantocsek						
	Cyclotella pseudostelligera Hustedt						
	Cyclotella spp						
	TOTAL DIATOMS	**85,894**	**26,165**	**44,537**	**52,199**	**17,663**	**19**
CYANOBACTERIA							
CYANOBACTERIA							
NOSTOCALES	*Anabaena aequalis Borge*						
	Anabaena circinalis Rabenhorst						
	Anabaena flos-aquae Brebisson		2,309				
	Anabaena solitaria Klebahn						
	Anabaena spiroides Klebahn						
	Anabaena sp						
	Gloeotrichia echinulata (J.E. Smith) Richter	24,940	303,594	3,079			
CHROOCOCCALES	*Chroococcus minutus* (Kuetz.) Naegeli						
	Aphanocapsa sp						
	Gloeocapsa sp			6,158			
	Merismopedia glauca (Ehrenberg) Naegeli						
	Snowella lacustris (Chodat) Komarek et Hindak	36,948	9,237				
	Rhabdoderma lineare Woloszynska						
OSCILLATORIALES	*Borzia* sp Cohn ex Gormont						
	Heteroleibleinia sp						
	Hormoscilla sp						
	Limnothrix redekei (Van Goor) Meffert						
	Limnothrix-like sp	13,855	3,079	24,632			
	Oscillatoria princeps Vaucher		9,237				
	Phormidium accutissima Kefferath						
	Phormidium spp						
	Planktothrix agardhii Gomont		26,941	114,951			
	Planktolyngya limnetica Lemmermann		9,237				
	Pesudanabaena galeata Bocher						
	TOTAL CYANOBACTERIA	**75,743**	**363,634**	**148,820**	**196,066**	**86,399**	**71**

(continued)

Appendix 3.1-7
Densities of Stream Periphyton Taxa, August 2001 (continued)

		km 2.2 Rep A 22/08/2001	km 2.2 Rep B 22/08/2001	km 2.2 Rep C 22/08/2001	Mean	Std. Error	%
BACILLARIOPHYCEAE (DIATOMS)							
BACILLARIOPHYCEAE	*Achnanthes biasolettiana* Grunow						
PENNALES	*Achnanthes flexella* (Kuetzing) Braun						
	Achnanthes minutissima Kuetzing	22,169	36,948	44,338			
	Achnanthes ploenensis Husdtedt						
	Amphora spp.			3,694			
	Anomoeoneis brachysira (Brebisson) Grunow						
	Anomoeoneis brachysira var zellensis (Grunow) Krammer						
	Asterionella formosa Hansall						
	Cymbella affinis Kuetzing						
	Cymbella cessatii (Rabenhorst) Grunow						
	Cymbella descripta (Hustedt) Lange-Bertalot						
	Cymbella microcephala Grunow						
	Cymbella minuta Hilse	57,270	13,855	40,643			
	Cymbella silesiaca Bleisch ex. Rabenhorst		2,309				
	Cymbella sinuata Gregory	1,847	6,927				
	Denticula subtilis Grunow						
	Diatoma moniliformis Kuetzing	188,437	182,433	225,386			
	Diatoma tenuis Agardh						
	Diatoma vulgaris Bory						
	Diploneis sp						
	Eunotia arcus Ehrenberg						
	Eunotia bilunaris (Ehrenberg) Mills	3,694					
	Eunotia diodon Ehrenberg						
	Eunotia exigua Brebisson (Rabenhorst)						
	Eunotia faba Ehrenberg						
	Eunotia incisa Gregory						
	Eunotia paludosa Grunow						
	Eunotia tenella (Grunow) Hustedt						
	Fragilaria capucina Desmazieres						
	Fragilaria construens (Ehrenberg) Grunow						
	Fragilaria crotonensis Kitton						
	Fragilaria spp.	155,184	205,525	125,623			
	Fragilaria ulna (Nitzsch) Lange-Bertalot		4,618				
	Frustulia rhomboides (Ehrenberg) de Toni						
	Gomphonema angustatum (Kuetzing) Rabenhorst	1,847	4,618	3,694			
	Gomphonema parvulum Kuetzing	3,694	46,185	25,864			
	Gomphonema pumilum (Grunow) Reichardt & Lange-Bertalot						
	Hannaea arcus (Ehrenberg) Patrick						
	Meridion circulare (Greville) Agardh		2,309				
	Navicula cryptocephala Kuetzing	3,694	4,618				
	Navicula cryptotenella Lange-Bertalot						
	Navicula decussis Ostrup			3,694			
	Navicula pupula Kuetzing		2,309				
	Navicula spp	3,694					
	Neidium spp						
	Nitzschia acicularis (Kuetzing) W. Smith	5,542	4,618				
	Nitzschia clausii Hantzsch	9,237	16,165	3,694			
	Nitzschia inconspicua Grunow						
	Nitzschia linearis (Agardh) W. Smith		4,618				
	Nitzschia palea (Kuetzing) W. Smith						
	Nitzschia perminuta Lange-Bertalot	182,895	193,980	147,794			
	Ntzschia spp	0	0	0			
	Tabellaria flocculosa (Roth) Kuetzing	5,542					
	Surirella brebisonii Krammer & Lange-Bertalot	24,016	87,752	70,202			
CENTRALES	*Aulacoseira granulata (Ehrenberg) Simonsen*						
	Aulacoseira spp.						
	Cyclotella ocellata Pantocsek						
	Cyclotella pseudostelligera Hustedt						
	Cyclotella spp						
	TOTAL DIATOMS	**668,762**	**819,787**	**694,626**	**727,725**	**46,633**	**58**
CYANOBACTERIA							
CYANOBACTERIA							
NOSTOCALES	*Anabaena aequalis Borge*						
	Anabaena circinalis Rabenhorst						
	Anabaena flos-aquae Brebisson						
	Anabaena solitaria Klebahn						
	Anabaena spiroides Klebahn						
	Anabaena sp						
	Gloeotrichia echinulata (J.E. Smith) Richter						
CHROOCOCCALES	*Chroococcus minutus* (Kuetz.) Naegeli						
	Aphanocapsa sp						
	Gloeocapsa sp						
	Merismopedia glauca (Ehrenberg) Naegeli		332,537				
	Snowella lacustris (Chodat) Komarek et Hindak						
	Rhabdoderma lineare Woloszynska						
OSCILLATORIALES	*Borzia* sp Cohn ex Gormont						
	Heteroleibleinia sp						
	Hormoscilla sp						
	Limnothrix redekei (Van Goor) Meffert						
	Limnothrix-like sp						
	Oscillatoria princeps Vaucher						
	Phormidium accutissima Kefferath						
	Phormidium spp						
	Planktothrix agardhii Gomont						
	Planktolyngya limnetica Lemmermann		496,496	387,960			
	Pesudanabaena galeata Bocher		230,928	92,371			
	TOTAL CYANOBACTERIA	**0**	**1,059,961**	**480,331**	**513,431**	**306,432**	**41**

(continued)

Appendix 3.1-7
Densities of Stream Periphyton Taxa, August 2001 (continued)

		km 206.9 Rep A 21/08/2001	km 206.9 Rep B 21/08/2001	km 206.9 Rep C 21/08/2001	Mean	Std. Error	%
CHLOROPHYCEAE							
CHLOROPHYCEAE							
VOLVOCALES	*Chamydomonas* spp.						
ZYGENEMATALES	*Closterium dianae* Ehrenberg		205	615			
	Closterium leibleinii Kuetzing						
	Closterium spp						
	Cosmarium asphaerosporum Nordst						
	Cosmaruim bioculatum Brebisson		410				
	Cosmariun botrytis Meneghini						
	Cosmarium granatum Brebisson			615			
	Cosmarium impressulum Elfv.						
	Cosmarium margaritatum (Lund.) Roy & Biss						
	Cosmarium ornatum Ralfs						
	Cosmarium phaseolus Brebisson						
	Cosmarium regnellii Wille						
	Cosmarium subreniforme Nordstedt						
	Cosmarium subcrenatum Hantz.						
	Euastrum ansatum Ehrenberg			923			
	Euastrum insulare (Wittrock) Roy	414	410				
	Euastrum sinuosum Lenor						
	Hyalotheca sp						
	Mesotaenium macrococcum (Kuetzing) Roy & Bisset						
	Mesotaenium sp						
	Penium sp						
	Staurastrum anatinum Cooke & Wills						
	Staurastrum cf. comptum						
	Staurastrum furgicerum Brebisson						
	Staurastrum hexacerum (Ehrenberg) Wittrock						
	Staurodesmus incus (Brebisson) Teiling						
	Staurastrum spp			0			
	Mougeotia sp. Agardh		2,463	2,463			
	Zygnema sp						
CYLINDROCAPSALES	*Cylindrocapsa* sp.						
MICROSPORALES	*Microspora crassior (Hansigig) Hazen*						
	Microspora spp.						
CHLOROCOCCALES	*Actinastrum hantzschii* Lagerheim						
	Ankistrodesmus bernardii Komarek						
	Ankistrodesmus spiralis (Turner) Lemmermann						
	Crucegenia quadrata Morren						
	Elaktothrix gelatinosa						
	Elaktothrix genevensis						
	Gloeocystis gigas (Kutzing) Lagerheim						
	Kirchneriella obesa (W. West) Schmidle						
	Monoraphidium arcuatum (Kors) Hind.		205				
	Monoraphidium circinale (Nygaard) Nygaard						
	Monoraphidium contortum (Thuret) Komarkova-Legenerova						
	Monoraphidium griffithii (Berkeley) Kamarkova-Legenerova						
	Monoraphidium mirabile (W. & G.S. West) Pankow						
	Monoraphidium spp						
	Monoraphidium tortile (W. & G.S. West) Komarkova-Legenerova						
	Oocystis solitaria Wittrock						
	Oocystis sp.						
	Pediastrum tetras (Ehrenberg) Ralfs						
	Scenedesmus ecornis (Ehrenberg) Chodat						
	Scenedesmus obliquus (Turpin) Kuetzing						
	Scenedesmus subspicatus Chodat		821				
	Scenedesmus spp						
	Sphaerozosoma granulatum Roy & Biss.						
	Spondylosium pygaeum Rabenhorst		821				
ULOTRICHALES	*Gloeotilia pelagica (Nygaard) Skuja*			1,539			
	Geminella sp.						
CHAETOPHORALES	*Stigeoclonium lumbricum (Dillw.) Kuetzing*						
	TOTAL CHLOROPHYCEAE	**414**	**5,335**	**6,155**	**3,968**	**1,793**	**4**
XANTHOPHYTA							
MISCHOCOCCALES	*Tetraederon minimum (A. Braun) Hansgird*			307			
	Tetraederon triangulare Korshikov						
	Tetraedron sp.						
	TOTAL XANTHOPHYCEAE	**0**	**0**	**307**	**102**	**102**	**0**
CHRYSOPHYCEAE							
CHRYSOPHYCEAE							
CHROMULINALES	*Kephyrion boreale* Skuja						
	Kephyrion obliquum Hilliard						
	Kephyrion spp						
	TOTAL CHRYSOPHYCEAE	**0**	**0**	**0**	**0**	**0**	**0**
TOTAL		**25,083**	**36,532**	**244,460**	**102,025**	**71,294**	**100**

(continued)

Appendix 3.1-7
Densities of Stream Periphyton Taxa, August 2001 (continued)

		192.4a Rep A 21/08/2001	192.4a Rep B 21/08/2001	192.4a Rep C 21/08/2001	Mean	Std. Error	%
CHLOROPHYCEAE							
CHLOROPHYCEAE							
VOLVOCALES	*Chamydomonas* spp.						
ZYGENEMATALES	*Closterium dianae* Ehrenberg	1,924					
	Closterium leibleinii Kuetzing						
	Closterium spp						
	Cosmarium asphaerosporum Nordst						
	Cosmaruim bioculatum Brebisson			366			
	Cosmariun botrytis Meneghini						
	Cosmarium granatum Brebisson						
	Cosmarium impressulum Elfv.						
	Cosmarium margaritatum (Lund.) Roy & Biss	481		733			
	Cosmarium ornatum Ralfs						
	Cosmarium phaseolus Brebisson	481		1,466			
	Cosmarium regnellii Wille						
	Cosmarium subreniforme Nordstedt						
	Cosmarium subcrenatum Hantz.						
	Euastrum ansatum Ehrenberg	1,443					
	Euastrum insulare (Wittrock) Roy	481		1,099			
	Euastrum sinuosum Lenor						
	Hyalotheca sp						
	Mesotaenium macrococcum (Kuetzing) Roy & Bisset						
	Mesotaenium sp	962					
	Penium sp						
	Staurastrum anatinum Cooke & Wills						
	Staurastrum cf. comptum						
	Staurastrum furgicerum Brebisson						
	Staurastrum hexacerum (Ehrenberg) Wittrock			366			
	Staurodesmus incus (Brebisson) Teiling	481		733			
	Staurastrum spp						
	Mougeotia sp. Agardh	17,800					
	Zygnema sp						
CYLINDROCAPSALES	*Cylindrocapsa* sp.						
MICROSPORALES	*Microspora crassior (Hansigig) Hazen*						
	Microspora spp.						
CHLOROCOCCALES	*Actinastrum hantzschii* Lagerheim						
	Ankistrodesmus bernardii Komarek						
	Ankistrodesmus spiralis (Turner) Lemmermann	7,697		1,466			
	Crucegenia quadrata Morren		2,463				
	Elaktothrix gelatinosa						
	Elaktothrix genevensis						
	Gloeocystis gigas (Kutzing) Lagerheim						
	Kirchneriella obesa (W. West) Schmidle						
	Monoraphidium arcuatum (Kors) Hind.	1,443		366			
	Monoraphidium circinale (Nygaard) Nygaard	962		733			
	Monoraphidium contortum (Thuret) Komarkova-Legenerova	1,924	2,155	366			
	Monoraphidium griffithii (Berkeley) Kamarkova-Legenerova		307				
	Monoraphidium mirabile (W. & G.S. West) Pankow						
	Monoraphidium spp						
	Monoraphidium tortile (W. & G.S. West) Komarkova-Legenerova	481					
	Oocystis solitaria Wittrock						
	Oocystis sp.						
	Pediastrum tetras (Ehrenberg) Ralfs						
	Scenedesmus ecornis (Ehrenberg) Chodat			1,466			
	Scenedesmus obliquus (Turpin) Kuetzing		4,926	2,932			
	Scenedesmus subspicatus Chodat						
	Scenedesmus spp						
	Sphaerozosoma granulatum Roy & Biss.						
	Spondylosium pygaeum Rabenhorst						
ULOTRICHALES	*Gloeotilia pelagica (Nygaard) Skuja*						
	Geminella sp.	5,773					
CHAETOPHORALES	*Stigeoclonium lumbricum (Dillw.) Kuetzing*	19,244					
	TOTAL CHLOROPHYCEAE	**61,577**	**9,851**	**12,092**	**27,840**	**16,881**	**20**
XANTHOPHYTA							
MISCHOCOCCALES	*Tetraederon minimum (A. Braun) Hansgird*						
	Tetraederon triangulare Korshikov		307				
	Tetraedron sp.						
	TOTAL XANTHOPHYCEAE	**0**	**307**	**0**	**102**	**102**	**0**
CHRYSOPHYCEAE							
CHRYSOPHYCEAE							
CHROMULINALES	*Kephyrion boreale* Skuja	481	307	366			
	Kephyrion obliquum Hilliard			733			
	Kephyrion spp						
	TOTAL CHRYSOPHYCEAE	**481**	**307**	**1,099**	**629**	**240**	**0**
TOTAL		**170,100**	**139,551**	**111,653**	**140,435**	**16,878**	**87**

(continued)

Appendix 3.1-7
Densities of Stream Periphyton Taxa, August 2001 (continued)

		km 134.6 Rep A 21/08/2001	km 134.6 Rep B 21/08/2001	km 134.6 Rep C 21/08/2001	Mean	Std. Error	%
CHLOROPHYCEAE							
CHLOROPHYCEAE							
VOLVOCALES	*Chamydomonas* spp.						
ZYGENEMATALES	*Closterium dianae* Ehrenberg			461			
	Closterium leibleinii Kuetzing						
	Closterium spp						
	Cosmarium asphaerosporum Nordst						
	Cosmaruim bioculatum Brebisson	307	923				
	Cosmariun botrytis Meneghini						
	Cosmarium granatum Brebisson						
	Cosmarium impressulum Elfv.						
	Cosmarium margaritatum (Lund.) Roy & Biss						
	Cosmarium ornatum Ralfs						
	Cosmarium phaseolus Brebisson						
	Cosmarium regnellii Wille						
	Cosmarium subreniforme Nordstedt						
	Cosmarium subcrenatum Hantz.						
	Euastrum ansatum Ehrenberg						
	Euastrum insulare (Wittrock) Roy			461			
	Euastrum sinuosum Lenor	307		923			
	Hyalotheca sp		1,385				
	Mesotaenium macrococcum (Kuetzing) Roy & Bisset						
	Mesotaenium sp						
	Penium sp			461			
	Staurastrum anatinum Cooke & Wills	307					
	Staurastrum cf. comptum						
	Staurastrum furgicerum Brebisson			461			
	Staurastrum hexacerum (Ehrenberg) Wittrock						
	Staurodesmus incus (Brebisson) Teiling		461				
	Staurastrum spp			922			
	Mougeotia sp. Agardh		2,309				
	Zygnema sp	29,558	2,771	71,587			
CYLINDROCAPSALES	*Cylindrocapsa* sp.						
MICROSPORALES	*Microspora crassior (Hansigig) Hazen*						
	Microspora spp.			11,546			
CHLOROCOCCALES	*Actinastrum hantzschii* Lagerheim						
	Ankistrodesmus bernardii Komarek						
	Ankistrodesmus spiralis (Turner) Lemmermann						
	Crucegenia quadrata Morren						
	Elaktothrix gelatinosa		923				
	Elaktothrix genevensis						
	Gloeocystis gigas (Kutzing) Lagerheim			1,847			
	Kirchneriella obesa (W. West) Schmidle			2,771			
	Monoraphidium arcuatum (Kors) Hind.						
	Monoraphidium circinale (Nygaard) Nygaard						
	Monoraphidium contortum (Thuret) Komarkova-Legenerova			461			
	Monoraphidium griffithii (Berkeley) Kamarkova-Legenerova						
	Monoraphidium mirabile (W. & G.S. West) Pankow						
	Monoraphidium spp	307	461				
	Monoraphidium tortile (W. & G.S. West) Komarkova-Legenerova	307					
	Oocystis solitaria Wittrock						
	Oocystis sp.						
	Pediastrum tetras (Ehrenberg) Ralfs						
	Scenedesmus ecornis (Ehrenberg) Chodat						
	Scenedesmus obliquus (Turpin) Kuetzing						
	Scenedesmus subspicatus Chodat						
	Scenedesmus spp						
	Sphaerozosoma granulatum Roy & Biss.			9,237			
	Spondylosium pygaeum Rabenhorst						
ULOTRICHALES	*Gloeotilia pelagica (Nygaard) Skuja*						
	Geminella sp.			3,694			
CHAETOPHORALES	*Stigeoclonium lumbricum (Dillw.) Kuetzing*						
	TOTAL CHLOROPHYCEAE	**31,093**	**9,233**	**104,832**	**48,386**	**28,920**	**15**
XANTHOPHYTA							
MISCHOCOCCALES	*Tetraederon minimum (A. Braun) Hansgird*						
	Tetraederon triangulare Korshikov						
	Tetraedron sp.			461			
	TOTAL XANTHOPHYCEAE	**0**	**0**	**461**	**154**	**154**	**0**
CHRYSOPHYCEAE							
CHRYSOPHYCEAE							
CHROMULINALES	*Kephyrion boreale* Skuja						
	Kephyrion obliquum Hilliard						
	Kephyrion spp	307	461				
	TOTAL CHRYSOPHYCEAE	**307**	**461**	**0**	**256**	**136**	**0**
TOTAL		**239,926**	**169,107**	**554,293**	**321,109**	**118,371**	**94**

(continued)

Appendix 3.1-7
Densities of Stream Periphyton Taxa, August 2001 (continued)

		km 84.2 Rep A 22/08/2001	km 84.2 Rep B 22/08/2001	km 84.2 Rep C 22/08/2001	Mean	Std. Error	%
CHLOROPHYCEAE							
CHLOROPHYCEAE							
VOLVOCALES	*Chamydomonas* spp.						
ZYGENEMATALES	*Closterium dianae* Ehrenberg						
	Closterium leibleinii Kuetzing						
	Closterium spp						
	Cosmarium asphaerosporum Nordst						
	Cosmaruim bioculatum Brebisson	461	481				
	Cosmariun botrytis Meneghini						
	Cosmarium granatum Brebisson						
	Cosmarium impressulum Elfv.						
	Cosmarium margaritatum (Lund.) Roy & Biss						
	Cosmarium ornatum Ralfs						
	Cosmarium phaseolus Brebisson		481	513			
	Cosmarium regnellii Wille						
	Cosmarium subreniforme Nordstedt						
	Cosmarium subcrenatum Hantz.		481				
	Euastrum ansatum Ehrenberg						
	Euastrum insulare (Wittrock) Roy						
	Euastrum sinuosum Lenor						
	Hyalotheca sp						
	Mesotaenium macrococcum (Kuetzing) Roy & Bisset						
	Mesotaenium sp						
	Penium sp						
	Staurastrum anatinum Cooke & Wills						
	Staurastrum cf. comptum						
	Staurastrum furgicerum Brebisson						
	Staurastrum hexacerum (Ehrenberg) Wittrock						
	Staurodesmus incus (Brebisson) Teiling						
	Staurastrum spp						
	Mougeotia sp. Agardh						
	Zygnema sp	3,233		513			
CYLINDROCAPSALES	*Cylindrocapsa* sp.						
MICROSPORALES	*Microspora crassior (Hansigig) Hazen*						
	Microspora spp.						
CHLOROCOCCALES	*Actinastrum hantzschii* Lagerheim						
	Ankistrodesmus bernardii Komarek						
	Ankistrodesmus spiralis (Turner) Lemmermann						
	Crucegenia quadrata Morren						
	Elaktothrix gelatinosa						
	Elaktothrix genevensis						
	Gloeocystis gigas (Kutzing) Lagerheim						
	Kirchneriella obesa (W. West) Schmidle						
	Monoraphidium arcuatum (Kors) Hind.						
	Monoraphidium circinale (Nygaard) Nygaard						
	Monoraphidium contortum (Thuret) Komarkova-Legenerova						
	Monoraphidium griffithii (Berkeley) Kamarkova-Legenerova						
	Monoraphidium mirabile (W. & G.S. West) Pankow			513			
	Monoraphidium spp						
	Monoraphidium tortile (W. & G.S. West) Komarkova-Legenerova						
	Oocystis solitaria Wittrock						
	Oocystis sp.						
	Pediastrum tetras (Ehrenberg) Ralfs						
	Scenedesmus ecornis (Ehrenberg) Chodat						
	Scenedesmus obliquus (Turpin) Kuetzing						
	Scenedesmus subspicatus Chodat						
	Scenedesmus spp						
	Sphaerozosoma granulatum Roy & Biss.						
	Spondylosium pygaeum Rabenhorst						
ULOTRICHALES	*Gloeotilia pelagica (Nygaard) Skuja*						
	Geminella sp.						
CHAETOPHORALES	*Stigeoclonium lumbricum (Dillw.) Kuetzing*						
	TOTAL CHLOROPHYCEAE	**3,694**	**1,443**	**1,539**	**2,225**	**735**	**1**
XANTHOPHYTA							
MISCHOCOCCALES	*Tetraederon minimum (A. Braun) Hansgird*						
	Tetraederon triangulare Korshikov						
	Tetraedron sp.						
	TOTAL XANTHOPHYCEAE	**0**	**0**	**0**	**0**	**0**	**0**
CHRYSOPHYCEAE							
CHRYSOPHYCEAE							
CHROMULINALES	*Kephyrion boreale* Skuja						
	Kephyrion obliquum Hilliard						
	Kephyrion spp						
	TOTAL CHRYSOPHYCEAE	**0**	**0**	**0**	**0**	**0**	**0**
TOTAL		**146,490**	**741,651**	**107,338**	**331,826**	**205,224**	**94**

(continued)

Appendix 3.1-7
Densities of Stream Periphyton Taxa, August 2001 (continued)

		km 72.2 Rep A 20/08/2001	km 72.2 Rep B 20/08/2001	km 72.2 Rep C 20/08/2001	Mean	Std. Error	%
CHLOROPHYCEAE							
CHLOROPHYCEAE							
VOLVOCALES	*Chamydomonas* spp.						
ZYGENEMATALES	*Closterium dianae* Ehrenberg			1,026			
	Closterium leibleinii Kuetzing		153				
	Closterium spp	1,154					
	Cosmarium asphaerosporum Nordst						
	Cosmaruim bioculatum Brebisson	461		205			
	Cosmariun botrytis Meneghini			410			
	Cosmarium granatum Brebisson						
	Cosmarium impressulum Elfv.		461				
	Cosmarium margaritatum (Lund.) Roy & Biss						
	Cosmarium ornatum Ralfs						
	Cosmarium phaseolus Brebisson	230					
	Cosmarium regnellii Wille						
	Cosmarium subreniforme Nordstedt	230		205			
	Cosmarium subcrenatum Hantz.						
	Euastrum ansatum Ehrenberg		615				
	Euastrum insulare (Wittrock) Roy	2,771	4,002	615			
	Euastrum sinuosum Lenor						
	Hyalotheca sp						
	Mesotaenium macrococcum (Kuetzing) Roy & Bisset						
	Mesotaenium sp						
	Penium sp						
	Staurastrum anatinum Cooke & Wills						
	Staurastrum cf. comptum						
	Staurastrum furgicerum Brebisson						
	Staurastrum hexacerum (Ehrenberg) Wittrock						
	Staurodesmus incus (Brebisson) Teiling						
	Staurastrum spp						
	Mougeotia sp. Agardh						
	Zygnema sp	3,002					
CYLINDROCAPSALES	*Cylindrocapsa* sp.						
MICROSPORALES	*Microspora crassior (Hansigig) Hazen*						
	Microspora spp.						
CHLOROCOCCALES	*Actinastrum hantzschii* Lagerheim						
	Ankistrodesmus bernardii Komarek						
	Ankistrodesmus spiralis (Turner) Lemmermann	6,466	1,847	3,284			
	Crucegenia quadrata Morren						
	Elaktothrix gelatinosa						
	Elaktothrix genevensis	230					
	Gloeocystis gigas (Kutzing) Lagerheim						
	Kirchneriella obesa (W. West) Schmidle						
	Monoraphidium arcuatum (Kors) Hind.	230		205			
	Monoraphidium circinale (Nygaard) Nygaard						
	Monoraphidium contortum (Thuret) Komarkova-Legenerova						
	Monoraphidium griffithii (Berkeley) Kamarkova-Legenerova						
	Monoraphidium mirabile (W. & G.S. West) Pankow						
	Monoraphidium spp						
	Monoraphidium tortile (W. & G.S. West) Komarkova-Legenerova	461	153	205			
	Oocystis solitaria Wittrock		153				
	Oocystis sp.						
	Pediastrum tetras (Ehrenberg) Ralfs						
	Scenedesmus ecornis (Ehrenberg) Chodat	1,847		2,052			
	Scenedesmus obliquus (Turpin) Kuetzing						
	Scenedesmus subspicatus Chodat						
	Scenedesmus spp		615				
	Sphaerozosoma granulatum Roy & Biss.						
	Spondylosium pygaeum Rabenhorst						
ULOTRICHALES	*Gloeotilia pelagica (Nygaard) Skuja*						
	Geminella sp.						
CHAETOPHORALES	*Stigeoclonium lumbricum (Dillw.) Kuetzing*						
	TOTAL CHLOROPHYCEAE	**17,082**	**7,999**	**8,207**	**11,096**	**2,994**	**4**
XANTHOPHYTA							
MISCHOCOCCALES	*Tetraederon minimum (A. Braun) Hansgird*		153				
	Tetraederon triangulare Korshikov						
	Tetraedron sp.						
	TOTAL XANTHOPHYCEAE	**0**	**153**	**0**	**51**	**51**	**0**
CHRYSOPHYCEAE							
CHRYSOPHYCEAE							
CHROMULINALES	*Kephyrion boreale* Skuja						
	Kephyrion obliquum Hilliard						
	Kephyrion spp						
	TOTAL CHRYSOPHYCEAE	**0**	**0**	**0**	**0**	**0**	**0**
TOTAL		**197,281**	**416,513**	**220,126**	**277,973**	**69,583**	**93**

(continued)

Appendix 3.1-7
Densities of Stream Periphyton Taxa, August 2001 (completed)

		km 2.2 Rep A 22/08/2001	km 2.2 Rep B 22/08/2001	km 2.2 Rep C 22/08/2001	Mean	Std. Error	%
CHLOROPHYCEAE							
CHLOROPHYCEAE							
VOLVOCALES	*Chamydomonas* spp.						
ZYGENEMATALES	*Closterium dianae* Ehrenberg	1,847		3,694			
	Closterium leibleinii Kuetzing						
	Closterium spp			3,694			
	Cosmarium asphaerosporum Nordst						
	Cosmaruim bioculatum Brebisson						
	Cosmariun botrytis Meneghini						
	Cosmarium granatum Brebisson						
	Cosmarium impressulum Elfv.						
	Cosmarium margaritatum (Lund.) Roy & Biss						
	Cosmarium ornatum Ralfs	1,847					
	Cosmarium phaseolus Brebisson						
	Cosmarium regnellii Wille						
	Cosmarium subreniforme Nordstedt						
	Cosmarium subcrenatum Hantz.						
	Euastrum ansatum Ehrenberg						
	Euastrum insulare (Wittrock) Roy						
	Euastrum sinuosum Lenor						
	Hyalotheca sp						
	Mesotaenium macrococcum (Kuetzing) Roy & Bisset						
	Mesotaenium sp						
	Penium sp						
	Staurastrum anatinum Cooke & Wills						
	Staurastrum cf. comptum						
	Staurastrum furgicerum Brebisson						
	Staurastrum hexacerum (Ehrenberg) Wittrock						
	Staurodesmus incus (Brebisson) Teiling						
	Staurastrum spp						
	Mougeotia sp. Agardh						
	Zygnema sp						
CYLINDROCAPSALES	*Cylindrocapsa* sp.						
MICROSPORALES	*Microspora crassior (Hansigig) Hazen*						
	Microspora spp.						
CHLOROCOCCALES	*Actinastrum hantzschii* Lagerheim						
	Ankistrodesmus bernardii Komarek						
	Ankistrodesmus spiralis (Turner) Lemmermann						
	Crucegenia quadrata Morren						
	Elaktothrix gelatinosa						
	Elaktothrix genevensis						
	Gloeocystis gigas (Kutzing) Lagerheim						
	Kirchneriella obesa (W. West) Schmidle						
	Monoraphidium arcuatum (Kors) Hind.						
	Monoraphidium circinale (Nygaard) Nygaard						
	Monoraphidium contortum (Thuret) Komarkova-Legenerova						
	Monoraphidium griffithii (Berkeley) Kamarkova-Legenerova						
	Monoraphidium mirabile (W. & G.S. West) Pankow						
	Monoraphidium spp						
	Monoraphidium tortile (W. & G.S. West) Komarkova-Legenerova						
	Oocystis solitaria Wittrock			0			
	Oocystis sp.						
	Pediastrum tetras (Ehrenberg) Ralfs						
	Scenedesmus ecornis (Ehrenberg) Chodat						
	Scenedesmus obliquus (Turpin) Kuetzing						
	Scenedesmus subspicatus Chodat						
	Scenedesmus spp						
	Sphaerozosoma granulatum Roy & Biss.						
	Spondylosium pygaeum Rabenhorst						
ULOTRICHALES	*Gloeotilia pelagica (Nygaard) Skuja*						
	Geminella sp.						
CHAETOPHORALES	*Stigeoclonium lumbricum (Dillw.) Kuetzing*						
	TOTAL CHLOROPHYCEAE	**3,694**	**0**	**7,388**	**3,694**	**2,133**	**0**
XANTHOPHYTA							
MISCHOCOCCALES	*Tetraederon minimum (A. Braun) Hansgird*						
	Tetraederon triangulare Korshikov						
	Tetraedron sp.						
	TOTAL XANTHOPHYCEAE	**0**	**0**	**0**	**0**	**0**	**0**
CHRYSOPHYCEAE							
CHRYSOPHYCEAE							
CHROMULINALES	*Kephyrion boreale* Skuja						
	Kephyrion obliquum Hilliard						
	Kephyrion spp						
	TOTAL CHRYSOPHYCEAE	**0**	**0**	**0**	**0**	**0**	**0**
TOTAL		**691,019**	**1,898,311**	**1,200,908**	**1,263,412**	**349,914**	**99**

APPENDIX 3.1-8
PERIPHYTON CHLOROPHYLL *A* CONCENTRATIONS IN STREAMS, AUGUST 2001

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Appendix 3.1-8
Periphyton Chlorophyll *a* Concentrations in Streams, August 2001

Stream Crossing	Replicate	Date	Chlorophyll *a* (µg/cm2)
km 206.9	A	Aug-21	16.2
km 206.9	B	Aug-21	9.7
km 206.9	C	Aug-21	13.2
km 192.4a	A	Aug-21	163.9
km 192.4a	B	Aug-21	72.2
km 192.4a	C	Aug-21	54.3
km 134.6	A	Aug-21	438.8
km 134.6	B	Aug-21	92.0
km 134.6	C	Aug-21	288.4
km 84.2	A	Aug-22	38.7
km 84.2	B	Aug-22	44.3
km 84.2	C	Aug-22	22.9
km 72.2	A	Aug-20	77.0
km 72.2	B	Aug-20	28.9
km 72.2	C	Aug-20	82.4
km 2.2	A	Aug-22	76.3
km 2.2	B	Aug-22	77.2
km 2.2	C	Aug-22	53.2

APPENDIX 3.1-9
DENSITIES OF BENTHIC INVERTEBRATES IN STREAMS, AUGUST 2001

Appendix 3.1-9
Densities of Benthic Invertebrates in Streams, August 2001

Species/Group	Stage	Bathurst km 206.9 Rep A 8/21/2001	Bathurst km 206.9 Rep B 8/21/2001	Bathurst km 206.9 Rep C 8/21/2001	Mean	Std. Error	%	Bathurst km 192.4a Rep A 8/21/2001	Bathurst km 192.4a Rep B 8/21/2001	Bathurst km 192.4a Rep C 8/21/2001	Mean	Std. Error	%	Bathurst km 134.6 Rep A 8/21/2001	Bathurst km 134.6 Rep B 8/21/2001	Bathurst km 134.6 Rep C 8/21/2001	Mean	Std. Error	%
COELENTERATA																			
Hydra														144	256	11			
SUM (org/m^2)		0	0	0	0	0	0	0	0	0	0	0	0	144	256	11	137	71	2
NEMATODA		111	200	1,478				111	56	44				1,011	133	89			
SUM (org/m^2)		111	200	1,478	596	441	50	111	56	44	70	21	4	1,011	133	89	411	300	6
TURBELLARIA																			
SUM (org/m^2)		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
OLIGOCHAETA																			
Unidentified	juv		11											122					
Naididae	juv	11		11					11	11				22	56				
Nais															22				
Lumbriculidae	juv																		
Lumbriculus				11				22	11	44				33	22	22			
Tubificidae	juv																		
Enchytraeidae			11	11				11	11					67	22	11			
SUM (org/m^2)		11	22	33	22	6	2	33	33	56	41	7	2	244	122	33	133	61	2
CLADOCERA																			
Chydoridae	juv																		
Alonella excisa																			
Chydorus sphaericus															11				
Eurycercus lamellatus																			
SUM (org/m^2)		0	0	0	0	0	0	0	0	0	0	0	0	0	11	0	4	4	0
COPEPODA																			
Cyclopoida														33					
Macrocyclops albidus	M/F	11																	
Eucyclops agilis	M/F																		
Harpacticoida																			
Canthocamptidae										11				100	11				
SUM (org/m^2)		11	0	0	4	4	0	0	0	11	4	4	0	133	11	0	48	43	1
OSTRACODA																			
Candona														289	33				
Cypria									11					478	100	22			
Cyclocypris																			
SUM (org/m^2)		0	0	0	0	0	0	0	11	0	4	4	0	767	133	22	307	232	4
ARACHNIDA																			
Oribatidae	A													11					
Hydracarina	A	22	22	56				122	411	178				378	89	322			
SUM (org/m^2)		22	22	56	33	11	3	122	411	178	237	89	14	389	89	322	267	91	4
COLLEMBOLA																			
Sminthuridae																			
Sminthurus	A									11									
SUM (org/m^2)		0	0	0	0	0	0	0	0	11	4	4	0	0	0	0	0	0	0
EPHEMEROPTERA	A																		
Baetidae								11											
Baetis tricaudatus	N								22	33						56			
Pseudocloeon	N																		
Ephemerellidae	N*																		
Ephemerella inermis	N													67	11	122			
Heptageneiidae	N*																		
Ameletidae																			
Parameletus	N																		
SUM (org/m^2)		0	0	0	0	0	0	11	22	33	22	6	1	67	11	178	85	49	1

A = adult
juv = juvenile
L = larva
L* = larva too small to be identified, or damaged
unid = unidentified
N = nymph
N* = nymph too small to be identified, or damaged
P = pupa
P* = pupa too small to be identified, or damaged

(continued)

Appendix 3.1-9
Densities of Benthic Invertebrates in Streams, August 2001 (continued)

Species/Group	Stage	Bathurst km 84.2 Rep A 8/22/2001	Bathurst km 84.2 Rep B 8/22/2001	Bathurst km 84.2 Rep C 8/22/2001	Mean	Std. Error	%	Bathurst km 72.2 Rep A 8/20/2001	Bathurst km 72.2 Rep B 8/20/2001	Bathurst km 72.2 Rep C 8/20/2001	Mean	Std. Error	%	Bathurst km 2.2 Rep A 8/22/2001	Bathurst km 2.2 Rep B 8/22/2001	Bathurst km 2.2 Rep C 8/22/2001	Mean	Std. Error	%
COELENTERATA																			
Hydra		211	56	467															
SUM (org/m^2)		211	56	467	244	120	7	0	0	0	0	0	0	0	0	0	0	0	0
NEMATODA		100	22	78											11				
SUM (org/m^2)		100	22	78	67	23	2	0	0	0	0	0	0	0	11	0	4	4	1
TURBELLARIA																			
SUM (org/m^2)		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
OLIGOCHAETA																			
Unidentified	juv		11																
Naididae	juv	22	11	44															
Nais				11															
Lumbriculidae	juv																		
Lumbriculus				11					144	22									
Tubificidae	juv																		
Enchytraeidae																			
SUM (org/m^2)		22	22	67	37	15	1	0	144	22	56	45	14	0	0	0	0	0	0
CLADOCERA																			
Chydoridae	juv																		
Alonella excisa																			
Chydorus sphaericus																			
Eurycercus lamellatus			11																
SUM (org/m^2)		0	11	0	4	4	0	0	0	0	0	0	0	0	0	0	0	0	0
COPEPODA																			
Cyclopoida				11					11										
Macrocyclops albidus	M/F									11									
Eucyclops agilis	M/F																		
Harpacticoida																			
Canthocamptidae																			
SUM (org/m^2)		0	0	11	4	4	0	0	11	11	7	4	2	0	0	0	0	0	0
OSTRACODA																			
Candona										22									
Cypria								22	11	33									
Cyclocypris		22	11																
SUM (org/m^2)		22	11	0	11	6	0	22	11	56	30	13	7	0	0	0	0	0	0
ARACHNIDA																			
Oribatidae	A																		
Hydracarina	A	67	56	144					56	33					22	22			
SUM (org/m^2)		67	56	144	89	28	3	0	56	33	30	16	7	0	22	22	15	7	2
COLLEMBOLA																			
Sminthuridae																			
Sminthurus	A																		
SUM (org/m^2)		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EPHEMEROPTERA	A		11											11		89			
Baetidae																			
Baetis tricaudatus	N	22	22	89				11	11						22	11			
Pseudocloeon	N													44	167	644			
Ephemerellidae	N*																		
Ephemerella inermis	N	11		44															
Heptageneiidae	N*			11															
Ameletidae																			
Parameletus	N								11										
SUM (org/m^2)		33	33	144	70	37	2	11	22	0	11	6	3	56	189	744	330	211	45

A = adult
juv = juvenile
L = larva
L* = larva too small to be identified, or damaged
unid = unidentified
N = nymph
N* = nymph too small to be identified, or damaged
P = pupa
P* = pupa too small to be identified, or damaged

(continued)

Appendix 3.1-9
Densities of Benthic Invertebrates in Streams, August 2001 (continued)

Species/Group	Stage	Bathurst km 206.9 Rep A 8/21/2001	Bathurst km 206.9 Rep B 8/21/2001	Bathurst km 206.9 Rep C 8/21/2001	Mean	Std. Error	%	Bathurst km 192.4a Rep A 8/21/2001	Bathurst km 192.4a Rep B 8/21/2001	Bathurst km 192.4a Rep C 8/21/2001	Mean	Std. Error	%	Bathurst km 134.6 Rep A 8/21/2001	Bathurst km 134.6 Rep B 8/21/2001	Bathurst km 134.6 Rep C 8/21/2001	Mean	Std. Error	%
PLECOPTERA	N*													111	556	56			
Nemouridae	N*																		
Nemoura	N	156	300	433				167	300	211				422	244	667			
Capnidae																			
Capnia	N																		
SUM (org/m^2)		156	300	433	296	80	25	167	300	211	226	39	13	533	800	722	685	79	10
HEMIPTERA																			
Aphididae	N																		
SUM (org/m^2)		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRICHOPTERA																			
Brachycentridae	L*																		
Brachycentrus americana	L							267	322	344				367	356	633			
Brachycentrus americana	P															11			
Hydroptilidae	L*																		
Agraylea	L														22				
Oxyethira	L																		
Leptoceridae	L*																		
Limnephilidae	L*	11																	
Limnephilus	L									11									
Polycentropodidae	L*																		
Polycentropus	L																		
Rhyacophilidae																			
Rhyacophila vepulsa	L	11														11			
SUM (org/m^2)		22	0	0	7	7	1	267	322	356	315	26	18	367	378	656	467	94	6
COLEOPTERA																			
Dytiscidae	A																		
Hydroporus	A							22	11	33									
SUM (org/m^2)		0	0	0	0	0	0	22	11	33	22	6	1	0	0	0	0	0	0
HYMENOPTERA																			
Braconidae	A																		
SUM (org/m^2)		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DIPTERA	unid																		
Canaceidae	A																		
Ceratopogonidae																			
Bezzia	L																		
Probezzia	L		11																
Empididae	P									11				11					
Chelifera	L			11															
Clinocera	L							22		11					44				
Oreogoton	L																		
Ephydridae	A																		
Simulidae	P			11															
Prosimulium	L																		
Simulium	L							11	22					11					
Simulium	P		11					11	22	11				111	111	89			
Simulium	A													11		22			
Tabanidae	L*																		
Limnophora	L	11						11											
Tipulidae																			
Dicranota	L								22	22									
Hexatoma	L		11	11															
Tipula	L	11	56	56				22	11					11	22	22			
Chironomidae	L*	33	33					22	11	489				1,400	1,667	333			

A = adult
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L = larva
L* = larva too small to be identified, or damaged
unid = unidentified
N = nymph
N* = nymph too small to be identified, or damaged
P = pupa
P* = pupa too small to be identified, or damaged

(continued)

Appendix 3.1-9
Densities of Benthic Invertebrates in Streams, August 2001 (continued)

Species/Group	Stage	Bathurst km 84.2 Rep A 8/22/2001	Bathurst km 84.2 Rep B 8/22/2001	Bathurst km 84.2 Rep C 8/22/2001	Mean	Std. Error	%	Bathurst km 72.2 Rep A 8/20/2001	Bathurst km 72.2 Rep B 8/20/2001	Bathurst km 72.2 Rep C 8/20/2001	Mean	Std. Error	%	Bathurst km 2.2 Rep A 8/22/2001	Bathurst km 2.2 Rep B 8/22/2001	Bathurst km 2.2 Rep C 8/22/2001	Mean	Std. Error	%
PLECOPTERA	N*																		
Nemouridae	N*																		
Nemoura	N	33	78	56				67	156	167	130			11	344	433			
Capnidae																			
Capnia	N													11					
SUM (org/m^2)		33	78	56	56	13	2	67	156	167	130	32	32	22	344	433	267	125	37
HEMIPTERA																			
Aphididae	N		11																
SUM (org/m^2)		0	11	0	4	4	0	0	0	0	0	0	0	0	0	0	0	0	0
TRICHOPTERA																			
Brachycentridae	L*																		
Brachycentrus americana	L	56	33	133												11			
Brachycentrus americana	P																		
Hydroptilidae	L*																		
Agraylea	L																		
Oxyethira	L																		
Leptoceridae	L*			11															
Limnephilidae	L*	11																	
Limnephilus	L																		
Polycentropodidae	L*																		
Polycentropus	L			11				11		11									
Rhyacophilidae																			
Rhyacophila vepulsa	L	11	11																
SUM (org/m^2)		78	44	156	93	33	3	11	0	11	7	4	2	0	0	11	4	4	1
COLEOPTERA																			
Dytiscidae	A																		
Hydroporus	A	11																	
SUM (org/m^2)		11	0	0	4	4	0	0	0	0	0	0	0	0	0	0	0	0	0
HYMENOPTERA																			
Braconidae	A		11																
SUM (org/m^2)		0	11	0	4	4	0	0	0	0	0	0	0	0	0	0	0	0	0
DIPTERA	unid																		
Canaceidae	A	11																	
Ceratopogonidae																			
Bezzia	L																		
Probezzia	L																		
Empididae	P																		
Chelifera	L																		
Clinocera	L																		
Oreogoton	L																		
Ephydridae	A																		
Simulidae	P								11										
Prosimulium	L																		
Simulium	L	11	11	11															
Simulium	P		11	33															
Simulium	A	67	56	22					11										
Tabanidae	L*																		
Limnophora	L																		
Tipulidae																			
Dicranota	L														11				
Hexatoma	L																		
Tipula	L							11	67	11				11	11	22			
Chironomidae	L*	811	611	844					33	33					11				

A = adult
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L* = larva too small to be identified, or damaged
unid = unidentified
N = nymph
N* = nymph too small to be identified, or damaged
P = pupa
P* = pupa too small to be identified, or damaged

(continued)

Appendix 3.1-9
Densities of Benthic Invertebrates in Streams, August 2001 (continued)

Species/Group	Stage	Bathurst km 206.9 Rep A 8/21/2001	Bathurst km 206.9 Rep B 8/21/2001	Bathurst km 206.9 Rep C 8/21/2001	Mean	Std. Error	%	Bathurst km 192.4a Rep A 8/21/2001	Bathurst km 192.4a Rep B 8/21/2001	Bathurst km 192.4a Rep C 8/21/2001	Mean	Std. Error	%	Bathurst km 134.6 Rep A 8/21/2001	Bathurst km 134.6 Rep B 8/21/2001	Bathurst km 134.6 Rep C 8/21/2001	Mean	Std. Error	%
Chironomidae	P							22											
Tanypodinae	L*													589	111				
Thiennemannimyia	L	11	11	11				144	44	156				367	122	289			
Tanytarsini	L	22	44	11				22	44	44				2,589	1,778	444			
Micropsectra	L													22	67	11			
Paratanytarsus	L							11		56				22		11			
Rheotanytarsus	L							211	89	144				89	100	144			
Stempellinella	L													111	22				
Tanytarsus	L																		
Tanytarsus	P																		
Chironomini	L*		22	44										22					
Dicrotendipes	L														33				
Demicryptochironomus	L/P			11												22			
Parachironomus	L		11											11	11				
Phaenopsectra	L								11					11	11				
Polypedilum (polypedilum)	L			11															
Orthocladiinae	L*	56	11	11				22		44				133	444	778			
Orthocladiinae	P																		
Orthocladiinae	A																		
Corynoneura	L													78	44	11			
Corynoneura	P																		
Corynoneura	A													11					
Cricotopus	L														44	78			
Cricotopus	P																		
Eukiefferiella	L		22	78				89		33				78	100	44			
Eukiefferiella	P							56		100				44	67	11			
Euryhapsis	L									189						33			
Gymnometriocnemus	L																		
Heterotanytarsus	L																		
Orthocladius	L	11	11	11										22	122	78			
Orthocladius	P																		
Psectrocladius	L																		
Thienemanniella	L													44	333	333			
Diamesinae																			
Diamesa								11		44				11					
Monodiamesa	L													11	11	56			
Potthastia	L																		
Pseudokiefferiella	L															11			
SUM (org/m^2)		37,280	37,380	37,402	37,354	38	3,142	37,813	37,402	38,480	37,898	314	2,205	42,946	42,391	39,946	41,761	921	582
MOLLUSCA																			
Gastropoda																			
Valvata sincera sincera																			
SUM (org/m^2)		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL (org/m^2)		56,175	56,486	57,964	56,875	552	3,222	57,108	57,130	57,975	57,405	285	2,260	65,164	62,897	60,542	62,867	1,334	617

A = adult
juv = juvenile
L = larva
L* = larva too small to be identified, or damaged
unid = unidentified
N = nymph
N* = nymph too small to be identified, or damaged
P = pupa
P* = pupa too small to be identified, or damaged

(continued)

Appendix 3.1-9
Densities of Benthic Invertebrates in Streams, August 2001 (completed)

Species/Group	Stage	Bathurst km 84.2 Rep A 8/22/2001	Bathurst km 84.2 Rep B 8/22/2001	Bathurst km 84.2 Rep C 8/22/2001	Mean	Std. Error	%	Bathurst km 72.2 Rep A 8/20/2001	Bathurst km 72.2 Rep B 8/20/2001	Bathurst km 72.2 Rep C 8/20/2001	Mean	Std. Error	%	Bathurst km 2.2 Rep A 8/22/2001	Bathurst km 2.2 Rep B 8/22/2001	Bathurst km 2.2 Rep C 8/22/2001	Mean	Std. Error	%
Chironomidae	P	11	56	11															
Tanypodinae	L*			11															
Thiennemannimyia	L	44	56	67				44	11	33									
Tanytarsini	L	244	111	611						11									
Micropsectra	L																		
Paratanytarsus	L		22	22				22											
Rheotanytarsus	L	311	78	2,267					11	11									
Stempellinella	L	33	11																
Tanytarsus	L																		
Tanytarsus	P																		
Chironomini	L*																		
Dicrotendipes	L																		
Demicryptochironomus	L/P																		
Parachironomus	L																		
Phaenopsectra	L									11									
Polypedilum (polypedilum)	L													11					
Orthocladiinae	L*	244	44	144															
Orthocladiinae	P		11																
Orthocladiinae	A		11																
Corynoneura	L	22	22	11															
Corynoneura	P	11												11					
Corynoneura	A																		
Cricotopus	L	33	11	89				56								111			
Cricotopus	P							11											
Eukiefferiella	L	56	100	144												11			
Eukiefferiella	P	22	22	44											33	44			
Euryhapsis	L	11	11																
Gymnometriocnemus	L																		
Heterotanytarsus	L		11																
Orthocladius	L		22											22					
Orthocladius	P		11													11			
Psectrocladius	L																		
Thienemanniella	L	44	33	22															
Diamesinae																			
Diamesa				11															
Monodiamesa	L	11		33															
Potthastia	L																		
Pseudokiefferiella	L		11	11															
SUM (org/m^2)		39,125	38,469	41,536	39,710	932	1,214	37,267	37,267	37,234	37,256	11	9,222	37,181	37,192	37,325	37,232	46	5,128
MOLLUSCA																			
Gastropoda																			
Valvata sincera sincera																			
SUM (org/m^2)		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL (org/m^2)		58,265	57,388	61,221	58,958	1,160	1,235	55,940	56,229	56,096	56,088	83	9,289	55,821	56,321	57,099	56,413	372	5,214

A = adult
juv = juvenile
L = larva
L* = larva too small to be identified, or damaged
unid = unidentified
N = nymph
N* = nymph too small to be identified, or damaged
P = pupa
P* = pupa too small to be identified, or damaged

APPENDIX 3.1-10
COORDINATES OF ALL 55 STREAM CROSSINGS SURVEYED FOR FISH AND FISH HABITAT ASSESSMENTS

Appendix 3.1-10
Coordinates of all 55 Stream Crossings Surveyed for Fish and Fish Habitat Assessments, August 2001

KM	Surveyed Upstream Limit				Surveyed Downstream Limit			
	Latitude		Longitude		Latitude		Longitude	
	Degrees	Minutes	Degrees	Minutes	Degrees	Minutes	Degrees	Minutes
2.2	66	31.105	107	31.263	66	31.210	107	31.430
2.8	66	30.953	107	32.003	66	31.055	107	32.035
7.8	66	31.742	107	37.396	66	31.828	107	37.498
11.7	66	29.514	107	37.579	66	29.602	107	37.721
22.9	66	24.519	107	37.024	66	24.603	107	37.171
33.7	66	19.603	107	42.383	66	19.534	107	42.247
33.8	66	19.499	107	42.363	66	19.507	107	42.252
34.8	66	18.969	107	43.025	66	19.012	107	42.827
35.9	66	18.421	107	43.174	66	18.507	107	43.327
36.6	66	17.994	107	44.233	66	17.928	107	44.108
42.3	66	15.750	107	47.992	66	15.724	107	47.812
43.3	66	15.217	107	48.190	66	15.209	107	48.076
44.5	66	14.535	107	47.955	66	14.578	107	48.165
49.7	66	11.861	107	49.031	66	11.931	107	49.193
52.0	66	10.602	107	48.695	66	10.696	107	48.995
58.7	66	7.206	107	48.742	66	7.230	107	48.550
67.9	66	2.123	107	47.480	66	2.183	107	47.701
68.3	66	1.803	107	47.858	66	1.755	107	48.055
68.6	66	1.626	107	48.191	66	1.537	107	48.104
69.4	66	1.504	107	48.489	66	1.426	107	48.385
70.1	66	1.227	107	48.701	66	1.201	107	48.528
72.2	66	0.166	107	47.968	66	0.182	107	47.663
76	65	58.454	107	49.946	65	58.423	107	49.756
77	65	57.947	107	50.380	65	57.917	107	50.165
84.2	65	54.558	107	54.739	65	54.484	107	54.627
85	65	54.080	107	55.058	65	54.095	107	54.853
90.3	65	51.418	107	57.540	65	51.309	107	57.526
103	65	45.736	108	5.908	65	45.850	108	6.022
103.3a	65	45.739	108	5.953	65	45.769	108	6.218
107	65	44.710	108	9.501	65	44.795	108	9.668
113	65	42.851	108	16.846	65	42.817	108	16.696
114	65	42.611	108	17.279	65	42.680	108	17.401
115	65	41.989	108	18.232	65	41.935	108	18.019
129	65	38.984	108	34.178	65	39.088	108	34.174
135	65	36.921	108	39.354	65	36.984	108	39.514
160	65	29.464	109	5.170	65	29.387	109	5.297
161	65	28.979	109	6.505	65	28.997	109	6.286
168	65	29.572	109	14.956	65	29.713	109	14.917
170	65	29.661	109	16.900	65	29.574	109	16.864
171	65	29.322	109	18.070	65	29.419	109	18.068
173	65	28.682	109	20.996	65	28.591	109	20.883
181	65	27.187	109	30.353	65	27.099	109	30.433
184	65	27.179	109	33.242	65	27.108	109	33.258
187	65	27.318	109	36.960	65	27.472	109	36.872
190	65	27.699	109	40.229	65	27.713	109	40.025
192	65	28.157	109	44.131	65	28.227	109	43.834
192.4a	65	28.226	109	44.683	65	28.136	109	44.689
197	65	28.503	109	50.138	65	28.417	109	49.994
197	65	28.519	109	49.733	65	28.423	109	49.743
197	65	28.434	109	49.578	65	28.344	109	49.516
202	65	27.932	109	55.093	65	27.832	109	55.151
203	65	27.620	109	56.588	65	27.721	109	56.649
204	65	27.821	109	58.493	65	27.731	109	58.605
207	65	27.549	110	1.759	65	27.471	110	1.832
208	65	27.442	110	2.897	65	27.489	110	3.136

APPENDIX 3.1-11
PRELIMINARY ASSESSMENT OF STREAMS AND LAKES ALONG THE ROAD ROUTE, JULY 23-26, 2001

Appendix 3.1-11
Preliminary Assessment of Streams and Lakes Along the Road Route, July 23-26, 2001

Stream Crossing	Km	Fish Bearing	Drainage	Photos	Re-Alignment	Comments
1	2.2	Y	L	3-10	N	long wadable stream
2	2.8	M	M	3-11	N	flowing water
3	7.8	Y	M	3-14	N	tributary to Amagok Creek, very narrow, doubt fish present
4	11.1	Y	M		N	not connected, seepage over grassy area
5	11.7	Y	L	3-16	N	good habitat
6	15.8	M			Y	lake, shallow not connected at both ends
7	18.3	M	S		N	small stream, dry at both ends, no fish passage upstream and downstream
8	22.9	Y	L	3-17,18,19	N	large creek, high flow
9	25.7	M	S		N	dry
10	27.4	M	S		N	dry, very small
11	27.8	M	S		Y	dry
12	27.9	Y			Y	lake
13	28.9	M	S		N	dry at both ends
14	29.9	M			Y	lake, not connected at both ends
15	30.4	M	M		Y	dry - small pond
16	32.1	M	S		Y	dry - seepage
17	33.4	M	S		N	dry, puddles
18	33.7	Y	L	3-20	N	lake east connected downstream, 2-3 ft deep
19	33.8	Y	M		N	lake west, 2-3 ft deep
20	34.2	M			Y	lake, 2 feet deep, no fish
21	34.8	Y	L	3-21	Y	shallow ponds at both ends
22	35.9	Y	L	3-22,23	Y	flowing water
23	36.6	Y	L	3-24	N	flowing, lake downstream deep
24	37.6	M			N	lake, no fish not connected at both ends
25	39.0	M	S		N	marsh, disconnected
26	39.5	M	S		N	dry
27	40.6	M	S		N	deep lake
28	41.4	M	S		N	not connected, dry
29	41.6	Y	S		N	dry
30	42.3	Y	L	4-1	N	flows under rocks upstream, lake
31	43.3	M	L	4-2	N	lakes, lake downstream deep
32	44.1	Y			N	lake
33	44.5	Y	M	4-3	N	nothing upstream, maybe used for rearing
34	47.5	M	S		N	dry
35	49.7	Y	M	4-4	N	dries up upstream, lake downstream deep
36	52.0	Y	L	4-5	N	flows underground downstream and upstream
37	54.3	Y	M		N	dry, lake west shallow
38	56.9	M	S		Y	dry, seepage
39	58.7	Y	M	4-6	N	no distinct channels, flows underground, connected downstream to shallow lakes
40	66.4	M	S		N	dry
41	67.9	Y	M	4-7	Y	flowing
42	68.3	Y	L	4-8	Y	flowing
43	68.6	Y	L	4-9	N	flowing
44	69.4	Y	L	4-10	N	flowing
45	70.1	Y	S	4-11	N	very small creek
46	72.2	M	M	4-12	N	flowing
47	73.9	M	S		N	seepage over grassy area
48	74.1	M	S		N	seepage over grassy area
49	74.9	M	S		N	seepage over grassy area
50	76	M	M	4-13	N	connected downstream, flowing
51	77	M	M	4-14	N	connected flowing
52	78.5	M	S		N	isolated, no fish
53	78.6	M	S		N	isolated, puddles
54	78.9	M	S		N	seepage over grassy area, disconnected
55	80.4	M	S		Y	pond, dry channel
56	81.5	M	S		N	dry
57	83.7	M	S		N	dry
58	84.2	Y	L	2-5	N	should have fish
59	85	M	M	2-6	N	multiple channels over grasy area
60	87.5	M			N	shallow lake
61	88.3	M			N	shallow lake
62	90.3	M	S	2-7	N	lake south not connected, larger not connected at either end
63	91.1	M	S		N	dry, no water at all
64	91.4	M	S		N	no water at all, no outlet, no inlet
65	92.3	M	S		N	dry
66	94.1	M	S		N	dry
67	95.3	M	S		Y	dry
68	97.2	M			N	lake, 2 feet deep, lake across, mostly shallow 1 -2 m

(continued)

Appendix 3.1-11
Preliminary Assessment of Streams and Lakes Along the Road Route, July 23-26, 2001 (completed)

Stream Crossing	Km	Fish Bearing	Drainage	Photos	Re-Alignment	Comments
69	98.8	M	S		N	dry no water
70	100.3	M	S		N	dry no water
71	103.3	M	M	2-9	N	channel between 2 streams, mulitple channels
72	103.3a	Y	M	2-8	N	potential habitat - lake nearby
73	104.5				N	lake - 2 feet maximum very shallow
74	106.7	Y	L	2-10	N	shallow ponds along channel, flowing water
75	113.2	M	M	2-11	N	narrow channel flowing, grassy, lake upstream very shallow
76	113.8	M	S	2-13	N	flowing
77	115.2	Y	L	2-14	N	flowing, grassy
78	117.4	Y	M		Y	no distinct channel, dry, lake very shallow ~ 1-2 feet
79	119.4	M	S		N	seepage, grassy area, no water flowing between lakes, north lake shallow, south deep
80	123.3	M	S		N	dry, high land
81	123.8	M	S		N	some flowing water underground, very small pond no fish
82	125.3	Y	L		N	drains underground through rocks
83	128.8	Y	L	2-15	N	Mara River
84	134.6	Y	L	2-16	N	large, wide wadable
85	136.6	Y	S		Y	dry between both lakes
86	144.6	Y	S		N	dry
87	145.7	M	S		N	dry
88	146.6	M	S		N	seepage through grass area
89	147.5	M	S		N	rocks, dry, grassy area
90	149.7	M	S		N	dry
91	151.6	Y	M		N	dry, water flowing under rocks
92	152.4	M	S		Y	dry
93	155.7	M	S		N	long ways dry under rocks
94	158.2	M	S		N	dry
95	158.8	M	S		N	dry
96	159.2	M	S		N	dry
97	159.5	M	S	2-17	N	very narrow, doubt there is some fish, shallow lake downstream
98	159.7	M	S		N	water flows underground in middle, shallow lake on both sides
99	160.7	Y	L	2-18	N	need to survey
100	160.8	Y	L		N	connected to km 158.3
101	167.6	M	S		N	dry
102	168	M	?	2-22	N	need to survey
103	169.1	M	?		N	dry
104	169.2	M	?		N	dry
105	169.4	M	?		N	dry
106	169.6	M	?	2-21	N	large, lots of rocks, first lake upstream shallow
107	170.8	M	M	2-23	N	meandering channels
108	173.1	M	L	2-24	N	flowing, lake downstream deep
109	177.2	M	L		N	flows under boulders at half way, lake upstream very shallow, no habitat
110	181.4	M	L	2-25	N	large channel
111	182.9	M	S		N	seepage over grassy area, tiny channels
112	183.6	Y	M	3-1	N	multiple channels, grassy area
113	186.5	M	S	3-3	N	lake downstream shallow
114	189.6	M	S	3-2	N	flows under rocks at one end, not much of a channel
115	192.4	M	M	3-4	N	flowing
116	192.4a	M	M	3-5	N	flowing
117	193.8	M	S		N	dry
118	195.9	M	S		N	seepage over grassy area
119	196.7	M	S	4-16	N	flowing
120	197	M	S	4-17	N	flowing
121	197.2	M	S		N	flowing
122	198.2	M	S		N	seepage over grassy area - no stream
123	201.9	Y	L	4-18	N	flowing, lake downstream is deep
124	202.8	Y	L	4-19	N	flowing
125	204.3	M	S	4-20	N	lakes north and south are deep, lake downstream is disconnected
126	206.8	Y	L	4-21	N	flowing
127	208	M	S	4-22	N	very narrow channel
128	212.5				N	seepage
129	212.8	M	M		N	seepage

Fish Bearing : Y = fish-bearing, M = potentially fish bearing

Re-Alignment: potential for re-alignment of road, Y = yes, N = no

Drainage: S = small, M = medium, L = large

Comments: dry = no visible channel, or no water or minimal amount

APPENDIX 3.1-12
STREAM HABITAT DATA SHEETS

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: 208.0	**Survey Date (d/m/y):** 08/10/2001	**A: Downstream**				**B:Upstream**			
Drainage Area (Km²):	**Survey Crew:** MM,GH	**N:** 65	27	0.458		**N:** 65	27	0.442	
Survey Distance (m): 200	**Aerial photo:** 5-10	**W:** 110	3	0.100		**W:** 110	2	0.896	
Approx. Distance from Over-wintering Habitat (Km):		**Barriers to Over-Wintering Habitat:**							
Temperature (°C): 9.3,9.3	**Visibility:** clear								
Channel Velocity (m/s): 0	**Conductivity (uS/cm):** 11								
Current Flow Conditions: low	**pH:** 6.4	**Weather:**							
Discharge estimate (m³/s) 0		overcast, wind, cool, scattered rain.							

Hab Unit No.	Hab Type	Dist. fr start (m)	Length (m)	Slope (%)	Depth (m)		Width (m)		Bed Material					Pool Info			Fish Passage Barriers	
					Mean	Bank-full	Mean	Bank-full	Sand (%)	Gravel (%)	Cobble (%)	Boulder (%)	Bedrock (%)	Type	Depth (m) Max	Depth (m) Crest	Type	T/P
1	G	0	200	0.5	0.05	0.20	1.0	1.7	100								NC	T
2		200																
3																		
4																		
5																		
6																		
7																		
8																		
9																		
10																		
11																		
12																		
13																		
14																		
15																		
16																		
17																		
18																		
19																		
20																		

Flow Conditions H = High flow, M = Medium flow, L = Low flow

Habitat Unit Under bankfull conditions: 0 - 2.5 m = > 1 m^2, 2.5 - 5 m = > 2 m^2, 5 - 10 m = > 4 m^2, 10 -15 m = > 6 m^2, 15 -20 = > 8 m^2, > 20 m = > 10 m^2

Hab Type P = pool, G = glide, R = riffle, C = cascade, O = other

Dist. fr start distance from beginning of the survey to the beginning of the habitat unit being surveyed

Pool Type S = scour, D = dammed, U = unknown

Substrate Sand (silt, clay, fine organic< 2 mm), Gravel (2 - 64 mm), Cobble (64 - 256), Boulders (256 - 4000 mm), Bedrock (>4000 mm)

Fish Passage Barriers IF = Impassible waterfall

BF = Boulder Field, passage through the boulder arrangement is not possible for fish

D = dry channel, no stream flow

NC = no distinct channel, water drains over land

N = no barrier to fish passage through the habitat unit

T/P T = temporary, portion of open water season

P = Permanent, all year round

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: **208**
Survey Date (d/m/y): 08/10/2001
Survey Crew: MM,GH
Aerial photo: 5-10

Hab Unit No.	Banks of Channel				Instream Cover					Photos (Role #) (Photo #)
	L Bank Height (m)	R Bank Height (m)	L Bank Stab	R Bank Stab	Pool %	Boulder %	Instream Veg %	Overhang Veg %	Undercut Bank %	
1	0.17	0.17	U	U			50			5-8
2										5-9
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										

Comments:
Narrow, shallow, swampy stream. Poor fish habitat. A ditch. Upstream of zero point is a smaller,narrower reach with even less potential fish habitat. This is the eastern tributary. Its upper reaches are a boulder garden. The boulder garden starts 120m upstream of ther glide habitat. The western trubutary shown on the map does not exist! Water velocity is zero-no movement. The entrance to the lake is blocked by beach sand. No electro fishing was done because water was too shallow and the possibility of fish presence was close to zero.

Preliminary Assessment

Spawning:	0	Rearing:	0	Over-wintering:	0	Adult Feeding:	0	Migration:	0

Banks of Channel (Stability) H = highly stable, S = stable, U = unstable
Preliminary Assessment 0 = no habitat present, 1 = poor, 2 = fair, 3 = good, 4 = excellent

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: 206.9		**Survey Date (d/m/y):** 08/10/2001			**A: Downstream**				**B:Upstream**								
Drainage Area (Km^2):		**Survey Crew:** MM, GH			**N:** 65	27	0.471		**N:** 65	27	0.549						
Survey Distance (m) 184		**Aerial photo:** 5-12			**W:** 110	1	0.833		**W:** 110	1	0.759						
Approx. Distance from Over-wintering Habitat (Km):					**Barriers to Over-Wintering Habitat:**												
Temperature (^{o}C): 6.1,7.4		**Visibility:** clear															
Channel Velocity (m/s): 0.17		**Conductivity (uS/cm):** 7															
Current Flow Conditions: M		**pH:** 6.2			**Weather:**												
Discharge estimate (m^3/s) 0.088					**overcast, cool, strong wind, scattered rain**												

Hab Unit No.	Hab Type	Dist. fr start (m)	Length (m)	Slope (%)	Depth (m)		Width (m)		Bed Material					Pool Info			Fish Passage Barriers	
					Mean	Bank-full	Mean	Bank-full	Sand (%)	Gravel (%)	Cobble (%)	Boulder (%)	Bedrock (%)	Type	Depth (m) Max	Depth (m) Crest	Type	T/P
1	G	0	12	0.5	0.15	0.30	2.0	2.0	25	25	25	25						
2	R	12	9	0.5	0.15	0.33	1.9	1.9	25	25	40	10						
3	G	21	27	0.5	0.18	0.30	1.9	2.0	30	30	30	10						
4	R	48	7	0.5	0.10	0.27	2.1	2.1	30	30	30	10						
5	G	55	17	0.5	0.15	0.30	2.0	3.2		90	10							
6	R	72	13	0.5	0.12	0.28	2.8	2.8		70	20	10						
7	G	85	7	0.5	0.18	0.28	1.5	1.5	25	50	10	15						
8	R	93	15	0.5	0.10	0.20	3.7	3.7	25	50	10	15						
9	G	108	6	0.5	0.09	0.20	3.4	3.4	5	80	5	10						
10	R	114	10	0.5	0.08	0.16	3.8	4.2	10	90								
11	G	124	60	0.5	0.42	0.50	21.0	21.0	25	25	25	25						
12		184																
13																		
14																		
15																		
16																		
17																		
18																		
19																		
20																		

Flow Conditions H = High flow, M = Medium flow, L = Low flow

Habitat Unit Under bankfull conditions: 0 - 2.5 m = > 1 m^2, 2.5 - 5 m = > 2 m^2, 5 - 10 m = > 4 m^2, 10 -15 m = > 6 m^2, 15 -20 = > 8 m^2, > 20 m = > 10 m^2

Hab Type P = pool, G = glide, R = riffle, C = cascade, O = other

Dist. fr start distance from beginning of the survey to the beginning of the habitat unit being surveyed

Pool Type S = scour, D = dammed, U = unknown

Substrate Sand (silt, clay, fine organic< 2 mm), Gravel (2 - 64 mm), Cobble (64 - 256), Boulders (256 - 4000 mm), Bedrock (>4000 mm)

Fish Passage Barriers IF = Impassible waterfall

BF = Boulder Field, passage through the boulder arrangement is not possible for fish

D = dry channel, no stream flow

NC = no distinct channel, water drains over land

N = no barrier to fish passage through the habitat unit

T/P T = temporary, portion of open water season

P = Permanent, all year round

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: **206.9**
Survey Date (d/m/y): 08/10/2001
Survey Crew: MM, GH
Aerial photo: 5-12

Hab Unit No.	Banks of Channel				Instream Cover					
	L Bank Height (m)	R Bank Height (m)	L Bank Stab	R Bank Stab	Pool %	Boulder %	Instream Veg %	Overhang Veg %	Undercut Bank %	Photos (Role #) (Photo #)
1	0.15	0.15	S	S		25	25			
2	0.20	0.20	S	S		10	10		5	
3	0.10	0.10	S	S		10	10			
4	0.15	0.15	S	S		30	25			
5	0.12	0.12	S	S			25			
6	0.20	0.20	S	S		10	30			
7	0.10	0.10	S	S		15				5-11
8	0.17	0.17	S	S		15	60			
9	0.10	0.12	S	S		10	60			
10	0.09	0.13	S	S			60			
11	0.10	0.10	S	S		25				5-10
12										
13										
14										
15										
16										
17										
18										
19										
20										

Comments:
Narrow, shallow stream connecting two lakes. Lots of small fish seen. Good substrate for spawning, and cover (boulder and instream vegetation) for rearing.

Preliminary Assessment

Spawning:	3	Rearing:	3	Over-wintering:	0	Adult Feeding:	1	Migration:	3

Banks of Channel (Stability) H = highly stable, S = stable, U = unstable
Preliminary Assessment 0 = no habitat present, 1 = poor, 2 = fair, 3 = good, 4 = excellent

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: 204.3	**Survey Date (d/m/y):** 08/10/2001	**A: Downstream**			**B:Upstream**		
Drainage Area (Km^2):	**Survey Crew:** MM,GH	**N:** 65	27	0.725	**N:** 65	27	0.821
Survey Distance (m) 218	**Aerial photo:**	**W:** 109	58	0.625	**W:** 109	58	0.493

Approx. Distance from Over-wintering Habitat (Km):

Barriers to Over-Wintering Habitat:

Temperature (^oC): 8.2,8.7 **Visibility:** clear

Channel Velocity (m/s): ~0 **Conductivity (uS/cm):** 12

Current Flow Conditions: low **pH:** 6.2

Weather:

Discharge estimate (m^3/s) 0

overcast, windy, cool, scattered showers.

Hab Unit No.	Hab Type	Dist. fr start (m)	Length (m)	Slope (%)	Depth (m)		Width (m)		Bed Material					Pool Info			Fish Passage Barriers	
					Mean	Bank-full	Mean	Bank-full	Sand (%)	Gravel (%)	Cobble (%)	Boulder (%)	Bedrock (%)	Type	Depth (m) Max	Depth (m) Crest	Type	T/P
1	SBG	0	100	0.5	0.50	1.00	19.0	25.0			10	90					BF	P
2	G	100	18	0.5	0.35	0.55	2.4	3.0	95			5						
3	SBG	118	50	0.5	0.20	0.39	7.7	7.7				100					BF	P
4	G	168	50	0.5	0.12	0.30	4.0	4.0	40		20	40						
5		218																
6																		
7																		
8																		
9																		
10																		
11																		
12																		
13																		
14																		
15																		
16																		
17																		
18																		
19																		
20																		

Flow Conditions H = High flow, M = Medium flow, L = Low flow

Habitat Unit Under bankfull conditions: 0 - 2.5 m = > 1 m^2, 2.5 - 5 m = > 2 m^2, 5 - 10 m = > 4 m^2, 10 -15 m = > 6 m^2, 15 -20 = > 8 m^2, > 20 m = > 10 m^2

Hab Type P = pool, G = glide, R = riffle, C = cascade, O = other, SBG=subsurface boulder garden

Dist. fr start distance from beginning of the survey to the beginning of the habitat unit being surveyed

Pool Type S = scour, D = dammed, U = unknown

Substrate Sand (silt, clay, fine organic< 2 mm), Gravel (2 - 64 mm), Cobble (64 - 256), Boulders (256 - 4000 mm), Bedrock (>4000 mm)

Fish Passage Barriers IF = Impassible waterfall

BF = Boulder Field, passage through the boulder arrangement is not possible for fish

D = dry channel, no stream flow

NC = no distinct channel, water drains over land

N = no barrier to fish passage through the habitat unit

T/P T = temporary, portion of open water season

P = Permanent, all year round

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: **204.3**
Survey Date (d/m/y): 08/10/2001
Survey Crew: MM,GH
Aerial photo: 0

Hab Unit No.	Banks of Channel				Instream Cover					Photos (Role #) (Photo #)
	L Bank Height (m)	R Bank Height (m)	L Bank Stab	R Bank Stab	Pool %	Boulder %	Instream Veg %	Overhang Veg %	Undercut Bank %	
1	1.00	1.00	S	S		100				5-13
2	0.18	0.18	S	U		5				
3	0.30	0.18	S	S		100				
4	0.27	0.24	S	S		40	60			5-14
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										

Comments:
The stream is impassible because of almost continuous boulder fields between the two lakes. Fish were seen at both ends of the stream. Even at maximum flows, the water would pass under the boulders. SGB = subsurface boulder garden.

Preliminary Assessment

Spawning:	0	Rearing:	0	Over-wintering:	0	Adult Feeding:	0	Migration:	0

Banks of Channel (Stability) H = highly stable, S = stable, U = unstable
Preliminary Assessment 0 = no habitat present, 1 = poor, 2 = fair, 3 = good, 4 = excellent

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: 202.8			**Survey Date (d/m/y):** 08/10/2001			**A: Downstream**						**B:Upstream**							
Drainage Area (Km^2):			**Survey Crew:** MM,GH			**N:** 65	27	0.721				**N:** 65	27	0.620					
Survey Distance (m) 200			**Aerial photo:** 5-19			**W:** 109	56	0.649				**W:** 109	56	0.588					
Approx. Distance from Over-wintering Habitat (Km):						**Barriers to Over-Wintering Habitat:**													
Temperature (^{o}C): 8.2,10.7			**Visibility:** clear																
Channel Velocity (m/s): 0.29			**Conductivity (uS/cm):** 6																
Current Flow Conditions: m			**pH:** 6.5			**Weather:**													
Discharge estimate (m^3/s) 1.37						**Broken cloud, windy, scattered rain showers.**													

Hab Unit No.	Hab Type	Dist. fr start (m)	Length (m)	Slope (%)	Depth (m)		Width (m)		Bed Material					Pool Info			Fish Passage Barriers	
					Mean	Bank-full	Mean	Bank-full	Sand (%)	Gravel (%)	Cobble (%)	Boulder (%)	Bedrock (%)	Type	Depth (m) Max	Depth (m) Crest	Type	T/P
1	R	0	200	3.0	0.30	0.53	26.6	26.6	5	20	35	40						
2																		
3																		
4																		
5																		
6																		
7																		
8																		
9																		
10																		
11																		
12																		
13																		
14																		
15																		
16																		
17																		
18																		
19																		
20																		

Flow Conditions H = High flow, M = Medium flow, L = Low flow

Habitat Unit Under bankfull conditions: 0 - 2.5 m = > 1 m^2, 2.5 - 5 m = > 2 m^2, 5 - 10 m = > 4 m^2, 10 -15 m = > 6 m^2, 15 -20 = > 8 m^2, > 20 m = > 10 m^2

Hab Type P = pool, G = glide, R = riffle, C = cascade, O = other

Dist. fr start distance from beginning of the survey to the beginning of the habitat unit being surveyed

Pool Type S = scour, D = dammed, U = unknown

Substrate Sand (silt, clay, fine organic< 2 mm), Gravel (2 - 64 mm), Cobble (64 - 256), Boulders (256 - 4000 mm), Bedrock (>4000 mm)

Fish Passage Barriers IF = Impassible waterfall

BF = Boulder Field, passage through the boulder arrangement is not possible for fish

D = dry channel, no stream flow

NC = no distinct channel, water drains over land

N = no barrier to fish passage through the habitat unit

T/P T = temporary, portion of open water season

P = Permanent, all year round

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: **202.8**
Survey Date (d/m/y): 08/10/2001
Survey Crew: MM,GH
Aerial photo: 5-19

Hab Unit No.	Banks of Channel				Instream Cover					Photos (Role #) (Photo #)
	L Bank Height (m)	R Bank Height (m)	L Bank Stab	R Bank Stab	Pool %	Boulder %	Instream Veg %	Overhang Veg %	Undercut Bank %	
1	0.23	0.25	S	S		40				5-16
2										5-17
3										5-18
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
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20										

Comments:
This reach was one long, shallow riffle. The stream has one main channel and numerous side channels and islands. Flow is rapid. Above the zero point is a glide that leaves the lake. The side channels are each smaller than the main channel, but together their flow is the same or greater than the main channel. Photos:5-16 looking upstream; 5-17 looking downstream; 5-18 looking upstream from zero point to lake.

Preliminary Assessment

Spawning:	1	Rearing:	2	Over-wintering:	0	Adult Feeding:	1	Migration:	1

Banks of Channel (Stability) H = highly stable, S = stable, U = unstable
Preliminary Assessment 0 = no habitat present, 1 = poor, 2 = fair, 3 = good, 4 = excellent

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: 201.9 **Survey Date (d/m/y):** 08/11/2001
Drainage Area (Km²): **Survey Crew:** SLU, DN
Survey Distance (m) **Aerial photo:** R15-17 looking u/s

A: Downstream				B:Upstream		
N: 65	27	0.832		N: 65	27	0.91
W: 109	55	0.151		W: 109	55	0.065

Approx. Distance from Over-wintering Habitat (Km): 0.4 km
Temperature (°C): 9.4 **Visibility:** clear
Channel Velocity (m/s): 1.05 **Conductivity (uS/cm):** 2
Current Flow Conditions: low **pH:** 6.0
Discharge estimate (m³/s) 7.088

Barriers to Over-Wintering Habitat:
no apparent barriers

Weather:
Overcast, 4°C.

Hab Unit No.	Hab Type	Dist. fr start (m)	Length (m)	Slope (%)	Depth (m)		Width (m)		Bed Material					Pool Info			Fish Passage Barriers	
					Mean	Bank-full	Mean	Bank-full	Sand (%)	Gravel (%)	Cobble (%)	Boulder (%)	Bedrock (%)	Type	Depth (m) Max	Depth (m) Crest	Type	T/P
1	G	0	120	0.5	0.40	0.90	65.0	70.0	10	10	20	60						
2	R	120	12	2.0	0.25	0.60	29.0	35.0		5	20	75						
3	G	132	27	0.5	0.35	0.60	29.0	40.0	30	30	10	30						
4	R	159	8	2.0	0.20	0.30	34.0	45.0		10	30	60						
5	G	167	29	0.5	0.40	0.75	34.0	53.0	10	40	20	30						
6																		
7																		
8																		
9																		
10																		
11																		
12																		
13																		
14																		
15																		
16																		
17																		
18																		
19																		
20																		

Flow Conditions H = High flow, M = Medium flow, L = Low flow

Habitat Unit Under bankfull conditions: 0 - 2.5 m = > 1 m^2, 2.5 - 5 m = > 2 m^2, 5 - 10 m = > 4 m^2, 10 -15 m = > 6 m^2, 15 -20 = > 8 m^2, > 20 m = > 10 m^2

Hab Type P = pool, G = glide, R = riffle, C = cascade, O = other

Dist. fr start distance from beginning of the survey to the beginning of the habitat unit being surveyed

Pool Type S = scour, D = dammed, U = unknown

Substrate Sand (silt, clay, fine organic< 2 mm), Gravel (2 - 64 mm), Cobble (64 - 256), Boulders (256 - 4000 mm), Bedrock (>4000 mm)

Fish Passage Barriers IF = Impassible waterfall

BF = Boulder Field, passage through the boulder arrangement is not possible for fish
D = dry channel, no stream flow
NC = no distinct channel, water drains over land
N = no barrier to fish passage through the habitat unit

T/P T = temporary, portion of open water season
P = Permanent, all year round

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: **201.9**
Survey Date (d/m/y): 08/11/2001
Survey Crew: SLU, DN
Aerial photo: ' looking u/s

Hab Unit No.	Banks of Channel				Instream Cover					
	L Bank Height (m)	R Bank Height (m)	L Bank Stab	R Bank Stab	Pool %	Boulder %	Instream Veg %	Overhang Veg %	Undercut Bank %	Photos (Role #) (Photo #)
1	0.60	0.60	S	S		60				
2	0.50	0.50	S	S		70				
3	0.50	0.50	S	S		30				
4	1.00	0.70	S	S		60				
5	0.60	0.60	S	S		30	5			15-18
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										

Comments:
Photo 15-18 looking downstream.

Preliminary Assessment

Spawning:	2	Rearing:	2	Over-wintering:	0	Adult Feeding:	1	Migration:	2

Banks of Channel (Stability) H = highly stable, S = stable, U = unstable
Preliminary Assessment 0 = no habitat present, 1 = poor, 2 = fair, 3 = good, 4 = excellent

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: 197.4 **Survey Date (d/m/y):** 08/11/2001
Drainage Area (Km^2): **Survey Crew:** MM, GH
Survey Distance (m) 200 **Aerial photo:** 10-3,4,5

A: Downstream
N: 65 28 0.428
W: 109 49 0.878

B:Upstream
N: 65 28 0.398
W: 109 49 0.784

Approx. Distance from Over-wintering Habitat (Km):
Temperature (^{o}C): 8.2 **Visibility:** clear
Channel Velocity (m/s): ~0 **Conductivity (uS/cm):** 119
Current Flow Conditions: M **pH:** 5.3
Discharge estimate (m^3/s) 0

Barriers to Over-Wintering Habitat:

Weather:
Overcast, wind, cool.

Hab Unit No.	Hab Type	Dist. fr start (m)	Length (m)	Slope (%)	Depth (m)		Width (m)		Bed Material					Pool Info			Fish Passage Barriers	
					Mean	Bank-full	Mean	Bank-full	Sand (%)	Gravel (%)	Cobble (%)	Boulder (%)	Bedrock (%)	Type	Depth (m) Max	Depth (m) Crest	Type	T/P
1	O	0	200	0.5	0.11	0.16	1.9	1.9	100								NC	T
2																		
3																		
4																		
5																		
6																		
7																		
8																		
9																		
10																		
11																		
12																		
13																		
14																		
15																		
16																		
17																		
18																		
19																		
20																		

Flow Conditions H = High flow, M = Medium flow, L = Low flow

Habitat Unit Under bankfull conditions: 0 - 2.5 m = > 1 m^2, 2.5 - 5 m = > 2 m^2, 5 - 10 m = > 4 m^2, 10 -15 m = > 6 m^2, 15 -20 = > 8 m^2, > 20 m = > 10 m^2

Hab Type P = pool, G = glide, R = riffle, C = cascade, O = other

Dist. fr start distance from beginning of the survey to the beginning of the habitat unit being surveyed

Pool Type S = scour, D = dammed, U = unknown

Substrate Sand (silt, clay, fine organic< 2 mm), Gravel (2 - 64 mm), Cobble (64 - 256), Boulders (256 - 4000 mm), Bedrock (>4000 mm)

Fish Passage Barriers IF = Impassible waterfall

BF = Boulder Field, passage through the boulder arrangement is not possible for fish
D = dry channel, no stream flow
NC = no distinct channel, water drains over land
N = no barrier to fish passage through the habitat unit

T/P T = temporary, portion of open water season
P = Permanent, all year round

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: **197.4**
Survey Date (d/m/y): 08/11/2001
Survey Crew: MM, GH
Aerial photo: 10-3,4,5

Hab Unit No.	Banks of Channel				Instream Cover					Photos (Role #) (Photo #)
	L Bank Height (m)	R Bank Height (m)	L Bank Stab	R Bank Stab	Pool %	Boulder %	Instream Veg %	Overhang Veg %	Undercut Bank %	
1	0.15	0.15	U	U			80			5-20
2										5-21
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										

Comments:
A very shallow stream over a grassy meadow. Little likelihood of fish passage at these flows. The pond on the map doesn't exist. Photo 5-20 looking downstream. Photo 5-21 looking upstream. Velocity too low to measure.

Preliminary Assessment

Spawning:	0	Rearing:	0	Over-wintering:	0	Adult Feeding:	0	Migration:	0

Banks of Channel (Stability) H = highly stable, S = stable, U = unstable
Preliminary Assessment 0 = no habitat present, 1 = poor, 2 = fair, 3 = good, 4 = excellent

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: 197	**Survey Date (d/m/y):** 08/11/2001	**A: Downstream**			**B:Upstream**		
Drainage Area (Km^2):	**Survey Crew:** MM,GH	**N:** 65	28	0.419	**N:** 65	28	0.331
Survey Distance (m) 200	**Aerial photo:** 10-3,4,5	**W:** 109	49	0.781	**W:** 109	49	0.773

Approx. Distance from Over-wintering Habitat (Km):	**Barriers to Over-Wintering Habitat:**
Temperature (^oC): 5.6	**Visibility:** clear
Channel Velocity (m/s): ~0	**Conductivity (uS/cm):** 25
Current Flow Conditions: m	**pH:** 5.9
Discharge estimate (m^3/s) 0	**Weather:** Overcast, windy cool.

Hab Unit No.	Hab Type	Dist. fr start (m)	Length (m)	Slope (%)	Depth (m)		Width (m)		Bed Material					Pool Info			Fish Passage Barriers	
					Mean	Bank-full	Mean	Bank-full	Sand (%)	Gravel (%)	Cobble (%)	Boulder (%)	Bedrock (%)	Type	Depth (m) Max	Depth (m) Crest	Type	T/P
1	R	0.0	3.5	1.0	0.05	0.10	0.5	0.6	80	20							NC	T
2	G	3.5	9.0	0.5	0.15	0.30	0.5	0.7	80	20							NC	T
3	G	12.5	5.0	0.5	0.18	0.33	0.8	0.7	50	40	10						NC	T
4	R	17.5	1.0	3.0	0.05	0.13	0.5	0.7	80	20							NC	T
5	G	18.5	4.5	0.5	0.15	0.27	1.0	1.0	20	40	40							
6	R	23.0	2.4	0.5	0.05	0.21	0.8	0.9		100							NC	T
7	G	25.4	8.0	0.5	0.20	0.15	1.4	1.5	50	50								
8	R	33.4	1.0	0.5	0.03	0.08	0.7	0.8		100							NC	T
9	G	34.4	4.7	0.5	0.15	0.23	1.0	2.0	10	80	10							
10	R	39.1	1.7	0.5	0.04	0.08	1.1	1.1		100								
11	G	40.8	19.0	0.5	0.16	0.26	1.5	1.5	50	40	10							
12	R	59.8	12.0	1.0	0.12	0.24	0.6	0.6	90	10							NC	T
13	G1	71.8	2.5															
14	G2	74.3	14.6															
15	R1	88.9	1.0															
16	G3	89.9	8.0															
17	R2	97.9	4.6															
18	G4	102.5	3.2															
19	C	105.7	5.7	5.0	0.05	0.10	1.0	1.5	100								NC	T
20	O	111.4	3.9															
21	G5	115.3	4.2															
22	R3	119.5	4.1															
23	R4	123.6	3.2															
24	G6	126.8	12.6															
25	R5	139.4	25.8															
26	G7	165.2	3.3															
27	R6	168.5	2.0															
28	G8	170.5	3.3															
29	R7	173.8	4.2															
30	G9	178.0	2.2															
31	R8	180.2	1.0															
32	G10	181.2	14.2															
33	R9	195.4	4.1															
34		199.5																
35																		

Flow Conditions H = High flow, M = Medium flow, L = Low flow

Habitat Unit Under bankfull conditions: 0 - 2.5 m = > 1 m^2, 2.5 - 5 m = > 2 m^2, 5 - 10 m = > 4 m^2, 10 -15 m = > 6 m^2, 15 -20 = > 8 m^2, > 20 m = > 10 m^2

Hab Type P = pool, G = glide, R = riffle, C = cascade, O = other

Dist. fr start distance from beginning of the survey to the beginning of the habitat unit being surveyed

Pool Type S = scour, D = dammed, U = unknown

Substrate Sand (silt, clay, fine organic< 2 mm), Gravel (2 - 64 mm), Cobble (64 - 256), Boulders (256 - 4000 mm), Bedrock (>4000 mm)

Fish Passage Barriers IF = Impassible waterfall

BF = Boulder Field, passage through the boulder arrangement is not possible for fish

D = dry channel, no stream flow

NC = no distinct channel, water drains over land

N = no barrier to fish passage through the habitat unit

T/P T = temporary, portion of open water season

P = Permanent, all year round

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: **197**
Survey Date (d/m/y): 08/11/2001
Survey Crew: MM,GH
Aerial photo: 10-3,4,5

Hab Unit No.	Banks of Channel				Instream Cover					Photos (Role #) (Photo #)
	L Bank Height (m)	R Bank Height (m)	L Bank Stab	R Bank Stab	Pool %	Boulder %	Instream Veg %	Overhang Veg %	Undercut Bank %	
1	0.22	0.19	U	U			50			
2	0.15	0.15	S	S			40			
3	0.15	0.15	S	S			25		10	5-22
4	0.13	0.13	S	S			80			
5	0.24	0.24	S	S			10			
6	0.25	0.10	S	U			20			
7	0.20	0.15	S	S			10			
8	0.10	0.10	S	S			5			
9	0.15	0.10	S	U						
10	0.05	0.05	S	U			50			
11	0.10	0.10	S	S			20			
12	0.12	0.12	S	S			50			
13										
14										
15										
16										
17										
18										
19	0.10	0.10	U	U			95			
20										
21										
22										
23										
24										
25										
26										
27										
28										
29										
30										
31										
32										
33										
34										
35										

Comments:
A small narrow stream consisting of glide, riffle, glide etc. Multiple fish barriers due to stream crossing grassy meadows. No fish likely. Velocity too low to measure. Photo 5-22 looking upstream, photo 5-23 looking upstream at end of survey length.

Preliminary Assessment

Spawning:	0	Rearing:	0	Over-wintering:	0	Adult Feeding:	0	Migration:	0

Banks of Channel (Stability) H = highly stable, S = stable, U = unstable
Preliminary Assessment 0 = no habitat present, 1 = poor, 2 = fair, 3 = good, 4 = excellent

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: 196.7		**Survey Date (d/m/y):** 08/11/2001			**A: Downstream**				**B:Upstream**								
Drainage Area (Km^2):		**Survey Crew:** MM, GH			**N:** 65	28	0.344		**N:** 65	28	0.264						
Survey Distance (m) 200		**Aerial photo:** 10-3,4,5			**W:** 109	49	0.517		**W:** 109	43	0.585						
Approx. Distance from Over-wintering Habitat (Km):					**Barriers to Over-Wintering Habitat:**												
Temperature (^oC): 10.5		**Visibility:** clear															
Channel Velocity (m/s): ~0		**Conductivity (uS/cm):** 26															
Current Flow Conditions: m		**pH:** 6.8			**Weather:**												
Discharge estimate (m^3/s) 0					**Broken cloud, wind, cool.**												

Hab Unit No.	Hab Type	Dist. fr start (m)	Length (m)	Slope (%)	Depth (m)		Width (m)		Bed Material					Pool Info			Fish Passage Barriers	
					Mean	Bank-full	Mean	Bank-full	Sand (%)	Gravel (%)	Cobble (%)	Boulder (%)	Bedrock (%)	Type	Depth (m) Max	Depth (m) Crest	Type	T/P
1	G	0	32	0.5	0.15	0.28	1.0	1.5	80	20								
2	R	32	4	1.0	0.04	0.29	0.6	0.6	5	5	40	50					BF	T
3	G	36	20	0.5	0.14	0.31	1.0	1.0	20	10	20	50						
4	R	56	8	2.0	0.15	0.30	0.6	0.6	100									
5	G	64	27	0.5	0.25	0.37	1.0	1.8	100									
6	R	91	12	1.0	0.05	0.38	0.8	1.4	10	10	80							
7	G	103	17	0.5	0.05	0.30	1.0	1.2	20	50	30							
8	R	120	1	1.0	0.05	0.22	0.3	0.3		50	50							
9	G	121	12	0.5	0.10	0.47	1.1	1.1			100							
10	R	133	14	1.0	0.05	0.21	0.8	1.2		100								
11	G	147	53	0.5	0.05	0.20	1.2	1.2	100								NC	T
12		200																
13																		
14																		
15																		
16																		
17																		
18																		
19																		
20																		

Flow Conditions H = High flow, M = Medium flow, L = Low flow

Habitat Unit Under bankfull conditions: 0 - 2.5 m = > 1 m^2, 2.5 - 5 m = > 2 m^2, 5 - 10 m = > 4 m^2, 10 -15 m = > 6 m^2, 15 -20 = > 8 m^2, > 20 m = > 10 m^2

Hab Type P = pool, G = glide, R = riffle, C = cascade, O = other

Dist. fr start distance from beginning of the survey to the beginning of the habitat unit being surveyed

Pool Type S = scour, D = dammed, U = unknown

Substrate Sand (silt, clay, fine organic< 2 mm), Gravel (2 - 64 mm), Cobble (64 - 256), Boulders (256 - 4000 mm), Bedrock (>4000 mm)

Fish Passage Barriers IF = Impassible waterfall

BF = Boulder Field, passage through the boulder arrangement is not possible for fish

D = dry channel, no stream flow

NC = no distinct channel, water drains over land

N = no barrier to fish passage through the habitat unit

T/P T = temporary, portion of open water season

P = Permanent, all year round

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: **196.7**
Survey Date (d/m/y): 08/11/2001
Survey Crew: MM, GH
Aerial photo: 10-3,4,5

Hab Unit No.	Banks of Channel				Instream Cover					Photos (Role #) (Photo #)
	L Bank Height (m)	R Bank Height (m)	L Bank Stab	R Bank Stab	Pool %	Boulder %	Instream Veg %	Overhang Veg %	Undercut Bank %	
1	0.13	0.13	S	S						5-24
2	0.25	0.25	S	S		50	10			
3	0.25	0.25	S	S		50	20			
4	0.15	0.15	S	S			90			
5	0.15	0.15	U	S			30			
6	0.33	0.33	S	S			10	10		
7	0.25	0.25	S	S				10		
8	0.17	0.17	S	S				10		
9	0.37	0.37	S	S				10		
10	0.16	0.16	S	S						10-1
11	0.15	0.15	S	S			100			10-2
12										
13										
14										
15										
16										
17										
18										
19										
20										

Comments:
Small, shallow stream with barriers to fish migration. Stream exit at lake has definite rock barriers to fish migration. Photo 5-24 looking downstream. Photo 5-25,26,27 taken of caribou herd.

Preliminary Assessment

Spawning:	0	Rearing:	0	Over-wintering:	0	Adult Feeding:	0	Migration:	0

Banks of Channel (Stability) H = highly stable, S = stable, U = unstable
Preliminary Assessment 0 = no habitat present, 1 = poor, 2 = fair, 3 = good, 4 = excellent

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: 192.4a		**Survey Date (d/m/y):** 08/11/2001			**A: Downstream**				**B:Upstream**								
Drainage Area (Km^2):		**Survey Crew:** SLU, DN			**N:** 65	28	0.136		**N:** 65	28	0.226						
Survey Distance (m) 197		**Aerial photo:** R15-16			**W:** 109	44	0.689		**W:** 109	44	0.683						
Approx. Distance from Over-wintering Habitat (Km): 2 km					**Barriers to Over-Wintering Habitat:**												
Temperature (^{o}C): 9.3,9.9		**Visibility:** clear			None at this flow.												
Channel Velocity (m/s): 0.3		**Conductivity (uS/cm):** 2															
Current Flow Conditions: low		**pH:** 5.9			**Weather:**												
Discharge estimate (m^3/s) 0.03					partly cloudy												

Hab Unit No.	Hab Type	Dist. fr start (m)	Length (m)	Slope (%)	Depth (m)		Width (m)		Bed Material					Pool Info			Fish Passage Barriers	
					Mean	Bank-full	Mean	Bank-full	Sand (%)	Gravel (%)	Cobble (%)	Boulder (%)	Bedrock (%)	Type	Depth (m) Max	Depth (m) Crest	Type	T/P
1	G	0	38	0.5	0.10	0.25	1.8	2.2		10	70	20						
2	R	38	63	1.5	0.10	0.25	1.7	2.1		20	40	40						
3	G	101	10	0.5	0.15	0.25	1.6	2.0	10	30	30	30						
4	R	111	19	1.5	0.15	0.30	1.3	1.8	10	60	10	20						
5	G	130	8	0.5	0.15	0.30	0.85	1.7	5	35	40	20						
6	R	138	5	1.5	0.05	0.20	1.0	1.8	5	90		5						
7	G	143	25	0.5	0.25	0.40	0.8	1.2	5	5	30	60						
8	R	168	15	1.5	0.10	0.25	0.9	1.5		15	45	40						
9	G	183	14	0.5	0.15	0.40	1.4	1.6	10	30	30	30						
10																		
11																		
12																		
13																		
14																		
15																		
16																		
17																		
18																		
19																		
20																		

Flow Conditions H = High flow, M = Medium flow, L = Low flow

Habitat Unit Under bankfull conditions: 0 - 2.5 m = > 1 m^2, 2.5 - 5 m = > 2 m^2, 5 - 10 m = > 4 m^2, 10 -15 m = > 6 m^2, 15 -20 = > 8 m^2, > 20 m = > 10 m^2

Hab Type P = pool, G = glide, R = riffle, C = cascade, O = other

Dist. fr start distance from beginning of the survey to the beginning of the habitat unit being surveyed

Pool Type S = scour, D = dammed, U = unknown

Substrate Sand (silt, clay, fine organic< 2 mm), Gravel (2 - 64 mm), Cobble (64 - 256), Boulders (256 - 4000 mm), Bedrock (>4000 mm)

Fish Passage Barriers IF = Impassible waterfall

BF = Boulder Field, passage through the boulder arrangement is not possible for fish

D = dry channel, no stream flow

NC = no distinct channel, water drains over land

N = no barrier to fish passage through the habitat unit

T/P T = temporary, portion of open water season

P = Permanent, all year round

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: **192.4a**
Survey Date (d/m/y): 08/11/2001
Survey Crew: SLU, DN
Aerial photo: R15-16

Hab Unit No.	Banks of Channel				Instream Cover					Photos (Role #) (Photo #)
	L Bank Height (m)	R Bank Height (m)	L Bank Stab	R Bank Stab	Pool %	Boulder %	Instream Veg %	Overhang Veg %	Undercut Bank %	
1	0.30	0.30	S	S		20	5			15-17
2	0.25	0.25	S	S		40	20			
3	0.25	0.25	S	S		30	20			
4	0.30	0.35	S	S		20	30			
5	0.30	0.30	S	S		20	10			
6	0.30	0.40	S	S		5	35			
7	0.30	0.30	S	S		60		5	5	
8	0.45	0.45	S	S		40	5			
9	0.30	0.25	S	S		30	5		5	
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										

Comments:
velocity = 0.3, w = 1.0, D = 0.10.

Preliminary Assessment

Spawning:	2	Rearing:	2	Over-wintering:	0	Adult Feeding:	0	Migration:	2

Banks of Channel (Stability) H = highly stable, S = stable, U = unstable
Preliminary Assessment 0 = no habitat present, 1 = poor, 2 = fair, 3 = good, 4 = excellent

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: 192.4 **Survey Date (d/m/y):** 08/11/2001
Drainage Area (Km^2): **Survey Crew:** MM, GH
Survey Distance (m) 226 **Aerial photo:** 10-9,10

A: Downstream
N: 65 28 0.227
W: 109 43 0.834

B:Upstream
N: 65 28 0.157
W: 109 44 0.130

Approx. Distance from Over-wintering Habitat (Km):
Temperature (^{o}C): 14 **Visibility:** clear
Channel Velocity (m/s): ~0 **Conductivity (uS/cm):** 13
Current Flow Conditions: m **pH:** 6.4
Discharge estimate (m^3/s) 0

Barriers to Over-Wintering Habitat:

Weather:
Broken cloud, windy cool.

Hab Unit No.	Hab Type	Dist. fr start (m)	Length (m)	Slope (%)	Depth (m)		Width (m)		Bed Material					Pool Info			Fish Passage Barriers	
					Mean	Bank-full	Mean	Bank-full	Sand (%)	Gravel (%)	Cobble (%)	Boulder (%)	Bedrock (%)	Type	Depth (m) Max	Depth (m) Crest	Type	T/P
1	G	0	84	0.5	0.26	0.44	7.5	9.5	20		50	30						
2	SGB	84	38	3.0	0.10	0.43	2.3	2.3			50	50					BG	P
3	G	122	12	0.5	0.10	0.37	0.5	0.5	10	20	30	40						
4	SGB	144	39	0.5	0.25	0.52	1.3	1.3			50	50					BG	P
5	G	183	43	0.5	0.20	0.39	1.4	1.4	70	10		20						
6		226																
7																		
8																		
9																		
10																		
11																		
12																		
13																		
14																		
15																		
16																		
17																		
18																		
19																		
20																		

Flow Conditions H = High flow, M = Medium flow, L = Low flow

Habitat Unit Under bankfull conditions: 0 - 2.5 m = > 1 m^2, 2.5 - 5 m = > 2 m^2, 5 - 10 m = > 4 m^2, 10 -15 m = > 6 m^2, 15 -20 = > 8 m^2, > 20 m = > 10 m^2

Hab Type P = pool, G = glide, R = riffle, C = cascade, O = other, SBG=subsurface boulder garden

Dist. fr start distance from beginning of the survey to the beginning of the habitat unit being surveyed

Pool Type S = scour, D = dammed, U = unknown

Substrate Sand (silt, clay, fine organic< 2 mm), Gravel (2 - 64 mm), Cobble (64 - 256), Boulders (256 - 4000 mm), Bedrock (>4000 mm)

Fish Passage Barriers IF = Impassible waterfall

BF = Boulder Field, passage through the boulder arrangement is not possible for fish
D = dry channel, no stream flow
NC = no distinct channel, water drains over land
N = no barrier to fish passage through the habitat unit

T/P T = temporary, portion of open water season
P = Permanent, all year round

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: **192.4**
Survey Date (d/m/y): 08/11/2001
Survey Crew: MM, GH
Aerial photo: 10-9,10

Hab Unit No.	Banks of Channel				Instream Cover					Photos (Role #) (Photo #)
	L Bank Height (m)	R Bank Height (m)	L Bank Stab	R Bank Stab	Pool %	Boulder %	Instream Veg %	Overhang Veg %	Undercut Bank %	
1	0.18	0.18	S	S		50	50			10-6
2	0.33	0.33	S	S		50		50		10-7
3	0.27	0.27	S	S		40		50	10	
4	0.27	0.27	S	S		50		50		
5	0.19	0.19	U	U		20	80	20		10-8
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										

Comments:
Stream leaves lake and rapidly narrows to an impassible boulder field. Fish barrier is permanent, no migration possible. Photo 10-7 taken looking downstream at subsurface flow through boulder garden. Photo 10-6 taken looking downstream about 50m from lake outlet. Velocity measurement not possible due to very low flows.

Preliminary Assessment

Spawning:	0	Rearing:	1	Over-wintering:	0	Adult Feeding:	0	Migration:	0

Banks of Channel (Stability) H = highly stable, S = stable, U = unstable
Preliminary Assessment 0 = no habitat present, 1 = poor, 2 = fair, 3 = good, 4 = excellent

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: 189.6 **Survey Date (d/m/y):** 08/11/2001
Drainage Area (Km^2): **Survey Crew:** SLU,DN
Survey Distance (m) 199 **Aerial photo:** R15-14,13 looking u/s

A: Downstream				B:Upstream		
N: 65	27	0.713		**N:** 65	27	0.699
W: 109	40	0.025		**W:** 109	40	0.229

Approx. Distance from Over-wintering Habitat (Km): 0.3 km
Temperature (^{o}C): 12.8,13.6 **Visibility:** clear
Channel Velocity (m/s): 0.1 **Conductivity (uS/cm):** 4
Current Flow Conditions: low **pH:** 6.4
Discharge estimate (m^3/s) 0.003 w=6, d=.05

Barriers to Over-Wintering Habitat:
None, but the flows very low and fish could have trouble getting to the lake.

Weather:
Sunny with some clouds but windy.

Hab Unit No.	Hab Type	Dist. fr start (m)	Length (m)	Slope (%)	Depth (m)		Width (m)		Bed Material					Pool Info			Fish Passage Barriers	
					Mean	Bank-full	Mean	Bank-full	Sand (%)	Gravel (%)	Cobble (%)	Boulder (%)	Bedrock (%)	Type	Depth (m) Max	Depth (m) Crest	Type	T/P
1	G	0	40	0.5	0.20	0.35	1.2	2.4	45	5	20	30						
2	R	40	4	1.5	0.11	0.25	1.4	2.1	10	5	75	10						
3	G	44	37	0.5	0.20	0.40	1.1	3.0	60	10	20	10						
4	R	81	9	1.5	0.20	0.40	0.8	1.5	10	10	40	40						
5	G	90	38	0.5	0.25	0.60	0.6	1.5	30	40	20	10						
6	P	128	7	0.0	0.60	0.75	1.0	1.0	90	5	5			S	0.65	0.05		
7	C	135	1	45.0	0.05	0.15	0.4	0.45	100								IF	T
8	G	136	25	0.5	0.30	0.55	0.6	1.1	35	35	20	10						
9	R	161	7	2.5	0.05	0.20	0.4	0.5	100									
10	G	167	10	0.5	0.20	0.40	0.75	1.35	50	40	5	5						
11	P	177	2	0.0	0.50	0.70	0.6	0.9	20	50	30			S	0.65	0.05		
12	R	179	7	1.5	0.10	0.30	0.3	0.4	5	15	80							
13	G	186	13	0.5	0.20	0.35	0.6	0.8	50	20	30							
14																		
15																		
16																		
17																		
18																		
19																		
20																		

Flow Conditions H = High flow, M = Medium flow, L = Low flow

Habitat Unit Under bankfull conditions: 0 - 2.5 m = > 1 m^2, 2.5 - 5 m = > 2 m^2, 5 - 10 m = > 4 m^2, 10 -15 m = > 6 m^2, 15 -20 = > 8 m^2, > 20 m = > 10 m^2

Hab Type P = pool, G = glide, R = riffle, C = cascade, O = other

Dist. fr start distance from beginning of the survey to the beginning of the habitat unit being surveyed

Pool Type S = scour, D = dammed, U = unknown

Substrate Sand (silt, clay, fine organic< 2 mm), Gravel (2 - 64 mm), Cobble (64 - 256), Boulders (256 - 4000 mm), Bedrock (>4000 mm)

Fish Passage Barriers IF = Impassible waterfall

BF = Boulder Field, passage through the boulder arrangement is not possible for fish

D = dry channel, no stream flow

NC = no distinct channel, water drains over land

N = no barrier to fish passage through the habitat unit

T/P T = temporary, portion of open water season

P = Permanent, all year round

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: **189.6**
Survey Date (d/m/y): 08/11/2001
Survey Crew: SLU,DN
Aerial photo: looking u/s

Hab Unit No.	Banks of Channel				Instream Cover					Photos (Role #) (Photo #)
	L Bank Height (m)	R Bank Height (m)	L Bank Stab	R Bank Stab	Pool %	Boulder %	Instream Veg %	Overhang Veg %	Undercut Bank %	
1	0.25	0.25	S	S		30				
2	0.20	0.30	S	S		10		5		
3	0.20	0.40	S	S		10	5			
4	0.40	0.30	S	S		40	5			
5	0.60	0.60	S	S		10	5		5	
6	0.25	0.25	S	S	100				5	
7	0.15	0.15	S	S						
8	0.30	0.45	S	S		10			5	
9	0.35	0.35	S	S			40			
10	0.30	0.35	S	S		5				
11	0.20	0.30	S	S	50				5	
12	0.30	0.45	S	S						
13	0.20	0.30	S	S			5			
14										
15										
16										
17										
18										
19										
20										

Comments:
No fish observed, elevation of waterfall is 0.35 m.

Preliminary Assessment

Spawning:	1	Rearing:	1	Over-wintering:	0	Adult Feeding:	0	Migration:	1

Banks of Channel (Stability) H = highly stable, S = stable, U = unstable
Preliminary Assessment 0 = no habitat present, 1 = poor, 2 = fair, 3 = good, 4 = excellent

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: 186.5 **Survey Date (d/m/y):** 08/12/2001
Drainage Area (Km^2): **Survey Crew:** MM,GH
Survey Distance (m) 287 **Aerial photo:** 10-18

A: Downstream
N: 65 27 0.472
W: 109 36 0.872

B:Upstream
N: 65 27 0.318
W: 109 36 0.960

Approx. Distance from Over-wintering Habitat (Km):
Temperature (^{o}C): 13.9 **Visibility:** clear
Channel Velocity (m/s): ~0 **Conductivity (uS/cm):** 22
Current Flow Conditions: low **pH:** 6.5
Discharge estimate (m^3/s) 0

Barriers to Over-Wintering Habitat:

Weather:
Clear with scattered cloud, good wind, cool, (~10°C).

Hab Unit No.	Hab Type	Dist. fr start (m)	Length (m)	Slope (%)	Depth (m)		Width (m)		Bed Material					Pool Info			Fish Passage Barriers	
					Mean	Bank-full	Mean	Bank-full	Sand (%)	Gravel (%)	Cobble (%)	Boulder (%)	Bedrock (%)	Type	Depth (m) Max	Depth (m) Crest	Type	T/P
1	G	0	13	0.5	0.12	0.29	1.9	3.0	80			20						
2	O	13	20	0.5	0.00	0.00	1.0	1.0	100								NC	P
3	G	33	10	0.5	0.03	0.08	1.0	1.0	100								NC	P
4	O	43	128	2.0	0.00	0.00	0.0	0.0	100								NC	P
5	BG	171	116	5.0	0.00	0.00	0.0	0.0	100								NC	P
6		287																
7																		
8																		
9																		
10																		
11																		
12																		
13																		
14																		
15																		
16																		
17																		
18																		
19																		
20																		

Flow Conditions H = High flow, M = Medium flow, L = Low flow

Habitat Unit Under bankfull conditions: 0 - 2.5 m = > 1 m^2, 2.5 - 5 m = > 2 m^2, 5 - 10 m = > 4 m^2, 10 -15 m = > 6 m^2, 15 -20 = > 8 m^2, > 20 m = > 10 m^2

Hab Type P = pool, G = glide, R = riffle, C = cascade, O = other

Dist. fr start distance from beginning of the survey to the beginning of the habitat unit being surveyed

Pool Type S = scour, D = dammed, U = unknown

Substrate Sand (silt, clay, fine organic< 2 mm), Gravel (2 - 64 mm), Cobble (64 - 256), Boulders (256 - 4000 mm), Bedrock (>4000 mm)

Fish Passage Barriers IF = Impassible waterfall

BF = Boulder Field, passage through the boulder arrangement is not possible for fish
D = dry channel, no stream flow
NC = no distinct channel, water drains over land
N = no barrier to fish passage through the habitat unit

T/P T = temporary, portion of open water season
P = Permanent, all year round

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: **186.5**
Survey Date (d/m/y): 08/12/2001
Survey Crew: MM,GH
Aerial photo: 10-18

Hab Unit No.	Banks of Channel				Instream Cover					Photos (Role #) (Photo #)
	L Bank Height (m)	R Bank Height (m)	L Bank Stab	R Bank Stab	Pool %	Boulder %	Instream Veg %	Overhang Veg %	Undercut Bank %	
1	0.17	0.17	S	S		20	40			10-12
2	0.00	0.00	S	S			100			
3	0.05	0.05	S	S			100			
4	0.00	0.00	S	S						10-16
5	0.00	0.00	S	S						10-16
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										

Comments:
Narrow shallow stream connecting two lakes. Dives into a wet meadow and then into a boulder garden after a short distance. Stream disappears into a wet meadow with a caribou trail down the center. Total fish barrier, no visible flow. Photo 10-17 looking north up at boulder field. Photo 10-12 looking south from small to big lake. Photo 10-16 looking north at caribou trail. photos 10-13,14,15 of a juvenile arctic fox.

Preliminary Assessment

Spawning:	0	Rearing:	0	Over-wintering:	0	Adult Feeding:	0	Migration:	0

Banks of Channel (Stability) H = highly stable, S = stable, U = unstable
Preliminary Assessment 0 = no habitat present, 1 = poor, 2 = fair, 3 = good, 4 = excellent

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: 183.6		**Survey Date (d/m/y):** 08/12/2001			**A: Downstream**				**B:Upstream**								
Drainage Area (Km^2):		**Survey Crew:** SLU,DN			**N:** 65	27	0.108		**N:** 65	27	0.179						
Survey Distance (m) 200		**Aerial photo:** R15-12,11,10			**W:** 109	33	0.258		**W:** 109	33	0.242						
		all looking u/s															
Approx. Distance from Over-wintering Habitat (Km): 0.3 km					**Barriers to Over-Wintering Habitat:**												
Temperature (^{o}C): 9.0,9.3		**Visibility:** clear			no permanent but flow may drop to zero												
Channel Velocity (m/s): 0		**Conductivity (uS/cm):** 3															
Current Flow Conditions: M		**pH:** 6.2			**Weather:**												
Discharge estimate (m^3/s) 0					partly cloudy, windy, 8°C												

Hab Unit No.	Hab Type	Dist. fr start (m)	Length (m)	Slope (%)	Depth (m)		Width (m)		Bed Material					Pool Info			Fish Passage Barriers	
					Mean	Bank-full	Mean	Bank-full	Sand (%)	Gravel (%)	Cobble (%)	Boulder (%)	Bedrock (%)	Type	Depth (m) Max	Depth (m) Crest	Type	T/P
1	G	0	11	0.0	0.15	0.35	1.0	1.2	5	85	5	5						
2	R	44	33	1.5	0.00	0.00	0.9	3.0	10	80	10						D	T
3	G	77	10	0.0	0.00	0.00	0.6	3.0	90	5	5							
4	R	87	10	1.5	0.00	0.00	0.0	2.5	5	90	5						D	T
5	G	97	3	0.0	0.00	0.00	1.1	3.5	40	5	5	50						
6	R	100	40	1.5	0.00	0.25	0.0	2.5	5	45	35	15					D	T
7	G	140	60	0.0	0.15	0.35	1.1	3.9	30	30	30	10						
8																		
9																		
10																		
11																		
12																		
13																		
14																		
15																		
16																		
17																		
18																		
19																		
20																		

Flow Conditions H = High flow, M = Medium flow, L = Low flow

Habitat Unit Under bankfull conditions: 0 - 2.5 m = > 1 m^2, 2.5 - 5 m = > 2 m^2, 5 - 10 m = > 4 m^2, 10 -15 m = > 6 m^2, 15 -20 = > 8 m^2, > 20 m = > 10 m^2

Hab Type P = pool, G = glide, R = riffle, C = cascade, O = other

Dist. fr start distance from beginning of the survey to the beginning of the habitat unit being surveyed

Pool Type S = scour, D = dammed, U = unknown

Substrate Sand (silt, clay, fine organic< 2 mm), Gravel (2 - 64 mm), Cobble (64 - 256), Boulders (256 - 4000 mm), Bedrock (>4000 mm)

Fish Passage Barriers IF = Impassible waterfall

BF = Boulder Field, passage through the boulder arrangement is not possible for fish

D = dry channel, no stream flow

NC = no distinct channel, water drains over land

N = no barrier to fish passage through the habitat unit

T/P T = temporary, portion of open water season

P = Permanent, all year round

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: **183.6**
Survey Date (d/m/y): 08/12/2001
Survey Crew: SLU,DN
Aerial photo: R15-12,11,10

Hab Unit No.	Banks of Channel				Instream Cover					
	L Bank Height (m)	R Bank Height (m)	L Bank Stab	R Bank Stab	Pool %	Boulder %	Instream Veg %	Overhang Veg %	Undercut Bank %	Photos (Role #) (Photo #)
1	0.30	0.30	S	S		5	5			
2	0.25	0.25	S	S						
3	0.30	0.30	S	S			30			
4	0.15	0.15	S	S			30			
5	0.30	0.30	S	S		50				
6	0.25	0.25	S	S		15	15			
7	0.30	0.30	S	S		10				
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										

Comments:
The glides with zero slopes are really residual pools but we have been calling them glides so I stayed with that. Hab Unit 2 - braided channel or multiple channels.

Preliminary Assessment

Spawning:	1	Rearing:	1	Over-wintering:	0	Adult Feeding:	0	Migration:	1

Banks of Channel (Stability) H = highly stable, S = stable, U = unstable
Preliminary Assessment 0 = no habitat present, 1 = poor, 2 = fair, 3 = good, 4 = excellent

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: 181.4		**Survey Date (d/m/y):** 08/12/2001			**A: Downstream**				**B:Upstream**								
Drainage Area (Km^2):		**Survey Crew:** MM,GH			**N:** 65	27	0.099		**N:** 65	27	0.187						
Survey Distance (m) 200		**Aerial photo:** 10-22			**W:** 109	30	0.433		**W:** 109	30	0.352						
Approx. Distance from Over-wintering Habitat (Km):					**Barriers to Over-Wintering Habitat:**												
Temperature (^{o}C): 13.9		**Visibility:** clear															
Channel Velocity (m/s): 0.48		**Conductivity (uS/cm):** 11															
Current Flow Conditions: M		**pH:** 6.4			**Weather:**												
Discharge estimate (m^3/s) 6.33					**Clear sunny windy.**												

Hab Unit No.	Hab Type	Dist. fr start (m)	Length (m)	Slope (%)	Depth (m)		Width (m)		Bed Material					Pool Info			Fish Passage Barriers	
					Mean	Bank-full	Mean	Bank-full	Sand (%)	Gravel (%)	Cobble (%)	Boulder (%)	Bedrock (%)	Type	Depth (m) Max	Depth (m) Crest	Type	T/P
1	G	0	42	1.5	0.35	0.55	50.0	60.0		10	70	20						
2	R	42	158	2.0	0.35	0.55	42.0	44.0		20	60	20						
3		200																
4																		
5																		
6																		
7																		
8																		
9																		
10																		
11																		
12																		
13																		
14																		
15																		
16																		
17																		
18																		
19																		
20																		

Flow Conditions H = High flow, M = Medium flow, L = Low flow

Habitat Unit Under bankfull conditions: 0 - 2.5 m = > 1 m^2, 2.5 - 5 m = > 2 m^2, 5 - 10 m = > 4 m^2, 10 -15 m = > 6 m^2, 15 -20 = > 8 m^2, > 20 m = > 10 m^2

Hab Type P = pool, G = glide, R = riffle, C = cascade, O = other

Dist. fr start distance from beginning of the survey to the beginning of the habitat unit being surveyed

Pool Type S = scour, D = dammed, U = unknown

Substrate Sand (silt, clay, fine organic< 2 mm), Gravel (2 - 64 mm), Cobble (64 - 256), Boulders (256 - 4000 mm), Bedrock (>4000 mm)

Fish Passage Barriers IF = Impassible waterfall

BF = Boulder Field, passage through the boulder arrangement is not possible for fish

D = dry channel, no stream flow

NC = no distinct channel, water drains over land

N = no barrier to fish passage through the habitat unit

T/P T = temporary, portion of open water season

P = Permanent, all year round

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: **181.4**
Survey Date (d/m/y): 08/12/2001
Survey Crew: MM,GH
Aerial photo: 10-22

Hab Unit No.	Banks of Channel				Instream Cover					Photos (Role #) (Photo #)
	L Bank Height (m)	R Bank Height (m)	L Bank Stab	R Bank Stab	Pool %	Boulder %	Instream Veg %	Overhang Veg %	Undercut Bank %	
1	0.20	0.20	S	S		20				10-19,20
2	0.20	0.20	S	S		20				10-21
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										

Comments:
Note: survey began above cascade. A wide shallow stream connecting two lakes, fast flow. Photo 10-19 looking upstream at downstream end of survey reach. Photo 10-20 looking east across downstream end of survey reach. Photo 10-21 looking downstream at upstream end of riffle.

Preliminary Assessment

Spawning:	4	Rearing:	3	Over-wintering:	0	Adult Feeding:	2	Migration:	4

Banks of Channel (Stability) H = highly stable, S = stable, U = unstable
Preliminary Assessment 0 = no habitat present, 1 = poor, 2 = fair, 3 = good, 4 = excellent

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: 173.1		**Survey Date (d/m/y):** 08/12/2001			**A: Downstream**				**B:Upstream**								
Drainage Area (Km^2):		**Survey Crew:** SLU,DN			**N:** 65	28	0.591		**N:** 65	28	0.682						
Survey Distance (m) 205		**Aerial photo:** R15-9			**W:** 109	20	0.883		**W:** 109	20	0.997						
Approx. Distance from Over-wintering Habitat (Km): 0.1 km					**Barriers to Over-Wintering Habitat:**												
Temperature (^{o}C): 11.7,12.3		**Visibility:** clear			None at this flow.												
Channel Velocity (m/s): 0.45		**Conductivity (uS/cm):** 3															
Current Flow Conditions: low		**pH:** 5.6			**Weather:**												
Discharge estimate (m^3/s) 0.108					Sunny with wind, 15^{3}C												

Hab Unit No.	Hab Type	Dist. fr start (m)	Length (m)	Slope (%)	Depth (m)		Width (m)		Bed Material					Pool Info			Fish Passage Barriers	
					Mean	Bank-full	Mean	Bank-full	Sand (%)	Gravel (%)	Cobble (%)	Boulder (%)	Bedrock (%)	Type	Depth (m) Max	Depth (m) Crest	Type	T/P
1	G	0	30	0.5	0.20	0.45	3.2	3.5	10	25	40	25						
2	R	30	8	1.5	0.10	0.25	2.2	2.4	10	80	10							
3	P	38	16	0.0	0.35	0.50	1.3	1.9	40	45	15			S	0.55	0.05		
4	R	54	9	1.5	0.20	0.50	1.8	2.1	10	5	40	45						
5	G	63	108	0.5	0.30	0.40	2.5	5.0	75	10	5	10						
6	R	171	13	1.5	0.20	0.35	1.3	1.9	10	20	40	30						
7	G	184	21	0.5	0.30	0.45	2.7	3.5	60	5	25	10						
8																		
9																		
10																		
11																		
12																		
13																		
14																		
15																		
16																		
17																		
18																		
19																		
20																		

Flow Conditions H = High flow, M = Medium flow, L = Low flow

Habitat Unit Under bankfull conditions: 0 - 2.5 m = > 1 m^2, 2.5 - 5 m = > 2 m^2, 5 - 10 m = > 4 m^2, 10 -15 m = > 6 m^2, 15 -20 = > 8 m^2, > 20 m = > 10 m^2

Hab Type P = pool, G = glide, R = riffle, C = cascade, O = other

Dist. fr start distance from beginning of the survey to the beginning of the habitat unit being surveyed

Pool Type S = scour, D = dammed, U = unknown

Substrate Sand (silt, clay, fine organic< 2 mm), Gravel (2 - 64 mm), Cobble (64 - 256), Boulders (256 - 4000 mm), Bedrock (>4000 mm)

Fish Passage Barriers IF = Impassible waterfall

BF = Boulder Field, passage through the boulder arrangement is not possible for fish

D = dry channel, no stream flow

NC = no distinct channel, water drains over land

N = no barrier to fish passage through the habitat unit

T/P T = temporary, portion of open water season

P = Permanent, all year round

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: **173.1**
Survey Date (d/m/y): 08/12/2001
Survey Crew: SLU,DN
Aerial photo: R15-9

Hab Unit No.	Banks of Channel				Instream Cover					Photos (Role #) (Photo #)
	L Bank Height (m)	R Bank Height (m)	L Bank Stab	R Bank Stab	Pool %	Boulder %	Instream Veg %	Overhang Veg %	Undercut Bank %	
1	0.40	0.30	S	S		25	10			
2	0.35	0.40	S	S						
3	0.20	0.20	S	S	5					
4	0.15	0.35	S	S		45	5			
5	0.10	0.20	S	S		10				
6	0.30	0.25	S	S						
7	0.10	0.10	S	S		10				
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										

Comments:
velocity 0.45 m/s, w = 1.6, D = 0.15.

Preliminary Assessment

Spawning:	2	Rearing:	3	Over-wintering:	0	Adult Feeding:	1	Migration:	2

Banks of Channel (Stability) H = highly stable, S = stable, U = unstable
Preliminary Assessment 0 = no habitat present, 1 = poor, 2 = fair, 3 = good, 4 = excellent

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: 170.8 **Survey Date (d/m/y):** 08/12/2001
Drainage Area (Km²): **Survey Crew:** MM,GH
Survey Distance (m) 200 **Aerial photo:** 10-26

	A: Downstream			B:Upstream		
N:	65	29	0.423	65	29	0.322
W:	109	17	0.951	109	18	0.070

Approx. Distance from Over-wintering Habitat (Km):
Temperature (°C): 12.6 **Visibility:** clear
Channel Velocity (m/s): 0.21 **Conductivity (uS/cm):** 16
Current Flow Conditions: M **pH:** 5.88
Discharge estimate (m³/s) 0.068 W=1.8m,D=0.1;0.12;0.38;0.21;0.09

Barriers to Over-Wintering Habitat:

Weather:
broken cloud, sunny little wind, super buggy.

Hab Unit No.	Hab Type	Dist. fr start (m)	Length (m)	Slope (%)	Depth (m)		Width (m)		Bed Material					Pool Info			Fish Passage Barriers	
					Mean	Bank-full	Mean	Bank-full	Sand (%)	Gravel (%)	Cobble (%)	Boulder (%)	Bedrock (%)	Type	Depth (m) Max	Depth (m) Crest	Type	T/P
1	SBG	0	187	0.5	0.25	0.50	31.0	41.0	0			100					BF	P
2	G	187	13	0.5	0.17	0.35	1.5	1.5	100									
3		200																
4																		
5																		
6																		
7																		
8																		
9																		
10																		
11																		
12																		
13																		
14																		
15																		
16																		
17																		
18																		
19																		
20																		

Flow Conditions H = High flow, M = Medium flow, L = Low flow

Habitat Unit Under bankfull conditions: 0 - 2.5 m = > 1 m², 2.5 - 5 m = > 2 m², 5 - 10 m = > 4 m², 10 -15 m = > 6 m², 15 -20 = > 8 m², > 20 m = > 10 m²

Hab Type P = pool, G = glide, R = riffle, C = cascade, O = other, SBG = subsurface boulder garden

Dist. fr start distance from beginning of the survey to the beginning of the habitat unit being surveyed

Pool Type S = scour, D = dammed, U = unknown

Substrate Sand (silt, clay, fine organic< 2 mm), Gravel (2 - 64 mm), Cobble (64 - 256), Boulders (256 - 4000 mm), Bedrock (>4000 mm)

Fish Passage Barriers IF = Impassible waterfall

BF = Boulder Field, passage through the boulder arrangement is not possible for fish
D = dry channel, no stream flow
NC = no distinct channel, water drains over land
N = no barrier to fish passage through the habitat unit

T/P T = temporary, portion of open water season
P = Permanent, all year round

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: **170.8**
Survey Date (d/m/y): 08/12/2001
Survey Crew: MM,GH
Aerial photo: 10-26

Hab Unit No.	Banks of Channel				Instream Cover					Photos (Role #) (Photo #)
	L Bank Height (m)	R Bank Height (m)	L Bank Stab	R Bank Stab	Pool %	Boulder %	Instream Veg %	Overhang Veg %	Undercut Bank %	
1	0.25	0.25	S	S		100				10-23
2	0.20	0.20	S	S			80			10-23
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										

Comments:
Wide shallow stream choked with boulders. BF at outlet of lake. No fish passage, low velocity. Velocity measured upstream of survey reach neaat outlet of lake in narrow pass. Photo 10-23 looking downstream (south) over boulder garden. Photo 10-24 looking upstream at glide and boulder garden. Photo 10-25 looking downstream below survey reach. Note: below glide is more glide and then a cascade into a boulder field, therefore no fish passage is likely from the other end.

Preliminary Assessment

Spawning:	0	Rearing:	0	Over-wintering:	0	Adult Feeding:	0	Migration:	0

Banks of Channel (Stability) H = highly stable, S = stable, U = unstable
Preliminary Assessment 0 = no habitat present, 1 = poor, 2 = fair, 3 = good, 4 = excellent

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: 169.6 **Survey Date (d/m/y):** 08/12/2001
Drainage Area (Km^2): **Survey Crew:** SLU,DN
Survey Distance (m) 200 **Aerial photo:** R15-8 looking u/s

A: Downstream			B:Upstream		
N: 65	29	0.574	N: 65	29	0.661
W: 109	16	0.864	W: 109	16	0.899

Approx. Distance from Over-wintering Habitat (Km): 0.1
Temperature (^{o}C): 15.3,15.7 **Visibility:** clear
Channel Velocity (m/s): 0.4 **Conductivity (uS/cm):** 1
Current Flow Conditions: low **pH:** 5.8
Discharge estimate (m^3/s) 0.028 w=.35;d=0.2

Barriers to Over-Wintering Habitat: none at this flow
Weather: partly cloudy, 15°C

Hab Unit No.	Hab Type	Dist. fr start (m)	Length (m)	Slope (%)	Depth (m) Mean	Depth (m) Bank-full	Width (m) Mean	Width (m) Bank-full	Bed Material Sand (%)	Gravel (%)	Cobble (%)	Boulder (%)	Bedrock (%)	Pool Info Type	Pool Info Depth (m) Max	Pool Info Depth (m) Crest	Fish Passage Barriers Type	Fish Passage Barriers T/P
1	R	0	11	2.0	0.10	0.25	0.25	1.00	100									
2	P	11	2	0.0	0.25	0.35	0.35	0.80	60	20	20			S	0.30	0.10		
3	R	13	26	2.0	0.10	0.20	0.30	0.90	30	50	20							
4	P	39	1	0.0	0.20	0.30	0.45	0.80	15	60	25			S	0.30	0.10		
5	R	40	24	1.5	0.10	0.20	0.25	0.65	40	25	35							
6	P	64	2	0.0	0.30	0.40	0.20	0.75	30	30		40		S	0.40	0.10		
7	R	66	5	1.5	0.10	0.20	0.35	0.75	80	20								
8	P	71	2	0.0	0.25	0.40	0.40	0.90	30	70				S	0.35	0.10		
9	R	73	18	1.5	0.10	0.25	0.20	0.70	80	20								
10	P	91	1	0.0	0.30	0.45	0.30	0.75	20	10	70			S	0.40	0.10		
11	R	92	31	1.5	0.30	0.55	0.10	0.20	35	50	15							
12	P	123	2	0.0	0.30	0.45	0.50	1.00	20	30	50			S	0.35	0.10		
13	R	125	25	1.5	0.15	0.25	0.40	0.85	75	20	5							
14	G	150	45	0.5	0.15	0.25	0.75	2.00	85	10	5							
15	R	195	5	1.5	0.15	0.25	0.50	1.50		10	10	80						
16																		
17																		
18																		
19																		
20																		

Flow Conditions H = High flow, M = Medium flow, L = Low flow

Habitat Unit Under bankfull conditions: 0 - 2.5 m = > 1 m^2, 2.5 - 5 m = > 2 m^2, 5 - 10 m = > 4 m^2, 10 -15 m = > 6 m^2, 15 -20 = > 8 m^2, > 20 m = > 10 m^2

Hab Type P = pool, G = glide, R = riffle, C = cascade, O = other

Dist. fr start distance from beginning of the survey to the beginning of the habitat unit being surveyed

Pool Type S = scour, D = dammed, U = unknown

Substrate Sand (silt, clay, fine organic< 2 mm), Gravel (2 - 64 mm), Cobble (64 - 256), Boulders (256 - 4000 mm), Bedrock (>4000 mm)

Fish Passage Barriers IF = Impassible waterfall

BF = Boulder Field, passage through the boulder arrangement is not possible for fish
D = dry channel, no stream flow
NC = no distinct channel, water drains over land
N = no barrier to fish passage through the habitat unit

T/P T = temporary, portion of open water season
P = Permanent, all year round

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: **169.6**
Survey Date (d/m/y): 08/12/2001
Survey Crew: SLU,DN
Aerial photo: looking u/s

Hab Unit No.	Banks of Channel				Instream Cover					
	L Bank Height (m)	R Bank Height (m)	L Bank Stab	R Bank Stab	Pool %	Boulder %	Instream Veg %	Overhang Veg %	Undercut Bank %	Photos (Role #) (Photo #)
1	0.10	0.10	S	S			20	50		
2	0.15	0.10	S	S	30				20	
3	0.10	0.10	S	S			20			
4	0.20	0.15	S	S						
5	0.15	0.20	S	S			10			
6	0.10	0.10	S	S	40	40			20	
7	0.20	0.20	S	S			30			
8	0.20	0.10	S	S					20	
9	0.15	0.15	S	S			30			
10	0.20	0.10	S	S						
11	0.15	0.20	S	S			20			
12	0.10	0.20	S	S						
13	0.10	0.10	S	S			5			
14	0.50	0.50	S	S			5			
15	0.60	0.60	S	S		80				
16										
17										
18										
19										
20										

Comments:
A 45cm step is located ~35 m upstream of survey making migration to upstream lake impossible for fry at this time. We saw arctic grayling fry, ~15.

Preliminary Assessment

Spawning:	2	Rearing:	2	Over-wintering:	0	Adult Feeding:	1	Migration:	2

Banks of Channel (Stability) H = highly stable, S = stable, U = unstable
Preliminary Assessment 0 = no habitat present, 1 = poor, 2 = fair, 3 = good, 4 = excellent

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: 168		**Survey Date (d/m/y):** 13-08-01			**A: Downstream**						**B:Upstream**								
Drainage Area (Km^2):		**Survey Crew:** MM,GH			**N:**	65	29	0.758			**N:**	65	29	0.712					
Survey Distance (m) 200		**Aerial photo:** 20-4			**W:**	109	14	0.893			**W:**	109	14	0.822					
Approx. Distance from Over-wintering Habitat (Km):					**Barriers to Over-Wintering Habitat:**														
Temperature (^oC): N/A		**Visibility:** N/A																	
Channel Velocity (m/s): 0		**onductivity (uS/cm):** N/A																	
Current Flow Conditions: no flow		**pH:** N/A			**Weather:**														
Discharge estimate (m^3/s) 0					**overcast, little wind from east**														

Hab Unit No.	Hab Type	Dist. fr start (m)	Length (m)	Slope (%)	Depth (m)		Width (m)		Bed Material						Pool Info			Fish Passage Barriers	
					Mean	Bank-full	Mean	Bank-full	Sand (%)	Gravel (%)	Cobble (%)	Cobble (%)	Boulder (%)	Bedrock (%)	Type	Depth (m) Max	Depth (m) Crest	Type	T/P
1	D	0	200	5.0	0.00	0.30	0.0	2.0				50	50					D	P
2		200																	
3																			
4																			
5																			
6																			
7																			
8																			
9																			
10																			
11																			
12																			
13																			
14																			
15																			
16																			
17																			
18																			
19																			
20																			

Flow Conditions H = High flow, M = Medium flow, L = Low flow

Habitat Unit Under bankfull conditions: 0 - 2.5 m = > 1 m^2, 2.5 - 5 m = > 2 m^2, 5 - 10 m = > 4 m^2, 10 -15 m = > 6 m^2, 15 -20 = > 8 m^2, > 20 m = > 10 m^2

Hab Type P = pool, G = glide, R = riffle, C = cascade, O = other

Dist. fr start distance from beginning of the survey to the beginning of the habitat unit being surveyed

Pool Type S = scour, D = dammed, U = unknown

Substrate Sand (silt, clay, fine organic< 2 mm), Gravel (2 - 64 mm), Cobble (64 - 256), Boulders (256 - 4000 mm), Bedrock (>4000 mm)

Fish Passage Barriers IF = Impassible waterfall

BF = Boulder Field, passage through the boulder arrangement is not possible for fish

D = dry channel, no stream flow

NC = no distinct channel, water drains over land

N = no barrier to fish passage through the habitat unit

T/P T = temporary, portion of open water season

P = Permanent, all year round

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: **168**
Survey Date (d/m/y): 13-08-01
Survey Crew: MM,GH
Aerial photo: 20-4

Hab Unit No.	Banks of Channel				Instream Cover					
	L Bank Height (m)	R Bank Height (m)	L Bank Stab	R Bank Stab	Pool %	Boulder %	Instream Veg %	Overhang Veg %	Undercut Bank %	Photos (Role #) (Photo #)
1	0.25	0.25	U	U		50	50			10-27/20-1
2										20-2,3
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										

Comments:
A completely dry stream bed leading from a pond to a large lake. Dry throughout the survey reach. A few pools below it for the next 100-200 m, the pond has a mud/sand substrate, no cover or boulders-little liklihood of fish. Therefore all electofishing done in inlet of big lake. Photo 10-27 and 20-1 taken looking downstream from pond. Photo 20-2 taken looking downstream, photo 20-3 taken looking upstream towards bend near pond outlet.

Preliminary Assessment

Spawning:	0	Rearing:	0	Over-wintering:	0	Adult Feeding:	0	Migration:	0

Banks of Channel (Stability) H = highly stable, S = stable, U = unstable
Preliminary Assessment 0 = no habitat present, 1 = poor, 2 = fair, 3 = good, 4 = excellent

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: 160.7		**Survey Date (d/m/y):** 13-08-01			**A: Downstream**				**B:Upstream**									
Drainage Area (Km^2):		**Survey Crew:** SLU,DN			**N:** 65	28	0.997		**N:** 65	28	0.979							
Survey Distance (m) 203		**Aerial photo:** R15-6			**W:** 109	6	0.285		**W:** 109	6	0.504							
Approx. Distance from Over-wintering Habitat (Km): 0.3					**Barriers to Over-Wintering Habitat:**													
Temperature (^{o}C): 14.4,13.9		**Visibility:** clear			**no barriers.**													
Channel Velocity (m/s): 0.66		**Conductivity (uS/cm):** 15																
Current Flow Conditions: L		**pH:** 6.5			**Weather:**													
Discharge estimate (m^3/s) 0.094	w=1.4;d=0.1;v=15sec/10m				**overcast**													

Hab Unit No.	Hab Type	Dist. fr start (m)	Length (m)	Slope (%)	Depth (m)		Width (m)		Bed Material					Pool Info			Fish Passage Barriers	
					Mean	Bank-full	Mean	Bank-full	Sand (%)	Gravel (%)	Cobble (%)	Boulder (%)	Bedrock (%)	Type	Depth (m) Max	Depth (m) Crest	Type	T/P
1	G	0	52	0.5	0.10	0.25	1.8	2.0		25	70	5						
2	R	52	17	1.5	0.10	0.25	1.35	1.6		30	70							
3	G	69	20	0.5	0.20	0.40	1.4	1.6	5	25	65	5						
4	R	89	22	1.5	0.10	0.25	1.6	1.9		35	60	5						
5	G	111	92	0.5	0.25	0.45	1.8	2.5	10	25	60	5						
6																		
7																		
8																		
9																		
10																		
11																		
12																		
13																		
14																		
15																		
16																		
17																		
18																		
19																		
20																		

Flow Conditions H = High flow, M = Medium flow, L = Low flow

Habitat Unit Under bankfull conditions: 0 - 2.5 m = > 1 m^2, 2.5 - 5 m = > 2 m^2, 5 - 10 m = > 4 m^2, 10 -15 m = > 6 m^2, 15 -20 = > 8 m^2, > 20 m = > 10 m^2

Hab Type P = pool, G = glide, R = riffle, C = cascade, O = other

Dist. fr start distance from beginning of the survey to the beginning of the habitat unit being surveyed

Pool Type S = scour, D = dammed, U = unknown

Substrate Sand (silt, clay, fine organic< 2 mm), Gravel (2 - 64 mm), Cobble (64 - 256), Boulders (256 - 4000 mm), Bedrock (>4000 mm)

Fish Passage Barriers IF = Impassible waterfall

BF = Boulder Field, passage through the boulder arrangement is not possible for fish

D = dry channel, no stream flow

NC = no distinct channel, water drains over land

N = no barrier to fish passage through the habitat unit

T/P T = temporary, portion of open water season

P = Permanent, all year round

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: **160.7**
Survey Date (d/m/y): 13-08-01
Survey Crew: SLU,DN
Aerial photo: R15-6

Hab Unit No.	Banks of Channel				Instream Cover					
	L Bank Height (m)	R Bank Height (m)	L Bank Stab	R Bank Stab	Pool %	Boulder %	Instream Veg %	Overhang Veg %	Undercut Bank %	Photos (Role #) (Photo #)
1	0.20	0.20	S	S		5	50			
2	0.20	0.20	S	S			50			
3	0.20	0.20	S	S		5	40			
4	0.25	0.25	S	S		5	35			
5	0.25	0.20	S	S		5	40			
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										

Comments:
Many fry ARGR observed during survey. Instream vegetation is periphyton.

Preliminary Assessment

Spawning: **Rearing:** **Over-wintering:** **Adult Feeding:** **Migration:**

Banks of Channel (Stability) H = highly stable, S = stable, U = unstable
Preliminary Assessment 0 = no habitat present, 1 = poor, 2 = fair, 3 = good, 4 = excellent

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: 159.5 **Survey Date (d/m/y):** 13-08-01
Drainage Area (Km²): **Survey Crew:** MM,GH
Survey Distance (m) 175 **Aerial photo:** 20-8

A: Downstream				B:Upstream			
N:	65	29	0.387	N:	65	29	0.464
W:	109	5	0.298	W:	109	5	0.170

Approx. Distance from Over-wintering Habitat (Km):
Barriers to Over-Wintering Habitat:

Temperature (°C): 11.5 **Visibility:** clear
Channel Velocity (m/s): 0.154 **Conductivity (uS/cm):** 22
Current Flow Conditions: m **pH:** 6.3
Weather: overcast
Discharge estimate (m³/s) 0.008 w=0.64
d=0.09,0.07,0.07,0.08,0.08

Hab Unit No.	Hab Type	Dist. fr start (m)	Length (m)	Slope (%)	Depth (m) Mean	Depth (m) Bank-full	Width (m) Mean	Width (m) Bank-full	Bed Material Sand (%)	Gravel (%)	Cobble (%)	Boulder (%)	Bedrock (%)	Pool Info Type	Pool Info Depth (m) Max	Pool Info Depth (m) Crest	Fish Passage Barriers Type	Fish Passage Barriers T/P
1	G1	0	4	0.5	0.20	0.45	0.7	0.7	10	0	90							
2	R1	4	12	0.5	0.12	0.26	0.7	0.7	50	30	20							
3	G2	16	7															
4	R2	23	5															
5	G3	28	11															
6	R3	39	5															
7	G4	44	15	0.5	0.15	0.35	0.7	0.7		10	80	10						
8	G5	59	6															
9	R4	65	5	0.5	0.15	0.30	0.7	0.7	30		70							
10	R5	70	12															
11	G6	82	5															
12	R6	87	3	0.5	0.14	0.28	0.3	0.3			100							
13	G7	90	20															
14	R7	110	5															
15	G9	115	10	0.5	0.27	0.42	0.8	0.8	50	50								
17	R8	125	1	0.5	0.05	0.15	0.2	0.7			100							
18	G10	126	11															
19	G11	137	4															
20	G12	141	6															
21	R9	147	4															
22	R10	151	1															
23	G13	152	4	0.5	0.19	0.34	0.8	0.8	50		50							
24	G14	156	8															
25	R11	164	5															
26	G15	169	9	0.5	0.12	0.27	0.5	0.5	80		20							
27		178																

Flow Conditions H = High flow, M = Medium flow, L = Low flow
Habitat Unit Under bankfull conditions: 0 - 2.5 m = > 1 m^2, 2.5 - 5 m = > 2 m^2, 5 - 10 m = > 4 m^2, 10 -15 m = > 6 m^2, 15 -20 = > 8 m^2, > 20 m = > 10 m^2
Hab Type P = pool, G = glide, R = riffle, C = cascade, O = other
Dist. fr start distance from beginning of the survey to the beginning of the habitat unit being surveyed
Pool Type S = scour, D = dammed, U = unknown
Substrate Sand (silt, clay, fine organic< 2 mm), Gravel (2 - 64 mm), Cobble (64 - 256), Boulders (256 - 4000 mm), Bedrock (>4000 mm)
Fish Passage Barriers IF = Impassible waterfall

BF = Boulder Field, passage through the boulder arrangement is not possible for fish
D = dry channel, no stream flow
NC = no distinct channel, water drains over land
N = no barrier to fish passage through the habitat unit
T/P T = temporary, portion of open water season
P = Permanent, all year round

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: **159.5**
Survey Date (d/m/y): 13-08-01
Survey Crew: MM,GH
Aerial photo: 20-8

Hab Unit No.	Banks of Channel				Instream Cover					Photos (Role #) (Photo #)
	L Bank Height (m)	R Bank Height (m)	L Bank Stab	R Bank Stab	Pool %	Boulder %	Instream Veg %	Overhang Veg %	Undercut Bank %	
1	0.25	0.25	S	S						20-5,6
2	0.25	0.25	S	S						
3										
4										
5										
6										
7	0.20	0.20	S	S		10		10	10	
8										
9	0.15	0.15	S	S				10	10	
10										
11										
12	0.14	0.14	S	S				40		
13										
14										
15	0.15	0.15	U	U				5		
17	0.10	0.10	S	S			50			
18										
19										
20										
21										
22										
23	0.15	0.15	S	S				5		
24										
25										
26	0.15	0.15	S	S			25	10		20-6,7
27										

Comments:
A small shallow stream that starts from seap in a wet meadow and then moves in multiple channels down to the lake. Multiple small boulder/cobble barriers (temporary), seperating glides. Upstream of ~170m it disappears into meadow. Caribou trails are more distinct than this stream. Photo 20-5 looking upstream from starting point (0). Photo 20-6 looking down stream from 169m, Photo 20-7 looking upsstream from 169.

Preliminary Assessment

Spawning:	0	Rearing:	1	Over-wintering:	0	Adult Feeding:	0	Migration:	0

Banks of Channel (Stability) H = highly stable, S = stable, U = unstable
Preliminary Assessment 0 = no habitat present, 1 = poor, 2 = fair, 3 = good, 4 = excellent

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: 134.6		**Survey Date (d/m/y):** 13-08-01			**A: Downstream**				**B:Upstream**								
Drainage Area (Km^2):		**Survey Crew:** MM,GH			**N:**	65	36	0.984	**N:**	65	36	0.921					
Survey Distance (m) 200		**Aerial photo:** 20-14			**W:**	108	39	0.514	**W:**	108	39	0.354					
Approx. Distance from Over-wintering Habitat (Km):					**Barriers to Over-Wintering Habitat:**													
Temperature (^{o}C): 15.4		**Visibility:** clear																
Channel Velocity (m/s): 0.38		**Conductivity (uS/cm):** 9																
Current Flow Conditions: low		**pH:** 6.6			**Weather:**													
Discharge estimate (m^3/s) 2.73					**Overcast, wind, ~15°C.**													

Hab Unit No.	Hab Type	Dist. fr start (m)	Length (m)	Slope (%)	Depth (m)		Width (m)		Bed Material					Pool Info			Fish Passage Barriers	
					Mean	Bank-full	Mean	Bank-full	Sand (%)	Gravel (%)	Cobble (%)	Boulder (%)	Bedrock (%)	Type	Depth (m) Max	Depth (m) Crest	Type	T/P
1	R	0	73	3.0	0.14	0.34	28.0	43.0		20	30	50						
2	BG	73	127	9.0	0.14	0.34	46.0	66.0		10	20	70					BG	P
3		200																
4																		
5																		
6																		
7																		
8																		
9																		
10																		
11																		
12																		
13																		
14																		
15																		
16																		
17																		
18																		
19																		
20																		

Flow Conditions H = High flow, M = Medium flow, L = Low flow

Habitat Unit Under bankfull conditions: 0 - 2.5 m = > 1 m^2, 2.5 - 5 m = > 2 m^2, 5 - 10 m = > 4 m^2, 10 -15 m = > 6 m^2, 15 -20 = > 8 m^2, > 20 m = > 10 m^2

Hab Type P = pool, G = glide, R = riffle, C = cascade, O = other, BG = boulder glide

Dist. fr start distance from beginning of the survey to the beginning of the habitat unit being surveyed

Pool Type S = scour, D = dammed, U = unknown

Substrate Sand (silt, clay, fine organic< 2 mm), Gravel (2 - 64 mm), Cobble (64 - 256), Boulders (256 - 4000 mm), Bedrock (>4000 mm)

Fish Passage Barriers IF = Impassible waterfall

BF = Boulder Field, passage through the boulder arrangement is not possible for fish

D = dry channel, no stream flow

NC = no distinct channel, water drains over land

N = no barrier to fish passage through the habitat unit

T/P T = temporary, portion of open water season

P = Permanent, all year round

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: **134.6**
Survey Date (d/m/y): 13-08-01
Survey Crew: MM,GH
Aerial photo: 20-14

Hab Unit No.	Banks of Channel				Instream Cover					Photos (Role #) (Photo #)
	L Bank Height (m)	R Bank Height (m)	L Bank Stab	R Bank Stab	Pool %	Boulder %	Instream Veg %	Overhang Veg %	Undercut Bank %	
1	0.20	0.20	U	U		50	5			20-9,10
2	0.59	0.59	U	U		70				20-11
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										

Comments:
Wide shallow stream, tributary to Mara River. Exits lake as a riffle then dives under a boulder garden for at least several hundred meters. Photo 20-9 looking upstream of lake, photo 20-10 looking downstream from 0m point, photo 20-11 looking upstream from 200m point.

Preliminary Assessment

Spawning:	1	Rearing:	1	Over-wintering:	0	Adult Feeding:	0	Migration:	0

Banks of Channel (Stability) H = highly stable, S = stable, U = unstable
Preliminary Assessment 0 = no habitat present, 1 = poor, 2 = fair, 3 = good, 4 = excellent

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: 128.8		**Survey Date (d/m/y):** 13-08-01			**A: Downstream**						**B:Upstream**								
Drainage Area (Km^2):		**Survey Crew:** SLU,DN			**N:**	65	39	0.088			**N:**	65	38	0.984					
Survey Distance (m) 200		**Aerial photo:** R15-10			**W:**	108	34	0.174			**W:**	108	34	0.177					
Approx. Distance from Over-wintering Habitat (Km): 1.0 km					**Barriers to Over-Wintering Habitat:**														
Temperature (^oC): 11.3,11.9		**Visibility:** clear			none														
Channel Velocity (m/s): 0.65		**Conductivity (uS/cm):** 10																	
Current Flow Conditions: low		**pH:** 6			**Weather:**														
Discharge estimate (m^3/s) 32.5	w=100, d=0.5				overcast with lots of bugs.														

Hab Unit No.	Hab Type	Dist. fr start (m)	Length (m)	Slope (%)	Depth (m)		Width (m)		Bed Material					Pool Info			Fish Passage Barriers	
					Mean	Bank-full	Mean	Bank-full	Sand (%)	Gravel (%)	Cobble (%)	Boulder (%)	Bedrock (%)	Type	Depth (m) Max	Depth (m) Crest	Type	T/P
1	R	0	124	1.5	0.50	0.80	110.0	120.0			15	85						
2	G	124	78	0.5	0.70	1.00	120.0	135.0			20	80						
3		202																
4																		
5																		
6																		
7																		
8																		
9																		
10																		
11																		
12																		
13																		
14																		
15																		
16																		
17																		
18																		
19																		
20																		

Flow Conditions H = High flow, M = Medium flow, L = Low flow

Habitat Unit Under bankfull conditions: 0 - 2.5 m = > 1 m^2, 2.5 - 5 m = > 2 m^2, 5 - 10 m = > 4 m^2, 10 -15 m = > 6 m^2, 15 -20 = > 8 m^2, > 20 m = > 10 m^2

Hab Type P = pool, G = glide, R = riffle, C = cascade, O = other

Dist. fr start distance from beginning of the survey to the beginning of the habitat unit being surveyed

Pool Type S = scour, D = dammed, U = unknown

Substrate Sand (silt, clay, fine organic< 2 mm), Gravel (2 - 64 mm), Cobble (64 - 256), Boulders (256 - 4000 mm), Bedrock (>4000 mm)

Fish Passage Barriers IF = Impassible waterfall

BF = Boulder Field, passage through the boulder arrangement is not possible for fish

D = dry channel, no stream flow

NC = no distinct channel, water drains over land

N = no barrier to fish passage through the habitat unit

T/P T = temporary, portion of open water season

P = Permanent, all year round

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: **128.8**
Survey Date (d/m/y): 13-08-01
Survey Crew: SLU,DN
Aerial photo: R15-10

Hab Unit No.	Banks of Channel				Instream Cover					Photos (Role #) (Photo #)
	L Bank Height (m)	R Bank Height (m)	L Bank Stab	R Bank Stab	Pool %	Boulder %	Instream Veg %	Overhang Veg %	Undercut Bank %	
1	0.50	0.50	S	S	5	85				
2	0.80	0.80	S	S	5	80				
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										

Comments:

Preliminary Assessment

Spawning: **Rearing:** **Over-wintering:** **Adult Feeding:** **Migration:**

Banks of Channel (Stability) H = highly stable, S = stable, U = unstable

Preliminary Assessment 0 = no habitat present, 1 = poor, 2 = fair, 3 = good, 4 = excellent

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: 115.2 **Survey Date (d/m/y):** 13-08-01
Drainage Area (Km^2): **Survey Crew:** SLU,DN
Survey Distance (m) 200 **Aerial photo:** R15-4,5

A: Downstream				B:Upstream
N:	65	41	0.935	N:
W:	108	18	0.019	W:

Approx. Distance from Over-wintering Habitat (Km): 2.5 km
Temperature (^oC): 13.1,12.6 **Visibility:** clear
Channel Velocity (m/s): 40sec/10m **Conductivity (uS/cm):** 15
Current Flow Conditions: low **pH:** 7.5
Discharge estimate (m^3/s) 0.125 w=2.0,d=0.25

Barriers to Over-Wintering Habitat:
Downstream from survey ~1km, is a cascade (photo 15-5) which appears to be a permanent barrier.

Weather:
overcast, 15°C.

Hab Unit No.	Hab Type	Dist. fr start (m)	Length (m)	Slope (%)	Depth (m)		Width (m)		Bed Material					Pool Info			Fish Passage Barriers	
					Mean	Bank-full	Mean	Bank-full	Sand (%)	Gravel (%)	Cobble (%)	Boulder (%)	Bedrock (%)	Type	Depth (m) Max	Depth (m) Crest	Type	T/P
1	G	0	18	0.5	0.30	0.45	2.1	4.4	20	30	40	10						
2	R	18	10	1.5	0.20	0.40	2.0	3.0		5	75	20						
3	G	28	40	0.5	0.30	0.40	2.2	4.0	10	15	50	25						
4	R	68	122	1.5	0.20	0.35	2.3	2.8		5	70	25						
5	G	190	10	0.5	0.30	0.45	1.7	2.2	5	10	65	20						
6																		
7																		
8																		
9																		
10																		
11																		
12																		
13																		
14																		
15																		
16																		
17																		
18																		
19																		
20																		

Flow Conditions H = High flow, M = Medium flow, L = Low flow

Habitat Unit Under bankfull conditions: 0 - 2.5 m = > 1 m^2, 2.5 - 5 m = > 2 m^2, 5 - 10 m = > 4 m^2, 10 -15 m = > 6 m^2, 15 -20 = > 8 m^2, > 20 m = > 10 m^2

Hab Type P = pool, G = glide, R = riffle, C = cascade, O = other

Dist. fr start distance from beginning of the survey to the beginning of the habitat unit being surveyed

Pool Type S = scour, D = dammed, U = unknown

Substrate Sand (silt, clay, fine organic< 2 mm), Gravel (2 - 64 mm), Cobble (64 - 256), Boulders (256 - 4000 mm), Bedrock (>4000 mm)

Fish Passage Barriers IF = Impassible waterfall

BF = Boulder Field, passage through the boulder arrangement is not possible for fish
D = dry channel, no stream flow
NC = no distinct channel, water drains over land
N = no barrier to fish passage through the habitat unit

T/P T = temporary, portion of open water season
P = Permanent, all year round

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: **115.2**
Survey Date (d/m/y): 13-08-01
Survey Crew: SLU,DN
Aerial photo: R15-4,5

Hab Unit No.	Banks of Channel				Instream Cover					Photos (Role #) (Photo #)
	L Bank Height (m)	R Bank Height (m)	L Bank Stab	R Bank Stab	Pool %	Boulder %	Instream Veg %	Overhang Veg %	Undercut Bank %	
1	0.05	0.05	S	S		10			10	
2	0.15	0.10	S	S		20				
3	0.05	0.05	S	S		25			5	
4	0.25	0.25	S	S		25				
5	0.15	0.15	S	S		20				
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										

Comments:
Did not see any ARGR during survey.
R15-5 waterfall, cascade.
R15-4 looking upstream.

Preliminary Assessment

Spawning:	2	Rearing:	2	Over-wintering:	1	Adult Feeding:	0	Migration:	1

Banks of Channel (Stability) H = highly stable, S = stable, U = unstable
Preliminary Assessment 0 = no habitat present, 1 = poor, 2 = fair, 3 = good, 4 = excellent

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: 113.8		**Survey Date (d/m/y):** 14-08-01			**A: Downstream**				**B:Upstream**									
Drainage Area (Km²):		**Survey Crew:** MM,GH			**N:**	65	42	0.68	**N:**	65	42	0.611						
Survey Distance (m) 200		**Aerial photo:** 20-19			**W:**	108	17	0.401	**W:**	108	17	0.279						
Approx. Distance from Over-wintering Habitat (Km):					**Barriers to Over-Wintering Habitat:**													
Temperature (°C): 12.8		**Visibility:** clear																
Channel Velocity (m/s): 0.17		**Conductivity (uS/cm):** 16																
Current Flow Conditions: m		**pH:** 6.4			**Weather:**													
Discharge estimate (m³/s) 0.022					overcast, 15km N wind, ~10°c, scattered rain showers.													

Hab Unit No.	Hab Type	Dist. fr start (m)	Length (m)	Slope (%)	Depth (m)		Width (m)		Bed Material					Pool Info			Fish Passage Barriers	
					Mean	Bank-full	Mean	Bank-full	Sand (%)	Gravel (%)	Cobble (%)	Boulder (%)	Bedrock (%)	Type	Depth (m) Max	Depth (m) Crest	Type	T/P
1	G1	0	7	0.5	0.27	0.43	0.6	0.6		80	20							
2	C1	7	1	4.0	0.05	0.21	0.2	0.2			100							
3	G2	8	1															
4	C2	9	10	5.5	0.25	0.38	0.3	0.3	10	20	60	10						
5	G3	19	3															
6	C3	22	22															
7	G4	44	4															
8	C4	48	5	9.0	0.24	0.42	0.5	0.5			20	80						
9	G5	53	7															
10	C5	60	2															
11	G6	62	2															
12	R1	64	3															
13	G7	67	4															
14	R2	71	1															
15	G8	72	2															
16	C6	74	4															
17	G9	78	2															
18	R3	80	2															
19	G10	82	9	0.5	0.45	0.58	0.6	0.6			40	60						
20	C7	91	1															
21	G11	92	9															
22	R4	101	5															
23	G12	106	21															
24	G13	127	7	0.5	0.25	0.41	0.5	0.5	80	20								
25	R5	134	5	3.5	0.30	0.42	0.7	0.9	50	50								
26	C14	139	3															
27	C8	142	3															
28	C15	145	7															
29	C9	152	2															
30	G16	154	17	1.0	0.40	0.55	1.0	1.0	90	5	5							
31	P1	171	6	0.0	1.00	1.25	5.0	6.0	100					U	1.10	0.16		
32	G17	177	19															
33	P2	196	4															
34		200																

Flow Conditions H = High flow, M = Medium flow, L = Low flow

Habitat Unit Under bankfull conditions: 0 - 2.5 m = > 1 m ^{2}, 2.5 - 5 m = > 2 m^2, 5 - 10 m = > 4 m^2, 10 -15 m = > 6 m^2, 15 -20 = > 8 m^2, > 20 m = > 10 m^2

Hab Type P = pool, G = glide, R = riffle, C = cascade, O = other

Dist. fr start distance from beginning of the survey to the beginning of the habitat unit being surveyed

Pool Type S = scour, D = dammed, U = unknown

Substrate Sand (silt, clay, fine organic< 2 mm), Gravel (2 - 64 mm), Cobble (64 - 256), Boulders (256 - 4000 mm), Bedrock (>4000 mm)

Fish Passage Barriers IF = Impassible waterfall

BF = Boulder Field, passage through the boulder arrangement is not possible for fish

D = dry channel, no stream flow

NC = no distinct channel, water drains over land

N = no barrier to fish passage through the habitat unit

T/P T = temporary, portion of open water season

P = Permanent, all year round

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: **113.8**
Survey Date (d/m/y): 14-08-01
Survey Crew: MM,GH
Aerial photo: 20-19

Hab Unit No.	Banks of Channel				Instream Cover					Photos (Role #) (Photo #)
	L Bank Height (m)	R Bank Height (m)	L Bank Stab	R Bank Stab	Pool %	Boulder %	Instream Veg %	Overhang Veg %	Undercut Bank %	
1	0.16	0.16	S	S		20				20-16,17
2	0.16	0.16	S	S				20		
3										
4	0.13	0.13	S	S		10		10	10	
5										
6										
7										
8	0.18	0.18	S	S		80		10		
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19	0.13	0.13	S	S		60		10	20	
20										
21										
22										
23										
24	0.13	0.13	S	S			60	10		
25	0.12	0.12	S	S			30			
26										
27										
28										
29										
30	0.15	0.15	S	S			40	5	10	
31	0.25	0.25	S	S	100					
32										20-18
33										
34										

Comments:
A narrow stream between two lakes. Falls down steep gradient in upper half of survey length. Cascades interspersed with short glides. The lower one third has lower gradient, long glides and two pools near the end of the survey reach. Cascades are fish migration barriers at low flows. Photo 20-16 looking downstream from zero point. Photo 20-17 looking upstream from zero point. Photo 20-18 looking upstream from 199m point showing 2 pools.
D = 0.24, w = 0.55m.

Preliminary Assessment

Spawning:	1	Rearing:	2	Over-wintering:	0	Adult Feeding:	2	Migration:	1

Banks of Channel (Stability) H = highly stable, S = stable, U = unstable
Preliminary Assessment 0 = no habitat present, 1 = poor, 2 = fair, 3 = good, 4 = excellent

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: 113.2		**Survey Date (d/m/y):** 14-08-10			**A: Downstream**						**B:Upstream**							
Drainage Area (Km^2):		**Survey Crew:** SLU, DN			**N:**	65	42	0.817			**N:**	65	42	0.851				
Survey Distance (m) 195		**Aerial photo:** 15-3			**W:**	108	16	0.695			**W:**	108	16	0.846				
Approx. Distance from Over-wintering Habitat (Km): 0.5					**Barriers to Over-Wintering Habitat:**													
Temperature (^{o}C): 11.6,12.2		**Visibility:** clear			**None to upstream lakes**													
Channel Velocity (m/s): 0.5		**Conductivity (uS/cm):** 16																
Current Flow Conditions: low		**pH:** 6.8			**Weather:**													
Discharge estimate (m^3/s) 0.180 w=1.2,d=0.3					**overcast, light rain.**													

Hab Unit No.	Hab Type	Dist. fr start (m)	Length (m)	Slope (%)	Depth (m)		Width (m)		Bed Material					Pool Info			Fish Passage Barriers	
					Mean	Bank-full	Mean	Bank-full	Sand (%)	Gravel (%)	Cobble (%)	Boulder (%)	Bedrock (%)	Type	Depth (m) Max	Depth (m) Crest	Type	T/P
1	G	0	61	0.5	0.45	0.65	1.00	2.10	100									
2	P	61	25	0.0	0.90	1.00	1.00	1.70	100					S	1.30	0.40		
3	G	86	3	0.5	0.55	0.75	0.75	1.30	100									
4	P	89	10	0.0	0.90	1.05	0.75	1.60	100					S	1.10	0.50		
5	G	99	29	0.5	0.30	0.45	1.20	1.85	100									
6	P	128	8	0.0	0.75	0.85	1.60	2.20	100					S	1.30	0.50		
7	G	136	24	0.5	0.40	0.55	1.30	2.00	100									
8	P	160	18	0.0	0.85	1.00	1.50	4.50	100					S	1.10	0.50		
9	G	178	17	0.5	0.40	0.55	0.85	1.80	100									
10		195																
11																		
12																		
13																		
14																		
15																		
16																		
17																		
18																		
19																		
20																		

Flow Conditions H = High flow, M = Medium flow, L = Low flow

Habitat Unit Under bankfull conditions: 0 - 2.5 m = > 1 m^2, 2.5 - 5 m = > 2 m^2, 5 - 10 m = > 4 m^2, 10 -15 m = > 6 m^2, 15 -20 = > 8 m^2, > 20 m = > 10 m^2

Hab Type P = pool, G = glide, R = riffle, C = cascade, O = other

Dist. fr start distance from beginning of the survey to the beginning of the habitat unit being surveyed

Pool Type S = scour, D = dammed, U = unknown

Substrate Sand (silt, clay, fine organic< 2 mm), Gravel (2 - 64 mm), Cobble (64 - 256), Boulders (256 - 4000 mm), Bedrock (>4000 mm)

Fish Passage Barriers IF = Impassible waterfall

BF = Boulder Field, passage through the boulder arrangement is not possible for fish

D = dry channel, no stream flow

NC = no distinct channel, water drains over land

N = no barrier to fish passage through the habitat unit

T/P T = temporary, portion of open water season

P = Permanent, all year round

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: **113.2**
Survey Date (d/m/y): 14-08-10
Survey Crew: SLU, DN
Aerial photo: 15-3

Hab Unit No.	Banks of Channel				Instream Cover					Photos (Role #) (Photo #)
	L Bank Height (m)	R Bank Height (m)	L Bank Stab	R Bank Stab	Pool %	Boulder %	Instream Veg %	Overhang Veg %	Undercut Bank %	
1	0.15	0.15	S	S			10		5	
2	0.10	0.10	S	S	35		10		10	
3	0.10	0.10	S	S			20			
4	0.10	0.10	S	S	25		10			
5	0.20	0.10	S	S			75			
6	0.20	0.10	S	S	40		15			
7	0.10	0.10	S	S			35		5	
8	0.20	0.10	S	S	30		20			
9	0.10	0.10	S	S			15		5	
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										

Comments:
Habitat unit 1 and 2 are all soil.

Preliminary Assessment

Spawning:	1	Rearing:	2	Over-wintering:	0	Adult Feeding:	0	Migration:	2

Banks of Channel (Stability) H = highly stable, S = stable, U = unstable
Preliminary Assessment 0 = no habitat present, 1 = poor, 2 = fair, 3 = good, 4 = excellent

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: 106.7		**Survey Date (d/m/y):** 14-08-01				**A: Downstream**						**B:Upstream**							
Drainage Area (Km^2):		**Survey Crew:** MM,GH				**N:**	65	44	0.800			**N:**	65	44	0.738				
Survey Distance (m) 200		**Aerial photo:** 20-24				**W:**	108	16	0.703			**W:**	108	9	0.500				
Approx. Distance from Over-wintering Habitat (Km):						**Barriers to Over-Wintering Habitat:**													
Temperature (^oC): 12.8		**Visibility:** clear																	
Channel Velocity (m/s): 0.2		**Conductivity (uS/cm):** 19																	
Current Flow Conditions: m		**pH:** 6				**Weather:**													
Discharge estimate (m^3/s) 1.86		w=30m,d=0.36,0.22,0.46,0.32,0.2				Broken clouds, 20 km/hr N. wind													

Hab Unit No.	Hab Type	Dist. fr start (m)	Length (m)	Slope (%)	Depth (m)		Width (m)		Bed Material					Pool Info			Fish Passage Barriers	
					Mean	Bank-full	Mean	Bank-full	Sand (%)	Gravel (%)	Cobble (%)	Boulder (%)	Bedrock (%)	Type	Depth (m) Max	Depth (m) Crest	Type	T/P
1	G	0	200	1.0	0.45	0.71	31.0	44.0			20	80						
2		200																
3																		
4																		
5																		
6																		
7																		
8																		
9																		
10																		
11																		
12																		
13																		
14																		
15																		
16																		
17																		
18																		
19																		
20																		

Flow Conditions H = High flow, M = Medium flow, L = Low flow

Habitat Unit Under bankfull conditions: 0 - 2.5 m = > 1 m^2, 2.5 - 5 m = > 2 m^2, 5 - 10 m = > 4 m^2, 10 -15 m = > 6 m^2, 15 -20 = > 8 m^2, > 20 m = > 10 m^2

Hab Type P = pool, G = glide, R = riffle, C = cascade, O = other

Dist. fr start distance from beginning of the survey to the beginning of the habitat unit being surveyed

Pool Type S = scour, D = dammed, U = unknown

Substrate Sand (silt, clay, fine organic< 2 mm), Gravel (2 - 64 mm), Cobble (64 - 256), Boulders (256 - 4000 mm), Bedrock (>4000 mm)

Fish Passage Barriers IF = Impassible waterfall

BF = Boulder Field, passage through the boulder arrangement is not possible for fish

D = dry channel, no stream flow

NC = no distinct channel, water drains over land

N = no barrier to fish passage through the habitat unit

T/P T = temporary, portion of open water season

P = Permanent, all year round

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: **106.7**
Survey Date (d/m/y): 14-08-01
Survey Crew: MM,GH
Aerial photo: 20-24

Hab Unit No.	Banks of Channel				Instream Cover					Photos (Role #) (Photo #)
	L Bank Height (m)	R Bank Height (m)	L Bank Stab	R Bank Stab	Pool %	Boulder %	Instream Veg %	Overhang Veg %	Undercut Bank %	
1	0.26	0.26	U	U		80		10		20-20,21
2										20-22,23
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										

Comments:
A wide shallow stream exiting a lake. Technically a glide but there are so many boulders and islands that it looks almost like a boulder field in some places. Not a riffle because of low flow gradient. Photo 20-20 taken looking upstream from 100m point. Photo 20-21 looking downstream of 0m point. Photo 20-22 looking downstream from 0m. Photo 20-23 looking upstream from 200m.

Preliminary Assessment

Spawning:	1	Rearing:	2	Over-wintering:	0	Adult Feeding:	1	Migration:	1

Banks of Channel (Stability) H = highly stable, S = stable, U = unstable
Preliminary Assessment 0 = no habitat present, 1 = poor, 2 = fair, 3 = good, 4 = excellent

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: 103.3a	**Survey Date (d/m/y):** 14-08-01	**A: Downstream**	**B:Upstream**		
Drainage Area (Km^2):	**Survey Crew:** SLU,DN	**N:**	**N:** 65	45	0.760
Survey Distance (m) 200	**Aerial photo:** 15-2,2-2	**W:**	**W:** 108	6	0.188

Approx. Distance from Over-wintering Habitat (Km): 0.1		**Barriers to Over-Wintering Habitat:**
Temperature (^oC): 12.7,12.3	**Visibility:** clear	none
Channel Velocity (m/s): 0.3	**Conductivity (uS/cm):** 53	
Current Flow Conditions: low	**pH:** 7	**Weather:**
Discharge estimate (m^3/s) 0.074	w=0.7, d=0.35	partly sunny, windy, 15°c

Hab Unit No.	Hab Type	Dist. fr start (m)	Length (m)	Slope (%)	Depth (m)		Width (m)		Bed Material					Pool Info			Fish Passage Barriers	
					Mean	Bank-full	Mean	Bank-full	Sand (%)	Gravel (%)	Cobble (%)	Boulder (%)	Bedrock (%)	Type	Depth (m) Max	Depth (m) Crest	Type	T/P
1	G	0	96	0.5	0.30	0.55	1.0	2.2	5		35	60						
2	SG	96	104	2.0	0.40	0.60	0.75	1.2		5	30	65						
3		200																
4																		
5																		
6																		
7																		
8																		
9																		
10																		
11																		
12																		
13																		
14																		
15																		
16																		
17																		
18																		
19																		
20																		

Flow Conditions H = High flow, M = Medium flow, L = Low flow

Habitat Unit Under bankfull conditions: 0 - 2.5 m = > 1 m^2, 2.5 - 5 m = > 2 m^2, 5 - 10 m = > 4 m^2, 10 -15 m = > 6 m^2, 15 -20 = > 8 m^2, > 20 m = > 10 m^2

Hab Type P = pool, G = glide, R = riffle, C = cascade, O = other, SG = step glide

Dist. fr start distance from beginning of the survey to the beginning of the habitat unit being surveyed

Pool Type S = scour, D = dammed, U = unknown

Substrate Sand (silt, clay, fine organic< 2 mm), Gravel (2 - 64 mm), Cobble (64 - 256), Boulders (256 - 4000 mm), Bedrock (>4000 mm)

Fish Passage Barriers IF = Impassible waterfall

BF = Boulder Field, passage through the boulder arrangement is not possible for fish

D = dry channel, no stream flow

NC = no distinct channel, water drains over land

N = no barrier to fish passage through the habitat unit

T/P T = temporary, portion of open water season

P = Permanent, all year round

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: **103.3a**
Survey Date (d/m/y): 14-08-01
Survey Crew: SLU,DN
Aerial photo: 15-2,2-2

Hab Unit No.	Banks of Channel				Instream Cover					Photos (Role #) (Photo #)
	L Bank Height (m)	R Bank Height (m)	L Bank Stab	R Bank Stab	Pool %	Boulder %	Instream Veg %	Overhang Veg %	Undercut Bank %	
1	0.30	0.30	S	S		60			5	
2	0.30	0.35	S	S		65				
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										

Comments:
SG =step glide, the largest step (elevation change) is 0.3m, therefore no fish passage barrier.

Preliminary Assessment

Spawning:	3	Rearing:	3	Over-wintering:	0	Adult Feeding:	1	Migration:	2

Banks of Channel (Stability) H = highly stable, S = stable, U = unstable
Preliminary Assessment 0 = no habitat present, 1 = poor, 2 = fair, 3 = good, 4 = excellent

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: 103.3		**Survey Date (d/m/y):** 14-08-01			**A: Downstream**						**B:Upstream**								
Drainage Area (Km^2):		**Survey Crew:** MM,GH			**N:**	65	45	0.817			**N:**	65	45	0.720					
Survey Distance (m) 200		**Aerial photo:** 14-4			**W:**	108	5	0.968			**W:**	108	5	0.842					
Approx. Distance from Over-wintering Habitat (Km):					**Barriers to Over-Wintering Habitat:**														
Temperature (^{o}C): 12.8		**Visibility:** clear																	
Channel Velocity (m/s): 0		**Conductivity (uS/cm):** 37																	
Current Flow Conditions: low		**pH:** 5.7			**Weather:**														
Discharge estimate (m^3/s) n/a		***pH and temp measured on Aug 15th.**			**Broken cloud, 20km/hr N. wind.**														

Hab Unit No.	Hab Type	Dist. fr start (m)	Length (m)	Slope (%)	Depth (m)		Width (m)		Bed Material					Pool Info			Fish Passage Barriers	
					Mean	Bank-full	Mean	Bank-full	Sand (%)	Gravel (%)	Cobble (%)	Boulder (%)	Bedrock (%)	Type	Depth (m) Max	Depth (m) Crest	Type	T/P
1	SBF	0	200	3.0	0.20	0.49	50.0	50.0			10	90					BF	P
2		200																
3																		
4																		
5																		
6																		
7																		
8																		
9																		
10																		
11																		
12																		
13																		
14																		
15																		
16																		
17																		
18																		
19																		
20																		

Flow Conditions H = High flow, M = Medium flow, L = Low flow

Habitat Unit Under bankfull conditions: 0 - 2.5 m = > 1 m^2, 2.5 - 5 m = > 2 m^2, 5 - 10 m = > 4 m^2, 10 -15 m = > 6 m^2, 15 -20 = > 8 m^2, > 20 m = > 10 m^2

Hab Type P = pool, G = glide, R = riffle, C = cascade, O = other, SBF=subsurface boulder field

Dist. fr start distance from beginning of the survey to the beginning of the habitat unit being surveyed

Pool Type S = scour, D = dammed, U = unknown

Substrate Sand (silt, clay, fine organic< 2 mm), Gravel (2 - 64 mm), Cobble (64 - 256), Boulders (256 - 4000 mm), Bedrock (>4000 mm)

Fish Passage Barriers IF = Impassible waterfall

BF = Boulder Field, passage through the boulder arrangement is not possible for fish

D = dry channel, no stream flow

NC = no distinct channel, water drains over land

N = no barrier to fish passage through the habitat unit

T/P T = temporary, portion of open water season

P = Permanent, all year round

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: **103.3**
Survey Date (d/m/y): 14-08-01
Survey Crew: MM,GH
Aerial photo: 14-4

Hab Unit No.	Banks of Channel				Instream Cover					Photos (Role #) (Photo #)
	L Bank Height (m)	R Bank Height (m)	L Bank Stab	R Bank Stab	Pool %	Boulder %	Instream Veg %	Overhang Veg %	Undercut Bank %	
1	0.30	0.30	U	U		90				14-1,2
2										14-3
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										

Comments:
A wide shallow stream that runs through a boulder field. Almost all flow in underneath a boulder field. No fish passage possible. Photo 14-1 looking upstream showing stream buried under boulder field (foreground is margin of downstream lake). Photo 14-2 is the same with caribou looking on. Photo 14-3 looking downstream.

Preliminary Assessment

Spawning:	0	Rearing:	0	Over-wintering:	0	Adult Feeding:	0	Migration:	0

Banks of Channel (Stability) H = highly stable, S = stable, U = unstable
Preliminary Assessment 0 = no habitat present, 1 = poor, 2 = fair, 3 = good, 4 = excellent

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: 90.3		**Survey Date (d/m/y):** 14-08-01			**A: Downstream**				**B:Upstream**								
Drainage Area (Km^2):		**Survey Crew:** SLU,DN			**N:**	65	51	0.309	**N:**	65	51	0.418					
Survey Distance (m) 74		**Aerial photo:** R3-26,27			**W:**	107	57	0.526	**W:**	107	57	0.540					
Approx. Distance from Over-wintering Habitat (Km):					**Barriers to Over-Wintering Habitat:**													
Temperature (^oC): 10.2,9.7		**Visibility:** clear			**Bedrock waterfall (cascade).**													
Channel Velocity (m/s):		**Conductivity (uS/cm):** 45.3																
Current Flow Conditions:		**pH:** 6.8			**Weather:**													
Discharge estimate (m^3/s) - no flows taken					**Windy, 15°c, overcast.**													

Hab Unit No.	Hab Type	Dist. fr start (m)	Length (m)	Slope (%)	Depth (m)		Width (m)		Bed Material					Pool Info			Fish Passage Barriers	
					Mean	Bank-full	Mean	Bank-full	Sand (%)	Gravel (%)	Cobble (%)	Boulder (%)	Bedrock (%)	Type	Depth (m) Max	Depth (m) Crest	Type	T/P
1	C	0	18	3.5	0.10	0.25	1.2	2.5					100				IF	P
2	SG	18	34	2.0	0.15	0.40	1.2	1.6	10	30	20		40					
3	G	52	22	0.5	0.20	0.25	4.0	9.0			10		90					
4																		
5																		
6																		
7																		
8																		
9																		
10																		
11																		
12																		
13																		
14																		
15																		
16																		
17																		
18																		
19																		
20																		

Flow Conditions H = High flow, M = Medium flow, L = Low flow

Habitat Unit Under bankfull conditions: 0 - 2.5 m = > 1 m^2, 2.5 - 5 m = > 2 m^2, 5 - 10 m = > 4 m^2, 10 -15 m = > 6 m^2, 15 -20 = > 8 m^2, > 20 m = > 10 m^2

Hab Type P = pool, G = glide, R = riffle, C = cascade, O = other, SG = step glide

Dist. fr start distance from beginning of the survey to the beginning of the habitat unit being surveyed

Pool Type S = scour, D = dammed, U = unknown

Substrate Sand (silt, clay, fine organic< 2 mm), Gravel (2 - 64 mm), Cobble (64 - 256), Boulders (256 - 4000 mm), Bedrock (>4000 mm)

Fish Passage Barriers IF = Impassible waterfall

BF = Boulder Field, passage through the boulder arrangement is not possible for fish

D = dry channel, no stream flow

NC = no distinct channel, water drains over land

N = no barrier to fish passage through the habitat unit

T/P T = temporary, portion of open water season

P = Permanent, all year round

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: **90.3**
Survey Date (d/m/y): 14-08-01
Survey Crew: SLU,DN
Aerial photo: R3-26,27

Hab Unit No.	Banks of Channel				Instream Cover					Photos (Role #) (Photo #)
	L Bank Height (m)	R Bank Height (m)	L Bank Stab	R Bank Stab	Pool %	Boulder %	Instream Veg %	Overhang Veg %	Undercut Bank %	
1	0.15	0.15	H	S						
2	0.30	0.30	H	S			5		5	
3	0.20	0.20	S	S			50			
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										

Comments:
From end of habitat unit 3, the flow goes sub-surface and does not return for at least 0.5km. Upstream GPS coordinates is ~200m upstream of downstream GPS coordinates. Note: about 200m after water resurfaces there is another bedrock cascade that makes a permanent impassable barrier for fish.

Preliminary Assessment

Spawning: **Rearing:** **Over-wintering:** **Adult Feeding:** **Migration:**

Banks of Channel (Stability) H = highly stable, S = stable, U = unstable
Preliminary Assessment 0 = no habitat present, 1 = poor, 2 = fair, 3 = good, 4 = excellent

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: 85.0		**Survey Date (d/m/y):** 15-08-01			**A: Downstream**				**B:Upstream**									
Drainage Area (Km^2):		**Survey Crew:** MM,GH			**N:**	65	54	0.095	**N:**	65	54	0.038						
Survey Distance (m) 200		**Aerial photo:** 14-8			**W:**	107	54	0.853	**W:**	107	55	0.050						
Approx. Distance from Over-wintering Habitat (Km):					**Barriers to Over-Wintering Habitat:**														
Temperature (^{o}C): 13.1		**Visibility:** clear																	
Channel Velocity (m/s): 0.2		**Conductivity (uS/cm):** 127																	
Current Flow Conditions: m		**pH:** 6.2			**Weather:**														
Discharge estimate (m^3/s) 0.020		w=1.2m,d=0.05,0.07,0.13,0.1,0.06			overcast, >20km/hr winds from east.														

Hab Unit No.	Hab Type	Dist. fr start (m)	Length (m)	Slope (%)	Depth (m)		Width (m)		Bed Material					Pool Info			Fish Passage Barriers	
					Mean	Bank-full	Mean	Bank-full	Sand (%)	Gravel (%)	Cobble (%)	Boulder (%)	Bedrock (%)	Type	Depth (m) Max	Depth (m) Crest	Type	T/P
1	G	0	20	0.5	0.10	0.19	1.7	2.5	100									
2	R	20	2	0.5	0.07	0.18	0.6	1.5	100									
3	G	22	21	0.5	0.55	0.70	6.0	7.0	100									
4	R	43	6	0.5	0.07	0.17	1.4	3.4	100									
5	G	49	8	0.5	0.14	0.24	1.8	1.8	100									
6	R	57	7	1.0	0.12	0.22	1.0	1.4	100									
7	G	64	7	0.5	0.23	0.39	0.7	1.0			100							
8	R	71	3	1.0	0.10	0.24	0.4	0.4			100							
9	G	74	13	0.5	0.18	0.35	0.5	0.5			80	20						
10	R	87	3	3.0	0.07	0.20	1.5	2.0	100									
11	G	90	16	0.5	0.17	0.29	1.4	4.4	70	30								
12	R	106	23	2.5	0.20	0.34	1.0	1.0	80									
13	BF	129	17	3.0	0.25	0.55	1.0	1.0				100					BF	P
14	R	146	24	3.5	0.17	0.29	1.6	2.0	80		20							
15	G	170	3	0.5	0.20	0.35	1.3	1.7	20		80							
16	R	173	27	3.0	0.15	0.30	1.0	1.0	30		60	10						
17		200																
18																		
19																		
20																		

Flow Conditions H = High flow, M = Medium flow, L = Low flow

Habitat Unit Under bankfull conditions: 0 - 2.5 m = > 1 m^2, 2.5 - 5 m = > 2 m^2, 5 - 10 m = > 4 m^2, 10 -15 m = > 6 m^2, 15 -20 = > 8 m^2, > 20 m = > 10 m^2

Hab Type P = pool, G = glide, R = riffle, C = cascade, O = other, BF = boulder field

Dist. fr start distance from beginning of the survey to the beginning of the habitat unit being surveyed

Pool Type S = scour, D = dammed, U = unknown

Substrate Sand (silt, clay, fine organic< 2 mm), Gravel (2 - 64 mm), Cobble (64 - 256), Boulders (256 - 4000 mm), Bedrock (>4000 mm)

Fish Passage Barriers IF = Impassible waterfall

BF = Boulder Field, passage through the boulder arrangement is not possible for fish

D = dry channel, no stream flow

NC = no distinct channel, water drains over land

N = no barrier to fish passage through the habitat unit

T/P T = temporary, portion of open water season

P = Permanent, all year round

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: **85**
Survey Date (d/m/y): 15-08-01
Survey Crew: MM,GH
Aerial photo: 14-8

Hab Unit No.	Banks of Channel				Instream Cover					Photos (Role #) (Photo #)
	L Bank Height (m)	R Bank Height (m)	L Bank Stab	R Bank Stab	Pool %	Boulder %	Instream Veg %	Overhang Veg %	Undercut Bank %	
1	0.09	0.09	U	U			20			14-5,6
2	0.11	0.11	U	U			95			
3	0.15	0.15	U	U			10			
4	0.10	0.10	U	U			85			
5	0.10	0.10	U	U			85			
6	0.16	0.16	U	U			50			
7	0.14	0.14	U	U			50			
8	0.17	0.17	S	S						
9	0.13	0.13	U	U			90			
10	0.15	0.15	U	U			40	10		14-7
11	0.20	0.20	S	S		100				
12	0.12	0.12	U	U			75			
13	0.15	0.15	U	S			60			
14	0.15	0.15	U	U		10	50			
15	0.15	0.15	U	U			50			
16	0.15	0.15	U	U			40			
17										
18										
19										
20										

Comments:
Narrow shallow, mud bottom stream that drains a wet meadow and an upstream pond. Photo 14-5 looking downstream from knoll overlooking 0m point. Photo 14-6 looking upstream from knoll overlooking 0m point. Photo 14-7 looking downstream from 129m point.

Preliminary Assessment

Spawning:	0	Rearing:	1	Over-wintering:	0	Adult Feeding:	0	Migration:	0

Banks of Channel (Stability) H = highly stable, S = stable, U = unstable
Preliminary Assessment 0 = no habitat present, 1 = poor, 2 = fair, 3 = good, 4 = excellent

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: 84.2		**Survey Date (d/m/y):** 15-08-01			**A: Downstream**						**B:Upstream**								
Drainage Area (Km^2):		**Survey Crew:** SLU,DN			**N:**	65	54	0.484			**N:**	65	54	0.558					
Survey Distance (m) 202		**Aerial photo:** 3-25,3-24			**W:**	107	54	0.627			**W:**	107	54	0.738					
Approx. Distance from Over-wintering Habitat (Km): 3.0km					**Barriers to Over-Wintering Habitat:**														
Temperature (^oC): 12.0,14.4		**Visibility:** clear			no apparent barriers														
Channel Velocity (m/s): 0.35		**Conductivity (uS/cm):** 17																	
Current Flow Conditions: I		**pH:** 7.1			**Weather:**														
Discharge estimate (m^3/s) 0.49	w=4, d=.35				overcast, 15°c.														

Hab Unit No.	Hab Type	Dist. fr start (m)	Length (m)	Slope (%)	Depth (m)		Width (m)		Bed Material					Pool Info			Fish Passage Barriers	
					Mean	Bank-full	Mean	Bank-full	Sand (%)	Gravel (%)	Cobble (%)	Boulder (%)	Bedrock (%)	Type	Depth (m) Max	Depth (m) Crest	Type	T/P
1	G	0	27	0.5	0.40	0.60	5.0	5.0			5	70	25					
2	R	27	17	1.5	0.30	0.55	6.5	6.5			15	60	25					
3	G	44	5	0.0	0.40	0.70	7.0	7.0			20	80						
4	R	49	5	1.5	0.20	0.50	7.0	7.0		10	70	20						
5	G	57	14	0.5	0.35	0.65	6.0	7.5		5	70	25						
6	R	68	7	1.5	0.30	0.60	5.0	5.0		5	80	15						
7	G	75	45	0.0	0.50	0.85	0.9	0.9		10	60	20	10					
8	R	120	17	1.5	0.35	0.60	5.0	7.0		5	60	35						
9	G	137	8	0.0	0.45	0.80	8.0	8.5		5	65	30						
10	R	145	11	1.5	0.20	0.40	10.0	10.0		10	30	60						
11	G	156	12	0.0	0.45	0.65	11.0	11.0		5	65	30						
12	R	168	10	1.0	0.30	0.55	8.0	8.0			35	65						
13	G	178	15	0.5	0.25	0.40	9.0	9.5			60	40						
14	R	195	7	1.5	0.25	0.55	9.0	11.5			80	20						
15																		
16																		
17																		
18																		
19																		
20																		

Flow Conditions H = High flow, M = Medium flow, L = Low flow

Habitat Unit Under bankfull conditions: 0 - 2.5 m = > 1 m^2, 2.5 - 5 m = > 2 m^2, 5 - 10 m = > 4 m^2, 10 -15 m = > 6 m^2, 15 -20 = > 8 m^2, > 20 m = > 10 m^2

Hab Type P = pool, G = glide, R = riffle, C = cascade, O = other

Dist. fr start distance from beginning of the survey to the beginning of the habitat unit being surveyed

Pool Type S = scour, D = dammed, U = unknown

Substrate Sand (silt, clay, fine organic< 2 mm), Gravel (2 - 64 mm), Cobble (64 - 256), Boulders (256 - 4000 mm), Bedrock (>4000 mm)

Fish Passage Barriers IF = Impassible waterfall

BF = Boulder Field, passage through the boulder arrangement is not possible for fish

D = dry channel, no stream flow

NC = no distinct channel, water drains over land

N = no barrier to fish passage through the habitat unit

T/P T = temporary, portion of open water season

P = Permanent, all year round

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: **84.2**
Survey Date (d/m/y): 15-08-01
Survey Crew: SLU,DN
Aerial photo: 3-25,3-24

Hab Unit No.	Banks of Channel				Instream Cover					
	L Bank Height (m)	R Bank Height (m)	L Bank Stab	R Bank Stab	Pool %	Boulder %	Instream Veg %	Overhang Veg %	Undercut Bank %	Photos (Role #) (Photo #)
1	0.30	0.60	S	S		70				
2	0.40	0.80	S	S		60				
3	0.50	0.60	S	S		40				
4	0.45	0.65	S	S		20				
5	0.40	0.50	S	S		25				
6	0.40	0.60	S	S		15				
7	0.35	0.40	S	S		20				
8	0.40	0.50	S	S		35				
9	0.50	0.40	S	S		30				
10	0.20	0.40	S	S		60				
11	0.20	0.30	S	S		30				
12	0.35	0.35	S	S		65				
13	0.40	0.40	S	S		40				
14	0.50	0.15	S	S		20				
15										
16										
17										
18										
19										
20										

Comments:

Preliminary Assessment

Spawning: **Rearing:** **Over-wintering:** **Adult Feeding:** **Migration:**

Banks of Channel (Stability) H = highly stable, S = stable, U = unstable

Preliminary Assessment 0 = no habitat present, 1 = poor, 2 = fair, 3 = good, 4 = excellent

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: 77.0		**Survey Date (d/m/y):** 15-08-01			**A: Downstream**				**B:Upstream**									
Drainage Area (Km^2):		**Survey Crew:** MM,GH			**N:**	65	57	0.917	**N:**	65	57	0.947						
Survey Distance (m) 200		**Aerial photo:** 14-12			**W:**	107	50	0.165	**W:**	107	50	0.380						
Approx. Distance from Over-wintering Habitat (Km):					**Barriers to Over-Wintering Habitat:**													
Temperature (^{o}C): 9.1		**Visibility:** clear																
Channel Velocity (m/s): 0.214		**Conductivity (uS/cm):** 41																
Current Flow Conditions: m		**pH:** 6.6			**Weather:**													
Discharge estimate (m^3/s) 0.032		w=0.6,d=0.25,0.25,0.24,0.24,0.25			broken cloud, >20km/hr E. wind.													

Hab Unit No.	Hab Type	Dist. fr start (m)	Length (m)	Slope (%)	Depth (m)		Width (m)		Bed Material					Pool Info			Fish Passage Barriers	
					Mean	Bank-full	Mean	Bank-full	Sand (%)	Gravel (%)	Cobble (%)	Boulder (%)	Bedrock (%)	Type	Depth (m) Max	Depth (m) Crest	Type	T/P
1	G	0	6	0.5	0.18	0.38	0.9	0.9	5	50	45							
2	R	6	48	1.0	0.23	0.43	0.9	0.9		50	45	5						
3	G	54	42	0.5	0.25	0.40	0.9	0.9		50	45	5						
4	R	96	34	1.0	0.18	0.33	1.4	1.4		10	70	20						
5	G	140	13	0.5	0.19	0.29	0.5	3.0	35	60		5						
6	R	153	22	1.0	0.19	0.34	0.9	1.2	35	60		5						
7	G	175	25	0.5	0.24	0.34	0.8	1.0	35	60		5						
8		200																
9																		
10																		
11																		
12																		
13																		
14																		
15																		
16																		
17																		
18																		
19																		
20																		

Flow Conditions H = High flow, M = Medium flow, L = Low flow

Habitat Unit Under bankfull conditions: 0 - 2.5 m = > 1 m^2, 2.5 - 5 m = > 2 m^2, 5 - 10 m = > 4 m^2, 10 -15 m = > 6 m^2, 15 -20 = > 8 m^2, > 20 m = > 10 m^2

Hab Type P = pool, G = glide, R = riffle, C = cascade, O = other

Dist. fr start distance from beginning of the survey to the beginning of the habitat unit being surveyed

Pool Type S = scour, D = dammed, U = unknown

Substrate Sand (silt, clay, fine organic< 2 mm), Gravel (2 - 64 mm), Cobble (64 - 256), Boulders (256 - 4000 mm), Bedrock (>4000 mm)

Fish Passage Barriers IF = Impassible waterfall

BF = Boulder Field, passage through the boulder arrangement is not possible for fish

D = dry channel, no stream flow

NC = no distinct channel, water drains over land

N = no barrier to fish passage through the habitat unit

T/P T = temporary, portion of open water season

P = Permanent, all year round

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: **77**
Survey Date (d/m/y): 15-08-01
Survey Crew: MM,GH
Aerial photo: 14-12

Hab Unit No.	Banks of Channel				Instream Cover					Photos (Role #) (Photo #)
	L Bank Height (m)	R Bank Height (m)	L Bank Stab	R Bank Stab	Pool %	Boulder %	Instream Veg %	Overhang Veg %	Undercut Bank %	
1	0.20	0.20	S	S			20			14-9,10
2	0.20	0.20	S	S		5	25	20		
3	0.15	0.15	S	S		5	10	10		
4	0.15	0.15	S	S		20	20	50		
5	0.10	0.10	U	U		5	30	50		
6	0.15	0.15	U	U			50	30		
7	0.10	0.10	U	U		5	25	20		14-11
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										

Comments:
Narrow shallow stream flowing through wide, flat meadow. Photo 14-9 looking upstream from 0 point. Photo 14-10 looking downstream from 0 point. Photo 14-11 looking downstream from 200m point.

Preliminary Assessment

Spawning:	1	Rearing:	2	Over-wintering:	0	Adult Feeding:	1	Migration:	0

Banks of Channel (Stability) H = highly stable, S = stable, U = unstable
Preliminary Assessment 0 = no habitat present, 1 = poor, 2 = fair, 3 = good, 4 = excellent

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: 76		**Survey Date (d/m/y):** 15-08-01			**A: Downstream**						**B:Upstream**								
Drainage Area (Km^2):		**Survey Crew:** SLU,DN			**N:**	65	58	0.423			**N:**	65	58	0.454					
Survey Distance (m) 203		**Aerial photo:** R3-22			**W:**	107	49	0.756			**W:**	107	49	0.946					
Approx. Distance from Over-wintering Habitat (Km): 1.5					**Barriers to Over-Wintering Habitat:**														
Temperature (^{o}C): 13.7,14.2		**Visibility:** clear			**No barriers, but uncertain as it if the downstream lake is over-wintering habitat.**														
Channel Velocity (m/s): 0.7		**Conductivity (uS/cm):** 72																	
Current Flow Conditions: low		**pH:** 7.4			**Weather:**														
Discharge estimate (m^3/s) 0.077	**w=1.1,d=0.1**				**partly cloudy, 15°c.**														

Hab Unit No.	Hab Type	Dist. fr start (m)	Length (m)	Slope (%)	Depth (m)		Width (m)		Bed Material					Pool Info			Fish Passage Barriers	
					Mean	Bank-full	Mean	Bank-full	Sand (%)	Gravel (%)	Cobble (%)	Boulder (%)	Bedrock (%)	Type	Depth (m) Max	Depth (m) Crest	Type	T/P
1	G	0	22	0.5	0.25	0.35	1.3	3.0	5	70	25							
2	P	22	6	0.0	0.60	0.70	0.9	3.0	85	10	5			S	0.75	0.20		
3	G	28	50	0.5	0.30	0.40	1.3	1.9	10	70	20							
4	P	78	11	0.0	0.60	0.80	2.0	3.0	35	65				S	0.75	0.30		
5	G	89	64	0.5	0.30	0.40	2.5	3.5	65	25	10							
6	R	153	10	1.0	0.20	0.45	1.1	1.2		15	80	5						
7	G	163	40	0.5	0.30	0.55	2.2	2.5	20	60	20							
8		203																
9																		
10																		
11																		
12																		
13																		
14																		
15																		
16																		
17																		
18																		
19																		
20																		

Flow Conditions H = High flow, M = Medium flow, L = Low flow

Habitat Unit Under bankfull conditions: 0 - 2.5 m = > 1 m^2, 2.5 - 5 m = > 2 m^2, 5 - 10 m = > 4 m^2, 10 -15 m = > 6 m^2, 15 -20 = > 8 m^2, > 20 m = > 10 m^2

Hab Type P = pool, G = glide, R = riffle, C = cascade, O = other

Dist. fr start distance from beginning of the survey to the beginning of the habitat unit being surveyed

Pool Type S = scour, D = dammed, U = unknown

Substrate Sand (silt, clay, fine organic< 2 mm), Gravel (2 - 64 mm), Cobble (64 - 256), Boulders (256 - 4000 mm), Bedrock (>4000 mm)

Fish Passage Barriers IF = Impassible waterfall

BF = Boulder Field, passage through the boulder arrangement is not possible for fish

D = dry channel, no stream flow

NC = no distinct channel, water drains over land

N = no barrier to fish passage through the habitat unit

T/P T = temporary, portion of open water season

P = Permanent, all year round

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: **76**
Survey Date (d/m/y): 15-08-01
Survey Crew: SLU,DN
Aerial photo: R3-22

Hab Unit No.	Banks of Channel				Instream Cover					
	L Bank Height (m)	R Bank Height (m)	L Bank Stab	R Bank Stab	Pool %	Boulder %	Instream Veg %	Overhang Veg %	Undercut Bank %	Photos (Role #) (Photo #)
1	0.10	0.10	S	S			5			
2	0.10	0.10	S	S	20		5			
3	0.30	0.30	S	S			5			
4	0.30	0.25	S	S	10		5			
5	0.15	0.15	S	S			40			
6	0.30	0.40	S	S		5				3-20
7	0.30	0.35	S	S			5			3-19
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										

Comments:
R3-19 looking upstream.

Preliminary Assessment

Spawning: **Rearing:** **Over-wintering:** **Adult Feeding:** **Migration:**

Banks of Channel (Stability) H = highly stable, S = stable, U = unstable
Preliminary Assessment 0 = no habitat present, 1 = poor, 2 = fair, 3 = good, 4 = excellent

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: 72.2		**Survey Date (d/m/y):** 15-08-01			**A: Downstream**						**B:Upstream**								
Drainage Area (Km^2):		**Survey Crew:** MM,GH			**N:**	66		0		0.158	**N:**	66		0		0.142			
Survey Distance (m) 200		**Aerial photo:** 14-18			**W:**	107		47		0.642	**W:**	107		47		0.885			
Approx. Distance from Over-wintering Habitat (Km):					**Barriers to Over-Wintering Habitat:**														
Temperature (^{o}C): 14.6		**Visibility:** clear																	
Channel Velocity (m/s): 0.33		**Conductivity (uS/cm):** 62																	
Current Flow Conditions: m		**pH:** 6.7			**Weather:**														
Discharge estimate (m^3/s) 0.198					**Overcast, 20-30 km/h NE wind, ~12°c.**														

Hab Unit No.	Hab Type	Dist. fr start (m)	Length (m)	Slope (%)	Depth (m)		Width (m)		Bed Material					Pool Info			Fish Passage Barriers	
					Mean	Bank-full	Mean	Bank-full	Sand (%)	Gravel (%)	Cobble (%)	Boulder (%)	Bedrock (%)	Type	Depth (m) Max	Depth (m) Crest	Type	T/P
1	R	0	38	2.5	0.27	0.52	4.0	4.0		30	40	30						
2	G	38	15	0.5	0.27	0.63	2.5	2.5		30	40	30						
3	R	53	6	1.0	0.20	0.40	2.6	3.1		10	40	50						
4	G	59	13	0.5	0.32	0.57	2.5	2.5		20	40	40						
5	P	72	27	0.0	>2.00	>2.3	16.3	16.3	100					U	>2.0	0.35		
6	G	99	12	0.5	0.33	0.53	3.3	3.3	100									
7	P	111	24	0.0	>2.00	>2.25	15.0	15.0	100					U	>2.0	0.55		
8	G	135	20	0.5	0.55	0.80	4.4	4.4	100									
9	P	155	43	0.0	>2.00	>2.35	23.0	23.0	100					U	>2.0	0.17		
10	R	198	2	2.0	0.17	0.42	4.3	4.3			25	75						
11		200																
12																		
13																		
14																		
15																		
16																		
17																		
18																		
19																		
20																		

Flow Conditions H = High flow, M = Medium flow, L = Low flow

Habitat Unit Under bankfull conditions: 0 - 2.5 m = > 1 m^2, 2.5 - 5 m = > 2 m^2, 5 - 10 m = > 4 m^2, 10 -15 m = > 6 m^2, 15 -20 = > 8 m^2, > 20 m = > 10 m^2

Hab Type P = pool, G = glide, R = riffle, C = cascade, O = other

Dist. fr start distance from beginning of the survey to the beginning of the habitat unit being surveyed

Pool Type S = scour, D = dammed, U = unknown

Substrate Sand (silt, clay, fine organic< 2 mm), Gravel (2 - 64 mm), Cobble (64 - 256), Boulders (256 - 4000 mm), Bedrock (>4000 mm)

Fish Passage Barriers IF = Impassible waterfall

BF = Boulder Field, passage through the boulder arrangement is not possible for fish

D = dry channel, no stream flow

NC = no distinct channel, water drains over land

N = no barrier to fish passage through the habitat unit

T/P T = temporary, portion of open water season

P = Permanent, all year round

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: **72.2**
Survey Date (d/m/y): 15-08-01
Survey Crew: MM,GH
Aerial photo: 14-18

Hab Unit No.	Banks of Channel				Instream Cover					Photos (Role #) (Photo #)
	L Bank Height (m)	R Bank Height (m)	L Bank Stab	R Bank Stab	Pool %	Boulder %	Instream Veg %	Overhang Veg %	Undercut Bank %	
1	0.25	0.25	S	S		30	5	5		14-13
2	0.30	0.30	S	S		30	30	5	10	
3	0.20	0.20	S	S		50	30	5		
4	0.25	0.25	S	S		40	40			
5	0.30	0.30	S	S	100		30			14-14
6	0.20	0.20	S	S			50			
7	0.25	0.25	S	S	100		30			
8	0.25	0.25	S	S			50			
9	0.25	0.25	S	S	100					
10	0.25	0.25	S	S		75	10			14-15
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										

Comments:
A wide stream with riffles and glides at the lower part of the survey reach and 3 large pools at the upstream end. Photo 14-13 looking upstream at 0 point. Photo 14-14 looking upstream at the first pool. Photo 14-15 looking downstream at 200m point. Photo 14-17 looking upstream at cascade ~200m above the upstream end of the survey reach, fish passage certainly possible.

Preliminary Assessment

Spawning:	3	Rearing:	3	Over-wintering:	2	Adult Feeding:	3	Migration:	3

Banks of Channel (Stability) H = highly stable, S = stable, U = unstable
Preliminary Assessment 0 = no habitat present, 1 = poor, 2 = fair, 3 = good, 4 = excellent

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID:	70.1		**Survey Date (d/m/y):**	15-08-01		**A: Downstream**						**B:Upstream**							
Drainage Area (Km^2):			**Survey Crew:**	SLU,DN		**N:**	66		1		0.201	**N:**	66		1		0.227		
Survey Distance (m)	200		**Aerial photo:**	3-17,18		**W:**	107		48		0.528	**W:**	107		48		0.701		
Approx. Distance from Over-wintering Habitat (Km):	0.0 km					**Barriers to Over-Wintering Habitat:**													
Temperature (^{o}C):	15.4,15.8		**Visibility:**	clear		none apparent													
Channel Velocity (m/s):	0.35		**Conductivity (uS/cm):**	37															
Current Flow Conditions:	low		**pH:**	7.9		**Weather:**													
Discharge estimate (m^3/s)	0.025	w=0.7,d=0.1				partly cloudy,15°c													

Hab Unit No.	Hab Type	Dist. fr start (m)	Length (m)	Slope (%)	Depth (m)		Width (m)		Bed Material					Pool Info			Fish Passage Barriers	
					Mean	Bank-full	Mean	Bank-full	Sand (%)	Gravel (%)	Cobble (%)	Boulder (%)	Bedrock (%)	Type	Depth (m) Max	Depth (m) Crest	Type	T/P
1	C	0	114	8.0	0.15	0.30	2.0	2.5		15	80	5					IF	P
2	G	114	86	0.5	0.25	0.35	1.2	3.0	60	25	15							
3																		
4																		
5																		
6																		
7																		
8																		
9																		
10																		
11																		
12																		
13																		
14																		
15																		
16																		
17																		
18																		
19																		
20																		

Flow Conditions H = High flow, M = Medium flow, L = Low flow

Habitat Unit Under bankfull conditions: 0 - 2.5 m = > 1 m^2, 2.5 - 5 m = > 2 m^2, 5 - 10 m = > 4 m^2, 10 -15 m = > 6 m^2, 15 -20 = > 8 m^2, > 20 m = > 10 m^2

Hab Type P = pool, G = glide, R = riffle, C = cascade, O = other

Dist. fr start distance from beginning of the survey to the beginning of the habitat unit being surveyed

Pool Type S = scour, D = dammed, U = unknown

Substrate Sand (silt, clay, fine organic< 2 mm), Gravel (2 - 64 mm), Cobble (64 - 256), Boulders (256 - 4000 mm), Bedrock (>4000 mm)

Fish Passage Barriers IF = Impassible waterfall

BF = Boulder Field, passage through the boulder arrangement is not possible for fish

D = dry channel, no stream flow

NC = no distinct channel, water drains over land

N = no barrier to fish passage through the habitat unit

T/P T = temporary, portion of open water season

P = Permanent, all year round

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: **70.1**
Survey Date (d/m/y): 15-08-01
Survey Crew: SLU,DN
Aerial photo: 3-17,18

Hab Unit No.	Banks of Channel				Instream Cover					Photos (Role #) (Photo #)
	L Bank Height (m)	R Bank Height (m)	L Bank Stab	R Bank Stab	Pool %	Boulder %	Instream Veg %	Overhang Veg %	Undercut Bank %	
1	0.20	0.20	S	S						3-16
2	0.10	0.10	S	S			40			
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										

Comments:

Preliminary Assessment

Spawning: **Rearing:** **Over-wintering:** **Adult Feeding:** **Migration:**

Banks of Channel (Stability) H = highly stable, S = stable, U = unstable

Preliminary Assessment 0 = no habitat present, 1 = poor, 2 = fair, 3 = good, 4 = excellent

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: 69.4	**Survey Date (d/m/y):** 15-08-01		**A: Downstream**						**B:Upstream**								
Drainage Area (Km^2):	**Survey Crew:** SLU,DN			**N:**	66	1	0.426			**N:**	66	1	0.504				
Survey Distance (m) 200	**Aerial photo:** 3-14			**W:**	107	48	0.384			**W:**	107	48	0.489				
Approx. Distance from Over-wintering Habitat (Km): 0			**Barriers to Over-Wintering Habitat:**														
Temperature (^oC): 14.4,14.8	**Visibility:** clear		The flow is low and thus could be barrier but otherwise no obvious barriers.														
Channel Velocity (m/s): 0.05	**Conductivity (uS/cm):** 59		overcast, windy, 15°c.														
Current Flow Conditions: low	**pH:** 7.8		**Weather:**														
Discharge estimate (m^3/s) 0.002 w=0.35,d=0.1			overcast, windy, 15°c.														

Hab Unit No.	Hab Type	Dist. fr start (m)	Length (m)	Slope (%)	Depth (m)		Width (m)		Bed Material					Pool Info			Fish Passage Barriers	
					Mean	Bank-full	Mean	Bank-full	Sand (%)	Gravel (%)	Cobble (%)	Boulder (%)	Bedrock (%)	Type	Depth (m) Max	Depth (m) Crest	Type	T/P
1	G	0	81	0.5	0.30	0.45	0.6	0.8	100									
2	R	81	1	2.0	0.25	0.40	0.4	0.5				100						
3	G	82	118	0.5	0.30	0.45	0.5	0.7	100									
4																		
5																		
6																		
7																		
8																		
9																		
10																		
11																		
12																		
13																		
14																		
15																		
16																		
17																		
18																		
19																		
20																		

Flow Conditions H = High flow, M = Medium flow, L = Low flow

Habitat Unit Under bankfull conditions: 0 - 2.5 m = > 1 m^2, 2.5 - 5 m = > 2 m^2, 5 - 10 m = > 4 m^2, 10 -15 m = > 6 m^2, 15 -20 = > 8 m^2, > 20 m = > 10 m^2

Hab Type P = pool, G = glide, R = riffle, C = cascade, O = other

Dist. fr start distance from beginning of the survey to the beginning of the habitat unit being surveyed

Pool Type S = scour, D = dammed, U = unknown

Substrate Sand (silt, clay, fine organic< 2 mm), Gravel (2 - 64 mm), Cobble (64 - 256), Boulders (256 - 4000 mm), Bedrock (>4000 mm)

Fish Passage Barriers IF = Impassible waterfall

BF = Boulder Field, passage through the boulder arrangement is not possible for fish

D = dry channel, no stream flow

NC = no distinct channel, water drains over land

N = no barrier to fish passage through the habitat unit

T/P T = temporary, portion of open water season

P = Permanent, all year round

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: **69.4**
Survey Date (d/m/y): 15-08-01
Survey Crew: SLU,DN
Aerial photo: 3-14

Hab Unit No.	Banks of Channel				Instream Cover					Photos (Role #) (Photo #)
	L Bank Height (m)	R Bank Height (m)	L Bank Stab	R Bank Stab	Pool %	Boulder %	Instream Veg %	Overhang Veg %	Undercut Bank %	
1	0.30	0.35	S	S					5	3-14
2	0.40	0.30	S	S						
3	0.30	0.40	S	S						
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										

Comments:
Step of 40 cm in habitat unit 2.

Preliminary Assessment

Spawning:	1	Rearing:	1	Over-wintering:	0	Adult Feeding:	0	Migration:	1

Banks of Channel (Stability) H = highly stable, S = stable, U = unstable
Preliminary Assessment 0 = no habitat present, 1 = poor, 2 = fair, 3 = good, 4 = excellent

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: 68.6 **Survey Date (d/m/y):** 16/08/01
Drainage Area (Km^2): **Survey Crew:** SLU,DN
Survey Distance (m) 209 **Aerial photo:** 3-8 looking upstream

A: Downstream				B:Upstream			
N:	66	1	0.537	N: 66	1	0.626	
W:	107	48	0.105	W: 107	48	0.191	

Approx. Distance from Over-wintering Habitat (Km): 0.2
Temperature (^oC): 10.5,9.8 **Visibility:** clear
Channel Velocity (m/s): 0.4 **Conductivity (uS/cm):** 31
Current Flow Conditions: low **pH:** 8.3
Discharge estimate (m^3/s) 0.08 w=2,d=0.1

Barriers to Over-Wintering Habitat:
no downstream barriers, upstream there is an impassible waterfall (~200m).

Weather:
overcast, windy, 15°c.

Hab Unit No.	Hab Type	Dist. fr start (m)	Length (m)	Slope (%)	Depth (m)		Width (m)		Bed Material					Pool Info			Fish Passage Barriers	
					Mean	Bank-full	Mean	Bank-full	Sand (%)	Gravel (%)	Cobble (%)	Boulder (%)	Bedrock (%)	Type	Depth (m) Max	Depth (m) Crest	Type	T/P
1	G	0	26	0.5	0.20	0.70	5.5	5.7	5	55	40							
2	R	26	5	1.0	0.15	0.55	3.5	5.0		65	20	15						
3	G	31	35	0.5	0.25	0.75	4.0	5.5	20	40	40							
4	R	66	13	1.0	0.15	0.45	2.2	4.2		80	20							
5	G	79	14	0.5	0.25	0.65	2.4	2.5		85	15							
6	R	93	17	1.5	0.15	0.50	3.3	4.0		80	20							
7	G	110	30	0.5	0.30	0.70	3.5	4.0	10	70	20							
8	R	140	26	1.0	0.15	0.50	2.8	4.9		85	15							
9	G	166	43	0.5	0.15	0.40	5.4	5.5		80	20							
10																		
11																		
12																		
13																		
14																		
15																		
16																		
17																		
18																		
19																		
20																		

Flow Conditions H = High flow, M = Medium flow, L = Low flow

Habitat Unit Under bankfull conditions: 0 - 2.5 m = > 1 m^2, 2.5 - 5 m = > 2 m^2, 5 - 10 m = > 4 m^2, 10 -15 m = > 6 m^2, 15 -20 = > 8 m^2, > 20 m = > 10 m^2

Hab Type P = pool, G = glide, R = riffle, C = cascade, O = other

Dist. fr start distance from beginning of the survey to the beginning of the habitat unit being surveyed

Pool Type S = scour, D = dammed, U = unknown

Substrate Sand (silt, clay, fine organic< 2 mm), Gravel (2 - 64 mm), Cobble (64 - 256), Boulders (256 - 4000 mm), Bedrock (>4000 mm)

Fish Passage Barriers IF = Impassible waterfall

BF = Boulder Field, passage through the boulder arrangement is not possible for fish

D = dry channel, no stream flow

NC = no distinct channel, water drains over land

N = no barrier to fish passage through the habitat unit

T/P T = temporary, portion of open water season

P = Permanent, all year round

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: **68.6**
Survey Date (d/m/y): 16/08/01
Survey Crew: SLU,DN
Aerial photo: ıg upstream

Hab Unit No.	Banks of Channel				Instream Cover					Photos (Role #) (Photo #)
	L Bank Height (m)	R Bank Height (m)	L Bank Stab	R Bank Stab	Pool %	Boulder %	Instream Veg %	Overhang Veg %	Undercut Bank %	
1	0.60	0.60	S	S						
2	0.65	0.65	S	S		15				
3	0.60	0.65	S	S						
4	0.50	0.35	S	S						
5	0.80	0.70	S	S						
6	0.55	0.70	S	S						
7	0.60	0.50	S	S			5			
8	0.45	0.70	S	S					5	
9	0.50	0.60	S	S						
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										

Comments:
R3-13 at mouth looking upstream.

Preliminary Assessment

Spawning:	3	Rearing:	3	Over-wintering:	0	Adult Feeding:	1	Migration:	0

Banks of Channel (Stability) H = highly stable, S = stable, U = unstable
Preliminary Assessment 0 = no habitat present, 1 = poor, 2 = fair, 3 = good, 4 = excellent

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: 68.3 **Survey Date (d/m/y):** 16-08-01
Drainage Area (Km^2): **Survey Crew:** SLU,DN
Survey Distance (m) 200 **Aerial photo:** 3-9

A: Downstream				B:Upstream
N:	66	1	0.755	N:
W:	107	48	0.055	W:

Approx. Distance from Over-wintering Habitat (Km): 0.5
Temperature (^{o}C): 10.8,11.8 **Visibility:** clear
Channel Velocity (m/s): 0.4 **Conductivity (uS/cm):** 29
Current Flow Conditions: low **pH:** 7.9
Discharge estimate (m^3/s) 0.36 w=6.0,d=0.15

Barriers to Over-Wintering Habitat:
downstream there is a cascade, (boulder), but fish could go over it to get to the lake if they were in stream.

Weather:
sunny, 18^{3}C.

Hab Unit No.	Hab Type	Dist. fr start (m)	Length (m)	Slope (%)	Depth (m)		Width (m)		Bed Material					Pool Info			Fish Passage Barriers	
					Mean	Bank-full	Mean	Bank-full	Sand (%)	Gravel (%)	Cobble (%)	Boulder (%)	Bedrock (%)	Type	Depth (m) Max	Depth (m) Crest	Type	T/P
1	G	0	74	0.5	0.20	0.45	5.0	6.0	10	10	70	10						
2	P	74	6	0.0	0.50	0.60	1.7	2.2	70	30				S	0.70	0.05		
3	R	80	16	2.0	0.15	0.40	1.9	2.4		20	70	10						
4	G	96	70	1.0	0.20	0.40	2.2	3.0		10	70	20						
5	R	166	13	1.5	0.15	0.30	2.7	2.9		5	80	15						
6	G	179	21	0.5	0.20	0.25	2.5	2.7		15	80	5						
7																		
8																		
9																		
10																		
11																		
12																		
13																		
14																		
15																		
16																		
17																		
18																		
19																		
20																		

Flow Conditions H = High flow, M = Medium flow, L = Low flow

Habitat Unit Under bankfull conditions: 0 - 2.5 m = > 1 m^2, 2.5 - 5 m = > 2 m^2, 5 - 10 m = > 4 m^2, 10 -15 m = > 6 m^2, 15 -20 = > 8 m^2, > 20 m = > 10 m^2

Hab Type P = pool, G = glide, R = riffle, C = cascade, O = other

Dist. fr start distance from beginning of the survey to the beginning of the habitat unit being surveyed

Pool Type S = scour, D = dammed, U = unknown

Substrate Sand (silt, clay, fine organic< 2 mm), Gravel (2 - 64 mm), Cobble (64 - 256), Boulders (256 - 4000 mm), Bedrock (>4000 mm)

Fish Passage Barriers IF = Impassible waterfall

BF = Boulder Field, passage through the boulder arrangement is not possible for fish
D = dry channel, no stream flow
NC = no distinct channel, water drains over land
N = no barrier to fish passage through the habitat unit

T/P T = temporary, portion of open water season
P = Permanent, all year round

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: **68.3**
Survey Date (d/m/y): 16-08-01
Survey Crew: SLU,DN
Aerial photo: 3-9

Hab Unit No.	Banks of Channel				Instream Cover					Photos (Role #) (Photo #)
	L Bank Height (m)	R Bank Height (m)	L Bank Stab	R Bank Stab	Pool %	Boulder %	Instream Veg %	Overhang Veg %	Undercut Bank %	
1	0.30	0.30	S	S		10			5	R3-11,10
2	0.20	0.20	S	S			5			
3	0.30	0.40	S	S		10				
4	0.20	0.30	S	S		20			5	
5	0.25	0.25	S	S		15	5			
6	0.25	0.25	S	S		5	5			
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										

Comments:
Habitat unit 1 is a braided stream. Fish can't get over the downstream waterfall.

Preliminary Assessment

Spawning:	0	Rearing:	0	Over-wintering:	0	Adult Feeding:	0	Migration:	0

Banks of Channel (Stability) H = highly stable, S = stable, U = unstable
Preliminary Assessment 0 = no habitat present, 1 = poor, 2 = fair, 3 = good, 4 = excellent

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: 67.9		**Survey Date (d/m/y):** 16-08-01			**A: Downstream**					**B:Upstream**							
Drainage Area (Km^2):		**Survey Crew:** MM,GH			**N:**	66	2	0.175		**N:**	66	2	0.123				
Survey Distance (m) 202		**Aerial photo:** 14-23			**W:**	107	47	0.701		**W:**	107	47	0.479				
Approx. Distance from Over-wintering Habitat (Km):					**Barriers to Over-Wintering Habitat:**													
Temperature (^oC): 12.7		**Visibility:** clear			None within survey reach and none observed above or below.													
Channel Velocity (m/s): 0.28		**Conductivity (uS/cm):** 33																
Current Flow Conditions: m		**pH:** 6.6			**Weather:**													
Discharge estimate (m^3/s) 0.091		w=1.3,d=0.22,0.32,0.29,0.2,0.21			overcast, ~5°c, wind from east.													

Hab Unit No.	Hab Type	Dist. fr start (m)	Length (m)	Slope (%)	Depth (m)		Width (m)		Bed Material					Pool Info			Fish Passage Barriers	
					Mean	Bank-full	Mean	Bank-full	Sand (%)	Gravel (%)	Cobble (%)	Boulder (%)	Bedrock (%)	Type	Depth (m) Max	Depth (m) Crest	Type	T/P
1	R	0	6	0.5	0.14	0.30	1.1	1.1		30	65	5						
2	G	6	7	0.5	0.19	0.34	1.3	2.2		50	45	5						
3	R	13	22	1.0	0.18	0.33	2.5	2.5		30	40	30						
4	G	35	63	0.5	0.23	0.38	3.2	3.2	10	20	40	30						
5	R	98	10	0.5	0.14	0.28	2.7	2.7			100							
6	G	108	6	0.5	0.14	0.26	2.3	2.3		20	75	5						
7	R	114	50	2.0	0.15	0.30	1.0	1.0		50	50							
8	G	164	38	0.5	0.35	0.55	2.0	2.0		20	75	5						
9		202																
10																		
11																		
12																		
13																		
14																		
15																		
16																		
17																		
18																		
19																		
20																		

Flow Conditions H = High flow, M = Medium flow, L = Low flow

Habitat Unit Under bankfull conditions: 0 - 2.5 m = > 1 m^2, 2.5 - 5 m = > 2 m^2, 5 - 10 m = > 4 m^2, 10 -15 m = > 6 m^2, 15 -20 = > 8 m^2, > 20 m = > 10 m^2

Hab Type P = pool, G = glide, R = riffle, C = cascade, O = other

Dist. fr start distance from beginning of the survey to the beginning of the habitat unit being surveyed

Pool Type S = scour, D = dammed, U = unknown

Substrate Sand (silt, clay, fine organic< 2 mm), Gravel (2 - 64 mm), Cobble (64 - 256), Boulders (256 - 4000 mm), Bedrock (>4000 mm)

Fish Passage Barriers IF = Impassible waterfall

BF = Boulder Field, passage through the boulder arrangement is not possible for fish

D = dry channel, no stream flow

NC = no distinct channel, water drains over land

N = no barrier to fish passage through the habitat unit

T/P T = temporary, portion of open water season

P = Permanent, all year round

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: **67.9**
Survey Date (d/m/y): 16-08-01
Survey Crew: MM,GH
Aerial photo: 14-23

Hab Unit No.	Banks of Channel				Instream Cover					
	L Bank Height (m)	R Bank Height (m)	L Bank Stab	R Bank Stab	Pool %	Boulder %	Instream Veg %	Overhang Veg %	Undercut Bank %	Photos (Role #) (Photo #)
1	0.16	0.16	S	S		5	10	10		14-20
2	0.15	0.15	S	U		5	30	10		
3	0.15	0.15	S	S		30	10	10		
4	0.15	0.15	S	S		30	50	10		
5	0.19	0.14	S	S			50	5		
6	0.12	0.12	S	S		5	40			
7	0.15	0.15	S	S			25	10		
8	0.20	0.20	S	S		5		10		14-21,22
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										

Comments:
A narrow shallow stream, excellent grayling rearing and spawning, however the lack of fish indicates a potential barrier below the survey reach. Photo 14-20 looking downstream from point 0. Photo 14-21 looking upstream from 202 point. Photo 14-22 looking downstream from 202 point.

Preliminary Assessment

Spawning:	3	Rearing:	4	Over-wintering:	0	Adult Feeding:	1	Migration:	2

Banks of Channel (Stability) H = highly stable, S = stable, U = unstable
Preliminary Assessment 0 = no habitat present, 1 = poor, 2 = fair, 3 = good, 4 = excellent

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: 58.7	**Survey Date (d/m/y):** 16-08-01	**A: Downstream**				**B:Upstream**			
Drainage Area (Km²):	**Survey Crew:** MM, GH	**N:**	66	7	0.198	**N:**	66	7	0.192
Survey Distance (m) 200	**Aerial photo:** 14-28	**W:**	107	48	0.502	**W:**	107	48	0.754

Approx. Distance from Over-wintering Habitat (Km):

Barriers to Over-Wintering Habitat: Only upstrean at the boulder field

Temperature (°C): 11.5 **Visibility:** clear

Channel Velocity (m/s): 0.19 **Conductivity (uS/cm):** 27

Current Flow Conditions: low **pH:** 7.1

Weather: clear, sunny, ~10km/hr SE wind

Discharge estimate (m³/s) 0.059 w=2.6,d=0.1,0.13,0.12,0.13,0.12

Hab Unit No.	Hab Type	Dist. fr start (m)	Length (m)	Slope (%)	Depth (m) Mean	Depth (m) Bank-full	Width (m) Mean	Width (m) Bank-full	Bed Material Sand (%)	Gravel (%)	Cobble (%)	Boulder (%)	Bedrock (%)	Pool Info Type	Pool Info Depth (m) Max	Pool Info Depth (m) Crest	Fish Passage Barriers Type	Fish Passage Barriers T/P
1	G	0	29	0.5	0.13	0.27	3.0	3.0	5	70	10	15						
2	R	29	4	0.5	0.07	0.21	1.5	1.5		50	50	15						
3	G	33	11	0.5	0.15	0.25	2.6	4.0	40	40	10	10						
4	R	44	35	0.5	0.15	0.27	6.2	6.2	10	30	30	30						
5	G	79	37	0.5	0.14	0.26	8.1	8.1	10	50	20	20						
6	R	116	26	2.0	0.12	0.28	3.3	3.3			20	80						
7	BF	142	58	1.0	0.18	0.33	10.2	10.2				100					BF	P
8		200																
9																		
10																		
11																		
12																		
13																		
14																		
15																		
16																		
17																		
18																		
19																		
20																		

Flow Conditions H = High flow, M = Medium flow, L = Low flow

Habitat Unit Under bankfull conditions: 0 - 2.5 m = > 1 m^2, 2.5 - 5 m = > 2 m^2, 5 - 10 m = > 4 m^2, 10 -15 m = > 6 m^2, 15 -20 = > 8 m^2, > 20 m = > 10 m^2

Hab Type P = pool, G = glide, R = riffle, C = cascade, O = other, BF = boulder field

Dist. fr start distance from beginning of the survey to the beginning of the habitat unit being surveyed

Pool Type S = scour, D = dammed, U = unknown

Substrate Sand (silt, clay, fine organic< 2 mm), Gravel (2 - 64 mm), Cobble (64 - 256), Boulders (256 - 4000 mm), Bedrock (>4000 mm)

Fish Passage Barriers IF = Impassible waterfall

BF = Boulder Field, passage through the boulder arrangement is not possible for fish

D = dry channel, no stream flow

NC = no distinct channel, water drains over land

N = no barrier to fish passage through the habitat unit

T/P T = temporary, portion of open water season

P = Permanent, all year round

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: **58.7**
Survey Date (d/m/y): 16-08-01
Survey Crew: MM, GH
Aerial photo: 14-28

Hab Unit No.	Banks of Channel				Instream Cover					Photos (Role #) (Photo #)
	L Bank Height (m)	R Bank Height (m)	L Bank Stab	R Bank Stab	Pool %	Boulder %	Instream Veg %	Overhang Veg %	Undercut Bank %	
1	0.14	0.14	S	S		15	5	10		14-24
2	0.14	0.14	S	S		15	5	5		
3	0.10	0.10	S	S		10	5	5	5	
4	0.15	0.15	S	U		30	20	10		
5	0.12	0.12	S	S		20				14-25
6	0.16	0.16	U	S		80		5		
7			U	U		100				14-26
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										

Comments:
The survey reach began as a mixture of low-gradient riffles and glides quite shallow, then became a boulder garden, complete upstream barrier to fish migration. Photo 14-24 looking upstream from 0 point. Photo 14-25 looking downstream from the upstream point of the third glide. Photo 14-26 looking downstream from the 200 point.

Preliminary Assessment

Spawning:	2	Rearing:	2	Over-wintering:	0	Adult Feeding:	0	Migration:	0

Banks of Channel (Stability) H = highly stable, S = stable, U = unstable
Preliminary Assessment 0 = no habitat present, 1 = poor, 2 = fair, 3 = good, 4 = excellent

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: 52.0		**Survey Date (d/m/y):** 16-08-01			**A: Downstream**				**B:Upstream**								
Drainage Area (Km^2):		**Survey Crew:** SLU,DN			**N:**	66	10	0.696	**N:**	66	10	0.602					
Survey Distance (m) 200		**Aerial photo:** 3-5 looking d/s			**W:**	107	48	0.995	**W:**	107	48	0.695					
Approx. Distance from Over-wintering Habitat (Km):					**Barriers to Over-Wintering Habitat:**													
Temperature (^oC):		**Visibility:**			**Dry now if flowing it should be possible**													
Channel Velocity (m/s):		**Conductivity (uS/cm):**																
Current Flow Conditions:		**pH:**			**Weather:**													
Discharge estimate (m^3/s) 0					**sunny, 20°c, windy**													

Hab Unit No.	Hab Type	Dist. fr start (m)	Length (m)	Slope (%)	Depth (m)		Width (m)		Bed Material					Pool Info			Fish Passage Barriers	
					Mean	Bank-full	Mean	Bank-full	Sand (%)	Gravel (%)	Cobble (%)	Boulder (%)	Bedrock (%)	Type	Depth (m) Max	Depth (m) Crest	Type	T/P
1	BG	0	200	0.5	0.00	0.30	0.0	50.0			60	40					D	T
2																		
3																		
4																		
5																		
6																		
7																		
8																		
9																		
10																		
11																		
12																		
13																		
14																		
15																		
16																		
17																		
18																		
19																		
20																		

Flow Conditions H = High flow, M = Medium flow, L = Low flow

Habitat Unit Under bankfull conditions: 0 - 2.5 m = > 1 m^2, 2.5 - 5 m = > 2 m^2, 5 - 10 m = > 4 m^2, 10 -15 m = > 6 m^2, 15 -20 = > 8 m^2, > 20 m = > 10 m^2

Hab Type P = pool, G = glide, R = riffle, C = cascade, O = other, BG = boulder glide

Dist. fr start distance from beginning of the survey to the beginning of the habitat unit being surveyed

Pool Type S = scour, D = dammed, U = unknown

Substrate Sand (silt, clay, fine organic< 2 mm), Gravel (2 - 64 mm), Cobble (64 - 256), Boulders (256 - 4000 mm), Bedrock (>4000 mm)

Fish Passage Barriers IF = Impassible waterfall

BF = Boulder Field, passage through the boulder arrangement is not possible for fish

D = dry channel, no stream flow

NC = no distinct channel, water drains over land

N = no barrier to fish passage through the habitat unit

T/P T = temporary, portion of open water season

P = Permanent, all year round

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: **52**
Survey Date (d/m/y): 16-08-01
Survey Crew: SLU,DN
Aerial photo: looking d/s

Hab Unit No.	Banks of Channel				Instream Cover					Photos (Role #) (Photo #)
	L Bank Height (m)	R Bank Height (m)	L Bank Stab	R Bank Stab	Pool %	Boulder %	Instream Veg %	Overhang Veg %	Undercut Bank %	
1	0.20	0.30	S	S		40				
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										

Comments:

Preliminary Assessment

Spawning:	1	Rearing:	1	Over-wintering:	0	Adult Feeding:	0	Migration:	1

Banks of Channel (Stability) H = highly stable, S = stable, U = unstable
Preliminary Assessment 0 = no habitat present, 1 = poor, 2 = fair, 3 = good, 4 = excellent

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: 49.7		**Survey Date (d/m/y):** 16-08-01			**A: Downstream**				**B:Upstream**								
Drainage Area (Km^2):		**Survey Crew:** MM,GH			**N:**	66	11	0.931	**N:**	66	11	0.861					
Survey Distance (m) 200		**Aerial photo:** 6-5			**W:**	107	49	0.194	**W:**	107	49	0.032					
Approx. Distance from Over-wintering Habitat (Km):					**Barriers to Over-Wintering Habitat:**													
Temperature (^{o}C): 15.6		**Visibility:** clear			**none if the lake is overwintering habitat**													
Channel Velocity (m/s): na		**Conductivity (uS/cm):** 29																
Current Flow Conditions: I		**pH:** 7.2			**Weather:**													
Discharge estimate (m^3/s) na					**clear, sunny,~20 km/hr SE wind**													

Hab Unit No.	Hab Type	Dist. fr start (m)	Length (m)	Slope (%)	Depth (m)		Width (m)		Bed Material					Pool Info			Fish Passage Barriers	
					Mean	Bank-full	Mean	Bank-full	Sand (%)	Gravel (%)	Cobble (%)	Boulder (%)	Bedrock (%)	Type	Depth (m) Max	Depth (m) Crest	Type	T/P
1	R	0	63	1.5	0.17	0.36	2.3	2.3		30	50	20						
2	G	63	38	1.0	0.24	0.47	2.0	2.0		30	50	20						
3	R	101	13	0.5	0.18	0.37	2.6	2.6		30	50	20						
4	G	114	28	0.5	0.23	0.43	6.2	6.2		30	50	20						
5	BF	142	48	0.5	0.00	0.00					20	80					BF	P
6		200																
7																		
8																		
9																		
10																		
11																		
12																		
13																		
14																		
15																		
16																		
17																		
18																		
19																		
20																		

Flow Conditions H = High flow, M = Medium flow, L = Low flow

Habitat Unit Under bankfull conditions: 0 - 2.5 m = > 1 m^2, 2.5 - 5 m = > 2 m^2, 5 - 10 m = > 4 m^2, 10 -15 m = > 6 m^2, 15 -20 = > 8 m^2, > 20 m = > 10 m^2

Hab Type P = pool, G = glide, R = riffle, C = cascade, O = other

Dist. fr start distance from beginning of the survey to the beginning of the habitat unit being surveyed

Pool Type S = scour, D = dammed, U = unknown

Substrate Sand (silt, clay, fine organic< 2 mm), Gravel (2 - 64 mm), Cobble (64 - 256), Boulders (256 - 4000 mm), Bedrock (>4000 mm)

Fish Passage Barriers IF = Impassible waterfall

BF = Boulder Field, passage through the boulder arrangement is not possible for fish

D = dry channel, no stream flow

NC = no distinct channel, water drains over land

N = no barrier to fish passage through the habitat unit

T/P T = temporary, portion of open water season

P = Permanent, all year round

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: **49.7**
Survey Date (d/m/y): 16-08-01
Survey Crew: MM,GH
Aerial photo: 6-5

Hab Unit No.	Banks of Channel				Instream Cover					
	L Bank Height (m)	R Bank Height (m)	L Bank Stab	R Bank Stab	Pool %	Boulder %	Instream Veg %	Overhang Veg %	Undercut Bank %	Photos (Role #) (Photo #)
1	0.20	0.20	U	U		20		10	10	6-1
2	0.24	0.24	U	U		20		10	10	
3	0.19	0.19	U	U		20		10	10	
4			U	U		100				6-2
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										

Comments:
Outlet from lake has multiple channels, main channel measured. Total wodth of all channelscombined was 18.0,13.3,15.3,17.3, including all hummocks. Very low water levels made it difficult to determine widths of individual channels or total widths. Note: depths not possible to measure in boulder field because no water could be seen. Velocity could not be measured due to very low flows and broken up nature of the channels. Photo 6-1 looking downstream from 0 point at edge of lake, photo 6-2 looking upstream from 200 point at edge of lake, photo 6-3 looking upstream from 50 on a hill close to road route.

Preliminary Assessment

Spawning:	1	Rearing:	2	Over-wintering:	0	Adult Feeding:	0	Migration:	0

Banks of Channel (Stability) H = highly stable, S = stable, U = unstable
Preliminary Assessment 0 = no habitat present, 1 = poor, 2 = fair, 3 = good, 4 = excellent

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: 44.5		**Survey Date (d/m/y):** 16-08-01			**A: Downstream**				**B:Upstream**								
Drainage Area (Km^2):		**Survey Crew:** SLU,DN			**N:**	66	14	0.578	**N:**	66	14	0.535					
Survey Distance (m) 200		**Aerial photo:**			**W:**	107	48	0.165	**W:**	107	47	0.955					
Approx. Distance from Over-wintering Habitat (Km): 0.1					**Barriers to Over-Wintering Habitat:**												
Temperature (^{o}C): 13.3,12.8		**Visibility:** clear			none												
Channel Velocity (m/s): 0.25		**Conductivity (uS/cm):** 35															
Current Flow Conditions:		**pH:** 8			**Weather:**												
Discharge estimate (m^3/s) 0.041	w=1.1,d=0.15				sunny, 20° c, windy scattered clouds.												

Hab Unit No.	Hab Type	Dist. fr start (m)	Length (m)	Slope (%)	Depth (m)		Width (m)		Bed Material					Pool Info			Fish Passage Barriers	
					Mean	Bank-full	Mean	Bank-full	Sand (%)	Gravel (%)	Cobble (%)	Boulder (%)	Bedrock (%)	Type	Depth (m) Max	Depth (m) Crest	Type	T/P
1	G	0	92	0.5	0.20	0.35	3.0	4.0		20	70	10						
2	BG	92	108	0.3	0.20	0.35	35.0	50.0			20	80						
3																		
4																		
5																		
6																		
7																		
8																		
9																		
10																		
11																		
12																		
13																		
14																		
15																		
16																		
17																		
18																		
19																		
20																		

Flow Conditions H = High flow, M = Medium flow, L = Low flow

Habitat Unit Under bankfull conditions: 0 - 2.5 m = > 1 m^2, 2.5 - 5 m = > 2 m^2, 5 - 10 m = > 4 m^2, 10 -15 m = > 6 m^2, 15 -20 = > 8 m^2, > 20 m = > 10 m^2

Hab Type P = pool, G = glide, R = riffle, C = cascade, O = other, BG = boulder glide

Dist. fr start distance from beginning of the survey to the beginning of the habitat unit being surveyed

Pool Type S = scour, D = dammed, U = unknown

Substrate Sand (silt, clay, fine organic< 2 mm), Gravel (2 - 64 mm), Cobble (64 - 256), Boulders (256 - 4000 mm), Bedrock (>4000 mm)

Fish Passage Barriers IF = Impassible waterfall

BF = Boulder Field, passage through the boulder arrangement is not possible for fish

D = dry channel, no stream flow

NC = no distinct channel, water drains over land

N = no barrier to fish passage through the habitat unit

T/P T = temporary, portion of open water season

P = Permanent, all year round

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: **44.5**
Survey Date (d/m/y): 16-08-01
Survey Crew: SLU,DN
Aerial photo: 0

Hab Unit No.	Banks of Channel				Instream Cover					Photos (Role #) (Photo #)
	L Bank Height (m)	R Bank Height (m)	L Bank Stab	R Bank Stab	Pool %	Boulder %	Instream Veg %	Overhang Veg %	Undercut Bank %	
1	0.20	0.20	S	S		10				3-6
2	0.10	0.10	S	S		80				
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										

Comments:
Upstream of veg-glide the wetted width is so wide that no flow is existant. Photo 3-6 glide through vegetated area, habitat unit 2 through boulder field.

Preliminary Assessment

Spawning:	1	Rearing:	1	Over-wintering:	0	Adult Feeding:	1	Migration:	0

Banks of Channel (Stability) H = highly stable, S = stable, U = unstable
Preliminary Assessment 0 = no habitat present, 1 = poor, 2 = fair, 3 = good, 4 = excellent

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: 43.6 **Survey Date (d/m/y):** 17-08-01
Drainage Area (Km^2): **Survey Crew:** SLU,DN
Survey Distance (m) 100 **Aerial photo:** 3-3

A: Downstream				B:Upstream			
N:	66	15	0.209	N:	66	15	0.217
W:	107	48	0.076	W:	107	48	0.189

Approx. Distance from Over-wintering Habitat (Km): 0.1
Temperature (^{o}C): 10.4,9.8 **Visibility:**
Channel Velocity (m/s): 0 **Conductivity (uS/cm):** 20.4
Current Flow Conditions: low **pH:** 8.8
Discharge estimate (m^3/s) 0

Barriers to Over-Wintering Habitat:
Stream is dry therefore a barrier, but during freshet the flow would be high enough for migration between lakes.

Weather:
overcast, windy, 10°C.

Hab Unit No.	Hab Type	Dist. fr start (m)	Length (m)	Slope (%)	Depth (m)		Width (m)		Bed Material					Pool Info			Fish Passage Barriers	
					Mean	Bank-full	Mean	Bank-full	Sand (%)	Gravel (%)	Cobble (%)	Boulder (%)	Bedrock (%)	Type	Depth (m) Max	Depth (m) Crest	Type	T/P
1	BG	0	100	0.1	0.00	0.40	0.0	13.0			20	80					D	T
2																		
3																		
4																		
5																		
6																		
7																		
8																		
9																		
10																		
11																		
12																		
13																		
14																		
15																		
16																		
17																		
18																		
19																		
20																		

Flow Conditions H = High flow, M = Medium flow, L = Low flow

Habitat Unit Under bankfull conditions: 0 - 2.5 m = > 1 m^2, 2.5 - 5 m = > 2 m^2, 5 - 10 m = > 4 m^2, 10 -15 m = > 6 m^2, 15 -20 = > 8 m^2, > 20 m = > 10 m^2

Hab Type P = pool, G = glide, R = riffle, C = cascade, O = other, BG = boulder glide

Dist. fr start distance from beginning of the survey to the beginning of the habitat unit being surveyed

Pool Type S = scour, D = dammed, U = unknown

Substrate Sand (silt, clay, fine organic< 2 mm), Gravel (2 - 64 mm), Cobble (64 - 256), Boulders (256 - 4000 mm), Bedrock (>4000 mm)

Fish Passage Barriers IF = Impassible waterfall

BF = Boulder Field, passage through the boulder arrangement is not possible for fish
D = dry channel, no stream flow
NC = no distinct channel, water drains over land
N = no barrier to fish passage through the habitat unit

T/P T = temporary, portion of open water season
P = Permanent, all year round

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: **43.6**
Survey Date (d/m/y): 17-08-01
Survey Crew: SLU,DN
Aerial photo: 3-3

Hab Unit No.	Banks of Channel				Instream Cover					Photos (Role #) (Photo #)
	L Bank Height (m)	R Bank Height (m)	L Bank Stab	R Bank Stab	Pool %	Boulder %	Instream Veg %	Overhang Veg %	Undercut Bank %	
1	0.40	0.40	S	S		80				3-2
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										

Comments:
Habitat is a braided boulder glide for most sof the 100m. Stream dry, took took pH, temp and conductivity measurements from the upstream lake.

Preliminary Assessment

Spawning:	1	Rearing:	1	Over-wintering:	0	Adult Feeding:	0	Migration:	1

Banks of Channel (Stability) H = highly stable, S = stable, U = unstable
Preliminary Assessment 0 = no habitat present, 1 = poor, 2 = fair, 3 = good, 4 = excellent

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: 42.3	**Survey Date (d/m/y):** 16-08-01	**A: Downstream**				**B:Upstream**			
Drainage Area (Km^2):	**Survey Crew:** SLU,DN	**N:**	66	15	0.724	**N:**	66	15	0.750
Survey Distance (m) 155	**Aerial photo:**	**W:**	107	47	0.812	**W:**	107	47	0.992

Approx. Distance from Over-wintering Habitat (Km): 0.5	**Barriers to Over-Wintering Habitat:**
Temperature (^{o}C): 12.7,13.3 **Visibility:** clear	***check to see if fish can get to second downstream lake.**
Channel Velocity (m/s): 0.5 **Conductivity (uS/cm):** 21	
Current Flow Conditions: low **pH:** 7.8	**Weather:**
Discharge estimate (m^3/s) 0.01 **d=0.1,w=0.2**	**sunny, windy, 20 °c.**

Hab Unit No.	Hab Type	Dist. fr start (m)	Length (m)	Slope (%)	Depth (m)		Width (m)		Bed Material					Pool Info			Fish Passage Barriers	
					Mean	Bank-full	Mean	Bank-full	Sand (%)	Gravel (%)	Cobble (%)	Boulder (%)	Bedrock (%)	Type	Depth (m) Max	Depth (m) Crest	Type	T/P
1	G	0	108	0.5	0.20	0.30	3.0	7.0			65	35					SF	T
2	R	108	11	1.5	0.10	0.30	1.0	3.8			70	30						
3	G	119	22	0.5	0.30	0.55	2.4	4.4		30	35	35						
4	R	141	14	2.0	0.15	0.25	2.1	4.2		40	40	20						
5		155																
6																		
7																		
8																		
9																		
10																		
11																		
12																		
13																		
14																		
15																		
16																		
17																		
18																		
19																		
20																		

Flow Conditions H = High flow, M = Medium flow, L = Low flow

Habitat Unit Under bankfull conditions: 0 - 2.5 m = > 1 m^2, 2.5 - 5 m = > 2 m^2, 5 - 10 m = > 4 m^2, 10 -15 m = > 6 m^2, 15 -20 = > 8 m^2, > 20 m = > 10 m^2

Hab Type P = pool, G = glide, R = riffle, C = cascade, O = other

Dist. fr start distance from beginning of the survey to the beginning of the habitat unit being surveyed

Pool Type S = scour, D = dammed, U = unknown

Substrate Sand (silt, clay, fine organic< 2 mm), Gravel (2 - 64 mm), Cobble (64 - 256), Boulders (256 - 4000 mm), Bedrock (>4000 mm)

Fish Passage Barriers IF = Impassible waterfall, SF = surface flow

BF = Boulder Field, passage through the boulder arrangement is not possible for fish

D = dry channel, no stream flow

NC = no distinct channel, water drains over land

N = no barrier to fish passage through the habitat unit

T/P T = temporary, portion of open water season

P = Permanent, all year round

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: **42.3**
Survey Date (d/m/y): 16-08-01
Survey Crew: SLU,DN
Aerial photo: 0

Hab Unit No.	Banks of Channel				Instream Cover					
	L Bank Height (m)	R Bank Height (m)	L Bank Stab	R Bank Stab	Pool %	Boulder %	Instream Veg %	Overhang Veg %	Undercut Bank %	Photos (Role #) (Photo #)
1	0.60	0.60	S	S		35				
2	0.40	0.20	S	S		30				
3	1.20	0.40	HS	S		35				
4	1.00	0.25	S	S		20				
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										

Comments:
Habitat unit #1 is a braided cobble/ boulder field with islands in between, no defined unit so called it glide because of low slope overall. SF= subsurface flow.

Preliminary Assessment

Spawning:	1	Rearing:	1	Over-wintering:	0	Adult Feeding:	0	Migration:	2

Banks of Channel (Stability) H = highly stable, S = stable, U = unstable
Preliminary Assessment 0 = no habitat present, 1 = poor, 2 = fair, 3 = good, 4 = excellent

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: 36.6		**Survey Date (d/m/y):** 17-08-01			**A: Downstream**					**B:Upstream**							
Drainage Area (Km^2):		**Survey Crew:** SLU, DN			**N:**	66	17	0.928		**N:**	66	17	0.994				
Survey Distance (m) 200		**Aerial photo:** 3-1			**W:**	107	44	0.107		**W:**	107	44	0.233				
Approx. Distance from Over-wintering Habitat (Km): 0.4					**Barriers to Over-Wintering Habitat:**													
Temperature (^{o}C): 10.8,10.3		**Visibility:** clear			no flow and therefore a barrier but am not certain if upstream(0.4km) lake is overwintering habitat.													
Channel Velocity (m/s): 0		**Conductivity (uS/cm):** 144																
Current Flow Conditions: low		**pH:** 9.1			**Weather:**													
Discharge estimate (m^3/s) 0					**overcast, windy, 5°c**													

Hab Unit No.	Hab Type	Dist. fr start (m)	Length (m)	Slope (%)	Depth (m)		Width (m)		Bed Material					Pool Info			Fish Passage Barriers	
					Mean	Bank-full	Mean	Bank-full	Sand (%)	Gravel (%)	Cobble (%)	Boulder (%)	Bedrock (%)	Type	Depth (m) Max	Depth (m) Crest	Type	T/P
1	BG	0	22	0.5	0.00	0.50	0.0	6.5		5	15	80					D	T
2	R	22	39	1.5	0.00	0.25	0.0	6.2		30	60	10					D	T
3	G	61	15	0.5	0.00	0.40	0.0	6.8		25	70	5					D	T
4	P	76	22	0.0	0.25	0.55	4.5	7.0			90	10		U	0.65	0.05		
5	BG	98	102	0.5	0.00	0.30	0.0	29.0		5	80	15					D	T
6																		
7																		
8																		
9																		
10																		
11																		
12																		
13																		
14																		
15																		
16																		
17																		
18																		
19																		
20																		

Flow Conditions H = High flow, M = Medium flow, L = Low flow

Habitat Unit Under bankfull conditions: 0 - 2.5 m = > 1 m^2, 2.5 - 5 m = > 2 m^2, 5 - 10 m = > 4 m^2, 10 -15 m = > 6 m^2, 15 -20 = > 8 m^2, > 20 m = > 10 m^2

Hab Type P = pool, G = glide, R = riffle, C = cascade, O = other, BG = boulder glide

Dist. fr start distance from beginning of the survey to the beginning of the habitat unit being surveyed

Pool Type S = scour, D = dammed, U = unknown

Substrate Sand (silt, clay, fine organic< 2 mm), Gravel (2 - 64 mm), Cobble (64 - 256), Boulders (256 - 4000 mm), Bedrock (>4000 mm)

Fish Passage Barriers IF = Impassible waterfall

BF = Boulder Field, passage through the boulder arrangement is not possible for fish

D = dry channel, no stream flow

NC = no distinct channel, water drains over land

N = no barrier to fish passage through the habitat unit

T/P T = temporary, portion of open water season

P = Permanent, all year round

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: **36.6**
Survey Date (d/m/y): 17-08-01
Survey Crew: SLU, DN
Aerial photo: 3-1

Hab Unit No.	Banks of Channel				Instream Cover					Photos (Role #) (Photo #)
	L Bank Height (m)	R Bank Height (m)	L Bank Stab	R Bank Stab	Pool %	Boulder %	Instream Veg %	Overhang Veg %	Undercut Bank %	
1	0.40	0.60	S	S		80				
2	0.30	0.25	S	S		10				R17-27
3	0.30	0.40	S	S		5				
4	0.30	0.40	S	S	5	10				
5	0.20	0.25	S	S		15				
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										

Comments:
Temperature, conductivity and pH were taken from residual pools. BG= boulder glide, the channel is braided.

Preliminary Assessment

Spawning:	1	Rearing:	1	Over-wintering:	0	Adult Feeding:	0	Migration:	1

Banks of Channel (Stability) H = highly stable, S = stable, U = unstable
Preliminary Assessment 0 = no habitat present, 1 = poor, 2 = fair, 3 = good, 4 = excellent

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: 35.9		**Survey Date (d/m/y):** 18-08-01				**A: Downstream**						**B:Upstream**							
Drainage Area (Km^2):		**Survey Crew:** SLU, DN				**N:**	66	18	0.507			**N:**	66	18	0.421				
Survey Distance (m) 200		**Aerial photo:** 17-26				**W:**	107	43	0.326			**W:**	107	43	0.174				
Approx. Distance from Over-wintering Habitat (Km): 0.3						**Barriers to Over-Wintering Habitat:** no upstream barriers if the upstream lake is overwintering, 300m downstream of survey is an impassible waterfall.														
Temperature (^{o}C): 7.4,8.1		**Visibility:** clear																	
Channel Velocity (m/s): 0.25		**Conductivity (uS/cm):** 53																	
Current Flow Conditions:		**pH:** 8.9				**Weather:** overcast, light rain.													
Discharge estimate (m^3/s) 0.205 w=8.2,d=0.1																			

Hab Unit No.	Hab Type	Dist. fr start (m)	Length (m)	Slope (%)	Depth (m)		Width (m)		Bed Material					Pool Info			Fish Passage Barriers	
					Mean	Bank-full	Mean	Bank-full	Sand (%)	Gravel (%)	Cobble (%)	Boulder (%)	Bedrock (%)	Type	Depth (m) Max	Depth (m) Crest	Type	T/P
1	G	0	200	0.5	0.15	0.25	32.0	34.0		5	70	25						
2																		
3																		
4																		
5																		
6																		
7																		
8																		
9																		
10																		
11																		
12																		
13																		
14																		
15																		
16																		
17																		
18																		
19																		
20																		

Flow Conditions H = High flow, M = Medium flow, L = Low flow

Habitat Unit Under bankfull conditions: 0 - 2.5 m = > 1 m^2, 2.5 - 5 m = > 2 m^2, 5 - 10 m = > 4 m^2, 10 -15 m = > 6 m^2, 15 -20 = > 8 m^2, > 20 m = > 10 m^2

Hab Type P = pool, G = glide, R = riffle, C = cascade, O = other

Dist. fr start distance from beginning of the survey to the beginning of the habitat unit being surveyed

Pool Type S = scour, D = dammed, U = unknown

Substrate Sand (silt, clay, fine organic< 2 mm), Gravel (2 - 64 mm), Cobble (64 - 256), Boulders (256 - 4000 mm), Bedrock (>4000 mm)

Fish Passage Barriers IF = Impassible waterfall

BF = Boulder Field, passage through the boulder arrangement is not possible for fish

D = dry channel, no stream flow

NC = no distinct channel, water drains over land

N = no barrier to fish passage through the habitat unit

T/P T = temporary, portion of open water season

P = Permanent, all year round

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: **35.9**
Survey Date (d/m/y): 18-08-01
Survey Crew: SLU, DN
Aerial photo: 17-26

Hab Unit No.	Banks of Channel				Instream Cover					Photos (Role #) (Photo #)
	L Bank Height (m)	R Bank Height (m)	L Bank Stab	R Bank Stab	Pool %	Boulder %	Instream Veg %	Overhang Veg %	Undercut Bank %	
1	0.20	0.20	S	S		25				17-24
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										

Comments:
R17-25 downstream of waterfall.

Preliminary Assessment

Spawning:	1	Rearing:	1	Over-wintering:	0	Adult Feeding:	0	Migration:	1

Banks of Channel (Stability) H = highly stable, S = stable, U = unstable
Preliminary Assessment 0 = no habitat present, 1 = poor, 2 = fair, 3 = good, 4 = excellent

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: 34.8	**Survey Date (d/m/y):** 18-08-01	**A: Downstream**			**B:Upstream**
Drainage Area (Km^2):	**Survey Crew:** SLU, DN	**N:** 66	19	0.012	**N:**
Survey Distance (m) 200	**Aerial photo:**	**W:** 107	42	0.827	**W:**

Approx. Distance from Over-wintering Habitat (Km): 1.8	**Barriers to Over-Wintering Habitat:**
Temperature (^oC): 8.8,8.2	Upstream is an impassible waterfall, no barriers to downstream larger lake
Visibility: clear	
Channel Velocity (m/s):	**Conductivity (uS/cm):** 81
Current Flow Conditions: low	**pH:** 9
Discharge estimate (m^3/s) 0.426	**Weather:** light rain, overcast, 5°c.

Hab Unit No.	Hab Type	Dist. fr start (m)	Length (m)	Slope (%)	Depth (m)		Width (m)		Bed Material					Pool Info			Fish Passage Barriers	
					Mean	Bank-full	Mean	Bank-full	Sand (%)	Gravel (%)	Cobble (%)	Boulder (%)	Bedrock (%)	Type	Depth (m) Max	Depth (m) Crest	Type	T/P
1	R	0	25	1.5	0.20	0.40	7.3	7.5		35	50	15						
2	G	25	5	0.5	0.25	0.45	14.0	20.0		50	40	10						
3	R	30	13	1.5	0.15	0.25	14.2	28.0		35	40	25						
4	G	43	20	0.5	0.20	0.40	9.5	17.5		85	15							
5	R	63	10	1.5	0.10	0.25	11.0	14.0		20	70	10						
6	G	73	18	0.5	0.20	0.40	21.0	25.0		40	40	20						
7	R	91	42	1.5	0.10	0.15	13.5	18.0		80	20							
8	G	133	17	0.5	0.25	0.40	5.8	10.0		85	15							
9	R	150	44	1.5	0.20	0.40	3.7	6.2		50	50							
10	G	194	6	0.5	0.20	0.45	5.6	6.1		50	50							
11																		
12																		
13																		
14																		
15																		
16																		
17																		
18																		
19																		
20																		

Flow Conditions H = High flow, M = Medium flow, L = Low flow

Habitat Unit Under bankfull conditions: 0 - 2.5 m = > 1 m^2, 2.5 - 5 m = > 2 m^2, 5 - 10 m = > 4 m^2, 10 -15 m = > 6 m^2, 15 -20 = > 8 m^2, > 20 m = > 10 m^2

Hab Type P = pool, G = glide, R = riffle, C = cascade, O = other

Dist. fr start distance from beginning of the survey to the beginning of the habitat unit being surveyed

Pool Type S = scour, D = dammed, U = unknown

Substrate Sand (silt, clay, fine organic< 2 mm), Gravel (2 - 64 mm), Cobble (64 - 256), Boulders (256 - 4000 mm), Bedrock (>4000 mm)

Fish Passage Barriers IF = Impassible waterfall

BF = Boulder Field, passage through the boulder arrangement is not possible for fish

D = dry channel, no stream flow

NC = no distinct channel, water drains over land

N = no barrier to fish passage through the habitat unit

T/P T = temporary, portion of open water season

P = Permanent, all year round

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: **34.8**
Survey Date (d/m/y): 18-08-01
Survey Crew: SLU, DN
Aerial photo: 0

Hab Unit No.	Banks of Channel				Instream Cover					
	L Bank Height (m)	R Bank Height (m)	L Bank Stab	R Bank Stab	Pool %	Boulder %	Instream Veg %	Overhang Veg %	Undercut Bank %	Photos (Role #) (Photo #)
1	0.30	0.20	S	S		15				
2	0.40	0.30	S	S		10				
3	0.40	0.20	S	S		25				
4	0.30	0.25	S	S						
5	0.40	0.15	S	S		10				
6	0.40	0.25	S	S		20	5			
7	0.10	0.10	S	S			20	10		17-20
8	0.15	0.35	S	S						
9	0.30	0.45	S	S						
10	0.30	0.40	S	S					5	17-21
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										

Comments:
Photo 17-22 taken from behind the pond,17-21 taken at end of survey looking downstream, 17-20 taken at the middle of the survey, looking downstream.

Preliminary Assessment

Spawning: **Rearing:** **Over-wintering:** **Adult Feeding:** **Migration:**

Banks of Channel (Stability) H = highly stable, S = stable, U = unstable
Preliminary Assessment 0 = no habitat present, 1 = poor, 2 = fair, 3 = good, 4 = excellent

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: 33.8		**Survey Date (d/m/y):** 18-08-01			**A: Downstream**				**B:Upstream**									
Drainage Area (Km^2):		**Survey Crew:** SLU,DN			**N:**	66	19	0.507	**N:**	66	19	0.499						
Survey Distance (m) 91		**Aerial photo:** 17-12,13			**W:**	107	42	0.252	**W:**	107	42	0.363						
Approx. Distance from Over-wintering Habitat (Km): 0					**Barriers to Over-Wintering Habitat:**													
Temperature (^oC): 8.5,9.2		**Visibility:** clear			**Glide upstream of downstream lake is dry, some flow subsurface.**													
Channel Velocity (m/s): 0.39		**Conductivity (uS/cm):** 134																
Current Flow Conditions:		**pH:** 9.4			**Weather:**													
Discharge estimate (m^3/s) 0.047 w=1.2,d=0.1					**overcast, 6°c.**													

Hab Unit No.	Hab Type	Dist. fr start (m)	Length (m)	Slope (%)	Depth (m)		Width (m)		Bed Material					Pool Info			Fish Passage Barriers	
					Mean	Bank-full	Mean	Bank-full	Sand (%)	Gravel (%)	Cobble (%)	Boulder (%)	Bedrock (%)	Type	Depth (m) Max	Depth (m) Crest	Type	T/P
1	G	0	91	0.5	0.20	0.45	3.7	9.9		30	60	10					D	T
2																		
3																		
4																		
5																		
6																		
7																		
8																		
9																		
10																		
11																		
12																		
13																		
14																		
15																		
16																		
17																		
18																		
19																		
20																		

Flow Conditions H = High flow, M = Medium flow, L = Low flow

Habitat Unit Under bankfull conditions: 0 - 2.5 m = > 1 m^2, 2.5 - 5 m = > 2 m^2, 5 - 10 m = > 4 m^2, 10 -15 m = > 6 m^2, 15 -20 = > 8 m^2, > 20 m = > 10 m^2

Hab Type P = pool, G = glide, R = riffle, C = cascade, O = other

Dist. fr start distance from beginning of the survey to the beginning of the habitat unit being surveyed

Pool Type S = scour, D = dammed, U = unknown

Substrate Sand (silt, clay, fine organic< 2 mm), Gravel (2 - 64 mm), Cobble (64 - 256), Boulders (256 - 4000 mm), Bedrock (>4000 mm)

Fish Passage Barriers IF = Impassible waterfall

BF = Boulder Field, passage through the boulder arrangement is not possible for fish

D = dry channel, no stream flow

NC = no distinct channel, water drains over land

N = no barrier to fish passage through the habitat unit

T/P T = temporary, portion of open water season

P = Permanent, all year round

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: **33.8**
Survey Date (d/m/y): 18-08-01
Survey Crew: SLU,DN
Aerial photo: 17-12,13

Hab Unit No.	Banks of Channel				Instream Cover					Photos (Role #) (Photo #)
	L Bank Height (m)	R Bank Height (m)	L Bank Stab	R Bank Stab	Pool %	Boulder %	Instream Veg %	Overhang Veg %	Undercut Bank %	
1	0.25	0.30	S	S		10				
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										

Comments:
While waiting for the helicopter we caught NNST and SLSC with our nets from the shore of the downstream lake. Photo17-13 furthest downstream, 17-12 halfway up the survey section. Only surface flow in upstream 15m of glide. No permanent fish barrier upstream of pond for at least 0.8 Km.

Preliminary Assessment

Spawning:	1	Rearing:	1	Over-wintering:	0	Adult Feeding:	1	Migration:	1

Banks of Channel (Stability) H = highly stable, S = stable, U = unstable
Preliminary Assessment 0 = no habitat present, 1 = poor, 2 = fair, 3 = good, 4 = excellent

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: 33.7		**Survey Date (d/m/y):** 20-08-01			**A: Downstream**				**B:Upstream**									
Drainage Area (Km^2):		**Survey Crew:** SLU,MM			**N:**	66	19	0.483	**N:**	66	19	0.564						
Survey Distance (m) 146		**Aerial photo:**			**W:**	107	42	0.152	**W:**	107	42	0.303						
Approx. Distance from Over-wintering Habitat (Km): 0.1					**Barriers to Over-Wintering Habitat:**													
Temperature (^{o}C): 9.2		**Visibility:** clear			**temporary due to low flow conditions.**													
Channel Velocity (m/s): 0.15		**Conductivity (uS/cm):** 185																
Current Flow Conditions:		**pH:** 9.4			**Weather:**													
Discharge estimate (m^3/s) 0.019	**d=0.05,w=2.5**				**overcast, windy 6°C.**													

Hab Unit No.	Hab Type	Dist. fr start (m)	Length (m)	Slope (%)	Depth (m)		Width (m)		Bed Material					Pool Info			Fish Passage Barriers	
					Mean	Bank-full	Mean	Bank-full	Sand (%)	Gravel (%)	Cobble (%)	Boulder (%)	Bedrock (%)	Type	Depth (m) Max	Depth (m) Crest	Type	T/P
1	G	0	30	0.5	0.20	0.45	14.0	12.6			20	80						
2	R	30	25	2.0	0.05	0.25	16.3	19.4			20	80						
3	G	55	91	0.5	0.13	0.50	31.0	49.0		15	20	65						
4		146																
5																		
6																		
7																		
8																		
9																		
10																		
11																		
12																		
13																		
14																		
15																		
16																		
17																		
18																		
19																		
20																		

Flow Conditions H = High flow, M = Medium flow, L = Low flow

Habitat Unit Under bankfull conditions: 0 - 2.5 m = > 1 m^2, 2.5 - 5 m = > 2 m^2, 5 - 10 m = > 4 m^2, 10 -15 m = > 6 m^2, 15 -20 = > 8 m^2, > 20 m = > 10 m^2

Hab Type P = pool, G = glide, R = riffle, C = cascade, O = other

Dist. fr start distance from beginning of the survey to the beginning of the habitat unit being surveyed

Pool Type S = scour, D = dammed, U = unknown

Substrate Sand (silt, clay, fine organic< 2 mm), Gravel (2 - 64 mm), Cobble (64 - 256), Boulders (256 - 4000 mm), Bedrock (>4000 mm)

Fish Passage Barriers IF = Impassible waterfall

BF = Boulder Field, passage through the boulder arrangement is not possible for fish

D = dry channel, no stream flow

NC = no distinct channel, water drains over land

N = no barrier to fish passage through the habitat unit

T/P T = temporary, portion of open water season

P = Permanent, all year round

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: **33.7**
Survey Date (d/m/y): 20-08-01
Survey Crew: SLU,MM
Aerial photo: 0

Hab Unit No.	Banks of Channel				Instream Cover					Photos (Role #) (Photo #)
	L Bank Height (m)	R Bank Height (m)	L Bank Stab	R Bank Stab	Pool %	Boulder %	Instream Veg %	Overhang Veg %	Undercut Bank %	
1	0.40	0.40	S	S		80		10		
2	0.25	0.25	S	S		80		5		
3	0.20	0.30	S	S		65		5		
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										

Comments:
Wide shallow stream connecting two lakes, low fisheries value. The 2 lakes are overwintering.

Preliminary Assessment

Spawning:	2	Rearing:	2	Over-wintering:	0	Adult Feeding:	1	Migration:	0

Banks of Channel (Stability) H = highly stable, S = stable, U = unstable
Preliminary Assessment 0 = no habitat present, 1 = poor, 2 = fair, 3 = good, 4 = excellent

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: 22.9		**Survey Date (d/m/y):** 19-08-01			**A: Downstream**						**B:Upstream**								
Drainage Area (Km^2):		**Survey Crew:** SLU, DN			**N:**	66	24	0.603			**N:**	66	24	0.519					
Survey Distance (m) 405		**Aerial photo:** R17-10,11 looking d/s			**W:**	107	37	0.170			**W:**	107	37	0.024					
Approx. Distance from Over-wintering Habitat (Km): 2.5					**Barriers to Over-Wintering Habitat:**														
Temperature (^oC): 10.2,9.5		**Visibility:** clear			None														
Channel Velocity (m/s): 1.1		**Conductivity (uS/cm):** 48																	
Current Flow Conditions:		**pH:** 8.7			**Weather:**														
Discharge estimate (m^3/s) 9.056 d=0.58,w=14.9					sunny,10°c														

Hab Unit No.	Hab Type	Dist. fr start (m)	Length (m)	Slope (%)	Depth (m)		Width (m)		Bed Material					Pool Info			Fish Passage Barriers	
					Mean	Bank-full	Mean	Bank-full	Sand (%)	Gravel (%)	Cobble (%)	Boulder (%)	Bedrock (%)	Type	Depth (m) Max	Depth (m) Crest	Type	T/P
1	G	0	184	0.5	0.60	0.90	44.0	50.0			30	65	5					
2	R	184	221	1.5	0.50	0.80	38.0	44.0			25	70	5					
3		405																
4																		
5																		
6																		
7																		
8																		
9																		
10																		
11																		
12																		
13																		
14																		
15																		
16																		
17																		
18																		
19																		
20																		

Flow Conditions H = High flow, M = Medium flow, L = Low flow

Habitat Unit Under bankfull conditions: 0 - 2.5 m = > 1 m^2, 2.5 - 5 m = > 2 m^2, 5 - 10 m = > 4 m^2, 10 -15 m = > 6 m^2, 15 -20 = > 8 m^2, > 20 m = > 10 m^2

Hab Type P = pool, G = glide, R = riffle, C = cascade, O = other

Dist. fr start distance from beginning of the survey to the beginning of the habitat unit being surveyed

Pool Type S = scour, D = dammed, U = unknown

Substrate Sand (silt, clay, fine organic< 2 mm), Gravel (2 - 64 mm), Cobble (64 - 256), Boulders (256 - 4000 mm), Bedrock (>4000 mm)

Fish Passage Barriers IF = Impassible waterfall

BF = Boulder Field, passage through the boulder arrangement is not possible for fish

D = dry channel, no stream flow

NC = no distinct channel, water drains over land

N = no barrier to fish passage through the habitat unit

T/P T = temporary, portion of open water season

P = Permanent, all year round

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: **22.9**
Survey Date (d/m/y): 19-08-01
Survey Crew: SLU, DN
Aerial photo: R17-10,11 looking d/s

Hab Unit No.	Banks of Channel				Instream Cover					Photos (Role #) (Photo #)
	L Bank Height (m)	R Bank Height (m)	L Bank Stab	R Bank Stab	Pool %	Boulder %	Instream Veg %	Overhang Veg %	Undercut Bank %	
1	4.00	2.50	HS	S/U		65				
2	2.50	0.80	HS	S		70				
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										

Comments:
Right bank of channel unstable during high flow.

Preliminary Assessment

Spawning:	2	Rearing:	2	Over-wintering:	1	Adult Feeding:	2	Migration:	3

Banks of Channel (Stability) H = highly stable, S = stable, U = unstable
Preliminary Assessment 0 = no habitat present, 1 = poor, 2 = fair, 3 = good, 4 = excellent

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: 11.7		**Survey Date (d/m/y):** 19-08-01			**A: Downstream**						**B:Upstream**								
Drainage Area (Km^2):		**Survey Crew:** SLU, DN			**N:**	66	29	0.959			**N:**	66	29	0.514					
Survey Distance (m) 207		**Aerial photo:** 17-9			**W:**	107	37	0.701			**W:**	107	37	0.579					
Approx. Distance from Over-wintering Habitat (Km):					**Barriers to Over-Wintering Habitat:**														
Temperature (^{o}C): 7.8,8.4		**Visibility:** clear			none														
Channel Velocity (m/s): 0.25		**Conductivity (uS/cm):** 109																	
Current Flow Conditions:		**pH:** 9.1,9.1			**Weather:**														
Discharge estimate (m^3/s) 0.128	w=3.4,D=0.15				no clouds, sunny														

Hab Unit No.	Hab Type	Dist. fr start (m)	Length (m)	Slope (%)	Depth (m)		Width (m)		Bed Material					Pool Info			Fish Passage Barriers	
					Mean	Bank-full	Mean	Bank-full	Sand (%)	Gravel (%)	Cobble (%)	Boulder (%)	Bedrock (%)	Type	Depth (m) Max	Depth (m) Crest	Type	T/P
1	G	0	24	0.5	0.60	0.85	7.0	7.5		60	20		20					
2	P	24	11	0.0	0.80	0.95	8.0	9.5	85	5	10			S	0.95	0.50		
3	G	35	43	0.5	0.75	0.85	8.0	9.0	75	10	15							
4	PD	78	43	0.0	0.70	0.80	32.0	36.0	40		15	45						
5	R	121	14	1.0	0.20	0.35	3.1	3.3		20	70	10						
6	G	135	14	0.5	0.35	0.45	3.5	3.8		10	70	20						
7	PD	149	44	0.0	0.70	0.85	29.0	30.0	20		80							
8	R	193	14	1.0	0.10	0.25	6.5	9.0			70	30						
9																		
10																		
11																		
12																		
13																		
14																		
15																		
16																		
17																		
18																		
19																		
20																		

Flow Conditions H = High flow, M = Medium flow, L = Low flow

Habitat Unit Under bankfull conditions: 0 - 2.5 m = > 1 m^2, 2.5 - 5 m = > 2 m^2, 5 - 10 m = > 4 m^2, 10 -15 m = > 6 m^2, 15 -20 = > 8 m^2, > 20 m = > 10 m^2

Hab Type P = pool, G = glide, R = riffle, C = cascade, O = other, PD = pond

Dist. fr start distance from beginning of the survey to the beginning of the habitat unit being surveyed

Pool Type S = scour, D = dammed, U = unknown

Substrate Sand (silt, clay, fine organic< 2 mm), Gravel (2 - 64 mm), Cobble (64 - 256), Boulders (256 - 4000 mm), Bedrock (>4000 mm)

Fish Passage Barriers IF = Impassible waterfall

BF = Boulder Field, passage through the boulder arrangement is not possible for fish

D = dry channel, no stream flow

NC = no distinct channel, water drains over land

N = no barrier to fish passage through the habitat unit

T/P T = temporary, portion of open water season

P = Permanent, all year round

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: **11.7**
Survey Date (d/m/y): 19-08-01
Survey Crew: SLU, DN
Aerial photo: 17-9

Hab Unit No.	Banks of Channel				Instream Cover					Photos (Role #) (Photo #)
	L Bank Height (m)	R Bank Height (m)	L Bank Stab	R Bank Stab	Pool %	Boulder %	Instream Veg %	Overhang Veg %	Undercut Bank %	
1	0.35	0.25	S	S				5		
2	0.15	0.15	S	S	5		30			
3	0.10	0.20	S	S			50			
4	0.10	0.10	S	S		45	10			
5	0.25	0.30	S	S		10				
6	0.15	0.20	S	S		20	30			
7	0.20	0.20	S	S	5					
8	0.20	0.25	S	S		30				R17-8
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										

Comments:
No fish observed. Photo 17-8 is habitat unit 8 looking downstream.

Preliminary Assessment

Spawning:	2	Rearing:	2	Over-wintering:	0	Adult Feeding:	1	Migration:	2

Banks of Channel (Stability) H = highly stable, S = stable, U = unstable
Preliminary Assessment 0 = no habitat present, 1 = poor, 2 = fair, 3 = good, 4 = excellent

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: 7.8		**Survey Date (d/m/y):** 19-08-01			**A: Downstream**						**B:Upstream**									
Drainage Area (Km^2):		**Survey Crew:** SLU,DN			**N:**	66	31	0.868			**N:**	66	31	47.1						
Survey Distance (m) 201		**Aerial photo:** 17-7			**W:**	107	37	0.472			**W:**	107	37	22.2						
						degrees	minutes						minutes	seconds						
Approx. Distance from Over-wintering Habitat (Km):					**Barriers to Over-Wintering Habitat:** upstream the waterfalls look impassable															
Temperature (^oC): 5.6,6.3		**Visibility:** clear																		
Channel Velocity (m/s): 0.2		**Conductivity (uS/cm):** 86																		
Current Flow Conditions: low		**pH:** 9.1			**Weather:** sunny															
Discharge estimate (m^3/s) 0.006	w=.15,d=0.2																			

Hab Unit No.	Hab Type	Dist. fr start (m)	Length (m)	Slope (%)	Depth (m)		Width (m)		Bed Material					Pool Info			Fish Passage Barriers	
					Mean	Bank-full	Mean	Bank-full	Sand (%)	Gravel (%)	Cobble (%)	Boulder (%)	Bedrock (%)	Type	Depth (m) Max	Depth (m) Crest	Type	T/P
1	G	0	135	0.5	0.40	0.65	1.2	1.9	80	10	10							
2	R	135	5	1.0	0.35	0.45	1.0	1.4	70	10	20							
3	G	140	61	0.5	0.30	0.40	0.9	1.2	30	30	40							
4																		
5																		
6																		
7																		
8																		
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16																		
17																		
18																		
19																		
20																		

Flow Conditions H = High flow, M = Medium flow, L = Low flow

Habitat Unit Under bankfull conditions: 0 - 2.5 m = > 1 m^2, 2.5 - 5 m = > 2 m^2, 5 - 10 m = > 4 m^2, 10 -15 m = > 6 m^2, 15 -20 = > 8 m^2, > 20 m = > 10 m^2

Hab Type P = pool, G = glide, R = riffle, C = cascade, O = other

Dist. fr start distance from beginning of the survey to the beginning of the habitat unit being surveyed

Pool Type S = scour, D = dammed, U = unknown

Substrate Sand (silt, clay, fine organic< 2 mm), Gravel (2 - 64 mm), Cobble (64 - 256), Boulders (256 - 4000 mm), Bedrock (>4000 mm)

Fish Passage Barriers IF = Impassible waterfall

BF = Boulder Field, passage through the boulder arrangement is not possible for fish

D = dry channel, no stream flow

NC = no distinct channel, water drains over land

N = no barrier to fish passage through the habitat unit

T/P T = temporary, portion of open water season

P = Permanent, all year round

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: **7.8**
Survey Date (d/m/y): 19-08-01
Survey Crew: SLU,DN
Aerial photo: 17-7

Hab Unit No.	Banks of Channel				Instream Cover					Photos (Role #) (Photo #)
	L Bank Height (m)	R Bank Height (m)	L Bank Stab	R Bank Stab	Pool %	Boulder %	Instream Veg %	Overhang Veg %	Undercut Bank %	
1	0.40	0.50	S	S				90	5	
2	0.50	0.40	S	S				80		
3	0.30	0.25	S	S				70		
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										

Comments:
The stream has so much overhanging vegetation that it is not visible from the air. Photo R17-6 downstream of falls.

Preliminary Assessment

Spawning:	1	Rearing:	2	Over-wintering:	0	Adult Feeding:	2	Migration:	1

Banks of Channel (Stability) H = highly stable, S = stable, U = unstable
Preliminary Assessment 0 = no habitat present, 1 = poor, 2 = fair, 3 = good, 4 = excellent

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID:	2.8		**Survey Date (d/m/y):**	19-08-01		**A: Downstream**						**B:Upstream**							
Drainage Area (Km^2):			**Survey Crew:**	SLU,DN		**N:**	66	31	0.280			**N:**	66	30	0.934				
Survey Distance (m)	200		**Aerial photo:**	17-5 looking u/s		**W:**	107	31	0.974			**W:**	107	31	0.935				
Approx. Distance from Over-wintering Habitat (Km):	0.2					**Barriers to Over-Wintering Habitat:**													
Temperature (^oC):	10.5,11.0		**Visibility:**	clear		**none**													
Channel Velocity (m/s):	0.2		**Conductivity (uS/cm):**	93															
Current Flow Conditions:	low		**pH:**	8.1		**Weather:**													
Discharge estimate (m^3/s)	0.003	w=0.25,d=0.05				**sunny, 15°c**													

Hab Unit No.	Hab Type	Dist. fr start (m)	Length (m)	Slope (%)	Depth (m)		Width (m)		Bed Material					Pool Info			Fish Passage Barriers	
					Mean	Bank-full	Mean	Bank-full	Sand (%)	Gravel (%)	Cobble (%)	Boulder (%)	Bedrock (%)	Type	Depth (m) Max	Depth (m) Crest	Type	T/P
1	G	0	51	0.5	0.15	0.20	0.45	5.8	100									
2	P	51	6	0.0	0.70	0.85	1.10	3.4	100					S	0.90	0.15		
3	G	57	89	0.5	0.15	0.25	0.35	4.0	100									
4	P	146	3	0.0	0.80	0.90	1.40	2.2	100					S	1.10	0.05		
5	G	149	29	0.5	0.10	0.20	0.30	0.8	100									
6	P	178	8	0.0	0.80	0.90	1.40	2.1	100					S	0.95	0.05		
7	G	186	14	0.5	0.10	0.20	0.60	3.2	100									
8																		
9																		
10																		
11																		
12																		
13																		
14																		
15																		
16																		
17																		
18																		
19																		
20																		

Flow Conditions H = High flow, M = Medium flow, L = Low flow

Habitat Unit Under bankfull conditions: 0 - 2.5 m = > 1 m^2, 2.5 - 5 m = > 2 m^2, 5 - 10 m = > 4 m^2, 10 -15 m = > 6 m^2, 15 -20 = > 8 m^2, > 20 m = > 10 m^2

Hab Type P = pool, G = glide, R = riffle, C = cascade, O = other

Dist. fr start distance from beginning of the survey to the beginning of the habitat unit being surveyed

Pool Type S = scour, D = dammed, U = unknown

Substrate Sand (silt, clay, fine organic< 2 mm), Gravel (2 - 64 mm), Cobble (64 - 256), Boulders (256 - 4000 mm), Bedrock (>4000 mm)

Fish Passage Barriers IF = Impassible waterfall

BF = Boulder Field, passage through the boulder arrangement is not possible for fish

D = dry channel, no stream flow

NC = no distinct channel, water drains over land

N = no barrier to fish passage through the habitat unit

T/P T = temporary, portion of open water season

P = Permanent, all year round

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: **2.8**
Survey Date (d/m/y): 19-08-01
Survey Crew: SLU,DN
Aerial photo: looking u/s

Hab Unit No.	Banks of Channel				Instream Cover					Photos (Role #) (Photo #)
	L Bank Height (m)	R Bank Height (m)	L Bank Stab	R Bank Stab	Pool %	Boulder %	Instream Veg %	Overhang Veg %	Undercut Bank %	
1	0.10	0.10	S	S			60			R17-4
2	0.10	0.10	S	S	10				10	
3	0.10	0.10	S	S			50			
4	0.20	0.10	S	S	20				10	
5	0.15	0.15	S	S			20			
6	0.10	0.10	S	S	5					
7	0.10	0.10	S	S			50			
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										

Comments:
The substrate was all recorded as sand but the material was all organic, the stream eroded vegetation and soil to form the channel. Photo R17-4 looking upstream.

Preliminary Assessment

Spawning:	1	Rearing:	1	Over-wintering:	0	Adult Feeding:	1	Migration:	1

Banks of Channel (Stability) H = highly stable, S = stable, U = unstable
Preliminary Assessment 0 = no habitat present, 1 = poor, 2 = fair, 3 = good, 4 = excellent

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: 2.2		**Survey Date (d/m/y):** 19-08-01				**A: Downstream**						**B:Upstream**							
Drainage Area (Km^2):		**Survey Crew:** SLU,DN				**N:**	66	31	0.208			**N:**	66	31	0.103				
Survey Distance (m) 200		**Aerial photo:** 17-3 looking u/s				**W:**	107	31	0.359			**W:**	107	31	0.197				
Approx. Distance from Over-wintering Habitat (Km): 1.5						**Barriers to Over-Wintering Habitat:**													
Temperature (^{o}C): 9.5,9.9		**Visibility:** light turbid				none													
Channel Velocity (m/s): 0.12		**Conductivity (uS/cm):** 445																	
Current Flow Conditions: low		**pH:** 9.2				**Weather:**													
Discharge estimate (m^3/s) 0.139	w=2.9,d=0.4					sunny, 15°c, no wind													

Hab Unit No.	Hab Type	Dist. fr start (m)	Length (m)	Slope (%)	Depth (m)		Width (m)		Bed Material					Pool Info			Fish Passage Barriers	
					Mean	Bank-full	Mean	Bank-full	Sand (%)	Gravel (%)	Cobble (%)	Boulder (%)	Bedrock (%)	Type	Depth (m) Max	Depth (m) Crest	Type	T/P
1	G	0	200	0.5	0.45	0.75	4.5	6.2	100									
2																		
3																		
4																		
5																		
6																		
7																		
8																		
9																		
10																		
11																		
12																		
13																		
14																		
15																		
16																		
17																		
18																		
19																		
20																		

Flow Conditions H = High flow, M = Medium flow, L = Low flow

Habitat Unit Under bankfull conditions: 0 - 2.5 m = > 1 m^2, 2.5 - 5 m = > 2 m^2, 5 - 10 m = > 4 m^2, 10 -15 m = > 6 m^2, 15 -20 = > 8 m^2, > 20 m = > 10 m^2

Hab Type P = pool, G = glide, R = riffle, C = cascade, O = other

Dist. fr start distance from beginning of the survey to the beginning of the habitat unit being surveyed

Pool Type S = scour, D = dammed, U = unknown

Substrate Sand (silt, clay, fine organic< 2 mm), Gravel (2 - 64 mm), Cobble (64 - 256), Boulders (256 - 4000 mm), Bedrock (>4000 mm)

Fish Passage Barriers IF = Impassible waterfall

BF = Boulder Field, passage through the boulder arrangement is not possible for fish

D = dry channel, no stream flow

NC = no distinct channel, water drains over land

N = no barrier to fish passage through the habitat unit

T/P T = temporary, portion of open water season

P = Permanent, all year round

Appendix 3.1-12
Stream Habitat Data Sheets

Stream Crossing ID: **2.2**
Survey Date (d/m/y): 19-08-01
Survey Crew: SLU,DN
Aerial photo: looking u/s

Hab Unit No.	Banks of Channel				Instream Cover					Photos (Role #) (Photo #)
	L Bank Height (m)	R Bank Height (m)	L Bank Stab	R Bank Stab	Pool %	Boulder %	Instream Veg %	Overhang Veg %	Undercut Bank %	
1	0.40	0.30	U	U					5	
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										

Comments:
Bed material was all sand, just downstream of the survey was nice gravel riffle slope (1.5%), and ~50m upstream of survey was another riffle. Water was very turbid in glide.

Preliminary Assessment

Spawning:	1	Rearing:	2	Over-wintering:	0	Adult Feeding:	1	Migration:	2

Banks of Channel (Stability) H = highly stable, S = stable, U = unstable
Preliminary Assessment 0 = no habitat present, 1 = poor, 2 = fair, 3 = good, 4 = excellent

APPENDIX 3.1-13
SUMMARY OF ALL HABITAT VARIABLES FOR THE 55 STREAM CROSSINGS SURVEYED ALONG THE ROAD ROUTE, AUGUST 2001

Appendix 3.1-13
Summary of All Habitat Variables for the 55 Stream Crossings Surveyed Along the Road Route, August 2001

Stream Crossing	Number of Habitat Units	Mean Habitat Length	Length Surveyed	Glide	Pool	Riffle	Cascade	Other	Wetted Surface Area	Slope	Wetted Depth	Bankfull Depth	Wetted Width	Bankfull Width	Sand	Gravel	Cobble	Boulder	Bedrock
Km		(m)	(m)	%	%	%	%	%	(m^2)	%	(m)	(m)	(m)	(m)	%	%	%	%	%
2.2	1	200	200	100	0	0	0	0	900	0.5	0.45	0.75	4.5	6.2	100	0	0	0	0
2.8	7	29	200	76	24	0	0	0	93	0.5	0.29	0.38	0.5	3.8	100	0	0	0	0
7.8	3	67	201	98	2	0	0	0	222	0.5	0.37	0.58	1.1	1.7	67	15	18	0	0
11.7	8	26	207	16	80	4	0	0	3435	0.3	0.68	0.80	16.6	18.2	33	4	42	19	1
22.9	2	203	405	49	0	51	0	0	16494	1.0	0.55	0.85	40.7	46.7	0	0	27	68	5
33.7	3	49	146	89	0	11	0	0	3649	0.8	0.13	0.47	25.0	36.5	0	12	20	68	0
33.8	1	91	91	100	0	0	0	0	337	0.5	0.20	0.45	3.7	9.9	0	30	60	10	0
34.8	10	20	200	39	0	61	0	0	1977	1.2	0.17	0.31	9.9	14.1	0	57	34	8	0
35.9	1	200	200	100	0	0	0	0	6400	0.5	0.15	0.25	32.0	34.0	0	5	70	25	0
36.6	5	40	200	100	0	0	0	0	99	0.6	0.25	0.55	0.5	18.0	0	0	90	10	0
42.3	4	39	155	90	0	10	0	0	417	0.7	0.21	0.33	2.7	6.2	0	7	60	34	0
43.3	1	100	100	0	0	0	0	0	0	0.1	0.00	0.40	0.0	13.0	0	0	20	80	0
44.5	2	100	100	100	0	0	0	0	4056	0.4	0.20	0.35	20.3	28.8	0	1	23	75	0
49.7	5	38	190	58	0	42	0	0	428	0.9	0.21	0.41	2.3	2.3	0	30	50	20	0
52.0	1	200	200	0	0	0	0	0	0	0.5	0.00	0.30	0.0	50.0	0	0	60	40	0
58.7	7	29	200	77	0	23	0	0	1316	0.8	0.16	0.29	6.6	6.7	5	22	12	61	0
67.9	8	25	202	68	0	32	0	0	439	0.9	0.22	0.38	2.2	2.2	5	24	52	19	0
68.3	6	33	200	88	2	10	0	0	652	0.8	0.20	0.41	3.3	4.0	7	11	70	12	0
68.6	9	23	209	79	0	21	0	0	829	0.7	0.20	0.58	4.0	4.8	6	68	26	0	0
69.4	3	67	200	100	0	0	0	0	108	0.5	0.30	0.45	0.5	0.7	100	0	0	0	0
70.1	2	100	200	31	0	0	69	0	331	4.8	0.18	0.32	1.7	2.7	19	18	60	3	0
72.2	10	20	200	9	83	8	0	0	2163	0.7	1.71	2.02	10.8	10.8	89	3	4	4	0
76.0	7	29	203	90	7	3	0	0	380	0.5	0.31	0.46	1.9	2.7	37	46	17	0	0
77	7	27	190	39	0	61	0	0	180	0.8	0.21	0.37	0.9	1.2	9	42	40	9	0
84.2	14	14	200	55	0	45	0	0	1144	0.7	0.33	0.58	5.7	6.1	0	3	47	44	6
85.0	16	13	200	67	0	33	0	0	340	1.7	0.30	0.44	1.7	2.3	79	2	11	6	0
90.3	3	25	74	86	0	0	14	0	150	1.9	0.17	0.29	2.0	4.0	3	8	11	0	78
103.3	1	200	200	100	0	0	0	0	10000	3.0	0.20	0.49	50.0	50.0	0	0	10	90	0
103.3a	2	100	200	100	0	0	0	0	174	1.3	0.34	0.57	0.9	1.7	3	2	33	62	0
106.7	1	200	200	100	0	0	0	0	6200	1.0	0.45	0.71	31.0	44.0	0	0	20	80	0
113.2	9	22	195	67	33	0	0	0	216	0.3	0.55	0.71	1.1	2.2	100	0	0	0	0
113.8	33	6	200	57	5	8	30	0	69	2.2	0.63	0.82	1.0	1.1	72	11	9	8	0
115.2	5	40	200	32	0	68	0	0	443	1.2	0.25	0.37	2.2	3.2	4	9	64	23	0
128.8	2	101	202	41	0	59	0	0	23000	1.1	0.58	0.88	113.9	125.8	0	0	17	83	0
134.6	2	100	200	74	0	26	0	0	7886	6.8	0.14	0.34	39.4	57.6	0	13	23	65	0
159.5	25	7	178	67	0	33	0	0	41	0.5	0.17	0.34	0.7	0.7	35	18	45	3	0
160.7	5	41	203	83	0	17	0	0	345	0.7	0.18	0.36	1.7	2.1	5	26	64	5	0
168.0	1	200	200	0	0	0	0	0	0	5.0	0.00	0.30	0.0	2.0	0	0	50	50	0
169.6	15	13	200	45	5	50	0	0	75	1.3	0.15	0.26	0.4	1.0	67	20	10	3	0
170.8	2	100	100	100	0	0	0	0	5817	0.5	0.25	0.50	29.1	38.4	0	0	0	100	0
173.1	7	29	205	86	4	10	0	0	494	0.6	0.27	0.42	2.4	4.0	53	16	17	14	0
181.4	2	100	200	24	76	0	0	0	8736	1.9	0.35	0.55	43.7	47.4	0	18	62	20	0
183.6	7	24	167	74	0	26	0	0	116	0.7	0.10	0.23	0.7	3.1	26	46	21	8	0
186.5	5	57	287	63	0	0	0	37	55	3.0	0.06	0.15	0.2	0.2	91	0	0	9	0
189.6	13	15	199	85	5	10	0	0	168	0.8	0.23	0.43	0.8	1.8	46	16	22	16	0
192.4	5	43	216	100	0	0	0	0	834	0.9	0.24	0.44	3.9	4.6	20	1	46	33	0
192.4a	9	22	197	47	0	53	0	0	280	1.0	0.12	0.28	1.4	1.9	3	23	42	32	0
196.7	11	18	200	86	0	14	0	0	201	0.6	0.11	0.29	1.0	1.3	64	15	15	6	0
197	33	6	200	59	0	36	3	2	77	1.0	0.14	0.22	1.0	1.1	53	40	7	0	0
197.2	1	200	200	0	0	0	0	100	380	0.5	0.11	0.16	1.9	1.9	100	0	0	0	0
201.9	5	39	196	94	0	6	0	0	10189	0.7	0.39	0.84	52.0	60.2	11	14	19	55	0
202.8	1	200	200	0	0	100	0	0	5320	3.0	0.30	0.53	26.6	26.6	5	20	35	40	0
204.3	4	55	218	100	0	0	0	0	2528	0.5	0.42	0.84	11.6	14.4	5	0	9	86	0
206.8	11	17	183	90	0	10	0	0	1562	0.5	0.36	0.45	8.5	8.7	23	31	23	22	0
208.0	1	200	200	100	0	0	0	0	200	0.5	0.05	0.20	1.0	1.7	100	0	0	0	0

(continued)

Appendix 3.1-13

Summary of All Habitat Variables for the 55 Stream Crossings Surveyed Along the Road Route, August 2001 (completed)

Stream Crossing	Left Bank Height	Right Bank Height	Pool Cover	Boulder Cover	Instream Cover	Overhanging Cover	Undercut Cover	Mean Pool Max Depth	Mean Pool Crest Depth	Discharge
Km	(m)	(m)	%	%	%	%	%	(m)	(m)	m^3/s
2.2	0.40	0.30	0.0	0.0	0.0	0.0	5.0	0.00	0.00	0.139
2.8	0.11	0.11	2.2	0.0	37.9	0.0	1.2	0.98	0.08	0.003
7.8	0.37	0.42	0.0	0.0	0.0	84.8	3.7	0.00	0.00	0.006
11.7	0.17	0.19	2.0	19.2	10.2	0.2	0.0	0.95	0.50	0.128
22.9	3.18	1.57	0.0	67.5	0.0	0.0	0.0	0.00	0.00	9.506
33.7	0.25	0.31	0.0	68.4	0.0	5.6	0.0	0.00	0.00	0.019
33.8	0.25	0.30	0.0	10.0	0.0	0.0	0.0	0.00	0.00	0.047
34.8	0.27	0.26	0.0	8.5	6.7	2.9	0.1	0.00	0.00	0.426
35.9	0.20	0.20	0.0	25.0	0.0	0.0	0.0	0.00	0.00	0.205
36.6	0.26	0.32	5.0	10.0	0.0	0.0	0.0	0.65	0.05	0.000
42.3	0.71	0.51	0.0	33.8	0.0	0.0	0.0	0.00	0.00	0.010
43.3	0.40	0.40	0.0	80.0	0.0	0.0	0.0	0.00	0.00	0.000
44.5	0.15	0.15	0.0	75.2	0.0	0.0	0.0	0.00	0.00	0.041
49.7	0.13	0.13	0.0	52.4	0.0	5.9	5.9	0.00	0.00	0.041
52.0	0.20	0.30	0.0	40.0	0.0	0.0	0.0	0.00	0.00	0.000
58.7	0.10	0.10	0.0	61.0	3.8	2.8	0.1	0.00	0.00	0.059
67.9	0.16	0.16	0.0	18.7	32.2	9.4	0.0	0.00	0.00	0.091
68.3	0.25	0.30	0.0	12.1	0.7	0.0	4.0	0.70	0.05	0.360
68.6	0.57	0.61	0.0	0.3	0.6	0.0	0.4	0.00	0.00	0.080
69.4	0.30	0.38	0.0	0.0	0.0	0.0	2.3	0.00	0.00	0.002
70.1	0.16	0.16	0.0	0.0	12.5	0.0	0.0	0.00	0.00	0.025
72.2	0.26	0.26	82.7	3.9	15.8	0.5	0.2	2.00	0.36	0.198
76.0	0.23	0.24	0.9	0.1	19.6	0.0	0.0	0.75	0.25	0.077
77	0.15	0.15	0.0	8.3	23.3	27.4	0.0	0.00	0.00	0.032
84.2	0.36	0.48	0.0	42.8	0.0	0.0	0.0	0.00	0.00	0.490
85.0	0.14	0.14	0.0	7.7	33.2	0.1	0.0	0.00	0.00	0.020
90.3	0.23	0.23	0.0	0.0	30.6	0.0	1.4	0.00	0.00	0.041
103.3	0.30	0.30	0.0	90.0	0.0	0.0	0.0	0.00	0.00	0.041
103.3a	0.30	0.33	0.0	62.2	0.0	0.0	2.8	0.00	0.00	0.074
106.7	0.26	0.26	0.0	80.0	0.0	10.0	0.0	0.00	0.00	1.860
113.2	0.14	0.12	11.0	0.0	26.1	0.0	3.6	1.20	0.48	0.180
113.8	0.15	0.15	43.2	9.3	14.5	3.3	4.5	1.10	0.16	0.022
115.2	0.18	0.18	0.0	23.3	0.0	0.0	1.8	0.00	0.00	0.125
128.8	0.62	0.62	5.0	83.0	0.0	0.0	0.0	0.00	0.00	32.500
134.6	0.45	0.45	0.0	64.8	1.3	0.0	0.0	0.00	0.00	2.728
159.5	0.19	0.19	0.0	2.6	3.1	6.6	3.4	0.00	0.00	0.008
160.7	0.23	0.21	0.0	4.7	42.9	0.0	0.0	0.00	0.00	0.094
168.0	0.25	0.25	0.0	50.0	50.0	0.0	0.0	0.00	0.00	0.000
169.6	0.23	0.24	0.5	2.9	9.5	1.8	0.5	0.35	0.10	0.028
170.8	0.25	0.25	0.0	99.7	0.3	0.0	0.0	0.00	0.00	0.068
173.1	0.18	0.22	0.2	12.9	2.1	0.0	0.0	0.55	0.05	0.108
181.4	0.20	0.20	0.0	20.0	0.0	0.0	0.0	0.00	0.00	6.330
183.6	0.27	0.27	0.0	7.6	2.0	0.0	0.0	0.00	0.00	0.000
186.5	0.01	0.01	0.0	9.0	72.9	0.0	0.0	0.00	0.00	0.000
189.6	0.32	0.39	4.5	15.5	3.0	0.2	1.4	0.65	0.05	0.003
192.4	0.23	0.23	0.0	47.8	43.5	10.1	0.1	0.00	0.00	0.000
192.4a	0.29	0.30	0.0	32.4	14.1	0.4	0.7	0.00	0.00	0.030
196.7	0.19	0.19	0.0	5.6	40.4	2.0	0.0	0.00	0.00	0.000
197	0.14	0.13	0.0	0.0	28.2	0.0	0.5	0.00	0.00	0.000
197.2	0.15	0.15	0.0	0.0	80.0	0.0	0.0	0.00	0.00	0.000
201.9	0.60	0.58	0.0	55.1	0.5	0.0	0.0	0.00	0.00	7.088
202.8	0.23	0.25	0.0	40.0	0.0	0.0	0.0	0.00	0.00	1.370
204.3	0.60	0.57	0.0	93.6	4.7	0.0	0.0	0.00	0.00	0.000
206.8	0.12	0.13	0.0	22.3	6.7	0.0	0.1	0.00	0.00	0.088
208.0	0.17	0.17	0.0	0.0	50.0	0.0	0.0	0.00	0.00	0.000

APPENDIX 3.1-14
CORRELATION COEFFICIENTS FOR 34 STREAM HABITAT VARIABLES OBTAINED FROM THE STREAM HABITAT ASSESSMENTS CONDUCTED AT THE 55 CROSSINGS ALONG THE ROAD ROUTE, AUGUST 2001

Appendix 3.1-14
Correlation Coefficients for 34 Stream Habitat Variables Obtained from the Stream Habitat Assessments Conducted at the 55 Crossings Along the Road Route, August 2001

	ln(number units)	ln(unit length)	temperature	ln(conductivity)	pH	ln(wetted width + 0.1)	ln(bankfull width)	ln(wetted depth + 0.1)	ln(bankfull depth)
ln(number units)	1.00								
ln(unit length)	-0.97	1.00							
temperature	0.05	-0.01	1.00						
ln(conductivity)	-0.21	0.19	-0.18	1.00					
pH	-0.19	0.16	-0.25	0.65	1.00				
ln(wetted width + 0.1)	-0.20	0.25	-0.04	-0.01	0.02	1.00			
ln(bankfull width)	-0.49	0.49	-0.11	0.02	0.17	0.73	1.00		
ln(wetted depth + 0.1)	0.32	-0.27	0.09	0.11	0.03	0.58	0.12	1.00	
ln(bankfull depth)	0.05	-0.02	0.07	0.13	0.16	0.45	0.43	0.67	1.00
ln(wetted area + 10)	-0.21	0.28	-0.01	-0.01	0.03	0.99	0.70	0.60	0.45
arcsine(%gradient/100)$^{0.5}$	-0.14	0.18	0.37	-0.15	-0.23	0.09	0.01	-0.12	-0.15
arcsine(%glide/100)$^{0.5}$	0.00	0.00	0.01	0.11	0.14	0.25	0.02	0.34	0.08
arcsine(%pool/100)$^{0.5}$	0.20	-0.18	0.13	0.06	0.05	0.13	0.09	0.40	0.45
arcsine(%riffle/100)$^{0.5}$	0.37	-0.33	-0.03	-0.32	-0.16	0.18	-0.03	0.16	0.00
arcsine(%cascade/100)$^{0.5}$	0.09	-0.12	0.17	0.03	0.00	-0.11	-0.17	0.05	-0.04
arcsine(%other/100)$^{0.5}$	-0.15	0.18	-0.13	0.16	-0.24	-0.12	-0.23	-0.14	-0.40
arcsine(%sand/100)$^{0.5}$	0.26	-0.22	-0.01	0.13	-0.14	-0.36	-0.58	0.18	-0.07
arcsine(%gravel/100)$^{0.5}$	0.47	-0.51	-0.13	-0.19	0.03	0.01	-0.22	0.08	-0.17
arcsine(%cobble/100)$^{0.5}$	-0.03	0.01	0.05	-0.03	0.28	0.02	0.20	-0.13	-0.01
arcsine(%boulder/100)$^{0.5}$	-0.39	0.41	0.10	-0.21	-0.12	0.48	0.67	-0.09	0.25
arcsine(%bedrock/100)$^{0.5}$	-0.02	-0.08	-0.10	0.09	0.03	0.03	0.02	0.04	-0.03
ln(left bank height)	-0.21	0.21	-0.14	-0.05	0.20	0.36	0.48	0.19	0.49
ln(right bank height)	-0.21	0.20	-0.14	-0.07	0.21	0.32	0.49	0.14	0.49
arcsine(%pool cover/100)$^{0.5}$	0.32	-0.30	0.21	0.05	-0.06	0.01	-0.02	0.43	0.56
arcsine(%boulder cover/100)$^{0.5}$	-0.36	0.38	0.10	-0.21	-0.14	0.48	0.64	-0.08	0.25
arcsine(%instream cover/100)$^{0.5}$	0.23	-0.21	0.00	0.03	-0.37	-0.40	-0.57	-0.19	-0.43
arcsine(%overhanging cover/100)$^{0.5}$	0.13	-0.12	-0.18	0.14	0.14	-0.08	-0.21	0.12	0.08
arcsine(%undercut cover/100)$^{0.5}$	0.28	-0.29	0.08	0.12	0.14	-0.27	-0.44	0.24	0.15
pool max depth	0.38	-0.36	0.18	0.08	0.05	-0.08	-0.09	0.42	0.47
pool crest depth	0.30	-0.28	0.09	0.11	0.10	0.00	-0.05	0.39	0.43
temporary barrier	-0.11	0.04	-0.27	0.00	0.01	-0.41	-0.09	-0.45	-0.37
permanent barrier	-0.14	0.14	0.33	0.01	-0.23	0.05	-0.01	-0.16	-0.16
ln(velocity + 0.01)	0.10	-0.10	0.26	-0.04	0.13	0.53	0.27	0.58	0.42
ln(discharge + 0.001)	-0.10	0.14	0.14	-0.12	0.03	0.75	0.56	0.54	0.51

(continued)

Appendix 3.1-14
Correlation Coefficients for 34 Stream Habitat Variables Obtained from the Stream Habitat Assessments Conducted at the 55 Crossings Along the Road Route, August 2001 (continued)

	ln(wetted area + 10)	arcsine(%gradient/100)$^{0.5}$	arcsine(%glide/100)$^{0.5}$	arcsine(%pool/100)$^{0.5}$	arcsine(%riffle/100)$^{0.5}$	arcsine(%cascade/100)$^{0.5}$	arcsine(%other/100)$^{0.5}$
ln(number units)							
ln(unit length)							
temperature							
ln(conductivity)							
pH							
ln(wetted width + 0.1)							
ln(bankfull width)							
ln(wetted depth + 0.1)							
ln(bankfull depth)							
ln(wetted area + 10)	1.00						
arcsine(%gradient/100)$^{0.5}$	0.08	1.00					
arcsine(%glide/100)$^{0.5}$	0.26	-0.23	1.00				
arcsine(%pool/100)$^{0.5}$	0.13	-0.11	-0.27	1.00			
arcsine(%riffle/100)$^{0.5}$	0.18	0.16	-0.38	-0.16	1.00		
arcsine(%cascade/100)$^{0.5}$	-0.15	0.42	-0.11	-0.04	-0.13	1.00	
arcsine(%other/100)$^{0.5}$	-0.10	0.00	-0.29	-0.08	-0.15	-0.04	1.00
arcsine(%sand/100)$^{0.5}$	-0.32	-0.18	0.02	0.29	-0.21	0.05	0.35
arcsine(%gravel/100)$^{0.5}$	-0.01	0.03	-0.05	-0.05	0.49	0.10	-0.19
arcsine(%cobble/100)$^{0.5}$	0.01	0.11	-0.12	-0.09	0.21	0.05	-0.31
arcsine(%boulder/100)$^{0.5}$	0.47	0.13	0.06	-0.23	0.02	-0.20	-0.20
arcsine(%bedrock/100)$^{0.5}$	-0.02	0.10	0.01	-0.03	-0.05	0.27	-0.04
ln(left bank height)	0.36	-0.12	0.09	-0.10	0.15	-0.11	-0.32
ln(right bank height)	0.31	-0.13	0.09	-0.11	0.13	-0.13	-0.34
arcsine(%pool cover/100)$^{0.5}$	-0.01	-0.04	-0.19	0.60	-0.04	0.18	-0.06
arcsine(%boulder cover/100)$^{0.5}$	0.46	0.10	0.08	-0.23	0.03	-0.25	-0.19
arcsine(%instream cover/100)$^{0.5}$	-0.38	0.14	-0.21	0.07	-0.13	0.13	0.50
arcsine(%overhanging cover/100)$^{0.5}$	-0.07	-0.10	0.10	-0.03	0.06	-0.04	-0.08
arcsine(%undercut cover/100)$^{0.5}$	-0.29	-0.11	0.14	0.07	0.00	0.12	-0.11
pool max depth	-0.08	-0.16	-0.13	0.73	-0.13	0.08	-0.08
pool crest depth	0.01	-0.19	-0.18	0.77	-0.12	0.01	-0.07
temporary barrier	-0.43	-0.28	-0.08	-0.16	-0.17	-0.07	0.25
permanent barrier	0.05	0.56	0.08	-0.21	-0.18	0.25	0.03
ln(velocity + 0.01)	0.53	0.08	0.11	0.23	0.31	0.07	-0.34
ln(discharge + 0.001)	0.75	0.17	-0.02	0.21	0.37	-0.06	-0.26

(continued)

Appendix 3.1-14
Correlation Coefficients for 34 Stream Habitat Variables Obtained from the Stream Habitat Assessments Conducted at the 55 Crossings Along the Road Route, August 2001 (continued)

	arcsine(%sand/100)$^{0.5}$	arcsine(%gravel/100)$^{0.5}$	arcsine(%cobble/100)$^{0.5}$	arcsine(%boulder/100)$^{0.5}$	arcsine(%bedrock/100)$^{0.5}$	ln(left bank height)	ln(right bank height)
ln(number units)							
ln(unit length)							
temperature							
ln(conductivity)							
pH							
ln(wetted width + 0.1)							
ln(bankfull width)							
ln(wetted depth + 0.1)							
ln(bankfull depth)							
ln(wetted area + 10)							
arcsine(%gradient/100)$^{0.5}$							
arcsine(%glide/100)$^{0.5}$							
arcsine(%pool/100)$^{0.5}$							
arcsine(%riffle/100)$^{0.5}$							
arcsine(%cascade/100)$^{0.5}$							
arcsine(%other/100)$^{0.5}$							
arcsine(%sand/100)$^{0.5}$	1.00						
arcsine(%gravel/100)$^{0.5}$	-0.19	1.00					
arcsine(%cobble/100)$^{0.5}$	-0.70	0.30	1.00				
arcsine(%boulder/100)$^{0.5}$	-0.67	-0.34	0.13	1.00			
arcsine(%bedrock/100)$^{0.5}$	-0.13	-0.05	-0.04	-0.11	1.00		
ln(left bank height)	-0.36	-0.04	0.18	0.32	0.11	1.00	
ln(right bank height)	-0.40	-0.02	0.23	0.33	0.10	0.98	1.00
arcsine(%pool cover/100)$^{0.5}$	0.32	-0.12	-0.19	-0.17	-0.06	-0.03	-0.03
arcsine(%boulder cover/100)$^{0.5}$	-0.67	-0.33	0.13	0.99	-0.11	0.31	0.31
arcsine(%instream cover/100)$^{0.5}$	0.53	-0.05	-0.34	-0.46	0.09	-0.52	-0.58
arcsine(%overhanging cover/100)$^{0.5}$	0.04	0.20	0.05	-0.13	-0.08	-0.03	-0.01
arcsine(%undercut cover/100)$^{0.5}$	0.35	0.04	-0.14	-0.39	0.07	-0.05	-0.06
pool max depth	0.41	-0.09	-0.17	-0.30	-0.06	-0.11	-0.10
pool crest depth	0.36	-0.08	-0.18	-0.26	-0.02	-0.11	-0.13
temporary barrier	0.08	-0.03	0.05	-0.16	-0.10	0.04	0.07
permanent barrier	-0.15	-0.20	-0.12	0.29	0.21	-0.23	-0.25
ln(velocity + 0.01)	-0.24	0.30	0.17	0.08	0.13	0.28	0.26
ln(discharge + 0.001)	-0.35	0.14	0.17	0.29	0.10	0.36	0.33

(continued)

Appendix 3.1-14
Correlation Coefficients for 34 Stream Habitat Variables Obtained from the Stream Habitat Assessments Conducted at the 55 Crossings Along the Road Route, August 2001 (continued)

	arcsine(%pool cover/100)$^{0.5}$	arcsine(%boulder cover/100)$^{0.5}$	arcsine(%instream cover/100)$^{0.5}$	arcsine(%overhanging cover/100)$^{0.5}$	arcsine(%undercut cover/100)$^{0.5}$
ln(number units)					
ln(unit length)					
temperature					
ln(conductivity)					
pH					
ln(wetted width + 0.1)					
ln(bankfull width)					
ln(wetted depth + 0.1)					
ln(bankfull depth)					
ln(wetted area + 10)					
arcsine(%gradient/100)$^{0.5}$					
arcsine(%glide/100)$^{0.5}$					
arcsine(%pool/100)$^{0.5}$					
arcsine(%riffle/100)$^{0.5}$					
arcsine(%cascade/100)$^{0.5}$					
arcsine(%other/100)$^{0.5}$					
arcsine(%sand/100)$^{0.5}$					
arcsine(%gravel/100)$^{0.5}$					
arcsine(%cobble/100)$^{0.5}$					
arcsine(%boulder/100)$^{0.5}$					
arcsine(%bedrock/100)$^{0.5}$					
ln(left bank height)					
ln(right bank height)					
arcsine(%pool cover/100)$^{0.5}$	1.00				
arcsine(%boulder cover/100)$^{0.5}$	-0.17	1.00			
arcsine(%instream cover/100)$^{0.5}$	0.10	-0.45	1.00		
arcsine(%overhanging cover/100)$^{0.5}$	-0.02	-0.10	-0.02	1.00	
arcsine(%undercut cover/100)$^{0.5}$	0.19	-0.33	-0.13	0.25	1.00
pool max depth	0.85	-0.30	0.14	-0.08	0.25
pool crest depth	0.62	-0.25	0.16	-0.07	0.15
temporary barrier	-0.06	-0.16	0.08	-0.17	-0.21
permanent barrier	-0.17	0.32	0.22	-0.05	-0.10
ln(velocity + 0.01)	0.11	0.06	-0.39	0.03	0.16
ln(discharge + 0.001)	0.08	0.27	-0.44	-0.08	-0.04

(continued)

Appendix 3.1-14
Correlation Coefficients for 34 Stream Habitat Variables Obtained from the Stream Habitat Assessments Conducted at the 55 Crossings Along the Road Route, August 2001 (completed)

	pool max depth	pool crest depth	temporary barrier	permanent barrier	ln(velocity + 0.01)	ln(discharge + 0.001)
ln(number units)						
ln(unit length)						
temperature						
ln(conductivity)						
pH						
ln(wetted width + 0.1)						
ln(bankfull width)						
ln(wetted depth + 0.1)						
ln(bankfull depth)						
ln(wetted area + 10)						
arcsine(%gradient/100)$^{0.5}$						
arcsine(%glide/100)$^{0.5}$						
arcsine(%pool/100)$^{0.5}$						
arcsine(%riffle/100)$^{0.5}$						
arcsine(%cascade/100)$^{0.5}$						
arcsine(%other/100)$^{0.5}$						
arcsine(%sand/100)$^{0.5}$						
arcsine(%gravel/100)$^{0.5}$						
arcsine(%cobble/100)$^{0.5}$						
arcsine(%boulder/100)$^{0.5}$						
arcsine(%bedrock/100)$^{0.5}$						
ln(left bank height)						
ln(right bank height)						
arcsine(%pool cover/100)$^{0.5}$						
arcsine(%boulder cover/100)$^{0.5}$						
arcsine(%instream cover/100)$^{0.5}$						
arcsine(%overhanging cover/100)$^{0.5}$						
arcsine(%undercut cover/100)$^{0.5}$						
pool max depth	1.00					
pool crest depth	0.83	1.00				
temporary barrier	-0.08	-0.14	1.00			
permanent barrier	-0.23	-0.19	-0.26	1.00		
ln(velocity + 0.01)	0.16	0.20	-0.59	-0.16	1.00	
ln(discharge + 0.001)	0.04	0.11	-0.55	-0.16	0.82	1.00

APPENDIX 3.1-15
FISH EFFORT AND CATCH DATA FOR THE 55 STREAM CROSSINGS SURVEYED ALONG THE ROAD ROUTE, AUGUST 2001

Appendix 3.1-15
Fish Effort and Catch Data for the 55 Stream Crossings Surveyed Along the Road Route, August 2001

				Stream Characteristics					Electrofisher Settings			Fishing Effort		Number			
Date	Leg	Stream crossing (km)	Survey crew	Temperature (°C)	Average Temperature	Conductivity (uS/cm)	pH	Velocity (m/sec)	Frequency (Hz)	Pulse width (msec)	Voltage (V)	Distance (m)	Time (sec)	Arctic grayling	Slimy sculpin	Burbot	Arctic char
19-Aug	B	2.2	SLU/DN	9.5,9.9	9.7	445	9.2	0.12	60	6	100	200	318	0	0	0	0
19-Aug	B	2.8	SLU/DN	10.5,11.0	10.8	93	8.1	0.20	60	6	200	200	270	0	0	0	0
19-Aug	B	7.8	SLU/DN	5.6,6.3	6.0	86	9.1	0.20	60	6	300	150	108	0	0	0	0
19-Aug	B	11.7	SLU/DN	7.8,8.4	8.1	109	9.1	0.25	60	6	200	207	539	0	0	0	0
19-Aug	B	22.9	SLU/DN	10.2,9.5	9.9	48	8.7	1.10	60	6	400	405	514	0	0	0	0
19-Aug	B	33.7	MM/SLU	9.2	9.2	185	9.4	0.15	60	6	200	146	425	0	0	0	0
18-Aug	B	33.8	SLU/DN	8.5,9.2	8.9	134	9.4	0.39	60	6	300	90	138	0	0	0	0
18-Aug	B	34.8	SLU/DN	8.8,8.2	8.5	81	9.0	0.30	60	6	300	200	410	0	1	0	0
18-Aug	B	35.9	SLU/DN	7.4,8.1	7.8	53	8.9	0.25	60	6	500	200	399	0	0	0	0
17-Aug	B	36.6	SLU/DN	10.8,10.3	10.6	144	9.1		60	6	800	200	102	0	0	0	0
16-Aug	B	42.3	SLU/DN	12.7,13.3	13.0	21	7.8	0.50	60	6	800	155	314	0	3	0	0
16-Aug	B	43.3	SLU/DN	10.4,9.8	10.1	20	8.3		na	na	na	0	0	0	0	0	0
16-Aug	B	44.5	SLU/DN	13.3,12.8	13.1	35	8.0	0.25	60	6	500	200	304	0	3	0	0
16-Aug	B	49.7	MM/GH	15.6	15.6	29	7.2		60	6	500	150	574	0	21	0	0
16-Aug	B	52.0	SLU/DN	na	na	na	na		na	na	na	na	na	0	0	0	0
16-Aug	B	58.7	MM/GH	11.5	11.5	27	7.1	0.19	60	6	500	300	561	0	2	0	0
16-Aug	B	67.9	MM/GH	12.7	12.7	33	6.6	0.28	60	6	600	300	677	0	0	0	0
16-Aug	B	68.3	SLU/DN	10.8,11.8	11.3	29	7.9	0.40	60	6	700	200	340	0	0	0	0
16-Aug	B	68.6	SLU/DN	10.5,9.8	10.2	31	8.3	0.40	60	6	700	209	445	0	5	0	0
16-Aug	B	69.4	SLU/DN	14.4,14.8	14.6	59	7.8	0.05	60	6	400	200	129	0	0	0	0
15-Aug	B	70.1	SLU/DN	15.4,15.8	15.6	37	7.9	0.35	60	6	600	200	152	0	0	0	0
15-Aug	B	72.2	MM/GH	14.6	14.6	62	6.7	0.33	60	6	400	200	578	16	1	4	0
15-Aug	B	76.0	SLU/DN	13.7,14.2	14.0	72	7.4	0.70	60	6	400	203	450	0	0	0	0
15-Aug	B	77	MM/GH	9.1	9.1	41	6.6	0.21	60	6	600	400	494	0	0	0	0
15-Aug	B	84.2	SLU/DN	12.0,11.4	11.7	17	7.1	0.35	60	6	800	202	529	3	0	0	0
15-Aug	B	85.0	MM/GH	13.1	13.1	127	6.2	0.20	60	6	700	400	469	0	0	0	0
15-Aug	B	90.3	SLU/DN	10.2,9.7	10.0	45	6.8		60	6	500	60	117	0	0	0	0
15-Aug	B	103.3	MM/GH	12.8	12.8	37	5.7		60	6	600	100	462	3	0	0	0
14-Aug	B	103.3a	SLU/DN	12.7,12.3	12.5	53	7.0	0.30	60	6	500	200	441	11	13	1	0
14-Aug	B	106.7	MM/GH	12.8	12.8	19	6.0	0.20	60	6	700	200	421	0	0	0	0
14-Aug	B	113.2	SLU/DN	11.6, 12.2	11.9	16	6.8	0.50	60	6	700	195	399	0	0	0	0
14-Aug	B	113.8	MM/GH	12.8	12.8	16	6.4	0.17	60	6	600	200	787	2	0	0	0
13-Aug	B	115.2	SLU/DN	13.1,12.6	12.9	15	7.5	0.25	60	6	800	200	508	0	3	0	0
13-Aug	B	128.8	SLU/DN	11.3,11.9	11.6	10	6.0	0.65	60	6	900	200	549	0	0	0	0
13-Aug	B	134.6	MM/GH	15.4	15.4	9	6.6	0.38	60	6	800	200	428	22	1	1	0
13-Aug	B	159.5	MM/GH	11.5	11.5	22	6.3	0.154	60	6	800	200	421	0	2	0	0
13-Aug	B	160.7	SLU/DN	14.4,13.9	14.2	15	6.5	0.67	60	6	900	203	618	3	11	1	0
13-Aug	B	168.0	MM/GH	na	na	na	na	0	60	6	800	200	396	0	0	0	0
12-Aug	B	169.6	SLU/DN	15.3,15.7	15.5	1	5.8	0.4	na	na	na	200	413	0	4	0	0
12-Aug	B	170.8	MM/GH	12.6	12.6	16	5.9	0.214	60	6	700	100	260	0	0	1	0
12-Aug	B	173.1	SLU/DN	11.7,12.3	12.0	3	5.6	0.45	60	6	800	200	689	25	11	17	0
12-Aug	B	181.4	MM/GH	13.9	13.9	11	6.4	0.48	60	6	800	200	601	8	8	0	0
12-Aug	B	183.6	SLU/DN	9.0,9.3	9.2	3	6.2	0	60	6	900	200	204	0	0	0	0
12-Aug	B	186.5	MM/GH	13.9	13.9	22	6.5	0	60	6	800	200	504	0	2	0	0
11-Aug	B	189.6	SLU/DN	12.8,13.6	13.2	4	6.4	0.1	60	6	900	200	451	0	0	0	0
12-Aug	B	192.4	MM/GH	14.0	14.0	13	6.4	0	60	6	700	200	312	0	2	0	0
11-Aug	B	192.4a	SLU/DN	9.3,9.9	9.7	2	5.9	0.3	60	6	900	197	403	1	1	1	0
11-Aug	B	196.7	MM/GH	10.5	10.5	26	6.8		60	6	700	200	160	0	0	0	0
11-Aug	B	197	MM/GH	5.6	5.6	25	5.9		60	6	700	200	150	0	0	0	0
11-Aug	B	197.2	MM/GH	8.2	8.2	119	5.3	0	60	6	na	200	150	1	2	0	0
11-Aug	B	201.9	SLU/DN	9.4	9.4	2	6.0	1.05	60	6	900	200	758	1	4	0	0
10-Aug	B	202.8	MM/GH	8.2,10.7	9.5	6	6.5	0.29	60	6	900	200	503	3	1	1	0
10-Aug	B	204.3	MM/GH	8.2,8.7	8.5	12	6.2	0	60	6	700	218	365	0	1	0	0
10-Aug	B	206.8	MM/GH	6.1,7.4	6.8	7	6.2	0.17	60	6	700	184	527	21	0	9	0
10-Aug	B	208.0	MM/GH	9.3	9.3	11	6.4	0	na	na	na	na	na	0	0	0	0

Survey crew: FL = François Landry, SU = Shane Uren, MM = Michael McGurk, GH = George Hitolok, DN = David Nivingalok, IK = Isaac Klengenberg, JF = John Franklin

(continued)

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Appendix 3.1-15

Fish Effort and Catch Data for the 55 Stream Crossings Surveyed Along the Road Route, August 2001 (completed)

			Number						CPUE (number/sec)								
Date	Leg	Stream crossing (km)	Longnose sucker	Ninespine stickleback	Lake trout	Arctic cisco	Round whitefish	Total	Arctic grayling	Slimy sculpin	Burbot	Arctic char	Ninespine stickleback	Lake trout	Arctic cisco	Round whitefish	Total
19-Aug	B	2.2	0	0	0	1	0	**1**	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.000	0.003
19-Aug	B	2.8	0	0	0	0	0	**0**	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
19-Aug	B	7.8	0	0	0	0	0	**0**	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
19-Aug	B	11.7	0	0	0	0	0	**0**	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
19-Aug	B	22.9	0	0	0	0	0	**0**	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
19-Aug	B	33.7	0	1	0	0	0	**1**	0.000	0.000	0.000	0.000	0.002	0.000	0.000	0.000	0.002
18-Aug	B	33.8	0	0	0	0	0	**0**	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
18-Aug	B	34.8	0	0	0	0	0	**1**	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.002
18-Aug	B	35.9	0	0	0	0	0	**0**	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
17-Aug	B	36.6	0	0	0	0	0	**0**	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
16-Aug	B	42.3	0	0	0	0	0	**3**	0.000	0.010	0.000	0.000	0.000	0.000	0.000	0.000	0.010
16-Aug	B	43.3	0	0	0	0	0	**0**	na	na	na	na	na	na	na	na	na
16-Aug	B	44.5	0	0	0	0	0	**3**	0.000	0.010	0.000	0.000	0.000	0.000	0.000	0.000	0.010
16-Aug	B	49.7	0	0	0	0	0	**21**	0.000	0.037	0.000	0.000	0.000	0.000	0.000	0.000	0.037
16-Aug	B	52.0	0	0	0	0	0	**0**	na	na	na	na	na	na	na	na	na
16-Aug	B	58.7	0	0	0	0	0	**2**	0.000	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.004
16-Aug	B	67.9	0	0	0	0	0	**0**	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
16-Aug	B	68.3	0	0	0	0	0	**0**	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
16-Aug	B	68.6	0	0	0	0	1	**6**	0.000	0.011	0.000	0.000	0.000	0.000	0.000	0.002	0.013
16-Aug	B	69.4	0	0	0	0	0	**0**	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
15-Aug	B	70.1	0	0	0	0	0	**0**	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
15-Aug	B	72.2	0	0	0	0	0	**21**	0.028	0.002	0.007	0.000	0.000	0.000	0.000	0.000	0.036
15-Aug	B	76.0	0	0	0	0	0	**0**	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
15-Aug	B	77	0	0	0	0	0	**0**	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
15-Aug	B	84.2	0	0	0	0	1	**4**	0.006	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.008
15-Aug	B	85.0	0	0	0	0	0	**0**	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
15-Aug	B	90.3	0	0	0	0	0	**0**	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
15-Aug	B	103.3	0	0	1	0	0	**4**	0.006	0.000	0.000	0.000	0.000	0.002	0.000	0.000	0.009
14-Aug	B	103.3a	0	0	0	0	0	**25**	0.025	0.029	0.002	0.000	0.000	0.000	0.000	0.000	0.057
14-Aug	B	106.7	0	0	0	0	0	**0**	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
14-Aug	B	113.2	0	0	0	0	0	**0**	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
14-Aug	B	113.8	0	0	0	0	0	**2**	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003
13-Aug	B	115.2	0	0	0	0	0	**3**	0.000	0.006	0.000	0.000	0.000	0.000	0.000	0.000	0.006
13-Aug	B	128.8	0	0	0	0	0	**0**	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
13-Aug	B	134.6	0	0	1	0	0	**25**	0.051	0.002	0.002	0.000	0.000	0.002	0.000	0.000	0.058
13-Aug	B	159.5	0	2	0	0	0	**4**	0.000	0.005	0.000	0.000	0.005	0.000	0.000	0.000	0.010
13-Aug	B	160.7	0	19	0	0	0	**34**	0.005	0.018	0.002	0.000	0.031	0.000	0.000	0.000	0.055
13-Aug	B	168.0	0	0	0	0	0	**0**	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
12-Aug	B	169.6	0	18	0	0	0	**22**	0.000	0.010	0.000	0.000	0.044	0.000	0.000	0.000	0.053
12-Aug	B	170.8	0	0	0	0	0	**1**	0.000	0.000	0.004	0.000	0.000	0.000	0.000	0.000	0.004
12-Aug	B	173.1	0	0	0	0	0	**53**	0.036	0.016	0.025	0.000	0.000	0.000	0.000	0.000	0.077
12-Aug	B	181.4	0	1	0	0	0	**17**	0.013	0.013	0.000	0.000	0.002	0.000	0.000	0.000	0.028
12-Aug	B	183.6	0	0	0	0	0	**0**	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
12-Aug	B	186.5	0	0	0	0	0	**2**	0.000	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.004
11-Aug	B	189.6	0	0	0	0	0	**0**	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
12-Aug	B	192.4	0	0	0	0	0	**2**	0.000	0.006	0.000	0.000	0.000	0.000	0.000	0.000	0.006
11-Aug	B	192.4a	0	0	0	0	0	**3**	0.002	0.002	0.002	0.000	0.000	0.000	0.000	0.000	0.007
11-Aug	B	196.7	0	0	0	0	0	**0**	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
11-Aug	B	197	0	0	0	0	0	**0**	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
11-Aug	B	197.2	0	5	1	0	0	**9**	0.007	0.013	0.000	0.000	0.033	0.007	0.000	0.000	0.060
11-Aug	B	201.9	0	0	0	0	0	**5**	0.001	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.007
10-Aug	B	202.8	0	0	0	0	0	**5**	0.006	0.002	0.002	0.000	0.000	0.000	0.000	0.000	0.010
10-Aug	B	204.3	0	2	0	0	0	**3**	0.000	0.003	0.000	0.000	0.005	0.000	0.000	0.000	0.008
10-Aug	B	206.8	0	0	0	0	0	**30**	0.040	0.000	0.017	0.000	0.000	0.000	0.000	0.000	0.057
10-Aug	B	208.0	0	0	0	0	0	**0**	na	na	na	na	na	na	na	na	na

Survey crew: FL = François Landry, SU = Shane Uren, MM = Michael McGurk, GH = George Hitolok, DN = Da (completed)

APPENDIX 3.1-16
LENGTHS AND WEIGHTS FROM FISH CAPTURED WITHIN THE 55 STREAM CROSSINGS SURVEYED ALONG THE ROAD ROUTE, AUGUST 2001

Appendix 3.1-16
Lengths and Weights from Fish Captured Within the 55 Stream Crossings Along the Road Route, August 2001

Date	Route Leg	Stream crossing (km)	Fish ID number	Species	Fork length (mm)	Weight (g)	Comments
19-Aug	B	2.2	1	Arctic cisco	135	32.0	photo 17-1
20-Aug	B	33.7	1	Ninespine stickleback	46		caught in habitat adjacent to lake, lost before weight was taken
18-Aug	B	34.8	1	Slimy sculpin	67	2.0	
16-Aug	B	42.3	1	Slimy sculpin	70	3.1	
16-Aug	B	42.3	2	Slimy sculpin	77	4.5	
16-Aug	B	42.3	3	Slimy sculpin	51	1.2	
16-Aug	B	44.5	1	Slimy sculpin	84	5.0	
16-Aug	B	44.5	2	Slimy sculpin	84	5.5	
16-Aug	B	44.5	3	Slimy sculpin	62	2.2	
16-Aug	B	49.7	1	Slimy sculpin	90	8.0	
16-Aug	B	49.7	2	Slimy sculpin	85	4.0	
16-Aug	B	49.7	3	Slimy sculpin	58	2.0	
16-Aug	B	49.7	4	Slimy sculpin	56	2.0	
16-Aug	B	49.7	5	Slimy sculpin	59	4.0	
16-Aug	B	49.7	6	Slimy sculpin	51	2.0	
16-Aug	B	49.7	7	Slimy sculpin	65	4.0	
16-Aug	B	49.7	8	Slimy sculpin	59		
16-Aug	B	49.7	9	Slimy sculpin	59		
16-Aug	B	49.7	10	Slimy sculpin	47		mortality
16-Aug	B	49.7	11	Slimy sculpin	60		
16-Aug	B	49.7	12	Slimy sculpin	52		
16-Aug	B	49.7	13	Slimy sculpin	64		
16-Aug	B	49.7	14	Slimy sculpin	67	2.0	
16-Aug	B	49.7	15	Slimy sculpin	54	2.0	
16-Aug	B	49.7	16	Slimy sculpin	60		
16-Aug	B	49.7	17	Slimy sculpin	65		
16-Aug	B	49.7	18	Slimy sculpin	55		
16-Aug	B	49.7	19	Slimy sculpin	56		
16-Aug	B	49.7	20	Slimy sculpin	60		
16-Aug	B	49.7	21	Slimy sculpin	60		
16-Aug	B	58.7	1	Slimy sculpin	90	8.0	
16-Aug	B	58.7	2	Slimy sculpin	70	4.0	
16-Aug	B	68.6	1	Slimy sculpin	78	4.7	
16-Aug	B	68.6	2	Slimy sculpin	72	4.0	
16-Aug	B	68.6	3	Slimy sculpin	69	3.0	
16-Aug	B	68.6	4	Slimy sculpin	72	3.3	
16-Aug	B	68.6	5	Slimy sculpin	67	3.0	
16-Aug	B	68.6	6	Round whitefish	131	23.7	photo 3-12
15-Aug	B	72.2	1	Arctic grayling	44		
15-Aug	B	72.2	2	Arctic grayling	58		
15-Aug	B	72.2	3	Arctic grayling	54		
15-Aug	B	72.2	4	Arctic grayling	54		
15-Aug	B	72.2	5	Arctic grayling	51		
15-Aug	B	72.2	6	Arctic grayling	47		
15-Aug	B	72.2	7	Arctic grayling	42		
15-Aug	B	72.2	8	Arctic grayling	58		
15-Aug	B	72.2	9	Arctic grayling	58		
15-Aug	B	72.2	10	Arctic grayling	59		
15-Aug	B	72.2	11	Arctic grayling	53		
15-Aug	B	72.2	12	Arctic grayling	50		
15-Aug	B	72.2	13	Arctic grayling	56		
15-Aug	B	72.2	14	Arctic grayling	58		
15-Aug	B	72.2	15	Arctic grayling	45		
15-Aug	B	72.2	16	Arctic grayling	35		
15-Aug	B	72.2	17	Burbot	53		
15-Aug	B	72.2	18	Burbot	46		
15-Aug	B	72.2	19	Slimy sculpin	80	6.0	
15-Aug	B	72.2	20	Burbot	127	14.0	
15-Aug	B	72.2	21	Burbot	138	16.0	
15-Aug	B	84.2	1	Arctic grayling	52	1.0	
15-Aug	B	84.2	2	Arctic grayling	54	1.1	
15-Aug	B	84.2	3	Arctic grayling	45	0.9	
15-Aug	B	84.2	4	Round whitefish	105	9.9	photo 3-23
15-Aug	B	103.3	1	Arctic grayling	45		
15-Aug	B	103.3	2	Arctic grayling	43		
15-Aug	B	103.3	3	Arctic grayling	43		
15-Aug	B	103.3	4	Lake Trout	120	24.0	
14-Aug	B	103.3a	1	Arctic grayling	35	0.4	
14-Aug	B	103.3a	2	Arctic grayling	48	0.8	
14-Aug	B	103.3a	3	Arctic grayling	41	0.4	
14-Aug	B	103.3a	4	Arctic grayling	43	0.6	
14-Aug	B	103.3a	5	Arctic grayling	42	0.6	
14-Aug	B	103.3a	6	Arctic grayling	48	1.0	
14-Aug	B	103.3a	7	Arctic grayling	44	0.7	
14-Aug	B	103.3a	8	Arctic grayling	45	0.8	
14-Aug	B	103.3a	9	Arctic grayling	55	1.0	
14-Aug	B	103.3a	10	Arctic grayling	45	0.9	mortality
14-Aug	B	103.3a	11	Slimy sculpin	73	3.6	
14-Aug	B	103.3a	12	Slimy sculpin	56	1.4	
14-Aug	B	103.3a	13	Slimy sculpin	46	0.7	
14-Aug	B	103.3a	14	Slimy sculpin	45	0.9	
14-Aug	B	103.3a	15	Slimy sculpin	54	1.3	

(continued)

Appendix 3.1-16
Lengths and Weights from Fish Captured Within the 55 Stream Crossings Along the Road Route, August 2001 (continued)

Date	Route Leg	Stream crossing (km)	Fish ID number	Species	Fork length (mm)	Weight (g)	Comments
14-Aug	B	103.3a	16	Slimy sculpin	44	0.6	
14-Aug	B	103.3a	17	Slimy sculpin	46	0.8	
14-Aug	B	103.3a	18	Slimy sculpin	42	0.7	
14-Aug	B	103.3a	19	Slimy sculpin	47	0.9	
14-Aug	B	103.3a	20	Slimy sculpin	45	0.9	
14-Aug	B	103.3a	21	Slimy sculpin	56	1.5	
14-Aug	B	103.3a	22	Slimy sculpin	44	0.7	
14-Aug	B	103.3a	23	Slimy sculpin	40	0.5	
14-Aug	B	103.3a	24	Arctic grayling	124	18.4	
14-Aug	B	103.3a	25	Burbot	235	121.3	Ate a 10cm long grayling in container.
14-Aug	B	113.8	1	Arctic grayling	48		
14-Aug	B	113.8	2	Arctic grayling	48		
13-Aug	B	115.2	1	Slimy sculpin	96	10.5	
13-Aug	B	115.2	2	Slimy sculpin	76	4.5	
13-Aug	B	115.2	3	Slimy sculpin	82	6.6	
13-Aug	B	134.6	1	Arctic grayling	42		
13-Aug	B	134.6	2	Arctic grayling	52		
13-Aug	B	134.6	3	Arctic grayling	50		
13-Aug	B	134.6	4	Arctic grayling	45		
13-Aug	B	134.6	5	Arctic grayling	47		
13-Aug	B	134.6	6	Arctic grayling	41		
13-Aug	B	134.6	7	Arctic grayling	42		
13-Aug	B	134.6	8	Arctic grayling	47		
13-Aug	B	134.6	9	Arctic grayling	45		
13-Aug	B	134.6	10	Arctic grayling	46		
13-Aug	B	134.6	11	Arctic grayling	48		
13-Aug	B	134.6	12	Arctic grayling	43		
13-Aug	B	134.6	13	Arctic grayling	49		
13-Aug	B	134.6	14	Arctic grayling	49		
13-Aug	B	134.6	15	Arctic grayling	43		
13-Aug	B	134.6	16	Arctic grayling	46		
13-Aug	B	134.6	17	Slimy sculpin	83		
13-Aug	B	134.6	18	Arctic grayling	150	40.0	
13-Aug	B	134.6	19	Arctic grayling	115	20.0	
13-Aug	B	134.6	20	Arctic grayling	115	22.0	
13-Aug	B	134.6	21	Arctic grayling	115	18.0	
13-Aug	B	134.6	22	Arctic grayling	118	22.0	
13-Aug	B	134.6	23	Arctic grayling	142	38.0	
13-Aug	B	134.6	24	Lake Trout	155	50.0	photo 20-12
13-Aug	B	134.6	25	Burbot	190	38.0	photo 20-13
13-Aug	B	159.5	1	Ninespine stickleback	52		
13-Aug	B	159.5	2	Ninespine stickleback	56		
13-Aug	B	159.5	3	Slimy sculpin	40		
13-Aug	B	159.5	4	Slimy sculpin	39		
13-Aug	B	160.7	1	Ninespine stickleback	54	1.4	
13-Aug	B	160.7	2	Ninespine stickleback	56	1.5	
13-Aug	B	160.7	3	Ninespine stickleback	54	1.4	
13-Aug	B	160.7	4	Ninespine stickleback	60	1.7	
13-Aug	B	160.7	5	Ninespine stickleback	55	1.2	
13-Aug	B	160.7	6	Ninespine stickleback	56	1.2	
13-Aug	B	160.7	7	Ninespine stickleback	60	1.4	
13-Aug	B	160.7	8	Ninespine stickleback	26	0.2	
13-Aug	B	160.7	9	Ninespine stickleback	30	0.2	
13-Aug	B	160.7	10	Ninespine stickleback	60	1.5	
13-Aug	B	160.7	11	Ninespine stickleback	28	0.1	
13-Aug	B	160.7	12	Ninespine stickleback	26	0.1	
13-Aug	B	160.7	13	Ninespine stickleback	26	0.2	
13-Aug	B	160.7	14	Ninespine stickleback	28	0.2	
13-Aug	B	160.7	15	Ninespine stickleback	27	0.3	
13-Aug	B	160.7	16	Ninespine stickleback	27	0.2	
13-Aug	B	160.7	17	Ninespine stickleback	25	0.2	
13-Aug	B	160.7	18	Ninespine stickleback	30	0.2	
13-Aug	B	160.7	19	Ninespine stickleback	61	2.1	
13-Aug	B	160.7	20	Slimy sculpin	82	6.5	
13-Aug	B	160.7	21	Slimy sculpin	72	4.0	
13-Aug	B	160.7	22	Burbot	31	0.3	
13-Aug	B	160.7	23	Slimy sculpin	58	1.7	
13-Aug	B	160.7	24	Arctic grayling	57	1.5	
13-Aug	B	160.7	25	Arctic grayling	135	29.5	
13-Aug	B	160.7	26	Slimy sculpin	27	0.2	
13-Aug	B	160.7	27	Slimy sculpin	36	0.4	
13-Aug	B	160.7	28	Slimy sculpin	31	0.3	
13-Aug	B	160.7	29	Slimy sculpin	28	0.3	
13-Aug	B	160.7	30	Slimy sculpin	31	0.3	
13-Aug	B	160.7	31	Slimy sculpin	28	0.2	
13-Aug	B	160.7	32	Slimy sculpin	25	0.2	
13-Aug	B	160.7	33	Slimy sculpin	25	0.1	
13-Aug	B	160.7	34	Arctic grayling	190	92.6	
12-Aug	B	169.6	1	Ninespine stickleback	35	0.2	

(continued)

Appendix 3.1-16
Lengths and Weights from Fish Captured Within the 55 Stream Crossings Along the Road Route, August 2001 (continued)

Date	Route Leg	Stream crossing (km)	Fish ID number	Species	Fork length (mm)	Weight (g)	Comments
12-Aug	B	169.6	2	Ninespine stickleback	46	0.3	
12-Aug	B	169.6	3	Ninespine stickleback	34	0.2	
12-Aug	B	169.6	4	Ninespine stickleback	41	0.4	
12-Aug	B	169.6	5	Ninespine stickleback	56	1.8	
12-Aug	B	169.6	6	Ninespine stickleback	47	1.0	
12-Aug	B	169.6	7	Ninespine stickleback	28	0.2	
12-Aug	B	169.6	8	Ninespine stickleback	40	0.4	
12-Aug	B	169.6	9	Ninespine stickleback	41	0.4	
12-Aug	B	169.6	10	Ninespine stickleback	37	0.4	
12-Aug	B	169.6	11	Ninespine stickleback	44	0.7	
12-Aug	B	169.6	12	Ninespine stickleback	46	0.6	
12-Aug	B	169.6	13	Ninespine stickleback	45	0.4	
12-Aug	B	169.6	14	Ninespine stickleback	37	0.5	
12-Aug	B	169.6	15	Ninespine stickleback	38	0.3	
12-Aug	B	169.6	16	Ninespine stickleback	42	0.4	
12-Aug	B	169.6	17	Ninespine stickleback	45	0.5	
12-Aug	B	169.6	18	Ninespine stickleback	37	0.2	
12-Aug	B	169.6	19	Slimy sculpin	72	4.2	
12-Aug	B	169.6	20	Slimy sculpin	52	1.3	
12-Aug	B	169.6	21	Slimy sculpin	65	2.2	
12-Aug	B	169.6	22	Slimy sculpin	60	2.0	
12-Aug	B	170.8	1	Burbot	45		
12-Aug	B	173.1	1	Arctic grayling	46	0.8	
12-Aug	B	173.1	2	Arctic grayling	53	1.2	
12-Aug	B	173.1	3	Arctic grayling	54	1.3	
12-Aug	B	173.1	4	Arctic grayling	50	1.0	
12-Aug	B	173.1	5	Arctic grayling	45	0.8	
12-Aug	B	173.1	6	Arctic grayling	47	1.0	
12-Aug	B	173.1	7	Arctic grayling	50	1.0	
12-Aug	B	173.1	8	Arctic grayling	43	0.9	
12-Aug	B	173.1	9	Arctic grayling	54	1.2	
12-Aug	B	173.1	10	Arctic grayling	38	0.6	
12-Aug	B	173.1	11	Arctic grayling	42	0.6	
12-Aug	B	173.1	12	Arctic grayling	46	1.1	
12-Aug	B	173.1	13	Arctic grayling	43	0.9	
12-Aug	B	173.1	14	Arctic grayling	51	1.0	
12-Aug	B	173.1	15	Arctic grayling	47	1.1	
12-Aug	B	173.1	16	Arctic grayling	42	0.8	
12-Aug	B	173.1	17	Arctic grayling	42	0.5	
12-Aug	B	173.1	18	Arctic grayling	50	1.0	
12-Aug	B	173.1	19	Arctic grayling	43	0.7	
12-Aug	B	173.1	20	Arctic grayling	100	14.4	
12-Aug	B	173.1	21	Arctic grayling	108	15.2	mortality
12-Aug	B	173.1	22	Arctic grayling	115	16.2	
12-Aug	B	173.1	23	Arctic grayling	210	95.1	
12-Aug	B	173.1	24	Arctic grayling	104	15.4	
12-Aug	B	173.1	25	Arctic grayling	105	14.8	
12-Aug	B	173.1	26	Burbot	90	6.3	
12-Aug	B	173.1	27	Slimy sculpin	68	2.9	
12-Aug	B	173.1	28	Burbot	25	0.2	
12-Aug	B	173.1	29	Burbot	35	0.3	
12-Aug	B	173.1	30	Slimy sculpin	61	2.2	
12-Aug	B	173.1	31	Burbot	36	0.5	
12-Aug	B	173.1	32	Slimy sculpin	48	0.9	
12-Aug	B	173.1	33	Burbot	102	5.7	
12-Aug	B	173.1	34	Slimy sculpin	68	2.8	
12-Aug	B	173.1	35	Burbot	132	14.2	
12-Aug	B	173.1	36	Slimy sculpin	65	2.1	
12-Aug	B	173.1	37	Burbot	41	0.4	
12-Aug	B	173.1	38	Slimy sculpin	60	2.3	
12-Aug	B	173.1	39	Burbot	105	9.3	
12-Aug	B	173.1	40	Burbot	111	9.6	
12-Aug	B	173.1	41	Burbot	35	0.4	
12-Aug	B	173.1	42	Burbot	36	0.3	
12-Aug	B	173.1	43	Slimy sculpin	90	7.8	
12-Aug	B	173.1	44	Slimy sculpin	45	1.0	
12-Aug	B	173.1	45	Burbot	104	6.5	
12-Aug	B	173.1	46	Burbot	190	44.0	
12-Aug	B	173.1	47	Burbot	30	0.1	
12-Aug	B	173.1	48	Burbot	40	0.2	
12-Aug	B	173.1	49	Slimy sculpin	75	4.2	
12-Aug	B	173.1	50	Burbot	111	6.9	
12-Aug	B	173.1	51	Burbot	40	0.4	
12-Aug	B	173.1	52	Slimy sculpin	62	1.4	
12-Aug	B	173.1	53	Slimy sculpin	60	1.1	
12-Aug	B	181.4	1	Slimy sculpin	65		found dead and moldy
12-Aug	B	181.4	2	Arctic grayling	25		
12-Aug	B	181.4	3	Slimy sculpin	77	6.0	

(continued)

Appendix 3.1-16
Lengths and Weights from Fish Captured Within the 55 Stream Crossings Along the Road Route, August 2001 (completed)

Date	Route Leg	Stream crossing (km)	Fish ID number	Species	Fork length (mm)	Weight (g)	Comments
12-Aug	B	181.4	4	Slimy sculpin	67	4.0	
12-Aug	B	181.4	5	Slimy sculpin	55	2.0	
12-Aug	B	181.4	6	Slimy sculpin	67	4.0	
12-Aug	B	181.4	7	Slimy sculpin	58		
12-Aug	B	181.4	8	Slimy sculpin	60	2.0	
12-Aug	B	181.4	9	Slimy sculpin	63	2.0	
12-Aug	B	181.4	10	Ninespine stickleback	52		
12-Aug	B	181.4	11	Arctic grayling	25		
12-Aug	B	181.4	12	Arctic grayling	24		
12-Aug	B	181.4	13	Arctic grayling	32		
12-Aug	B	181.4	14	Arctic grayling	25		
12-Aug	B	181.4	15	Arctic grayling	25		
12-Aug	B	181.4	16	Arctic grayling	35		
12-Aug	B	181.4	17	Arctic grayling	30		
12-Aug	B	186.5	1	Slimy sculpin	35		
12-Aug	B	186.5	2	Slimy sculpin	60	2.0	
12-Aug	B	192.4	1	Slimy sculpin	75	2.0	
11-Aug	B	192.4a	1	Burbot	87	4.3	
11-Aug	B	192.4a	2	Slimy sculpin	97	8.9	
11-Aug	B	192.4a	3	Arctic grayling	41	1.3	
11-Aug	B	197.2	1	Ninespine stickleback	40		
11-Aug	B	197.2	2	Ninespine stickleback	41		
11-Aug	B	197.2	3	Arctic grayling	45		
11-Aug	B	197.2	4	Lake Trout	72	4.0	
11-Aug	B	197.2	5	Slimy sculpin	45		
11-Aug	B	197.2	6	Ninespine stickleback	49		
11-Aug	B	197.2	7	Slimy sculpin	55		
11-Aug	B	197.2	8	Ninespine stickleback	42		
11-Aug	B	197.2	9	Ninespine stickleback	42		
11-Aug	B	201.9	1	Slimy sculpin	71	4.7	
11-Aug	B	201.9	2	Slimy sculpin	82	4.8	
11-Aug	B	201.9	3	Slimy sculpin	48	1.1	
11-Aug	B	201.9	4	Slimy sculpin	46	0.8	
11-Aug	B	201.9	5	Arctic grayling	35	0.3	
10-Aug	B	202.8	1	Arctic grayling	120	22.0	
10-Aug	B	202.8	2	Arctic grayling	150	42.0	
10-Aug	B	202.8	3	Arctic grayling	102	10.0	
10-Aug	B	202.8	4	Burbot	76	2.0	
10-Aug	B	202.8	5	Slimy sculpin	65	4.0	
10-Aug	B	204.3	1	Ninespine stickleback	25		
10-Aug	B	204.3	2	Ninespine stickleback	30		
10-Aug	B	204.3	3	Slimy sculpin	50		Caught by dipnet
10-Aug	B	206.8	1	Burbot	30		
10-Aug	B	206.8	2	Arctic grayling	46		
10-Aug	B	206.8	3	Burbot	40		
10-Aug	B	206.8	4	Burbot	39		
10-Aug	B	206.8	5	Arctic grayling	37		
10-Aug	B	206.8	6	Arctic grayling	46		
10-Aug	B	206.8	7	Arctic grayling	50		
10-Aug	B	206.8	8	Arctic grayling	50		
10-Aug	B	206.8	9	Arctic grayling	45		
10-Aug	B	206.8	10	Arctic grayling	52		
10-Aug	B	206.8	11	Arctic grayling	50		
10-Aug	B	206.8	12	Arctic grayling	41		
10-Aug	B	206.8	13	Arctic grayling	52		
10-Aug	B	206.8	14	Burbot	40		
10-Aug	B	206.8	15	Arctic grayling	40		
10-Aug	B	206.8	16	Burbot	35		
10-Aug	B	206.8	17	Arctic grayling	51		
10-Aug	B	206.8	18	Arctic grayling	52		
10-Aug	B	206.8	19	Arctic grayling	47		
10-Aug	B	206.8	20	Arctic grayling	45		
10-Aug	B	206.8	21	Arctic grayling	48		
10-Aug	B	206.8	22	Arctic grayling	40		
10-Aug	B	206.8	23	Arctic grayling	45		
10-Aug	B	206.8	24	Burbot	37		
10-Aug	B	206.8	25	Arctic grayling	50		
10-Aug	B	206.8	26	Arctic grayling	48		
10-Aug	B	206.8	27	Burbot	35		
10-Aug	B	206.8	28	Burbot	32		
10-Aug	B	206.8	29	Arctic grayling	47		
10-Aug	B	206.8	30	Arctic grayling	42		

APPENDIX 3.2-1
VERTICAL PROFILES OF DISSOLVED OXYGEN AND TEMPERATURE IN CONTWOYTO LAKE, AUGUST 2001

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Appendix 3.2-1
Vertical Profiles of Dissolved Oxygen and Temperature in Contwoyto Lake, August 2001

Station: Contwoyto Lake
Date: August 17, 2001
Secchi Depth: > max. depth (8.5 m)

Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (% Saturation)
Surface	12.8	10.20	95.5
0.5	12.8	10.25	96.5
1.0	12.8	10.24	96.8
1.5	12.8	10.32	97.0
2.0	12.8	10.28	97.0
2.5	12.7	10.25	96.9
3.0	12.7	10.28	97.0
3.5	12.7	10.36	97.4
4.0	12.6	10.28	97.0
4.5	12.6	10.36	97.5
5.0	12.6	10.32	97.1
5.5	12.6	10.31	97.0
6.0	12.6	10.33	97.3
6.5	12.6	10.34	97.3
7.0	12.6	10.34	97.3
7.5	12.6	10.37	97.6
8.0	12.6	10.32	97.2

APPENDIX 3.2-2
ANALYTICAL RESULTS FOR PHYSICAL VARIABLES, NUTRIENTS, METALS AND PARTICLE SIZE OF SEDIMENTS IN CONTWOYTO LAKE, AUGUST 2001

Appendix 3.2-2
Analytical Results for Physical Variables, Nutrients, Metals and Particle Size of Sediments in Contwoyto Lake, August 2001

Variable	Units[1]	Contwoyto Lake Rep A 18/08/2001	Contwoyto Lake Rep B 18/08/2001	Contwoyto Lake Rep C 18/08/2001
Physical Variables				
Moisture	%	35.7	35	38.3
Nutrients				
Available Phosphorus	mg/kg	5	7	6
Total Nitrogen	% dry weight	0.05	0.04	0.04
Inorganic Variables				
Total Sulphur	% dry weight	<0.01	<0.01	<0.01
Organic Variables				
Total Organic Carbon	% dry weight	0.35	0.49	0.49
Particle Size				
Gravel (>2.00mm)	% dry weight	1.3	1.5	1.1
Sand (2.00mm - 0.063mm)	% dry weight	88.6	84.2	85.2
Silt (0.063mm - 4µm)	% dry weight	8.1	12.6	12
Clay (<4µm)	% dry weight	2	1.7	1.7
Total Metals				
Aluminum	mg/kg	6,540	5,680	5,680
Antimony	mg/kg	<20	<20	<20
Arsenic	mg/kg	3.6	4	3.8
Barium	mg/kg	24	27	25
Beryllium	mg/kg	<0.5	<0.5	<0.5
Bismuth	mg/kg	<20	<20	<20
Cadmium	mg/kg	<0.1	<0.1	<0.1
Calcium	mg/kg	1,750	1,670	1,810
Chromium	mg/kg	15	15	14
Cobalt	mg/kg	9	10	9
Copper	mg/kg	6	6	6
Iron	mg/kg	9,650	9,450	9,180
Lead	mg/kg	<2	<2	<2
Lithium	mg/kg	11	12	11
Magnesium	mg/kg	2,840	3,040	2,750
Manganese	mg/kg	886	1,000	1,010
Mercury	mg/kg	<0.005	<0.005	0.005
Molybdenum	mg/kg	<4	<4	<4
Nickel	mg/kg	12	15	13
Phosphorus	mg/kg	112	107	108
Potassium	mg/kg	1,090	1,160	1,090
Selenium	mg/kg	<50	<50	<50
Silver	mg/kg	<2	<2	<2
Strontium	mg/kg	14	13.6	14.1
Thallium	mg/kg	<50	<50	<50
Tin	mg/kg	<10	<10	<10
Titanium	mg/kg	570	543	561
Vanadium	mg/kg	16	16	15
Zinc	mg/kg	20	21	21

[1] **Results expressed as milligrams per kilogram were measured as dry weight.**

APPENDIX 3.2-3
ANALYTICAL RESULTS FOR EXTRACTABLE PETROLEUM HYDROCARBONS IN CONTWOYTO LAKE SEDIMENTS, AUGUST 2001

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Appendix 3.2-3
Analytical Results for Extractable Petroleum Hydrocarbons in Contwoyto Lake Sediments, August 2001

Parameter	Units[1]	Contwoyto Lake Rep A 19/09/2001	Contwoyto Lake Rep B 19/09/2001	Contwoyto Lake Rep C 19/09/2001
Physical Test				
Moisture %	%	37.9	33.8	31.4
Extractable Hydrocarbons				
C_{10}-C_{19}	mg/kg	<200	<200	<200
C_{19}-C_{32}	mg/kg	<200	<200	<200

[1] **Results expressed as mg/kg were measured as dry weight.**

APPENDIX 3.2-4
SEDIMENT DESCRIPTION SHEETS FOR CONTWOYTO LAKE, AUGUST 2001

Appendix 3.2-4
Sediment Description Sheets for Contwoyto Lake, August 2001

Replicate:	**Rep A**	**Rep B**	**Rep C**
Date:	**17 August, 2001**	**17 August, 2001**	**17 August, 2001**
Depth (m):	**8.3**	**8.5**	**8.5**
Grab Thickness (mm)	**30**	**36**	**26**
Physical Description:	Top layer: thin ~10 mm sand, gritty Bottom layer: Finer clay sand, more firm, abrupt horizon between layers	Top layer: thin ~10 mm sand, gritty Bottom layer: Finer clay sand, more firm, abrupt horizon between layers	Top layer: thin ~10 mm sand, gritty Bottom layer: Finer clay sand, more firm, abrupt horizon between layers
Munsell Color Classification:	Top layer: Very dark brown 10YR 2/2 Bottom layer: Dark yellowish brown 10YR 4/4	Top layer: Very dark brown 10YR 2/2 Bottom layer: Dark yellowish brown 10YR 4/4	Top layer: Very dark brown 10YR 2/2 Bottom layer: Dark yellowish brown 10YR 4/4
Biological Material:	Worm		
Debris Material:			
Notes:		Bottom layer contains pebbles	Bottom layer contains pebbles
Photograph (Y/N):	Yes	Yes	Yes

APPENDIX 3.2-5
PHOTOGRAPHIC RECORD OF CONTWOYTO LAKE SEDIMENTS, AUGUST 2001

APPENDIX 3.2-5
PHOTOGRAPHIC RECORD OF CONTWOYTO LAKE SEDIMENTS, AUGUST 2001



Plate 1: Contwoyto Lake, Rep. A, 8.5 m (August 18, 2001).



Plate 2: Contwoyto Lake, Rep. B, 8.5 m (August 18, 2001).



Plate 3: Contwoyto Lake, Rep. C, 8.5 m (August 18, 2001).

APPENDIX 3.2-6
ABUNDANCE OF PHYTOPLANKTON TAXA IN CONTWOYTO LAKE, AUGUST 2001

Appendix 3.2-6
Abundance of Phytoplankton Taxa in Contwoyto Lake, August 2001

		Contwoyto Lake Rep A 17/08/2001	Contwoyto Lake Rep B 17/08/2001	Contwoyto Lake Rep C 17/08/2001	Mean	Std. Error	%
BACILLARIOPHYCEAE							
PENNALES	*Achnanthes lanceolata* (Brebisson) Grunow						
	Achnanthes minutissima Kuetzing	1,154		2,886			
	Asterionella formosa Hansall						
	Cocconeis placentula Ehrenberg						
	Cymbella silesiaca Bleisch ex. Rabenhorst						
	Diatoma tenuis Agardh						
	Didymosphaeria germinata (Lyngyb.) M. Schmidt			2,886			
	Fragilaria capucina Desmazieres						
	Fragilaria crotonensis Kitton	2,309					
	Navicula cryptotenella Lange-Bertalot			1,443			
	Navicula pupula Kuetzing						
	Tabellaria flocculosa (Roth) Kuetzing		1,154				
CENTRALES	*Aulacoseira spp.*	4,618		2,886			
	Cyclotella spp	5,773	8,082	5,772			
	Rhizosolenia longiseta Ehrenberg						
	TOTAL DIATOMS	**13,854**	**9,236**	**15,873**	**12,988**	**1,964**	**10**
CHLOROPHYTA							
CHLOROCOCCALES							
	Ankistrodesmus fusiformis Corda						
	Ankistrodesmus spiralis (Turner) Lemmermann		1,154				
	Elaktothrix gelatinosa	5,773	12,701	11,546			
	Elaktothrix genvensis	4,618	5,773				
	Crucegenia quadrata Morren	1,154	1,154				
	Gloeocystis planctonica (W. & G.S. West) Lemmermann			1,443			
	Gloeocystis spp.						
	Monoraphidium arcuatum (Kors) Hind.		1,154				
	Monoraphidium circinale (Nygaard) Nygaard						
	Monoraphidium contortum (Thuret) Komarkovae-Legenerova	1,154					
	Monoraphdium griffithii (Berkeley) Komarkova-Legenerova						
	Monoraphidium komarkovae Nygaard	24,247	18,474	21,649			
	Monoraphidium mirabile (W. & G.S. West) Pankow			1,443			
	Monoraphidium tortile (W. & G.S. West) Komarkova-Legenerova			5,773			
	Oocystis solitaria Wittrock	1,154					
	Oocystis submarina Lagerheim						
	Pediastrum duplex Meyen						
	Pediastrum simplex Meyen		1,154				
	Scenedesmus acutus Meyen	1,154					
	Scenedesmus obliquus (Turpin) Kuetzing						
	Scenedesmus subspicatus Chodat						
	Scenedesmus sp		1,154				
	Tetraedron minimum (A. Braun) Hansgirg	1,154					
VOLVOCALES	*Chlamydomonas snowii Printz*		1,154				
	Chlamydomonas spp.	4,617	0	0			
ZYGENEMATALES	*Cosmaruim bioculatum* Brebisson						
	Cosmarium granatum Brebisson						
	Staurodesmus triangularis (Lagerheim) Teiling	6,927					
	Staurodesmus incus (Brebisson) Teiling		1,154				
	Staurodesmus spp						
ULOTRICALES	*Ulothrix sp*	10,391	8,082	10,103			
	TOTAL CHLOROPHYTA	**62,343**	**53,108**	**51,957**	**55,803**	**3,287**	**45**
PYRROPHYTA							
CRYPTOMONADALES	*Cryptomonas erosa Ehrenberg*	1,154					
	Cryptomonas marsonii Skuja	1,154	1,154	1,443			
	Cryptomonas parapyrenoidifera Geitler						
	Cryptomonas reflexa Skuja			1,443			
	Cryptomonas rostraformis Skuja						
	Katablepharis ovalis Skuja	9,237		2,886			
	Rhodomonas minuta Skuja						
	Rhodomonas minuta minuta var. nanoplanktonica	27,711	38,103	23,092			
DINOKONTAE	*Ceratium hirundinella* (O.F. Muller) Schrank			1,443			
	Gymnodinium inversum Nygaard	1,154	1,154				
	Gymnodinium ordinatum Skuja			2,886			
	Peridinium inconspicum Lemmermann						
	TOTAL PYRROPHYTA	**40,410**	**40,411**	**33,193**	**38,005**	**2,406**	**31**
CYANOBACTERIA							
NOSTOCALES	Anabaena affinis Lemmermann			1,443			
	Aphanizomenon flos-aquae						
CHROOCOCCALES	*Chroococcus limneticus Lemmermann*						
	Chroococcus minutus (Kuetz.) Naegeli						
	Gloeocapsa sp			1,443			
	TOTAL CYANOBACTERIA	**0**	**0**	**2,886**	**962**	**962**	**1**
CHRYSOPHYTA							
OCHROMONADALES	*Dinobryon attenatum (Hilliard) Hilliard*	1,154					
	Dinobryon balticum (Schutt) Lemmermann						
	Dinobryon bavaricum Imhof	2,309	1,154	1,443			
	Dinobryon cylindricum Imhof			1,443			
	Dinobryon divergens Imhof	1,154					
	Dinobryon setularia Ehrenberg						
	Dinobryon sociale Ehrenberg	2,309	1,154	4,329			
	Ochromonas sp	2,309		1,443			
	Dinobryon spp.	1,154					
CHROMULINALES	*Kephyrion sphaericum* (Hilliard) Starmach	2,309	4,618	1,443			
	Kephyrion boreale Skuja	3,463	5,773	2,886			
	Kephyrion spp.						
	Mallomonas pseudocoronata Prescott			1,443			
	Colourless flagellate	2,309					
	TOTAL CHRYSOPHYTA	**18,470**	**12,699**	**14,430**	**15,200**	**1,710**	**12**
XANTHOPHYTA							
MISCHOCOCCALES	*Centritractus belenophorus* Lemmermann			2,886			
	Tetraedron muticum (A. Braun) Hansgrig)						
	Isthmochloron trispinatum (W. & G.S. West) Skuja						
	TOTAL XANTHOPHYTA	**0**	**0**	**2,886**	**962**	**962**	**1**
EUGLENOPHYTA							
EUGLENALES	*Trachelomonas hispida* (Perty) Stein em. Deflandre						
	TOTAL EUGLENOPHYTA	**0**	**0**	**0**	**0**	**0**	**0**
TOTAL		**135,077**	**115,454**	**121,225**	**123,919**	**5,823**	**100**

APPENDIX 3.2-7
PHYTOPLANKTON CHLOROPHYLL *A* CONCENTRATIONS IN CONTWOYTO LAKE, AUGUST 2001

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Appendix 3.2-7
Phytoplankton Chlorophyll *a* Concentrations in Contwoyto Lake, August 2001

Station	Replicate	Date	Chlorophyll *a* (µg/L)
Contwoyto Lake	A	17-Aug-01	0.22
Contwoyto Lake	B	17-Aug-01	0.19
Contwoyto Lake	C	17-Aug-01	0.18

APPENDIX 3.2-8
ABUNDANCE OF ZOOPLANKTON TAXA IN CONTWOYTO LAKE, AUGUST 2001

Appendix 3.2-8
Abundance of Zooplankton Taxa in Contwoyto Lake, August 2001

Species/group	Stage	Contwoyto Lake Rep A 17/08/2001	Contwoyto Lake Rep B 17/08/2001	Contwoyto Lake Rep C 17/08/2001	Mean	Std. Error	Percent
ROTIFERA							
Kellicottia longispina		8,000	9,429	11,724			
Conochilus sp.	colony	1,429	2,000	4,483			
Asplanchna sp.			57				
SUM (org/m^3)		9,429	11,486	16,207	12,374	2,006	53
CLADOCERA							
Holopedium gibberum	F/J	2,286	2,857	1,931			
Daphnia longiremis	F/J	229	200	414			
Daphnia middendorffiana	F						
Bosmina longirostris		1,600	2,286	2,759			
SUM (org/m^3)		4,114	5,343	5,103	4,854	376	21
COPEPODA							
Calanoida							
Leptodiaptomus pribilofensis	M	20	14	17			
Leptodiaptomus pribilofensis	F	9	17	24			
Leptodiaptomus ashlandi	M	3	3	7			
Leptodiaptomus ashlandi	F	3	3	10			
Leptodiaptomus sicilis	M	49	26	31			
Leptodiaptomus sicilis	F	49	60	55			
Leptodiaptomus sp.	V	114	229	138			
Leptodiaptomus sp.	IV	486	686	414			
Leptodiaptomus sp.	III	400	571	931			
Leptodiaptomus sp.	II	200	286	241			
Leptodiaptomus sp.	I	29	86	34			
Heterocope septentrionalis	M	3	3	3			
Heterocope septentrionalis	F						
Heterocope septentrionalis	V						
Heterocope septentrionalis	IV						
Epischura nevadensis	M	69	69	66			
Epischura nevadensis	F	26	20	28			
Epischura nevadensis	V	94	49	62			
Epischura nevadensis	IV	54	114	207			
Epischura nevadensis	III	114	57	172			
Epischura nevadensis	II		29	69			
SUM (org/m^3)		1,720	2,320	2,510	2,183	238	9
Unidentified Calanoida	nauplius	86	57	103			
SUM (org/m^3)		86	57	103	82	13	0
Cyclopoida							
Cyclops scutifer	M	171	143	138			
Cyclops scutifer	F	200	200	172			
Cyclops sp.	copepodite	3,143	1,914	4,138			
SUM (org/m^3)		3,514	2,257	4,448	3,407	635	15
Unidentified Cyclopoida	nauplius	257	429	586			
SUM (org/m^3)		257	429	586	424	95	2
TOTAL		19,120	21,891	28,959	23,323	2,929	100

J = juvenile; M/F = male/female

APPENDIX 3.2-9
DENSITIES OF BENTHIC INVERTEBRATE TAXA IN CONTWOYTO LAKE, AUGUST 2001

Appendix 3.2-9

Densities of Benthic Invertebrate Taxa in Contwoyto Lake, August 2001

Species/Group	Stage	Contwoyto Lake Rep A 18/08/2001	Contwoyto Lake Rep B 18/08/2001	Contwoyto Lake Rep C 18/08/2001	Mean	Std. Error	Percent
COELENTERATA							
Hydra				89			
SUM (org/m^2)		0	0	89	30	30	2
NEMATODA			44	533			
SUM (org/m^2)		0	44	533	193	171	11
TURBELLARIA	juv						
SUM (org/m^2)		0	0	0	0	0	0
OLIGOCHAETA							
Unidentified	juv			44			
Lumbriculidae							
Lumbriculus			44				
Enchytraeidae							
SUM (org/m^2)		0	44	44	30	15	2
EUBRANCHIOPODA							
Notostraca							
Triops longicaudatus				44			
SUM (org/m^2)		0	0	44	15	15	1
CLADOCERA							
Bosmina longirostris				89			
SUM (org/m^2)		0	0	89	30	30	2
COPEPODA							
Calanoida							
Leptodiaptomus	cop			44			
Cyclopoida							
Harpacticoida							
Canthocamptidae				44			
SUM (org/m^2)		0	0	89	30	30	2
ARACHNIDA							
Hydracarina	A	44	44	44			
SUM (org/m^2)		44	44	44	44	0	3
TRICHOPTERA							
Limnephilidae							
Apatania	L	89	44	44			
SUM (org/m^2)		89	44	44	59	15	4
DIPTERA							
Simulidae							
Simulium	L						
Chironomidae	P	89		178			
Tanypodinae	L*						
Procladius	L		44	89			
Thiennemannimyia	L						
Tanytarsini	L						
Paratanytarsus	L	44	133	222			
Paratanytarsus	P						
Rheotanytarsus	L	178	89	222			
Rheotanytarsus	P	44	44	44			
Stempellinella	L			44			
Tanytarsus	L		222	44			
Tanytarsus	P			44			
Chironomini							
Parachironomus	L						
Orthocladiinae	L*			44			
Eukiefferiella	P			89			
Heteroctrissocladius	L						
Heteroctrissocladius	P						
Hydrobaenus	L						
Orthocladius	L		44				
Orthocladius	P	178	356	178			
Diamesinae							
Protanypus	L						
Pseudodiomesa	L						
SUM (org/m^2)		533	933	1,200	889	194	53
MOLLUSCA							
Bivalvia							
Sphaeriidae	juv	133	44	222			
Sphaerium		133	400	178			
SUM (org/m^2)		267	444	400	370	53	22
TOTAL		**933**	**1,556**	**2,578**	**1,689**	**479**	**100**

A = adult
cop = copepodite
juv = juvenile
L = larva
L* = larva too small to be identified, or damaged
P = pupa
P* = pupa too small to be identified, or damaged

APPENDIX 3.2-10
FISH COMMUNITY CATCH DATA FOR CONTWOYTO LAKE, AUGUST 2001

Appendix 3.2-10
Fish Community Catch Data for Contwoyto Lake, August 2001

Date	Site Number	Sample Method	Sampling Crew	Sample Number	Species Code	FL (mm)	WT (g)	Sex	Mat.	Repr. Stat.	Aging Structure	Age (yr)	Tissue Sample	Stomach Contents
14-Aug-01	GN1	GN	IK, FL	50	LKTR	506	1250				2,3	14		
14-Aug-01	F1	GN	IK, FL	51	ARCH	565	1800				2,3	12		
14-Aug-01	GN2	GN	IK, FL	52	LKTR	748	4150				2,3	27		
14-Aug-01	GN2	GN	IK, FL	53	LKTR	732	4800				2,3	28		
14-Aug-01	GN2	GN	IK, FL	54	LKTR	652	3450				2,3	21		
14-Aug-01	GN2	GN	IK, FL	55	LKTR	602	2575				2,3	19		
14-Aug-01	GN2	GN	IK, FL	56	LKTR	766	4300				2,3	23		
14-Aug-01	GN2	GN	IK, FL	57	LKTR	555	1850				2,3	15		
14-Aug-01	GN2	GN	IK, FL	58	LKTR	585	2150				2,3	14		
14-Aug-01	GN2	GN	IK, FL	59	LKTR	377	600				2,3	8		
14-Aug-01	GN2	GN	IK, FL	60	LKTR	245	125	F	1	1	1,2,3	7	MY	adult insects
14-Aug-01	GN2	GN	IK, FL	61	LKTR	207	82	M	1	1	1,2,3	6		chironomid larvae
14-Aug-01	GN2	GN	IK, FL	62	LKTR	200	80	F	1	1	1,2,3	6		empty
14-Aug-01	GN2	GN	IK, FL	63	LKTR	420	725	F	2	2	1,2,3	12	MY	adult insects, (moth, wasp)
14-Aug-01	GN2	GN	IK, FL	64	LKTR	191	72	M	1	1	1,2,3	6		fish
14-Aug-01	GN2	GN	IK, FL	65	LKTR	201	82	F	1	1	1,2,3	6		fish
14-Aug-01	GN2	GN	IK, FL	66	LKTR	165	46	U	0	0	2,3	4		
14-Aug-01	GN2	GN	IK, FL	67	LKTR	624	3350	F	2	3	1,2,3	24	MY	fish (sculpins)
14-Aug-01	GN2	GN	IK, FL	68	LKTR	750	4350	M	2	3	1,2,3	31	MY	empty
14-Aug-01	GN2	GN	IK, FL	69	LKTR	567	2250	F	2	3	1,2,3	18	MY	bivalves
14-Aug-01	GN2	GN	IK, FL	70	LKTR	620	2850	M	2	3	1,2,3	17	MY	fish
14-Aug-01	GN2	GN	IK, FL	71	LKTR	665	3350	F	2	3	1*,2,3	23	MY	fish (whitefish), large terrestrial insects
14-Aug-01	GN2	GN	IK, FL	72	LKTR	553	2025	M	2	3	1,2,3	20		fish and insects
14-Aug-01	GN2	GN	IK, FL	73	RDWH	363	525	F	2	3	1,2,3	9		caddisflies (sand cases) Photo 9-11
14-Aug-01	GN2	GN	IK, FL	74	LKTR	943	10775	F	2	resting	1,2,3	36	MY	lake trout (51cm) and whitefish (photo 19-12,13)
14-Aug-01	GN2	GN	IK, FL	75	LKTR	622	2725	M	2	3	1,2,3	26		burbot ~25cm
15-Aug-01	GN3	GN	IK, FL	76	LKTR	620	2975				2,3	24		
15-Aug-01	GN3	GN	IK, FL	77	LKTR	695	4050				2,3	27		
15-Aug-01	GN3	GN	IK, FL	78	LKTR	611	2600				2,3	15		
15-Aug-01	GN3	GN	IK, FL	79	LKTR	803	5600				2,3	28		
15-Aug-01	GN3	GN	IK, FL	80	LKTR	925	8875				2,3	29		
15-Aug-01	F3	GN	IK, FL	81	LKTR	435	875				2,3	10		
15-Aug-01	F3	GN	IK, FL	82	LKTR	480	1400				2,3	12		
15-Aug-01	F3	GN	IK, FL	83	LKCS	241	175	M	2	2	1,2,3	6		empty
15-Aug-01	GN3	GN	IK, FL	84	LKCS	235	138	M	2	2	1,2,3	5		detritus
15-Aug-01	GN3	GN	IK, FL	85	LKCS	255	170	M	2	2	1,2,3	5		detritus
15-Aug-01	GN3	GN	IK, FL	86	LKCS	290	300	F	2	3	1,2,3	7		zooplankton (photo19-4)
15-Aug-01	GN3	GN	IK, FL	87	LKCS	326	450	F	2	3	1,2,3	11		zooplankton
15-Aug-01	GN3	GN	IK, FL	88	LKCS	290	250	F	2	3	1,2,3	6		zooplankton
15-Aug-01	GN3	GN	IK, FL	89	RDWH	312	325	M	2	2	1,2,3	6		caddisflies
15-Aug-01	GN3	GN	IK, FL	90	RDWH	288	230	M	2	2	1,2,3	7		caddisflies
15-Aug-01	GN3	GN	IK, FL	91	RDWH	313	300	F	2	3	1,2,3	7		caddisflies and detritus
15-Aug-01	GN3	GN	IK, FL	92	RDWH	305	300	F	2	2	1,2,3	7		caddisflies and detritus (photo 9-3)
15-Aug-01	GN3	GN	IK, FL	93	RDWH	296	252	M	2	2	1,2,3	7		detritus
15-Aug-01	GN3	GN	IK, FL	94	RDWH	292	300	F	2	3	1,2,3	7		insects adult, detritus
15-Aug-01	GN3	GN	IK, FL	95	RDWH	329	325	M	2	2	1,2,3	7		detritus
15-Aug-01	GN3	GN	IK, FL	96	RDWH	302	250	M	2	2	1,2,3	7		detritus
15-Aug-01	GN3	GN	IK, FL	97	RDWH	310	350	M	2	2	1,2,3	7		caddisflies
15-Aug-01	GN3	GN	IK, FL	98	ARGR	425	850	M	2	2	1,2,3	13		detritus (photo 9-2)
15-Aug-01	GN3	GN	IK, FL	99	ARGR	399	800	M	2	3	1,2,3	9		detritus
15-Aug-01	GN3	GN	IK, FL	100	ARGR	425	850	M	2	3	1,2,3	18		detritus
15-Aug-01	GN3	GN	IK, FL	101	RDWH	255	162	M	1	1	1,2,3	4		detritus
15-Aug-01	GN3	GN	IK, FL	102	LKTR	266	166	F	1	1	1,2,3	8		terrestrial insects
15-Aug-01	GN3	GN	IK, FL	103	LKTR	221	112	F	1	1	1,2,3	7		terrestrial insects
15-Aug-01	GN3	GN	IK, FL	104	LKTR	280	230	M	1	1	1,2,3	8		terrestrial insects
15-Aug-01	GN3	GN	IK, FL	105	LKTR	190	76	M	1	1	1,2,3	6		terrestrial insects
15-Aug-01	GN3	GN	IK, FL	106	LKTR	200	72	M	1	1				terrestrial insects
15-Aug-01	GN3	GN	IK, FL	107	LKTR	215	90	F	1	1				terrestrial insects
15-Aug-01	GN3	GN	IK, FL	108	LKTR	187	66	M	1	1				terrestrial insects
15-Aug-01	GN3	GN	IK, FL	109	LKTR	176	50	M	1	1	1,2,3	4		terrestrial insects
15-Aug-01	GN3	GN	IK, FL	110	ARCH	387	600	F	2	2	1,2,3	9		terrestrial insects
15-Aug-01	GN3	GN	IK, FL	111	ARCH	445	925	M	1	1	1,2,3	8		terrestrial insects
15-Aug-01	GN3	GN	IK, FL	112	LKTR	500	1500	M	2	2	1,2,3	14	MY	fish
15-Aug-01	GN3	GN	IK, FL	113	LKTR	588	2550	M	2	3	1,2,3	22		chironomids
15-Aug-01	GN3	GN	IK, FL	114	LKTR	600	2375	F	2	3	1,2,3	19	MY	fish
15-Aug-01	GN3	GN	IK, FL	115	LKTR	515	1500	F	2	2	1,2,3	17	MY	terrestrial insects
15-Aug-01	GN3	GN	IK, FL	116	LKTR	555	2050	M	2	3	1,2,3	13		empty
15-Aug-01	GN3	GN	IK, FL	117	LKTR	630	2825	M	2	3	1,2,3	33		empty
15-Aug-01	GN3	GN	IK, FL	118	LKTR	705	3500	F	2	2	1,2,3	42	MY	empty
15-Aug-01	GN4	GN	IK, FL	120	LKTR	670	3300				2,3	24		
15-Aug-01	GN4	GN	IK, FL	121	RDWH	240	100				2,3	4		
15-Aug-01	GN5	GN	IK, FL	122	LKTR	870	6150				2,3	24		
15-Aug-01	F3	GN	IK, FL	123	ARCH	620	2700				2,3	12		
15-Aug-01	F3	GN	IK, FL	124	LKTR	459	950				2,3	9		
15-Aug-01	F3	GN	IK, FL	125	ARCH	388	500				2,3	8		
15-Aug-01	F3	GN	IK, FL	126	ARCH	385	525				2,3	8		

Site Number: GN = sinking gillnet, F = floating gillnet, M = minnow trap

(continued)

Sampling Method: GN = gillnet, MT = minnow trap

Sampling Crew: IK = Isaac Klengenberg, FL = François Landry

Species Code: ARCH = Arctic char, ARGR = Arctic grayling, LKCS = Lake ci

Appendix 3.2-10
Fish Community Catch Data for Contwoyto Lake, August 2001(completed)

Date	Site Number	Sample Method	Sampling Crew	Sample Number	Species Code	FL (mm)	WT (g)	Sex	Mat.	Repr. Stat.	Aging Structure	Age (yr)	Tissue Sample	Stomach Contents
15-Aug-01	GN3	GN	IK, FL	127	LKTR	620	2800	M	2	3	1,2,3	16		fish
16-Aug-01	M4	MT	IK, FL	128	NSST	47								
16-Aug-01	M4	MT	IK, FL	129	NSST	53								
16-Aug-01	M4	MT	IK, FL	130	NSST	52								
16-Aug-01	M4	MT	IK, FL	131	NSST	47								
16-Aug-01	M4	MT	IK, FL	132	NSST	50								
16-Aug-01	M4	MT	IK, FL	133	NSST	45								
16-Aug-01	M4	MT	IK, FL	134	NSST	49								
16-Aug-01	M4	MT	IK, FL	135	NSST	48								
16-Aug-01	M4	MT	IK, FL	136	NSST	57								
16-Aug-01	M4	MT	IK, FL	137	NSST	51								
16-Aug-01	M4	MT	IK, FL	138	NSST	55								
16-Aug-01	M4	MT	IK, FL	139	NSST	50								photo 11-11, 2 sticklebacks
16-Aug-01	M4	MT	IK, FL	140	NSST	48								
16-Aug-01	M4	MT	IK, FL	141	NSST	53								
16-Aug-01	M4	MT	IK, FL	142	NSST	52								
16-Aug-01	M4	MT	IK, FL	143	NSST	48								
16-Aug-01	M4	MT	IK, FL	144	NSST	55								
16-Aug-01	M4	MT	IK, FL	145	NSST	50								
16-Aug-01	M4	MT	IK, FL	146	NSST	52								
16-Aug-01	M4	MT	IK, FL	147	NSST	47								
16-Aug-01	M1	MT	IK, FL	148	NSST	49								
16-Aug-01	M2	MT	IK, FL	149	NSST	50								bucket with NSST + 3 burbot (11-10), burbot (9-8).
16-Aug-01	M2	MT	IK, FL	150	NSST	50								
16-Aug-01	M2	MT	IK, FL	151	NSST	51								
16-Aug-01	M2	MT	IK, FL	152	NSST	55								
16-Aug-01	M2	MT	IK, FL	153	NSST	51								
16-Aug-01	M2	MT	IK, FL	154	NSST	55								
16-Aug-01	M2	MT	IK, FL	155	NSST	50								
16-Aug-01	M2	MT	IK, FL	156	NSST	52								
16-Aug-01	M2	MT	IK, FL	157	NSST	50								
16-Aug-01	M2	MT	IK, FL	158	NSST	52								
16-Aug-01	M2	MT	IK, FL	159	NSST	53								
16-Aug-01	M2	MT	IK, FL	160	NSST	48								
16-Aug-01	M2	MT	IK, FL	161	NSST	52								
16-Aug-01	M2	MT	IK, FL	162	NSST	56								
16-Aug-01	M2	MT	IK, FL	163	NSST	53								
16-Aug-01	M2	MT	IK, FL	164	NSST	59								
16-Aug-01	M2	MT	IK, FL	165	NSST	52								
16-Aug-01	M2	MT	IK, FL	166	NSST	55								
16-Aug-01	M2	MT	IK, FL	167	NSST	56								
16-Aug-01	M2	MT	IK, FL	168	NSST	53								
16-Aug-01	M2	MT	IK, FL	169	NSST	54								
16-Aug-01	M2	MT	IK, FL	170	NSST	46								
16-Aug-01	M2	MT	IK, FL	171	NSST	50								
16-Aug-01	M2	MT	IK, FL	172	NSST	52								
16-Aug-01	M2	MT	IK, FL	173	NSST	62								
16-Aug-01	M2	MT	IK, FL	174	NSST	55								
16-Aug-01	M2	MT	IK, FL	175	NSST	50								
16-Aug-01	M2	MT	IK, FL	176	NSST	48								
16-Aug-01	M2	MT	IK, FL	177	NSST	51								
16-Aug-01	M2	MT	IK, FL	178	NSST	50								
16-Aug-01	M2	MT	IK, FL	179	NSST	50								
16-Aug-01	M2	MT	IK, FL	180	NSST	50								
16-Aug-01	M2	MT	IK, FL	181	BURB	97								
16-Aug-01	M2	MT	IK, FL	182	BURB	96								
16-Aug-01	M2	MT	IK, FL	183	BURB	113								
16-Aug-01	M3	MT	IK, FL	184	NSST	55								
16-Aug-01	M3	MT	IK, FL	185	NSST	59								
16-Aug-01	M3	MT	IK, FL	186	NSST	55								
16-Aug-01	M3	MT	IK, FL	187	NSST	47								
16-Aug-01	M3	MT	IK, FL	188	NSST	46								
16-Aug-01	M3	MT	IK, FL	189	NSST	54								
16-Aug-01	M5	MT	IK, FL	190	NSST	49								
16-Aug-01	M5	MT	IK, FL	191	NSST	45								
16-Aug-01	BS1	BS	IK, FL	192	NSST	50								
16-Aug-01	BS2	BS	IK, FL	193	NSST	55								
16-Aug-01	F4	GN	IK, FL	194	LKTR	470	1100				2,3	12		
16-Aug-01	F4	GN	IK, FL	195	ARCH	211	92				2,3	4		

Site Number: GN = sinking gillnet, F = floating gillnet, M = minnow trap

Sampling Method: GN = gillnet, MT = minnow trap

Sampling Crew: IK = Isaac Klengenberg, FL = François Landry

Species Code: ARCH = Arctic char, ARGR = Arctic grayling, LKCS = Lake ci

APPENDIX 3.2-11
GILLNET, SEINE AND MINNOW TRAP LOCATIONS, CONTWOYTO LAKE, AUGUST 2001

Appendix 3.2-11

Gillnet, Seine and Minnow Trap Locations, Contwoyto Lake, August 2001

Port	Methods	Site #	Date	Northing (degrees, minutes, decimal)			Easting (degrees, minutes, decimal)			Northing (degrees, minutes, decimal)			Easting (degrees, minutes, decimal)		
South Barge Terminal															
	Sinking Gillnet	GN1	14-Aug-01	65	28	0.408	110	9	0.935	65	28	0.372	110	9	0.764
		GN2	14-Aug-01	65	28	0.467	110	10	0.207	65	28	0.426	110	10	0.361
		GN3	15-Aug-01	65	28	0.408	110	9	0.935	65	28	0.332	110	9	0.919
		GN4	15-Aug-01	65	28	0.375	110	10	0.574	65	28	0.306	110	10	0.654
		GN5	15-Aug-01	65	28	0.250	110	10	0.507	65	28	0.188	110	10	0.364
		GN6	16-Aug-01	65	28	0.105	110	10	0.271	65	28	0.037	110	10	0.326
		GN7	16-Aug-01	65	27	0.826	110	10	0.622	65	27	0.890	110	10	0.526
	Floating Gillnet	F1	14-Aug-01	65	28	0.441	110	9	0.790	65	28	0.416	110	9	0.797
		F2	15-Aug-01	65	28	0.492	110	9	0.991	65	28	0.480	110	9	0.946
		F3	15-Aug-01	65	28	0.596	110	9	0.739	65	28	0.578	110	9	0.794
		F4	16-Aug-01	65	27	0.968	110	10	0.438	65	27	0.956	110	10	0.388
	Beach Seine	BS1	16-Aug-01	65	28	0.256	110	9	0.87						
		BS2	16-Aug-01	65	28	0.270	110	9	0.9						
	Minnow Trap	M1	16-Aug-01	65	28	0.3020	110	9	0.8						
		M2	16-Aug-01	65	28	0.3110	110	9	0.778						
		M3	16-Aug-01	65	28	0.3242	110	9	0.74						
		M4	16-Aug-01	65	28	0.3272	110	9	0.7						
		M5	16-Aug-01	65	28	0.3368	110	9	0.660						
		M6	16-Aug-01	65	28	0.3512	110	9	0.63						

APPENDIX 3.2-12
SET TIME AND RETRIEVAL TIME FOR NETS, TRAPS AND SEINES USED IN CONTWOYTO LAKE, AUGUST 2001

Appendix 3.2-12
Set Time and Retrieval Time for Nets, Traps and Seines used in Contwoyto Lake, August 2001

	Time Set		Time Pulled		Effort	Total	CPUE	Species Caught								Depth
Site ID	Date	Time	Date	Time out	(hours)	# fish		ARCH	ARGR	BURB	LKCS	LKTR	NSST	RDWH	SLSC	
GN1	14-Aug	14:45	14-Aug	16:50	2.08	1	4.62					1				shallow
F1	14-Aug	15:00	14-Aug	17:10	2.17	1	13.17	1								shallow
GN2	14-Aug	16:45	15-Aug	8:30	15.75	24	14.63					23		1		deep
GN3	14-Aug	17:00	15-Aug	12:00	19.0	41	20.72	2	3		5	21		10		shallow
F2	14-Aug	17:20	15-Aug	13:25	20.08	0	0									deep
M4	14-Aug	17:30	16-Aug	13:30	44.0	20	10.91						20			shallow
M1	14-Aug	17:31	16-Aug	13:40	44.15	1	0.54						1			shallow
M2	14-Aug	17:32	16-Aug	13:45	44.22	35	19.0			3			32			shallow
M3	14-Aug	17:33	16-Aug	13:50	44.28	6	3.25						6			shallow
M5	14-Aug	17:34	16-Aug	13:55	44.18	2	1.09						2			shallow
M6	14-Aug	17:35	16-Aug	14:00	44.42	0	0									shallow
GN4	15-Aug	11:45	15-Aug	16:15	4.5	2	4.27					1		1		deep
GN5	15-Aug	13:15	15-Aug	16:30	3.25	1	2.95					1				shallow
F3	15-Aug	13:30	15-Aug	16:55	3.42	7	58.48	3			1	3				shallow
F4	16-Aug	12:15	16-Aug	14:50	2.58	2	22.15	1				1				shallow
GN6	16-Aug	12:25	16-Aug	15:00	2.58	0	0									shallow
GN7	16-Aug	12:40	16-Aug	15:15	2.58	0	0									deep
BS1	16-Aug	14:05	16-Aug	14:10	-	1	-						1			shallow
BS2	16-Aug	14:15	16-Aug	14:20	-	1	-						1			shallow
					Total	**145**	**175.8**	**7**	**3**	**3**	**6**	**51**	**63**	**12**	**0**	

Notes: GN = sinking gillnet, F = floating gillnet, M = minnow trap, BS = beach seine
CPUE = catch-per-unit-effort, CPUE for gillnets = # fish / 100m2 of net / 24 hrs,
CPUE for minnow traps = # fish / 24 hrs / trap.
ARCH = Arctic char, ARGR = Arctic gra

APPENDIX 3.2-13
ANALYTICAL RESULTS FOR LAKE TROUT MUSCLE TISSUE SAMPLES FROM CONTWOYTO LAKE, AUGUST 2001

Appendix 3.2-13
Analytical Results for Lake Trout Muscle Tissue Samples from Contwoyto Lake, August 2001

ALS File No. N6125
Date Received 26-Sep-01

Sample ID	**60**	**63**	**68**	**69**	**70**	**71**	**74**	**114**	**115**	**118**
Date Sampled	**14/08/2001**	**14/08/2001**	**14/08/2001**	**14/08/2001**	**14/08/2001**	**14/08/2001**	**14/08/2001**	**15/08/2001**	**15/08/2001**	**15/08/2001**
ALS Sample ID	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Physical Tests										
Moisture %	**80.1**	**76.7**	**78.7**	**72.3**	**72**	**74.6**	**76.8**	**77.6**	**75.6**	**79.7**
Total Metals										
Aluminum T-Al	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Antimony T-Sb	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Arsenic T-As	0.16	0.09	0.26	0.21	0.28	0.23	0.28	0.24	0.17	0.18
Barium T-Ba	0.15	<0.05	0.08	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Beryllium T-Be	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
Bismuth T-Bi	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
Cadmium T-Cd	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Calcium T-Ca	371	243	267	185	162	220	221	184	229	269
Chromium T-Cr	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Cobalt T-Co	<0.1	<0.1	0.4	<0.1	<0.1	0.2	<0.1	<0.1	0.1	0.2
Copper T-Cu	2	1.74	1.59	1.33	1.66	1.44	1.07	2.82	1.34	0.97
Lead T-Pb	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Lithium T-Li	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Magnesium T-Mg	1350	1200	1240	982	1030	1100	1090	1200	1320	1300
Manganese T-Mn	0.91	0.42	0.4	0.3	0.41	0.39	0.39	0.34	0.35	0.43
Mercury T-Hg	0.59	0.59	1.71	0.66	0.823	1.29	5.25	1.48	0.963	1.55
Molybdenum T-Mo	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Nickel T-Ni	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Selenium T-Se	1	1	1	<1	<1	<1	1	<1	<1	1
Strontium T-Sr	0.55	0.39	0.32	0.17	0.19	0.24	0.26	0.15	0.22	0.28
Thallium T-Tl	0.07	0.05	0.05	0.04	0.06	0.11	0.04	0.06	0.05	0.05
Tin T-Sn	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Uranium T-U	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Vanadium T-V	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Zinc T-Zn	27.5	15.1	15.4	11.2	12.2	14.6	16	11.8	13.6	15.5

Notes: Results are expressed as milligrams per dry kilogram

< = Less than the detection limit indicated.

Appendix C-7
Freshwater Environment Baseline Studies, 2002

Author: **Rescan Environmental Services Ltd.**
Date: **November 2007**



the BATHURST INLET PORT AND ROAD PROJECT

Bathurst Inlet Port and Road Project

Nunavut, Canada

Bathurst Inlet Port and Road Project Freshwater Environment Baseline Studies, 2002



Prepared by:

Rescan™ Environmental Services Ltd.
Vancouver, British Columbia, Canada

November 2007

EXECUTIVE SUMMARY

Executive Summary

The Bathurst Inlet Port and Road Project is located in the Kitikmeot region of Nunavut. The proposed Port is located on the west side of Bathurst Inlet, about 40 km south of the community of Bathurst Inlet. The proposed all-weather Road will be from Bathurst Inlet to Contwoyto Lake, a distance of 211 km.

A survey of 35 streams crossing the proposed Road route was conducted between August 2 and 7, 2002. These streams were also surveyed for fish community composition to confirm the fisheries values they had been assigned in a survey conducted in 2001. An aerial survey of the entire road was also conducted to confirm the preliminary assessment done in 2001.

Habitat characteristics, averaged for all the streams surveyed in a give year, were similar in 2001 and 2002. However, the variability observed in 2001 was greater than that in 2002, due to the greater number and size range of streams surveyed in 2001. Average stream survey distance was 66% greater in 2002 than in 2001 because electrofishing effort per stream was increased in order to confirm the fisheries values of streams classified as non-fish-bearing in 2001.

A comparison of the fisheries value of streams with the presence/absence of barriers to fish passage, and of nearby overwintering lake habitat, showed that both habitat variables are implicated in fish presence or absence. The comparison also showed that the relationships between fish presence/absence, barriers to fish passage, and the presence of overwintering lake habitat, are not precise enough to be used to assess the fisheries value of a stream. A similar conclusion was developed from the 2001 study. Electrofishing catch is a more reliable indicator of stream fisheries value than habitat characteristics.

A total of 108 fish were captured in 15 streams. The same five species dominated the fish communities in both 2002 and 2001. Juvenile Arctic grayling were most abundant, followed by slimy sculpin. The relative proportions of burbot and ninespine stickleback were reversed in 2002, but lake trout remained the least common of the five most common species. The frequency distribution of species richness was similar between years with non-fish-bearing streams being the most common category. The differences in fish community between years were a matter of scale – the total number of fish caught (108 versus 311), the total number of species (5 versus 7), the maximum species richness (3 versus 4) and the number of age classes within each species were lower in 2002 than in 2001 due to the lower number of streams (and thus total fishing effort), and the lower range of stream sizes in 2002 compared to 2001.

Eighteen of the 35 streams retained the same fisheries value as they were assigned in 2001, but the fisheries value of 17 streams was upgraded as a result of the electrofishing survey.

Of the 104 streams/drainages that will be crossed by the road route, 35 were classified as nil fisheries value, 24 low fisheries value, 20 medium value, and 25 high value.

ACKNOWLEDGEMENTS

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Michael McGurk (Ph.D., R.P.Bio.) and François Landry (M.Sc., R.P.Bio.) wrote this report. François Landry was the principal investigator, and was assisted in the field by Shane Uren (M.A.Sc.) of Rescan and Allan Kapolak and Tony Akolak of the community of Bathurst Inlet. Report production was coordinated by Amanda Broda. Recent updates completed in 2007 were made to the report by Carolyn Duckham (B.Sc.) and Andrew Harwood (Ph.D., R.P.Bio).

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1. INTRODUCTION

1. Introduction

This report describes the freshwater environment baseline studies that were carried out by Rescan Environmental Services Ltd. (Rescan) in the summer of 2002 for the Bathurst Inlet Port and Road Project. Rescan (2002) described the first year of freshwater baseline field studies conducted in 2001.

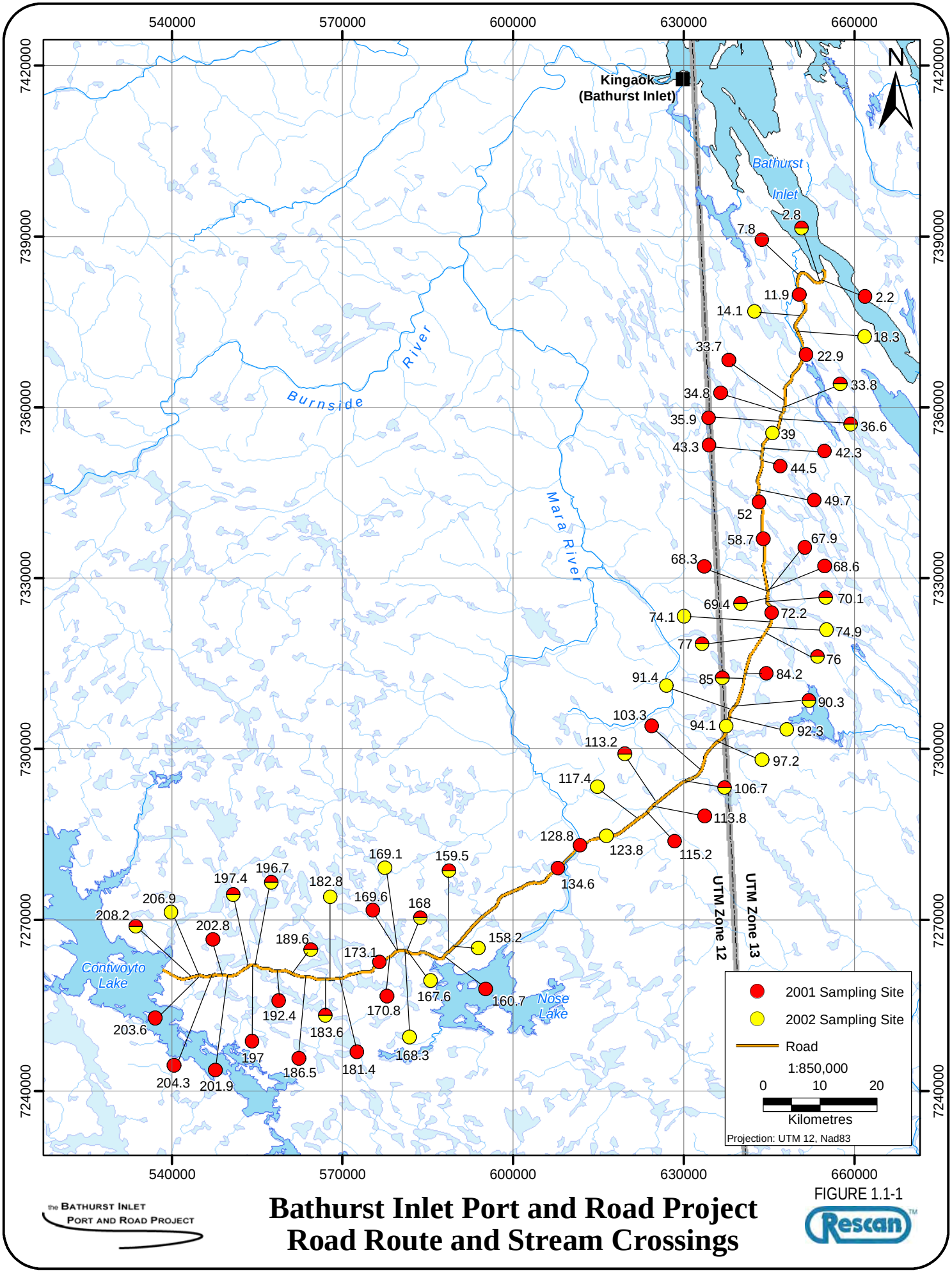
1.1 Background

The Bathurst Inlet Port and Road Project is located in the Kitikmeot region of Nunavut (Figure 1.1-1). The proposed Port is located on the west side of Bathurst Inlet (66°33'N and 107°31'W), about 40 km south of the community of Bathurst Inlet. The proposed all-weather Road will be from Bathurst Inlet to Contwoyto Lake, a distance of 211 km.

Environmental studies of the Project area began in 2001. In July and August, 2001, baseline studies were conducted of the freshwater environment of Contwoyto Lake and of the habitat characteristics and fish communities of streams that will be crossed by the Road (Rescan, 2002). The field study program was successfully completed, but changes in the design of the Road in the autumn of 2001 meant that further studies on Road stream crossings had to be conducted. Specifically, three new stream crossings created by alterations in the final Road route had to be surveyed for fish habitat characteristics and fish communities during the summer of 2002. In addition, follow-up studies had to be conducted to ensure accurate classification of the fisheries values of stream crossings.

The 55 streams that were surveyed in 2001 were selected from a larger set of 104 streams crossed by the Road, based on a reconnaissance helicopter survey conducted in July 2001. Only streams that had a distinct channel and contained water in July 2001 were surveyed. Since stream flow varies among years, it is possible that some of the streams that did not have a distinct channel containing water in 2001, may carry water in years with high precipitation. A few of those intermittent streams may support fish in years of very high flows. Therefore, it was necessary to repeat the stream reconnaissance survey in 2002 as flows may differ between years and to identify intermittent streams that may contain water. Environment Canada recorded the 6th wettest summer on record in 2002 (Environment Canada, 2002) for the Mackenzie District, the climatic region where Bathurst Inlet is located.

The 55 streams surveyed in 2001 were found to have very low fish densities due to the low productivity of the streams. In fact, no fish were caught in nearly half of the streams. Some of those streams may actually have contained some fish but densities were so low that none were caught with the amount of fishing effort that was employed in 2001. Therefore, those non-fish-bearing streams had to be re-sampled with greater fishing effort during the summer of 2002 in order to confirm their low fisheries value.



the Bathurst Inlet Port and Road Project

Bathurst Inlet Port and Road Project
Road Route and Stream Crossings

FIGURE 1.1-1

Rescan™

1.2 Objectives

There were three objectives for the 2002 freshwater environmental field season:

- survey the three stream crossings that were created by the revised Road route for habitat characteristics and fish community using the same techniques employed in August 2001;
- confirm the low fisheries value of non-fish-bearing streams surveyed in 2001 by re-fishing them in the summer of 2002 with two to three times more fishing effort. Effort was to be increased by either increasing the survey distance or the fishing effort or both, depending on stream characteristics. No habitat assessments were to be conducted for these streams; and
- confirm the preliminary assessment of stream status of drainages identified as not containing water in July 2001, by re-evaluating them. Any streams that were not surveyed in 2001, but which had a distinct channel containing water in 2002, were to be electrofished to see if they were fish-bearing.

2. METHODS

2. Methods

2.1 Study Design

All stream surveys were conducted between August 2 and 7, 2002. Prior to conducting the fish habitat and fish community surveys, a low level aerial survey was conducted along the entire proposed Road route. This survey was a replication of the reconnaissance survey conducted in July 2001. The purpose of the aerial survey was to take notes on characteristics of each stream (*e.g.* presence of water, presence of a channel), take pictures of each crossing, and identify streams that had water, but were classified as having no water or distinct channel in 2001.

Figure 1.1-1 shows the locations of each of the 35 stream crossings that were surveyed for fish habitat and/or fish community. Appendix 2.1-1 shows the latitude and longitude of both the upstream and downstream ends of the survey sections on each of the 35 stream crossings. Table 2.1-1 shows the chainage of the 35 stream crossings, and the reason for their inclusion in the 2002 field study.

The 35 streams were chosen for study in 2002 on the basis of three criteria:

1. they were new crossings created by changes in the Road route (3 streams);
2. they were assigned low fisheries value in August 2001, because no fish were caught within a 200 m survey distance, and hence they needed to be re-sampled in August 2002, to confirm their low fisheries value (14 streams); or
3. they were streams that were not surveyed in 2001 because they had no distinct channels with water, but which were found to contain some water in 2002 and hence needed to be surveyed for the presence or absence of fish (18 streams). Some of these crossings were located in the same streams as in 2001, however, due to a change in the road alignment, the new locations were downstream or upstream, where water was present.

2.2 Stream Crossing Identification

The stream crossings that were not surveyed in 2001 because they had no distinct channels with water, and were found to contain some water in 2002 during the low level aerial survey, were subsequently added to the list of crossings to be surveyed for fish community.

For each crossing to be surveyed, the crew established a survey distance with a meter tape along the part of the stream that would be crossed by the Road. The distances ranged from 40 m to 400 m, and depended on the length of the stream. GPS coordinates (latitude and longitude) were taken at the upstream and downstream ends of the survey distance. Those coordinates were eventually placed in a GIS database. An aerial photograph was taken of each crossing. If only fish community was surveyed, then the stream was electrofished and captured fish were counted and measured.

Table 2.1-1
Stream Crossings of the Bathurst Road Surveyed in August 2002

		Criteria for Inclusion in Study		
Stream Crossing (km)	**Type of Road Crossing**	**New Road Crossing**	**Surveyed in 2001 but no fish captured**	**Not surveyed in 2001 but water present in 2002**
208.2	C			X
206.9	B	X		
197.4	NA			X
196.7	F			X
189.6	C		X	
183.6	F		X	
182.8	NA			X
169.1	B			X
168.3	NA			X
168.0	F		X	
167.6	NA			X
159.5	F		X	
158.2	F			X
123.8	F			X
117.4	F			X
113.2	B		X	
106.7	B		X	
97.2	NA	X		
94.1	F			X
92.3	F			X
91.4	F			X
90.3	F		X	
85.0	F		X	
77.0	F		X	
76.0	B		X	
74.9	F			X
74.1	NA			X
70.1	F		X	
69.4	NA			X
39.0	F			X
35.9	B		X	
33.8	B		X	
18.3	F			X
14.1	B	X		
2.8	F		X	
Total		**3**	**14**	**18**

Type of crossing: C = culvert, B = bridge, F = ford, NA = not assigned

2.3 Fish Habitat Assessment

For each of the three streams in which fish habitat was assessed, a section of 200 m was walked. Fish habitat assessment techniques were based on those commonly used in British Columbia

(Johnston and Slaney, 1996). The methods were the same that were used during the survey conducted in 2001. Habitat units in each stream were first delineated into five types:

1. ***Riffle***: an area with turbulent, fast-flowing water and a gradient less than 4%. Riffles are found over a wide range of spatial scales;
2. ***Cascade***: an area with turbulent, fast-flowing water and a gradient greater than 4%;
3. ***Glide***: an area with smooth, non-turbulent water. This included boulder glides (or step glides) – a glide interspersed with boulders that create small steps with little downstream turbulence. It also included boulder fields (also known as boulder gardens or boulder gardens with subsurface flow) – a glide covered by a field of boulders. Closed boulder fields were almost always a permanent barrier to fish passage;
4. ***Pool***: an area with smooth, non-turbulent flow, a gradient near 0%, deeper water than a glide with a concave bottom and fine sediment. Pools were classified into three types based on their origin: scoured, dammed or unknown. Maximum depth of a pool was measured at the deepest part, and crest depth was measured at the downstream lip of the pool; and
5. ***Other***: undefined channels such as drainages that drifted through grassy meadows.

A suite of 11 physical characteristics were then recorded for each habitat unit. Length of each unit was measured to the nearest 1 m with a metre tape, gradient was measured to the nearest 0.5% with a clinometer, and depths and widths were measured with a metre stick to the nearest 5 and 10 cm, respectively. Bankfull width was measured from the top edges of the stream banks and wetted width from the wetted edges of the stream. The first measure was the expected stream width under maximum freshet conditions, and the second measure was the stream width measured in August 2002. Stream depth was also measured in two ways: from the top edges of the stream banks (bankfull depth) and from the wetted edges (wetted depth).

Percent composition of substrate (sand, gravel, cobble, boulder and bedrock) was estimated visually to the nearest 5%. Substrate was classified visually according to average particle size. Sand was defined as silt, clay or fine organic material that was less than 2 mm in average diameter. Gravel was defined as particles 2 to 64 mm in average diameter, cobble was 64 to 256 mm, boulders were 256 to 4,000 mm, and bedrock was greater than 4,000 mm.

Percent instream cover was also estimated visually to the nearest 5% and classified into five types: boulder, instream vegetation, overhanging vegetation, undercut banks or pool. There was no woody debris in any of the streams. Barriers to fish passage were classified as either temporary or permanent. Barriers were classified as temporary if it appeared that fish may be able to surmount them during periods of high flow or as permanent if it appeared that fish would never be able to pass regardless of flow levels (*e.g.*, high waterfalls or steep cascades).

Water temperature (to the nearest 0.1°C), pH (to the nearest 0.1 logarithmic unit) and conductivity (to the nearest 1 µS/cm) were measured once along the survey distance using electronic meters. These three variables were also measured for the majority of the streams that were electrofished but not assessed for fish habitat.

Stream discharge was estimated at one location along the survey length using the "floating chip" method. This method could only be used in streams with enough flow to measure velocity. For some streams, the flow was too low to use the "floating chip" method, but a visual estimate was made based on professional judgement. For the rest of the streams, flow was too low to estimate by visual means.

2.4 Fish Community Assessment

Fish were sampled from streams with a Smith-Root backpack electrofisher. The electrofisher produces an electrical field from an anode at the end of a pole that temporarily immobilises fish. Stunned fish are then scooped up with a dipnet and transferred to a water-filled pail. The crew walked the length of the survey distance, fishing any part that appeared to be potential fish habitat and stalking any fish that were seen in the channel. One pass was made of the entire survey distance. The objective of the survey was to describe fish presence, fish species richness and relative abundance. For some streams, only parts of the survey section could be electrofished either because the channel was dry or because they were covered by closed boulder fields.

Fishing effort was defined as the total number of seconds that the electrofisher was turned on during a stream survey. Once the electrofishing pass was completed, biological data were collected on the captured fish. Fork length (or total length in the case of burbot and slimy sculpin) was measured to the nearest 1 mm, and weight was measured to the nearest 0.1 g with an electronic balance. Notes were made on unusual markings or behaviour. No scales or other ageing structures were taken in order to reduce mortality. Fish were then released back into the stream.

For streams in which no fish were found (and in a few in which fish were found), an effort was made to discover whether the absence of fish was due to upstream or downstream habitat features such as impassable barriers or to a lack of nearby overwintering lake habitat (all fish in small Nunavut streams must overwinter in lakes because the streams freeze solid during winter, but only lakes with maximum depths greater than about 2 m provide such habitat). After completing the electrofishing survey, the crew flew in the helicopter upstream and downstream of the survey distance for up to several kilometres in each direction searching for the presence or absence of barriers and for deep sections in connected lakes that could serve as overwintering refuge.

2.5 Data Analysis

2.5.1 Habitat Data

The complete set of habitat data was collected from 3 of the 35 streams surveyed in 2002 – the other 32 streams were surveyed exclusively for their fish community. A sample size of three streams was too small to allow the correlation, regression and factor analyses that were used for the habitat data collected from the 55 streams surveyed in 2001. Instead, the habitat data collected in 2002 was presented and summarized, but not analyzed in detail.

To simplify analysis of habitat data, and to follow the protocol used for the 2001 studies, average stream dimensions and habitat types were calculated from the dimensions recorded for each habitat unit within a survey distance. Thus, the mean length of a habitat unit in a survey distance was the average of all the habitat unit lengths in that distance. Total wetted surface area of a survey distance was the sum of the wetted surface areas of all of the habitat units in that distance. Wetted surface area of a habitat unit was the wetted length of that unit multiplied by the wetted width of that unit. Percent habitat type (*e.g.*, glide, riffle, cascade and pool) of a survey distance was calculated by multiplying the habitat type by its wetted area, summing those numbers of that particular habitat type over all habitat units in the distance, and then dividing by the total surface area of that survey distance. Wetted depth, bankfull depth, percent substrate type, and percent cover were also calculated in the same way. However, average stream gradient, wetted width and bankfull width were calculated by weighting the dimensions of habitat units by wetted length, rather than wetted area, because they were linear dimensions.

Most habitat variables were not normally distributed because of the wide range of stream sizes and the non-linear geometry of streams. Hence, a variety of transformations were applied to normalize skewed frequency distributions and thereby calculate an average value for the data set. Natural logarithms normalized most variables except those that were intrinsically normally distributed (*e.g.*, water temperature), those that were already in logarithmic units (*e.g.*, pH), and percentages, which required the arcsine(percent/100)$^{0.5}$ transformation (Zar, 1984).

2.5.2 Fish Data

Following standard terminology (*e.g.*, Griffiths, 1997), fish species richness was defined as the total number of fish species in a survey distance of a stream, regardless of the relative abundance of each species.

Weight-length regressions were calculated for each species using the standard formula (Ricker, 1975):

$$\ln(W) = \ln(a) + b\ln(L)$$

where W = body weight (g), L = fork length (mm), ln(a) is the regression intercept and b is the slope of the regression. Both weight and length were ln-transformed to meet the statistical requirements of linear regression (*i.e.*, a normal distribution and homogeneity of variance). Weights and lengths were pooled across streams for each species to calculate the regressions. That meant they were not population-specific regressions. All r^2 were adjusted for the number of degrees of freedom of the regression. All regressions also cite the P statistic – an index of the significance of the regression.

Electrofishing catch-per-unit-effort (or CPUE) was defined as the number of fish captured in one pass of the survey distance divided by the total number of electrofishing seconds expended in that pass.

Rescan (2002) compared the habitat characteristics with the fish communities for 52 streams surveyed in August, 2001, in an unsuccessful attempt to identify habitat-fish relationships. No attempt was made in this report to repeat that analysis because only three streams were surveyed

for habitat characteristics in August 2002. However, an attempt was made to learn if the absence of fish in a stream was related to the presence or absence of barriers to fish passage and of connected overwintering lake habitat by calculating the proportions of non-fish-bearing streams with and without barriers and with and without nearby overwintering habitat.

All streams surveyed in this study were assigned a fisheries value based on the electrofishing catches and the aerial survey. Habitat was not used to assign value because the 2001 study showed there were poor correlations between habitat features, fish abundance and fish species composition (Rescan, 2002). The 2002 study also showed that the relationships between fish presence/absence and two habitat features (barriers to fish passage and the presence of nearby overwintering lake habitat) were not precise enough to be useful in assigning fisheries value (see Section 3.1.10). Rescan (2002) discussed the likely ecological reasons for this disconnection between fisheries value and habitat features.

A fourth category of fisheries value identified as *"Nil"* was added in 2002, to separate the *"Low"* category into two groups, as two different types of low category streams were observed in the field.

The categories of fisheries value used were:

1. ***Nil:*** stream crossings or drainages that were completely dry or did not have a distinct channel (wet grassy areas);
2. ***Low***: stream crossings with a distinct channel and containing water, with no fish captured;
3. ***Medium***: stream crossings that contained fish, but only small-bodied species with little commercial, food or cultural value, specifically slimy sculpin (*Cottus cognatus*) and ninespine stickleback (*Pungitius pungitius*); and
4. ***High***: stream crossings that contained valued fish such as Arctic grayling (*Thymallus articus*), burbot (*Lota lota*) or lake trout (*Salvelinus namaycush*).

2.6 Quality Assurance/Quality Control

All electronic instruments were calibrated with standards before being used in the survey. After data from field forms had been entered into electronic spreadsheets, it was compared between the spreadsheets and the field forms and any transcription errors were corrected. Once the final spreadsheets had been prepared, they were reviewed a second time to ensure that all data cells were filled, and that they were internally consistent (*e.g.*, percent substrates in a habitat unit summed to 100%, all riffles had gradients less than 4%, all cascades had gradients greater than 4%, and all pools had gradients of 0%). Weight-length plots were prepared for each species of fish, and outliers were examined to determine if they were the result of data transcription errors or errors that occurred during entry of field data. Lengths and weights that were in error were excluded from the data set.

3. RESULTS AND DISCUSSION

3. Results and Discussion

3.1 Aerial Assessment

A total of 104 streams/drainages were identified on the new road alignment using 1:50,000 maps. Each of the 104 crossings were photographed and assessed for potential fish habitat from the air while hovering at low level with a helicopter. Notes were taken on the status of each stream or drainage in terms of the presence or absence of a distinct channel and/or presence or absence of water (Appendix 3.1-1). Streams crossings that contained water and were assessed as not having a distinct channel or water in 2001, were surveyed for fish community.

3.2 Fish Habitat Assessment

Appendix 3.2-1 shows the fish habitat data sheets, and Appendix 3.2-2 shows the results of the electrofishing surveys (which also include the physical variables of water temperature, conductivity, pH, velocity and stream discharge or flow). Appendix 3.2-3 are notes on habitat, including notes on the presence/absence of barriers to fish passage and overwintering lake habitat. Appendix 3.2-4 shows the average of each of the habitat variables for each stream, where averages were calculated by weighting variables by the length or wetted surface area of each habitat unit.

Table 3.2-1 summarizes the habitat variables measured in August 2002, by averaging over all three streams. The table also shows the average survey distance, water temperature, conductivity and pH of all 35 streams. The following sections, 3.2.1 to 3.2.10, describe these variables.

Table 3.2-1
Summary of Habitat Variables Measured at 35 Streams Crossed by the Road, August 2002

Habitat variable	Units	Average	Minimum	Maximum	Number of streams
Survey distance[1]	m	297	40	400	35
Number of habitat units[2]	-	3	2	7	3
Average length of a habitat unit[2]	m	39	16	68	3
Water temperature[1]	°C	10.4	5.7	20.5	28
Conductivity[2]	µS/cm	23	8	91	28
pH[1]	log units	6.3	5.1	6.9	28
Water velocity[2]	m/sec	0.19	0.05	0.60	10
Stream discharge[2]	m^3/sec	0.0076	0.0003	0.1800	10
Bankfull width[2]	m	13.1	3.1	79.8	3
Wetted width[2]	m	10.8	2.0	77.8	3
Bankfull depth[2]	m	0.63	0.36	1.00	3
Wetted depth[2]	m	0.57	0.48	0.67	3
Wetted surface area[2]	m^2	1,468	218	8,790	3

(continued)

Table 3.2-1
Summary of Habitat Variables Measured at 35 Streams Crossed by the Road, August 2002 (completed)

Habitat variable	Units	Average	Minimum	Maximum	Number of streams
Stream gradient[3]	%	0.6	0.4	0.9	3
Glide habitat type[3]	%	20	0	79	3
Riffle habitat type[3]	%	3	0	21	3
Pool habitat type[3]	%	17	0	91	3
Cascades habitat type[3]	%	0	0	0	3
Other habitat type[3]	%	25	0	100	3
Sand substrate[3]	%	6	0	22	3
Gravel substrate[3]	%	7	0	49	3
Cobble substrate[3]	%	25	0	64	3
Boulder substrate[3]	%	34	0	100	3
Bedrock substrate[3]	%	0	0	0	3
Left bank height[2]	m	0.28	0.25	0.30	3
Right bank height[2]	m	0.30	0.26	0.33	3
Boulder cover[3]	%	40	4	100	3
Instream vegetation cover[3]	%	5	0	19	3
Overhanging vegetation cover[3]	%	0	0	0	3
Pool cover[3]	%	3	0	25	3
Undercut bank cover[3]	%	0	0	0	3
Pool maximum depth[1]	m	0.22	0	0.70	3
Pool crest depth[1]	m	0.07	0	0.20	3

Dashes indicate no units
[1]variables with normal frequency distributions; the average is an arithmetic average
[2]variables with frequency distributions normalized by ln-transformation; the average is a geometric average
[3]variables with frequency distributions normalized by the arcsin(%/100)$^{0.5}$ transformation; the average is the arithmetic version of the transformed average

3.2.1 Survey Distance and Number and Length of Habitat Units

The survey distances of the 35 streams ranged from 40 to 400 m with an average distance of 297 m. Distances less than 200 m only occurred in those streams in which the total length of the channel was less than 200 m (*e.g.*, the stream exited one lake and entered another lake in less than 200 m) or in those streams in which the channel went dry or flowed under a boulder field in less than 200 m. Survey distances greater than 200 m were established for streams that were electrofished to determine whether they were truly non-fish-bearing. The number of habitat units in each of the three streams surveyed for habitat ranged from 2 to 7, and the average length of a habitat unit ranged from 16 to 68 m.

3.2.2 Water Temperature, Conductivity and pH

Water temperature, conductivity and pH were measured in 28 of the 35 streams. It was not measured in the streams surveyed on August 6 to 7, 2002, because of equipment failure. Water temperatures ranged from 5.7 to 20.5°C with a mean of 10.4°C. The conductivity of stream

water ranged from 8 to 91 µS/cm, and was highly skewed to low values – 82% of values were less than 45 µS/cm. The geometric average conductivity was 23 µS/cm. The pH of stream water ranged from 5.1 to 6.9 with an average pH of 6.3.

3.2.3 Water Velocity and Stream Discharge

Velocity ranged over two orders of magnitude – from 0.05 to 0.60 m/sec in the streams sampled in 2002. The results of the 2001 field study showed that stream velocity was typically skewed to low velocities, mainly because most streams crossed by the Road are small, ephemeral streams, and that the distribution was normalized by ln-transformation (Rescan, 2002). The geometric average water velocity for the 10 streams surveyed in 2002 was 0.19 m/sec.

Stream discharge calculated from stream velocities, depths and widths ranged over three orders of magnitude – from 0.0003 to 0.1800 m^3/sec. The 2001 field study showed that the frequency distribution of discharge was highly skewed to low values, but it was normalized by ln-transformation.

3.2.4 Stream Width, Depth and Wetted Area

Bankfull width for the three streams surveyed in 2002 ranged from 3.1 to 79.8 m and wetted width ranged from 2.0 to 77.8 m. The 2001 study showed that the frequency distributions of bankfull width and wetted width were highly skewed to low values, but that they were normalized with ln-transformation. Hence, the geometric average bankfull width for 2002 was 13.1 m and the geometric average wetted width was 10.8 m.

Bankfull depth ranged from 0.36 to 1.00 m, and wetted depth ranged from 0.48 to 0.67 m. As with stream width, the 2001 investigation showed that the frequency distributions of stream depth were highly skewed to low values and were normalized with ln-transformation. Hence the geometric averages for 2002 were 0.63 m for bankfull depth and 0.57 m for wetted depth.

Wetted surface area of the three streams surveyed in 2002 ranged from 218 to 8,790 m^2. As with stream width and depth, the frequency distribution of surface area was shown by the 2001 investigations to be highly skewed to low values and was normalized by ln-transformation. Hence, the geometric average wetted surface area of the three streams surveyed in 2002 was 1,468 m^2.

3.2.5 Stream Gradient

Stream gradient ranged from 0.4 to 0.9%. The 2001 investigation showed that the frequency distribution of stream gradient was also skewed to low values, and that the standard transformation for percentages, arsine(percent/100)$^{0.5}$ (Zar, 1984), successfully normalized the distribution (all other habitat variables expressed in percentages were also normalized with this transformation). The average transformed gradient was 4.4°, which was equivalent to an average arithmetic gradient of 0.6%.

3.2.6 Habitat Type

For the three streams surveyed in 2002, glide habitat was the most common type, making up an average of 20% of wetted surface area (range = 0 to 79%). Pools were the next most common

type (mean = 17%, range = 0 to 91%), followed by the "other" type, mainly unconfined channels running through grassy meadows (mean = 25%, range = 0 to 100%), and riffles (mean = 3%, range = 0 to 21%). There were no cascades.

3.2.7 Substrate Composition

Boulders were the most common type of substrate, making up an average of 34% of wetted surface area (range = 0 to 100%), followed by cobble (average = 25%, range = 0 to 64%) and gravel (mean = 7%, range = 0 to 49%). No bedrock was found in any of the three crossings.

3.2.8 Bank Height

Stream bank height was measured from the water surface to the upper edge of the bank for both left and right banks. It ranged from 0.25 to 0.33 m. Following the results of the analysis of 2001 data, a geometric average of 0.28 m was calculated for the left bank height and 0.30 m for the right bank.

3.2.9 Cover

Boulders were the most common form of cover (mean = 40%, range = 4 to 100%), followed by instream vegetation (average = 5%, range = 0 to 19%) and pools (average = 3%, range = 0 to 25%). There was no overhanging vegetation cover and no undercut bank cover.

3.2.10 Habitat Features Related to Fish Presence or Absence

Table 3.2-2 shows that of the 15 streams with fish, only one stream (or 7% of the group) had permanent barriers to fish passage. In contrast, of the 20 streams with no fish, 40% had permanent barriers. Table 3.2-2 also shows that of the 20 streams with no fish, 60% had no obvious access to overwintering lake habitat, 35% had an indeterminate level of access and only 5% (*i.e.*, 1 stream) had clear access. These results indicate that fish presence or absence is a function of both barriers and the presence of nearby overwintering habitat. They also show that the relationships between fish presence/absence, barriers to fish passage and the presence of overwintering lake habitat are not precise enough to be used to assess the fisheries value of a stream. A similar conclusion was developed in the 2001 study (Rescan, 2002).

Table 3.2-2
Stream Habitat Characteristics Related to the Presence or Absence of Fish, August 2002

Stream crossing (km)	Barriers to fish passage	Access to overwintering lake habitat
Fish captured or observed[1]		
206.9	None	Yes
169.1	None	Yes
168.0	None	Yes
106.7	None	Yes
97.2	None	Yes
76.0	None	Yes
69.4	None	Yes

(continued)

Table 3.2-2
Stream Habitat Characteristics Related to the Presence or Absence of Fish, August 2002 (completed)

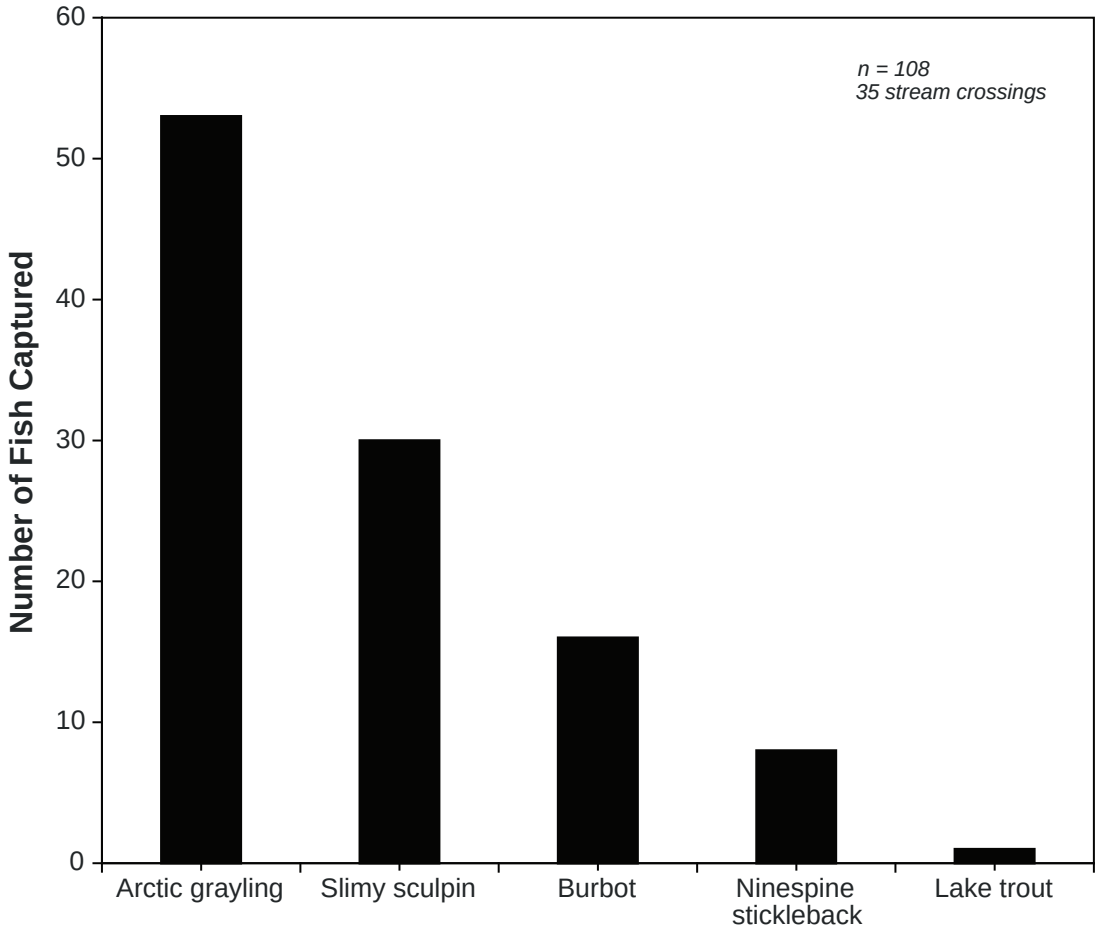
Stream crossing (km)	Barriers to fish passage	Access to overwintering lake habitat
Fish captured or observed[1]		
208.2	Temporary	Yes
196.7	Temporary	Yes
183.6	Temporary	Yes
168.3	Temporary	Yes
123.8	Temporary	Yes
70.1	Temporary	Yes
39.0	Temporary	Yes
35.9	Permanent	Yes
No fish captured or observed		
197.4	None	Undetermined
117.4	None	None
85.0	None	None
74.1	None	None
2.8	None	None
158.2	Temporary	Yes
182.8	Temporary	Undetermined
167.6	Temporary	Undetermined
77.0	Temporary	Undetermined
94.1	Temporary	None
90.3	Temporary	None
14.1	Temporary	None
159.5	Permanent	Undetermined
91.4	Permanent	Undetermined
33.8	Permanent	Undetermined
189.6	Permanent	None
113.2	Permanent	None
92.3	Permanent	None
18.3	Permanent	None
74.9	Permanent	None

[1]**access to overwintering habitat was assumed based on the presence of fish in the stream**

3.3 Fish Community Assessment

3.3.1 Number of Fish

A total of 108 fish were captured in 15 streams during the 2002 survey. Juvenile Arctic grayling was the most common species (n = 53 or 49% of the total number), followed by slimy sculpin (n = 30 or 28%), burbot (n = 16 or 15%), ninespine stickleback (n = 8 or 7%) and lake trout (n = 1 or 1%) (Appendix 3.2-2 and Figure 3.3-1). Table 3.3-1 briefly summarizes the life histories of these five species.



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Number by Species of the Fish Captured in the 35 Stream Crossings

FIGURE 3.3-1

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Table 3.3-1
Life Histories of Fish Species Captured in Streams Along the Road Route, August 2002

Common name	Scientific name	Habitat	Body size	Diet	Spawning: time	Spawning: location	Spawning: substrate
Arctic grayling	*Thymallus arcticus*	lakes/rivers	medium	zooplankton/insects	Apr-Jun	streams	gravel/rock
Slimy sculpin	*Cottus cognatus*	lakes/streams	small	benthic invertebrates/insects	May-Jun	lakes/streams	rock
Burbot	*Lota lota*	lakes/streams	medium	invertebrates/fish	Jan-Mar	lakes/streams	sand/gravel
Ninespine stickleback	*Pungitius pungitius*	lakes/streams	small	zooplankton/insects	Jun-Aug	lakes/streams	weeds
Lake trout	*Salvelinus namaycush*	lakes/rivers	large	invertebrates/fish	Sep-Oct	lakes	boulder

Species characteristics taken from Scott and Crossman (1973). Spawning times in Nunavut may be later than those reported by Scott and Crossman (1973)

3.3.2 Species Richness

A maximum of three species were found in a stream. The frequency distribution of species richness was skewed to low values (Figure 3.3-2). Twenty of the streams had no fish, 11 streams had one species, 3 streams had two species and only 1 stream had three species.

3.3.3 Length-Frequency Distributions

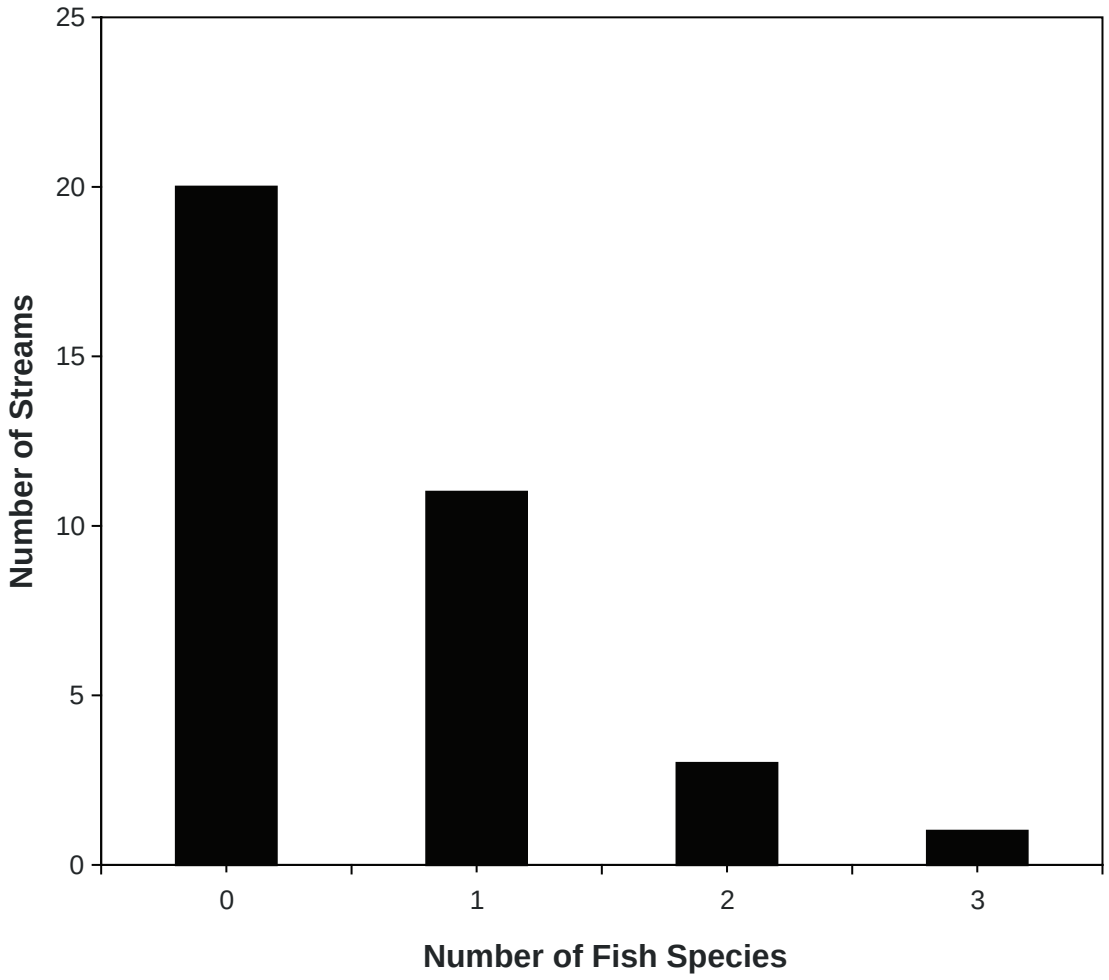
Appendix 3.3-1 shows the lengths and weights of each of the 108 fish. Length-frequency distributions were calculated for each species except lake trout (due to low sample size) by pooling fish across all streams. The purpose was to identify age-classes and display the length distribution.

Figure 3.3-3 shows the length-frequency distribution of Arctic grayling. Two modes are obvious. The first and largest mode occurred at lengths from 25 to 49 mm and 50 to 74 mm, which corresponds to 0^+ or young-of-the-year fish that hatched in July 2002, and were rearing in their natal stream in August. The second mode was represented by a single fish of 170 mm length that was captured at km 168.0. It was likely a 1 or 2 year-old juvenile that had returned from lake habitat to rear in stream habitat. Adult grayling are lake residents that return to streams only in spring to spawn. However, for some juvenile grayling, streams provide more cover from predators than lake habitat.

Figure 3.3-4 shows the length-frequency distribution of slimy sculpin. It contains a single mode that probably represents a combination of juveniles, subadults and adults. Scott and Crossman (1973) cited studies of slimy sculpin in Great Bear Lake (Northwest Territories) and northern Saskatchewan that indicated that reported sexual maturity over a length range of 60 to 120 mm. That range corresponds to the descending right-portion of the length-frequency distribution of the fish captured in August 2002, and it suggests that subadults (~30-60 mm) made up most of the ascending left portion. Adult slimy sculpin use stream habitat for spawning and feeding.

Figure 3.3-5 shows the length-frequency distribution of burbot. It contains a single mode in the 30 to 39 mm length interval that most likely corresponds to 0^+ fish that hatched in early spring of 2002 from eggs laid during mid-winter in shallow inshore areas of lakes and large rivers. Juveniles then swim up into small streams in search of food and refuge from lake and river predators.

Figure 3.3-6 shows the length-frequency distribution of ninespine stickleback. Two modes were obvious. The first mode represents juveniles and the second mode represents adults. Scott and Crossman (1973) cited reports from English rivers and the Atlantic coast of Canada that indicate that juveniles reach a length of 15 mm within 2 weeks of leaving their natal nest, and that maximum length after the first year of life was 38-46 mm. These records are not directly applicable to ninespine stickleback in Nunavut because the lower temperatures and shorter growing seasons would result in lower lengths-at-age. However, those reports suggest that most of the fish of the first mode were juveniles and that most of the fish of the second mode were adults. As with slimy sculpins, sticklebacks use stream habitat for spawning as well as feeding.

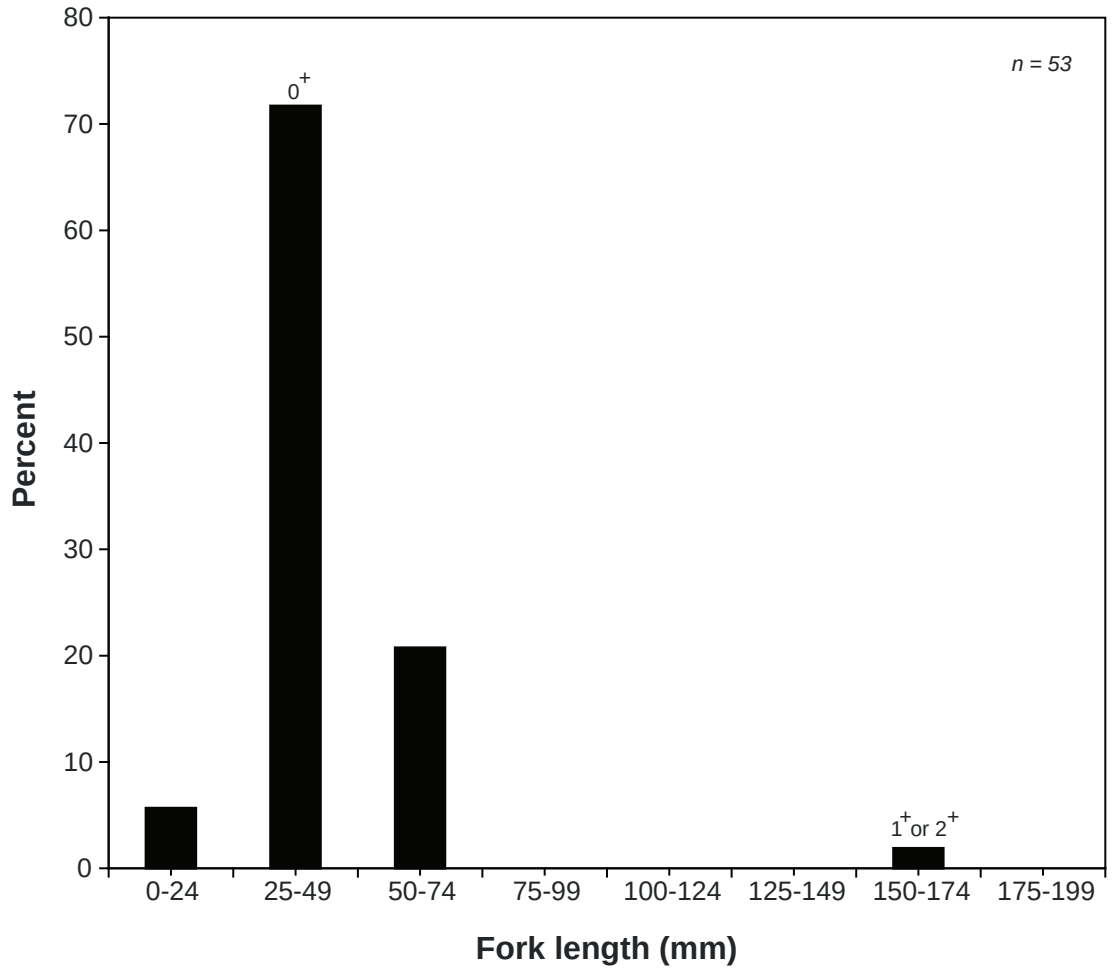


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Frequency Distribution of Fish Species Richness for the 35 Streams that were Fished

FIGURE 3.3-2

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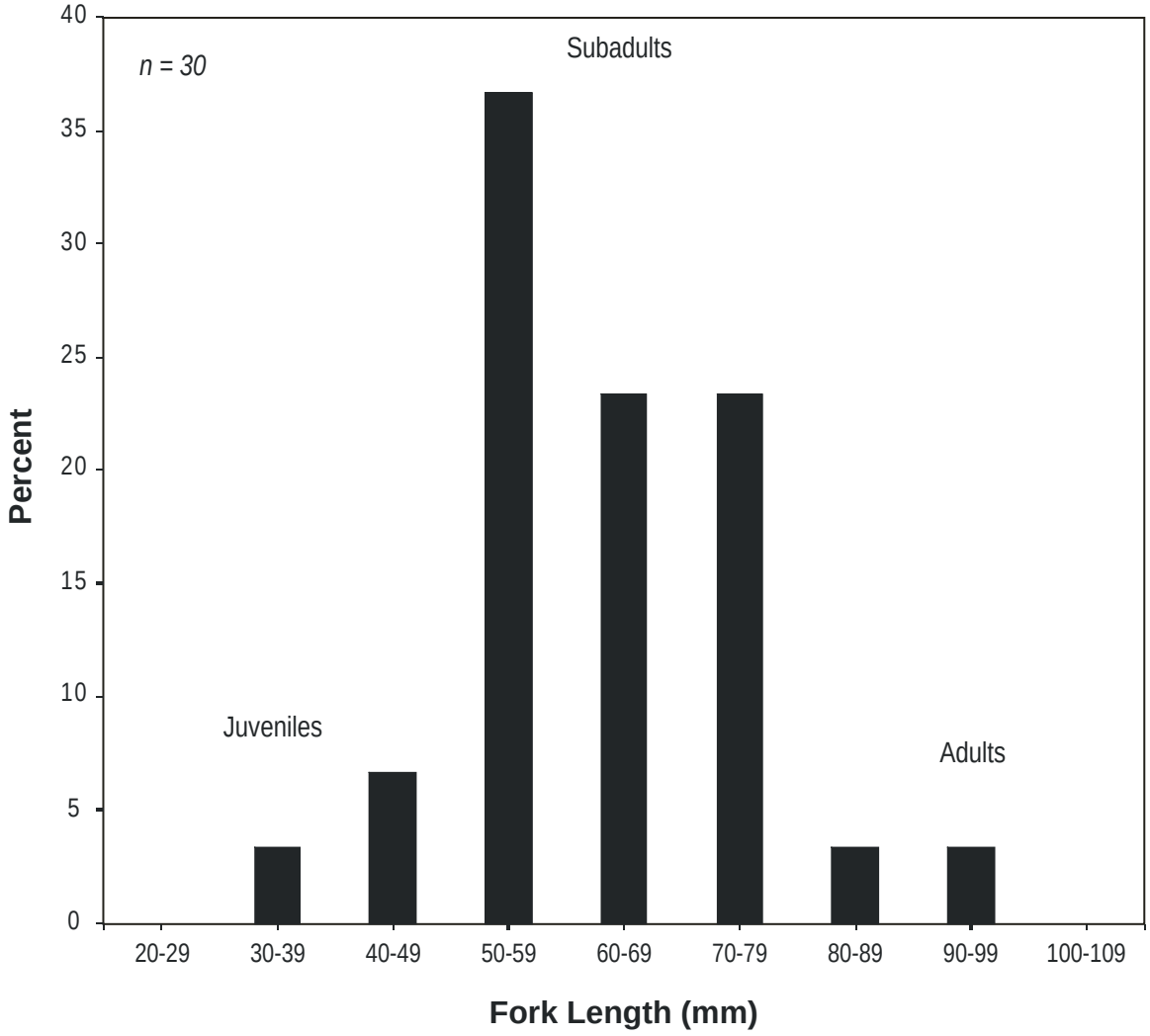


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Length-Frequency Distribution of Arctic Grayling, August 2002

FIGURE 3.3-3

Rescan™

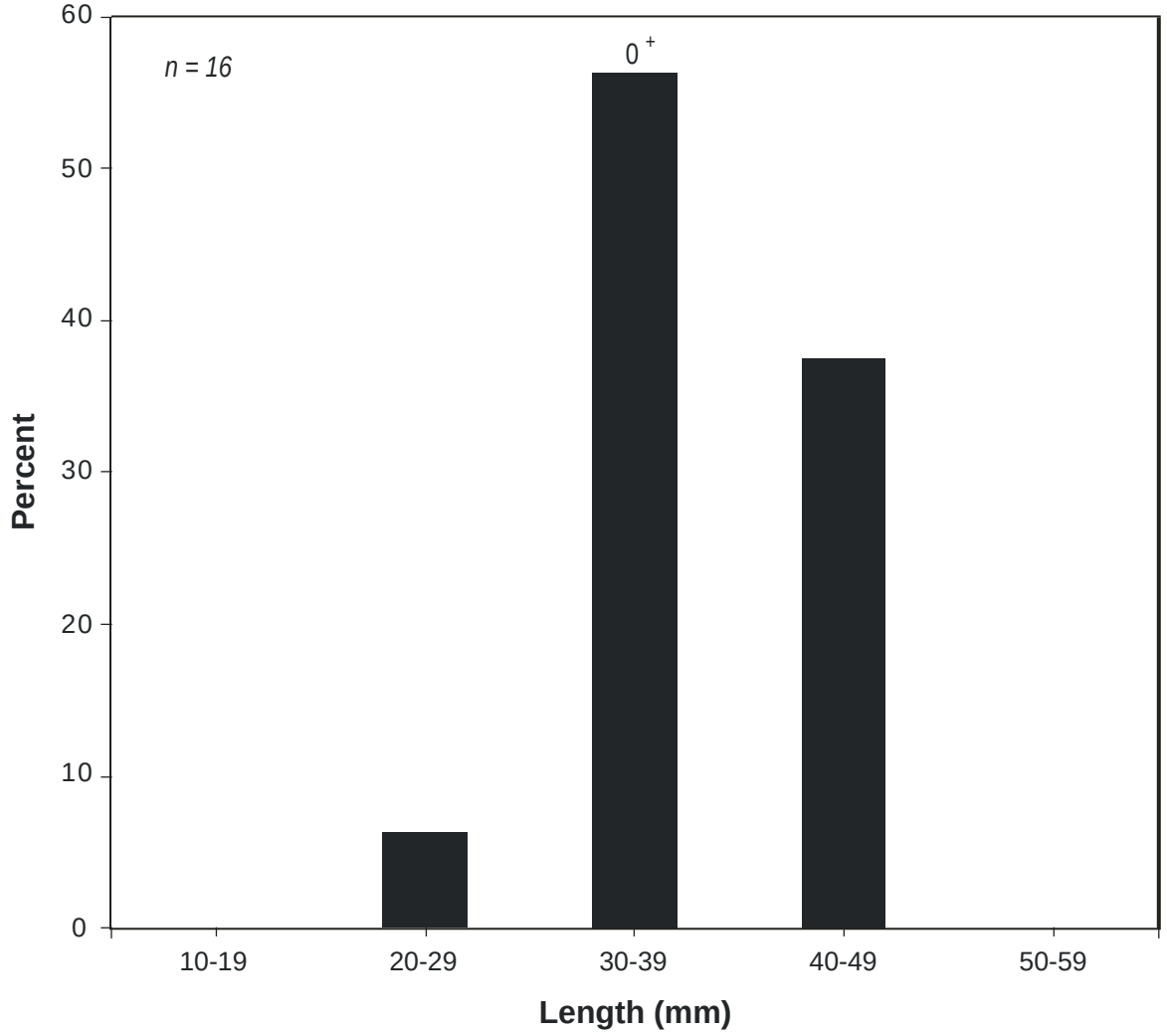


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Length-Frequency Distribution of Slimy Sculpin, August 2002

FIGURE 3.3-4

Rescan™

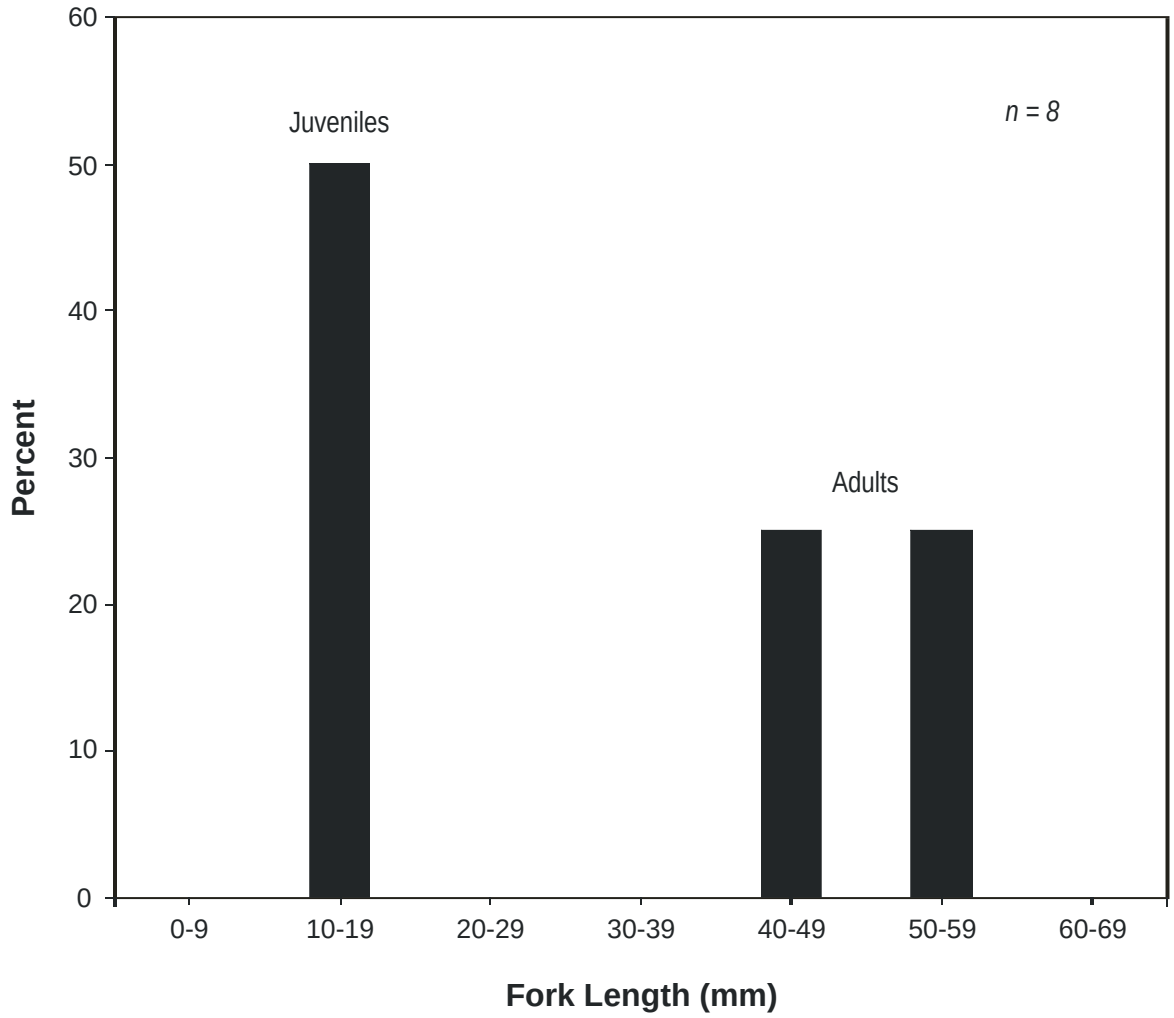


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Length-Frequency Distribution of Burbot, August 2002

FIGURE 3.3-5

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Length-Frequency Distribution of Ninespine Stickleback, August 2002

FIGURE 3.3-6

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3.3.4 Average Length and Weight

Table 3.3-2 shows average lengths and weights of the five species captured during the stream survey. No attempt was made to calculate average lengths and weights for age classes within species because of the difficulty of defining the size boundaries of age classes. As a result, the standard deviations of some averages are large. Lake trout were the largest species, but only one was caught. Slimy sculpin was the second largest species followed by Arctic grayling, burbot and ninespine stickleback.

Table 3.3-2
Average Lengths and Weights of
Fish Captured during Stream Surveys

	Fork Length (mm)					Weight (g)				
Species	**n**	**Mean**	**SD**	**min**	**max**	**n**	**Mean**	**SD**	**min**	**max**
Arctic grayling	53	43	20	22	170	53	1.92	8.77	0.12	62.00
Slimy sculpin	30	62	12	34	90	30	2.34	1.141	0.37	6.71
Burbot	16	37	6	28	49	16	0.47	0.20	0.21	0.90
Ninespine stickleback	8	33	18	12	50	8	0.43	0.39	0.04	0.84
Lake trout*	1	180	N/A	N/A	N/A	1	120	N/A	N/A	N/A

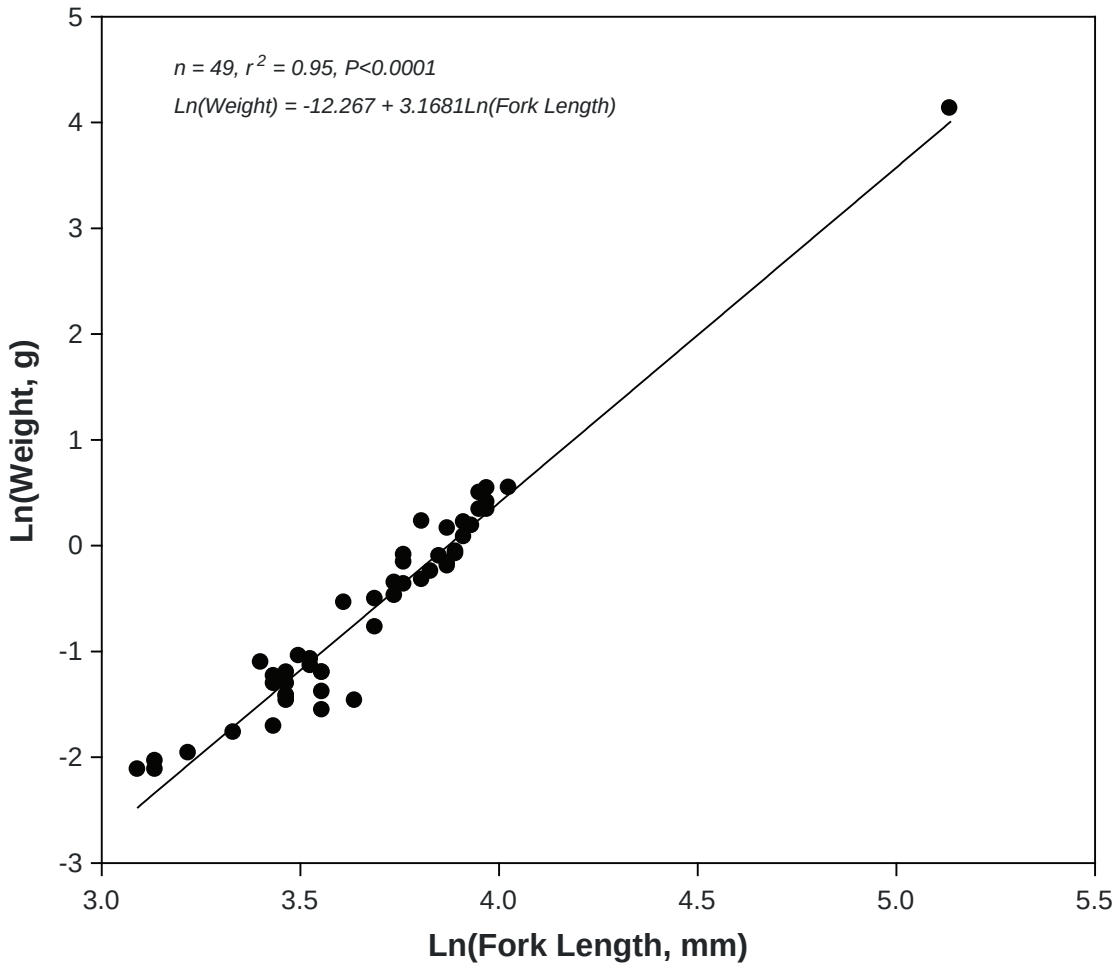
SD = standard deviation, n = sample size, min = minimum and max = maximum
*** Only one lake trout caught at stream crossing 97.2 km. Means are the measurement of this fish**
N/A = Non Applicable

3.3.5 Weight-Length Relationships

Sample sizes were sufficient to calculate regressions of ln(weight) on ln(fork length) for Arctic grayling, slimy sculpin, burbot and ninespine stickleback, but not for lake trout (Figures 3.3-7 to 3.3-10). All regressions were highly statistically significant ($P<0.001$) and explained between 90 and 97% of the variation in ln(weight). Weight-length exponents ranged between 2.28 and 3.16, bracketing the expected value of 3. The relatively low exponents for burbot and ninespine stickleback most likely reflected low sample sizes.

3.3.6 Fishing Effort and CPUE

All 35 streams were electrofished and fishing effort ranged from 51 to 817 seconds and averaged 321 seconds (SD = 208, n = 35) (Appendix 3.2-2). Total CPUE for each of the 35 streams ranged from 0.000 to 0.062 fish/second and was highly skewed towards low values because no fish were found in 20 of the 35 streams. Hence, the geometric mean CPUE was 0.002 fish/second. Skewness was reduced by excluding the zero counts from the frequency distribution (Figure 3.3-11). Two groups were obvious. The first mode represented streams in which only 1 to 7 fish were captured (0.000-0.019 fish/second), of which most were slimy sculpin. The second group represented streams in which 6 to 30 fish were caught, (0.020-0.099 fish/second) of which most were juvenile Arctic grayling. The geometric average CPUE of those 15 fish-bearing streams was 0.012 fish/second.

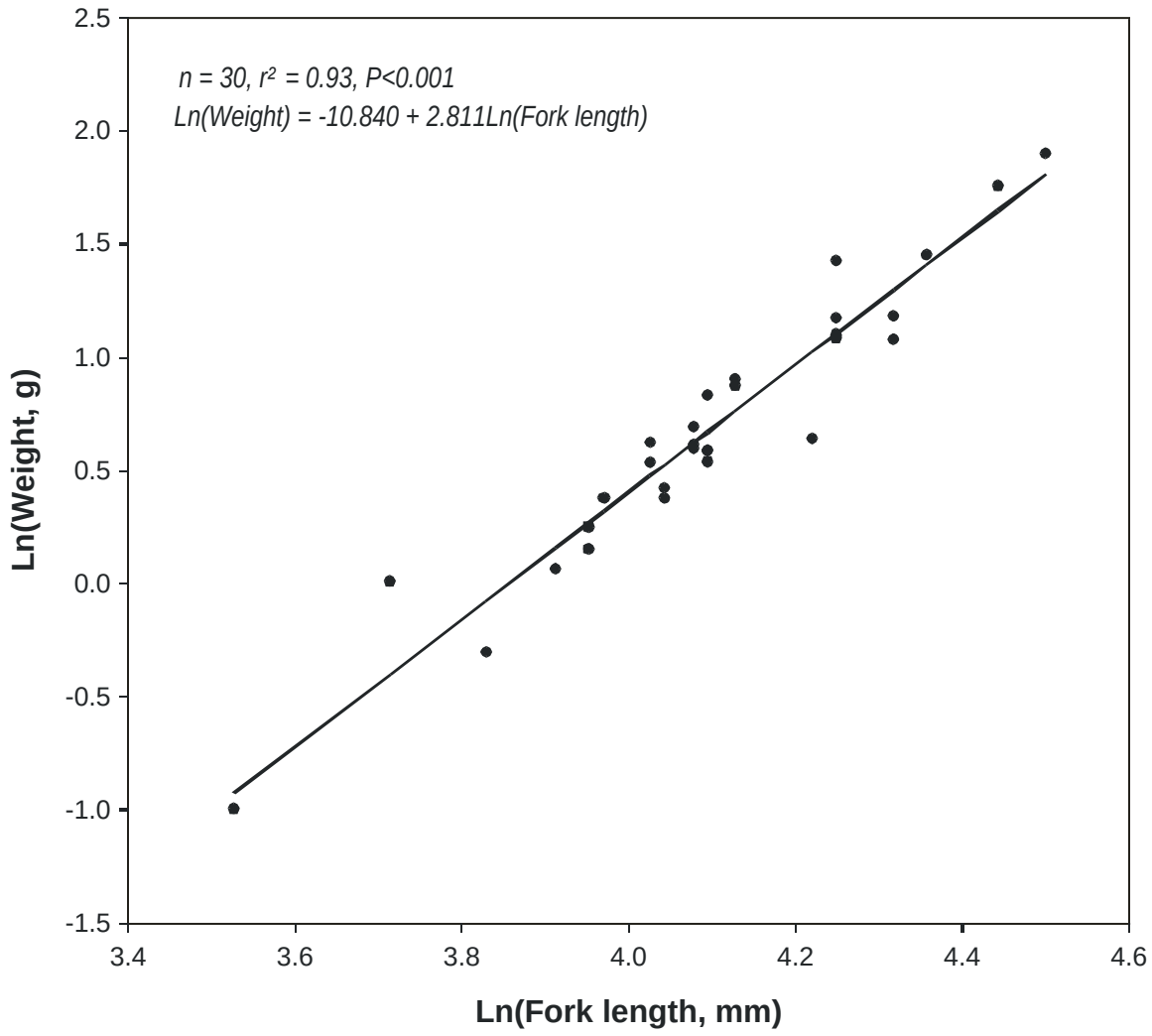


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Weight-Length Relationship of Arctic Grayling, August 2002

FIGURE 3.3-7

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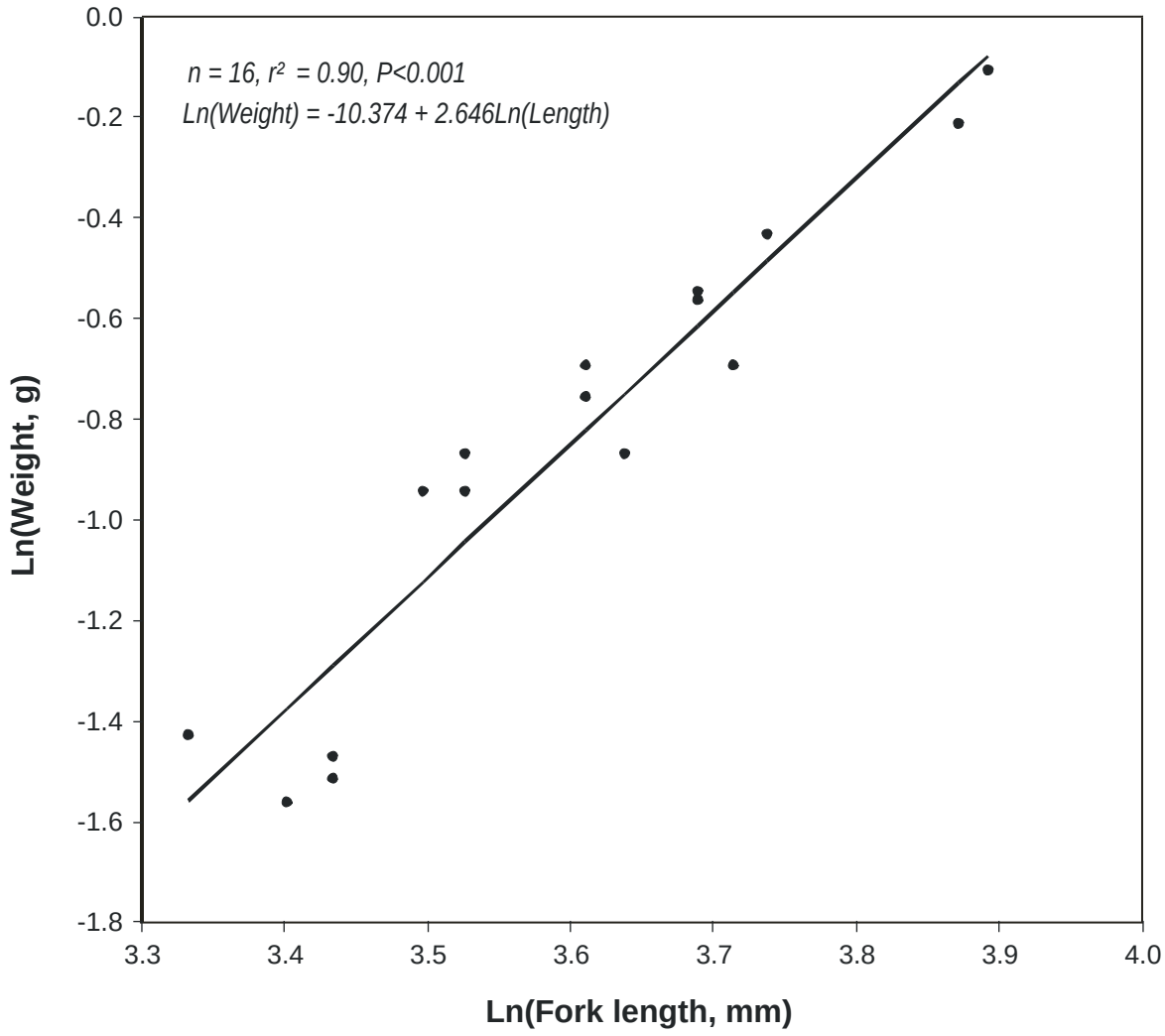


the BATHURST INLET PORT AND ROAD PROJECT

Weight-Length Relationship of Slimy Sculpin, August 2002

FIGURE 3.3-8

Rescan™

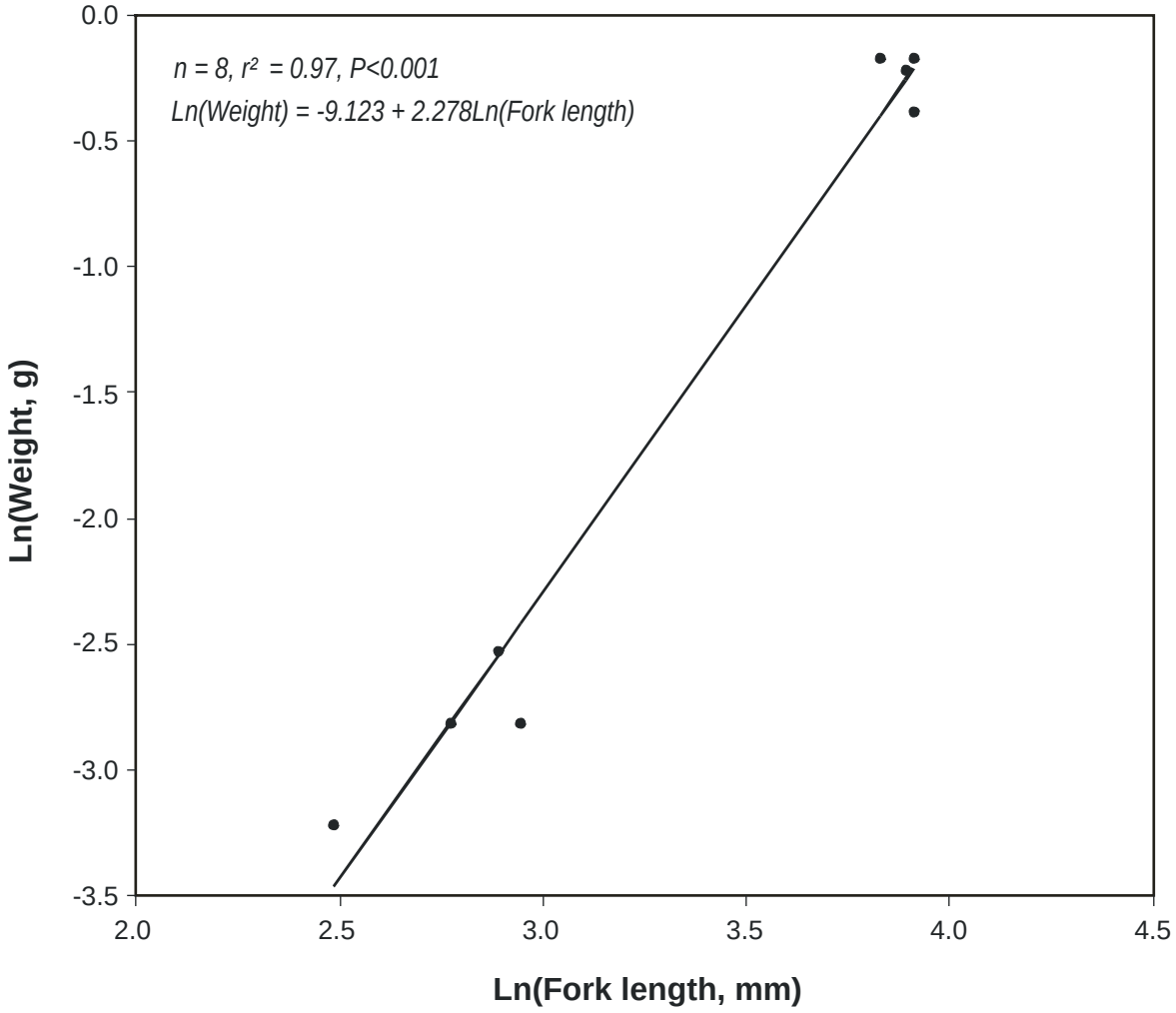


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Weight-Length Relationship of Burbot, August 2002

FIGURE 3.3-9

Rescan™

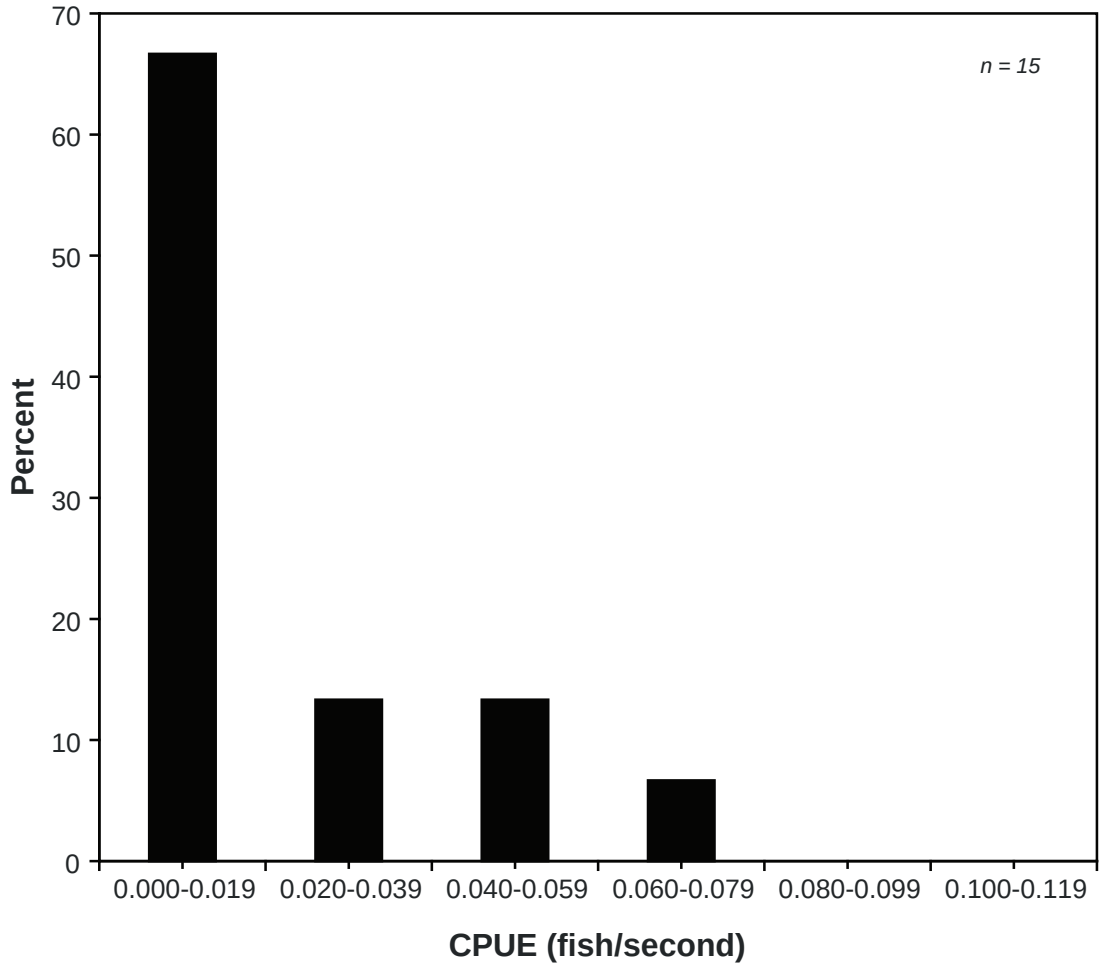


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Weight-Length Relationship of Ninespine Stickleback, August 2002

FIGURE 3.3-10

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Frequency Distribution of Electrofishing CPUE for the 15 Streams in which Fish were Caught

FIGURE 3.3-11

Rescan™

3.4 Comparison with 2001 Results

3.4.1 Habitat Characteristics

Table 3.4-1 compares the average, minimum and maximum values of the habitat variables measured in August 2002, with those measured in August 2001 and reported in Rescan (2002). In general, the results of the other year were similar (*i.e.*, averages of both years fell within the range observed in the other year), but the variability around the averages was greater in 2001 than in 2002 because of the greater number and size range of streams surveyed in 2001 than in 2002.

Average stream survey distance was 66% greater in 2002 than in 2001 because electrofishing effort per stream was increased in 2002 in order to confirm the fisheries values of streams classified as non-fish-bearing in 2001.

Table 3.4-1
Comparison of Habitat Variables Measured at 35 Streams in August, 2002, with those Measured at 55 Streams in August 2001

		August 2002				August 2001			
Habitat variable	**Units**	**Average**	**Min**	**Max**	**n**	**Average**	**Min**	**Max**	**n**
Survey distance[1]	m	297	40	400	35	197	74	405	55
Number of habitat units[2]	-	3	2	7	3	4	1	33	55
Average length of a habitat unit[2]	m	39	16	68	3	46	6	203	55
Water temperature[1]	°C	10.4	5.7	20.5	28	11.3	5.6	15.6	55
Conductivity[2]	µS/cm	23	8	91	28	25	1	445	55
pH[1]	log units	6.3	5.1	6.9	28	7.1	5.3	9.4	55
Water velocity[2]	m/sec	0.19	0.05	0.60	10	0.18	0.0	1.1	55
Stream discharge[2]	m^3/sec	0.0076	0.0003	0.1800	10	0.04	0.00	32.50	55
Bankfull width[2]	m	13.1	3.1	79.8	3	5.8	0.2	125.8	55
Wetted width[2]	m	10.8	2.0	77.8	3	3.1	0.0	113.9	55
Bankfull depth[2]	m	0.63	0.36	1.00	3	0.43	0.15	2.02	55
Wetted depth[2]	m	0.57	0.48	0.67	3	0.2	0.05	1.71	55
Wetted surface area[2]	m^2	1,468	218	8,790	3	562	0	23,000	55
Stream gradient[3]	%	0.6	0.4	0.9	3	0.8	0.1	6.8	55
Glide habitat type[3]	%	20	0	79	3	71	0	100	55
Riffle habitat type[3]	%	3	0	21	3	18	0	100	55
Pool habitat type[3]	%	17	0	91	3	6	0	83	55
Cascades habitat type[3]	%	0	0	0	3	2	0	69	55
"Other" habitat type[3]	%	25	0	100	3	3	0	100	55
Sand substrate[3]	%	6	0	22	3	28	0	100	55
Gravel substrate[3]	%	7	0	49	3	14	0	68	55
Cobble substrate[3]	%	25	0	64	3	29	0	90	55
Boulder substrate[3]	%	34	0	100	3	28	0	100	55
Bedrock substrate[3]	%	0	0	0	3	2	0	78	55
Left bank height[2]	m	0.28	0.25	0.30	3	0.23	0.01	3.18	55
Right bank height[2]	m	0.30	0.26	0.33	3	0.24	0.01	1.57	55
Boulder cover[3]	%	40	4.0	100	3	29	0	100	55
Instream vegetation cover[3]	%	5	0.0	19.0	3	13	0	80	55

(continued)

Table 3.4-1
Comparison of Habitat Variables Measured at 35 Streams in August, 2002, with those Measured at 55 Streams in August 2001 (completed)

		August 2002				August 2001			
Habitat variable	**Units**	**Average**	**Min**	**Max**	**n**	**Average**	**Min**	**Max**	**n**
Overhanging vegetation cover[3]	%	0	0	0	3	3	0	85	55
Pool cover[3]	%	3	0	25	3	3	0	83	55
Undercut bank cover[3]	%	0	0	0	3	1	0	6	55
Pool maximum depth[1]	m	0.22	0	0.70	3	0.90	0.35	2.00	55
Pool crest depth[1]	m	0.07	0	0.20	3	0.19	0.05	0.50	55

Dashes indicate no units
[1]variables with normal frequency distributions; the average is an arithmetic average
[2]variables with frequency distributions normalized by ln-transformation; the average is a geometric average
[3]variables with frequency distributions normalized by the arcsin(%/100)$^{0.5}$ transformation; the average is the arithmetic version of the transformed average

3.4.2 Fish Communities

The same five species dominated the fish communities in both 2002 and 2001. Juvenile Arctic grayling were most abundant, followed by slimy sculpin. The relative proportions of burbot and ninespine stickleback were reversed, but lake trout remained the least common of the five most common species. The proportion of each species was similar between years. Arctic grayling made up 49% of the catch in 2002 and 39 % in 2001, slimy sculpin 28% in 2002 and 32% in 2001, burbot with 15% versus 11%, ninespine stickleback 7% versus 15%, and finally 1% for lake trout in both years. The frequency distribution of species richness was similar between years with non-fish-bearing streams being the most common category. The differences in fish community between years were a matter of scale – the total number of fish caught, the total number of species, the maximum species richness and the number of age classes within each species were lower in 2002 than in 2001 due to the lower number of streams (and thus of total fishing effort), and the lower range of stream sizes surveyed in 2002 compared to 2001.

3.4.3 Fisheries Value of Low-Flow Streams

Of the 16 streams that were classified as low fisheries value in 2001, because no fish were captured during the electrofishing survey, eight were found to contain fish in 2002 (Table 3.4-2). Four of those eight streams contained high-valued fish species such as Arctic grayling, burbot or lake trout.

Table 3.4-2
2002 CPUE for Streams Classified as Low Fisheries Value in 2001

Stream Crossing (km)	CPUE in 2002 (fish/sec)	Comments
193.4	0.021	12 BURB captured
189.0	0.000	No fish
183.6	0.062	20 juvenile ARGR, 6 SLSC and 4 NNST captured
168.0	0.008	4 SLSC captured
159.5	0.000	No fish
113.2	0.000	No fish

(continued)

Table 3.4-2
2002 CPUE for Streams Classified as Low Fisheries Value in 2001 (completed)

Stream Crossing (km)	CPUE in 2002 (fish/sec)	Comments
106.7	0.003	1 BURB captured
90.3	0.000	No fish
85.0	0.000	No fish
77.0	0.000	No fish
76.0	0.024	18 juvenile ARGR captured
70.1	0.006	1 SLSC captured
69.4	0.018	3 SLSC captured
35.9	0.006	3 SLSC captured
33.8	0.000	No fish
2.8	0.000	No fish

ARGR = Arctic grayling, BURB = burbot, LKTR = lake trout, NNST = ninespine stickleback and SLSC = slimy sculpin

Sixteen streams were surveyed for fish presence for the first time in 2002, because they had not been surveyed in 2001 due to the absence of a distinct channel with water. The fact that these streams contained water in 2002 and no water in 2001, could be explained by the summer 2002 being the 6th wettest summer on record (Environment Canada, 2002) for the Mackenzie District. In addition, the location of some of the crossings had moved upstream or downstream due to the Road realignment and therefore the new location contained water. Of the 16 streams surveyed, 5 were found to contain fish (Table 3.4-3).

Table 3.4-3
Fish CPUE of Streams Surveyed in 2002, but not in 2001 Due to Lack of Flowing Water

Stream Crossing (km)	Original Type of Road Crossing	CPUE in 2002 (fish/sec)	Comments
208.2	C	0.055	2 SLSC and 4 NNST captured in residual pools
197.4	NA	0.000	No fish
182.8	NA	0.000	No fish
169.1	B	0.008	5 ARGR and 1 SLSC captured
168.3	NA	0.013	2 SLSC captured
167.6	NA	0.000	No fish
158.2	F	0.000	No fish
123.8	F	0.014	7 SLSC captured close to upstream lake
117.4	F	0.000	No fish
94.1	F	0.000	No fish
92.3	F	0.000	No fish
91.4	F	0.000	No fish
74.9	F	0.000	No fish
74.1	NA	0.000	No fish
39.0	F	0.005	1 SLSC captured
18.3	F	0.000	No fish

Type of crossing: C = culvert, B = bridge, F = ford, NA = not assigned
ARGR = Arctic grayling, BURB = burbot, LKTR = lake trout, NNST = ninespine stickleback and SLSC = slimy sculpin

These results indicate that the fisheries value of intermittent, low-flow streams along the Road route varies among years depending on stream flow levels and on the location of the crossing along the stream. Hence, more than one sampling season was required to accurately classify the fisheries values of such streams. This result also indicates that the fisheries value of some stream crossings, and hence the type of stream crossing structure assigned to those streams should be revised in the final Road design.

3.5 Stream Rank by Fisheries Value

Table 3.5-1 shows the fisheries value of each of the 35 streams surveyed in 2002, as assessed by electrofishing catches. The streams were organized into two groups: 17 streams that retained the same fisheries value or had a lower value as in 2001 and 18 streams with upgraded fisheries value as a result of the 2002 study. Five of those 18 streams rose from low to high fisheries values, 7 rose to medium from low values and 6 streams with no previous assigned fisheries values were assigned high, medium or low values.

Table 3.5-2 shows the revised fisheries values for all stream crossings surveyed. Values were obtained from the 2001 survey, and the aerial and the in-stream surveys conducted in 2002. The proposed Road route as of August 2002 will cross 104 streams/drainages. Thirty-five were classified as nil fisheries value, because there was no water present or there was no distinct channel, 24 were classified as low fisheries value due to the presence of a distinct channel with water, but where no fish were captured, 20 were classified as medium fisheries value, and 25 as high fisheries value.

Table 3.5-1
Fisheries Value of Stream Crossings of the Bathurst Road Surveyed in August 2002

Stream crossing (km)	Type of Road Crossing	Revised Fisheries Value	Previous Fisheries Value	Comments
No change to fisheries value				
189.6	C	Low	Low	No fish captured. Classified as Low in 2001 because no fish were captured
167.6	NA	Low	Low	No fish captured. Classified as Low in 2001 because no water was present
159.5	F	Low	Low	No fish captured. Classified as Low in 2001 because no fish were captured
158.2	F	Low	Low	No fish captured. Classified as Low in 2001 because no water was present
117.4	F	Low	Low	No fish captured. Classified as Low in 2001 because no water was present
113.2	B	Low	Low	No fish captured. Classified as Low in 2001 because no fish were captured
94.1	F	Low	Low	No fish captured. Classified as Low in 2001 because no water was present
92.3	F	Low	Low	No fish captured. Classified as Low in 2001 because no water was present
91.4	F	Low	Low	No fish captured. Classified as Low in 2001 because no water was present
90.3	F	Low	Low	No fish captured. Classified as Low in 2001 because no fish were captured
85.0	F	Low	Low	No fish captured. Classified as Low in 2001 because no fish were captured
77.0	F	Low	Low	No fish captured. Classified as Low in 2001 because no fish were captured
74.9	F	Low	Low	No fish captured. Classified as Low in 2001 because no water was present
74.1	NA	Low	Low	No fish captured. Classified as Low in 2001 because no water was present
33.8	B	Low	Low	No fish captured. Classified as Low in 2001 because no fish were captured
18.3	F	Low	Low	No fish captured. Classified as Low in 2001 because no water was present
2.8	F	Low	Low	No fish captured. Classified as Low in 2001 because no fish were captured
Change to fisheries value				
196.7	F	High	Low	12 BURB captured. Classified as Low in 2001 because no fish were captured
183.6	F	High	Low	20 ARGR, 6 SLSC and 4 NNST captured. Classified as Low in 2001 because no fish were captured
169.1	B	High	Low	5 ARGR and 1 SLSC captured. Classified as Low in 2001 because no water was present
106.7	B	High	Low	1 BURB captured. Classified as Low in 2001 because no fish were captured
76.0	B	High	Low	18 ARGR captured. Classified as Low in 2001 because no fish were captured
208.2	C	Medium	Low	2 SLSC and 4 NNST captured. Classified as Low in 2001 because no fish were captured
168.0	F	Medium	Low	4 SLSC captured. Classified as Low in 2001 because no fish were captured
123.8	F	Medium	Low	7 SLSC captured. Classified as Low in 2001 because no water was present
70.1	F	Medium	Low	1 SLSC captured. Classified as Low in 2001 because no fish were captured
69.4	NA	Medium	Low	3 SLSC captured. Classified as Low in 2001 because no fish were captured
39.0	F	Medium	Low	1 SLSC captured. Classified as Low in 2001 because no water was present
35.9	B	Medium	Low	3 SLSC captured. Classified as Low in 2001 because no fish were captured
206.9	B	High	NA	10 ARGR and 3 BURB captured. Not classified in 2001 because it is a new crossing
97.2	NA	High	NA	1 LKTR captured. Not classified in 2001 because it is a new crossing
168.3	NA	Medium	NA	2 SLSC captured. Not classified in 2001 because no water was present
197.4	NA	Low	NA	No fish captured. Not classified in 2001 because no water was present
182.8	NA	Low	NA	No fish captured. Not classified in 2001 because no water was present
14.1	B	Low	NA	No fish captured. Not classified in 2001 because it is a new crossing

Type of crossing: C = culvert, B = bridge, F = ford, NA = not assigned

ARGR = Arctic grayling, BURB = burbot, LKTR = lake trout, NNST = ninespine stickleback, SLSC = slimy sculpin

Fisheries value: Low = no fish captured; Medium = contains only NNST or SLSC; and High = contains ARGR, BURB or LKTR

Table 3.5-2
Fisheries Classification for all Stream Crossings along the Road of the Bathurst Inlet Port and Road Project

Stream Crossing (km)	Fisheries Value	Stream Crossing (km)	Fisheries Value	Stream Crossing (km)	Fisheries Value
2.2	High	72.2	High	149.7	Nil
2.8	Low	74.1	Low	151.6	Nil
7.8	Low	74.9	Low	155.7	Nil
14.1	Low	76.0	High	158.2	Low
18.3	Low	77.0	Low	159.5	Medium
22.9	High	78.9	Nil	159.7	Nil
25.7	Nil	80.4	Nil	160.7	High
27.4	Nil	83.7	Nil	167.6	Low
30.4	Nil	84.2	High	168.0	Medium
33.4	Nil	85.0	Low	168.3	Medium
33.7	Medium	90.3	Low	169.1	High
33.8	Low	91.1	Nil	169.4	Nil
34.8	Medium	91.4	Low	169.6	Medium
35.9	Medium	92.3	Low	170.8	High
36.6	Low	94.1	Low	173.1	High
38.1	Nil	97.2	High	177.2	Nil
39.0	Medium	98.8	Nil	181.4	High
40.6	Nil	100.3	Nil	182.8	Low
42.3	Medium	103.3	High	183.6	High
43.3	Nil	103.3a	High	186.5	Medium
44.5	Medium	106.7	High	189.6	Low
47.5	Nil	113.2	Low	192.4	Medium
49.7	Medium	113.8	High	192.4a	High
52.0	Nil	115.2	Medium	193.8	Nil
54.3	Nil	117.4	Low	196.7	High
56.9	Nil	119.4	Nil	197.0	Low
58.7	Medium	123.3	Nil	197.4	High
62.3	Low	123.8	Medium	198.2	Nil
63.5	Nil	125.3	Nil	201.9	High
66.5	Nil	128.8	High	202.8	High
67.9	Low	134.6	High	204.3	Medium
68.3	Low	136.6	Nil	206.9	High
68.6	High	144.6	Nil	208.2	Medium
69.4	Medium	146.6	Nil	211.0	Nil
70.1	Medium	147.5	Nil		

Fisheries value: Nil = no flow; Low = flow present but no fish; Medium = fish present but low-valued (slimy sculpin or ninespine stickleback); and High = high-valued fish present (Arctic grayling, burbot, lake trout, round whitefish, Arctic cisco, Arctic char or longnose sucker)

4. SUMMARY AND CONCLUSIONS

4. Summary and Conclusions

A survey of 35 stream crossings and a low level aerial survey of the Road route were conducted between August 2 and 7, 2002. Three of the streams were surveyed for habitat characteristics and fish community composition. All streams were surveyed for fish community composition.

Habitat characteristics, averaged for all the streams surveyed in a give year, were similar in 2001 and 2002. However, the variability observed in 2001 was greater than that in 2002, due to the greater number and size range of streams surveyed in 2001. Average stream survey distance was 66% greater in 2002 than in 2001 because electrofishing effort per stream was increased in order to confirm the fisheries values of streams classified as non-fish-bearing in 2001.

A comparison of the fisheries value of streams with the presence/absence of barriers to fish passage, and of nearby overwintering lake habitat, showed that both habitat variables are implicated in fish presence or absence. The comparison also showed that the relationships between fish presence/absence, barriers to fish passage, and the presence of overwintering lake habitat, are not precise enough to be used to assess the fisheries value of a stream. A similar conclusion was developed in the 2001 study. Electrofishing catch is a more reliable indicator of stream fisheries value than habitat characteristics.

A total of 108 fish were captured in 15 streams. The same five species dominated the fish communities in both 2002 and 2001. Juvenile Arctic grayling were most abundant, followed by slimy sculpin. The relative proportions of burbot and ninespine stickleback were reversed in 2002, but lake trout remained the least common of the five most common species. The frequency distribution of species richness was similar between years with non-fish-bearing streams being the most common category. The differences in fish community between years were a matter of scale – the total number of fish caught (108 versus 311), the total number of species (5 versus 7), and the maximum species richness (3 versus 4) were lower in 2002 than in 2001 due to the lower number of streams, and the lower range of stream sizes in 2002 than in 2001.

Seventeen of the 35 streams sampled retained the same fisheries value or had a lower value as they were assigned in 2001, but the fisheries value of 18 streams was upgraded as a result of the electrofishing survey. The proposed Road route will cross 104 streams/drainages, 35 were classified as having nil fisheries value, 24 as low fisheries value, 20 as medium value, and 25 as high value.

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APPENDIX 2.1-1
LOCATIONS OF STREAM CROSSINGS SURVEYED FOR FISH HABITAT AND FISH COMMUNITY, AUGUST 2002

Appendix 2.1-1
Locations of Stream Crossings Surveyed for Fish Habitat and Fish Community, August 2002

Stream crossing (km)	Surveyed upstream limit				Surveyed downstream limit			
	latitude		longitude		latitude		longitude	
	degrees	minutes	degrees	minutes	degrees	minutes	degrees	minutes
208.2	65	27.618	110	4.042	65	27.582	110	3.893
206.9	65	27.758	110	1.775	65	27.709	110	1.814
197.4	65	28.670	109	50.400	65	28.531	109	50.899
196.7	65	28.666	109	49.464	65	28.491	109	49.514
189.6	65	27.722	109	40.700	65	27.703	109	40.190
183.6	65	27.181	109	33.251	65	26.979	109	33.320
182.8	65	27.276	109	32.127	65	27.114	109	32.093
169.1	65	29.757	109	15.498	65	29.606	109	15.387
168.3	65	29.736	109	14.935	65	29.583	109	15.008
168.0	65	29.600	109	14.460	65	29.476	109	14.596
167.6	65	29.434	109	13.823	65	29.447	109	14.263
159.5	65	29.541	109	5.157	65	29.392	109	5.304
158.2	65	29.924	109	4.051	65	29.967	109	4.408
123.8	65	39.875	108	28.096	65	39.707	108	28.202
117.4	65	41.516	108	21.080	65	41.396	108	20.707
113.2	65	42.715	108	16.478	65	42.521	108	16.591
106.7	65	44.733	108	9.538	65	44.827	108	9.918
97.2	65	48.278	108	1.664	65	48.343	108	1.697
94.1	65	49.663	107	59.601	65	49.620	107	59.171
92.3	65	50.079	107	59.370	65	49.991	107	59.274
91.4	65	51.118	107	58.615	65	51.100	107	58.537
90.3	65	51.540	107	57.600	-	-	-	-
85.0	65	54.028	107	55.284	65	54.011	107	54.848
77.0	65	57.948	107	50.390	65	57.941	107	49.911
76.0	65	58.482	107	50.038	65	58.387	107	49.613
74.9	65	58.845	107	49.811	65	58.788	107	49.504
74.1	65	59.232	107	48.414	65	59.114	107	48.034
70.1	66	1.343	107	48.985	66	1.223	107	48.661
69.4	66	1.565	107	48.569	66	1.427	107	48.319
39.0	66	17.014	107	45.187	66	17.133	107	45.319
35.9	66	18.408	107	43.227	66	18.486	107	43.348
33.8	66	19.435	107	42.627	-	-	-	-
18.3	66	25.959	107	37.596	66	28.030	107	38.035
14.1	-	-	-	-	66	28.191	107	37.259
2.8	66	31.017	107	32.027	66	31.208	107	32.192

Dashes indicate no data available

APPENDIX 3.1-1
BATHURST INLET ROAD STREAM CROSSINGS
AERIAL SURVEY, AUGUST 2002

Appendix 3.1-1
Bathurst Inlet Road Stream Crossing Aerial Survey

Crossing (km)	Assessed as Low in July 2001	August 2001 Assessment	Streams Outside of Road Alignment	Streams Sampled in 2002	Photograph	Comments
212.5	L		R			
211.0					2-11	Dry
208.2				y	2-09	Intermittent dry with small pockets
208.0			R			
206.9				y	2-10	Habitat and fish
206.8			R			
204.3		M			3-24	
202.8		H			3-23	
201.9		H			3-22	
198.2	L				2-8	Dry
197.4				y	2-7, 2-5	Water flowing, wolf den
197.2			R			
197.0			R			
196.7				y	2-4	Water flowing, near wolf
195.9	L		R			
193.8	L				2-3	Dry
192.4a		M	R		2-2	Flowing, location moved downstream from 2001 survey
192.4		M				Joins previous
189.6		L		y	2-1	Lakes downstream and upstream are not connected, intermittent dry sections, boulder field, subsurface flow
187.3					3-21	Dry, not a stream or drainage
186.5		L			3-20	All dry
183.6		L		y	3-19	Boulder garden dry near downstream end, flowing, lots of channels
182.9	L			y	3-18	Not much water, no fish
181.4		H			3-17	
177.2	L				3-16	Dry, boulder garden
173.1		H			3-15	
170.8		H			3-14	
169.6		M			3-13	
169.4	L				3-12	Dry
169.2	L				3-11	Dry
168.0		L		y	3-9	Water flowing
169.1	L			y	3-8	Big crossing
168.3				y	3-10	Water flowing
167.6	L			y	3-7	Flowing
160.7		H			3-6	
159.7	L				3-5	Dry boulder field
159.5		L		y	3-4	
159.2	L				3-3	Dry
158.8	L				3-3	Dry
158.2	L			y	3-2	Flow connected all the way
155.7	L				3-1	Dry
152.4	L					Dry
151.6	L				6-24	Dry boulder field
149.7	L				6-23	Dry
147.5	L				6-22	Dry, boulder garden upstream and downstream of crossing
146.6	L				6-21	Moved 400 m upstream, dry
145.7	L		R			
144.6	L				6-20	Moved 600 m, dry
136.6	L				6-19	Dry
134.6		H			6-18	
128.8		H			6-17	
125.3	L				6-15	Dry boulder field
123.8	L			y	6-16	Flowing water, flows subsurface for 300-400 m - not connected to lake
123.3	L				6-14	Dry
119.4	L				6-13	No distinct channel, water dispersed and flowing over grass, wetted area
117.4	L			y	6-12	Flowing
115.2		M			6-10	Flowing water
113.8		H			6-11	Flowing water
113.2		L		y	6-9	Large stream
106.7		L		y	6-8	
103.3a		H			6-7	
103.3		L			6-6	Dry, no stream between the lakes, tiny stream 200 m long to the north doesn't cross the road
100.3	L				6-5	Dry, boulders.
98.8	L				6-4	Dry
97.2				y	6-3, 6-2	Large bay of a lake, need huge bridge, should use original route

(continued)

Appendix 3.1-1
Bathurst Inlet Road Stream Crossing Aerial Survey (completed)

Crossing (km)	Assessed as Low in July 2001	August 2001 Assessment	Streams Outside of Road Alignment	Streams Sampled in 2002	Photograph	Comments
95.3	L		R			
94.1	L			y	6-1	Flowing water
92.3	L			y	7-21	Flowing water
91.4	L			y	7-22	Big pool standing water
91.1	L				7-23	Dry
90.3		L		y	7-24	Small patch of water on rocks
85.0		L		y	7-17	
84.2		H			7-16	
83.7	L				7-15	Wet grasses, no channel
81.5	L				7-14,7-13	Dry
80.4	L				7-12	No channel, wet area upstream and downstream, no flow, no connection
78.9	L				7-11	No channel, wet grass, no stream
78.6	L				7-10	No channel
78.5	L				7-10	No channel
77.0		L		y	7-9, 7-8, 7-7	Small channel
76.0		L		y	7-6	Water flowing
74.9	L			y	7-5	
74.1	L			y	7-4	together with 72.2
73.9	L				7-3	together with 72.4
72.2		H			7-2	Moved 150 m
70.1		L		y	7-1, 8-23	Dry at bottom, some wet patches
69.4				y	8-22	Not removed, flowing
68.6		H			8-21	Flowing
68.3			R			
66.5					8-20	Dry grassy area
67.9			R			
66.4	L		R			
63.5					8-19	Dry grassy area, no channel
62.3					8-18, 8-17	Standing water and no connection above or below
58.7		M			8-16	
56.9	L				8-15	Completely dry, no water
54.3	L				8-14	Dry
52.0		L			8-13	Dry boulder garden
49.7		M			8-12	Flowing for 100 m
47.5	L				8-11	Dry, nothing
44.5		M			8-10	Flowing
43.3		L			8-9	No water, dry
42.3		M			8-8	largest of the two close to each other
41.6	L				8-7	Dry, no channel
	L				8-6	Dry, no channel
40.6	L				8-5	Dry, no channel
39.5	L				8-4	Dry, no channel
39.0	L			y	8-3	Standing water
38.1					8-2	Dry, no channel
36.6			R		8-1, 4-25	Removed
35.9		L		y	4-24, 4-23	Water flowing
34.8		M			4-16	Flowing
33.8		L		y	4-14	Low flow
33.7		M			4-18, 4-15	Flowing
33.4	L				4-17	Dry, no channel
32.1	L				2-12	No channel, no water
30.4	L				2-11	No channel, no water, subsurface
28.9	L		R			Removed
27.8	L		R			Removed
27.4	L				2-10	No channel, no flow, dry small puddle
25.7	L					Dry, no water, no channel
24.1					2-8	No water, no channel
22.9		H			2-7	Amagok Creek
18.3	L			y	2-6	Some small puddles near the lake
14.1				y	2-4	Flowing large stream
11.9			R			
11.1	L		R			
7.8		L		y	2-3	Flowing
2.8		L		y	2-2	Flowing
2.2		H			2-1	Flowing

L = low, M = medium, H = high

R = removed, outside of new road route

y = yes

APPENDIX 3.2-1
STREAM HABITAT DATA SHEETS

Stream Crossing ID: 14.1 **Survey Date (d/m/y):** 6/8/2002
Drainage Area (Km²): **Survey Crew:** SU/TA
Survey Distance (m) 203 **Aerial photo:**

A: Downstream
N: 66°28.190
W: 107°37.260

B:Upstream
N: 66°28.191
W: 107°37.259

Approx. Distance from Over-wintering Habitat (Km):
Temperature (°C): - **Visibility:** -
Channel Velocity (m/s): 0.3 **Conductivity (uS/cm):** -
Current Flow Conditions: - **pH:** -
Discharge estimate (m³/s) 0.114

Barriers to Over-Wintering Habitat: None in survey section

Weather: Rain

Stream Crossing ID: 14.1
Survey Date (d/m/y): 6/8/2002
Survey Crew: SU/TA
Aerial photo: 0

Hab Unit No.	Hab Type	Dist. fr start (m)	Length (m)	Slope (%)	Depth (m) Mean	Depth (m) Bank-full	Width (m) Mean	Width (m) Bank-full	Bed Material Sand (%)	Gravel (%)	Cobble (%)	Cobble (%)	Boulder (%)	Bedrock (%)	Pool Info Type	Pool Info Depth (m) Max	Pool Info Depth (m) Crest	Fish Passage Barriers Type	Fish Passage Barriers T/P
1	P	0	80	0.0	0.75	1.10	12.0	14.0	20	0		60	20	0	S	1.00	0.30		
2	G	80	82	1.0	0.25	0.55	1.9	2.4	40	0		50	10	0					
3	P	162	41	0.0	0.65	0.95	13.0	14.0	20	0		75	5	0	S	1.00	0.40		
4		203																	
5																			
6																			
7																			
8																			
9																			
10																			
11																			
12																			
13																			
14																			
15																			
16																			
17																			
18																			
19																			
20																			

Hab Unit No.	Banks of Channel L Bank Height (m	R Bank Height (m	L Bank Stab	R Bank Stab	Instream Cover Pool %	Boulder %	Instream Veg %	Overhang Veg %	Undercut Bank %	Photos (Role #) (Photo #)
1	0.30	0.40	S	S	40	10	20			S1-10
2	0.20	0.20	S	S		10	40			S1-9
3	0.40	0.40	S	S	5		10			
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										

Flow Conditions H = High flow, M = Medium flow, L = Low flow
Habitat Unit Under bankfull conditions: 0 - 2.5 m = > 1 m², 2.5 - 5 m = > 2 m², 5 - 10 m = > 4 m², 10 -15 m = > 6 m², 15 -20 = > 8 m², > 20 m = > 10 m²
Hab Type P = pool, G = glide, R = riffle, C = cascade, O = other
Dist. fr start distance from beginning of the survey to the beginning of the habitat unit being surveyed
Pool Type S = scour, D = dammed, U = unknown
Substrate Sand (silt, clay, fine organic< 2 mm), Gravel (2 - 64 mm), Cobble (64 - 256), Boulders (256 - 4000 mm), Bedrock (>4000 mm)
Fish Passage Barriers IF = Impassible waterfall
BF = Boulder Field, passage through the boulder arrangement is not possible for fish
D = dry channel, no stream flow
NC = no distinct channel, water drains over land
N = no barrier to fish passage through the habitat unit
T/P T = temporary, portion of open water season
P = Permanent, all year round

Comments:

Preliminary Assessment

Spawning:	Rearing:	Over-wintering:	Adult Feeding:	Migration:
3	3	0	3	3

Banks of Channel (Stability) H = highly stable, S = stable, U = unstable
Preliminary Assessment 0 = no habitat present, 1 = poor, 2 = fair, 3 = good, 4 = excellent

Stream Crossing ID: 97.2 **Survey Date (d/m/y):** 4/8/2002
Drainage Area (Km²): **Survey Crew:** SU/AK/FL/TA
Survey Distance (m) 113 **Aerial photo:**

A: Downstream
N: 65°48.343
W: 108°1.697

B:Upstream
N: 65°48.278
W: 108°1.664

Approx. Distance from Over-wintering Habitat (Km):
Temperature (°C): 12.7 **Visibility:**
Channel Velocity (m/s): **Conductivity (uS/cm):** 45.2
Current Flow Conditions: **pH:** 5.97
Discharge estimate (m³/s)

Barriers to Over-Wintering Habitat:

Weather:

Hab Unit No.	Hab Type	Dist. fr start (m)	Length (m)	Slope (%)	Depth (m) Mean	Depth (m) Bank-full	Width (m) Mean	Width (m) Bank-full	Bed Material Sand (%)	Gravel (%)	Cobble (%)	Boulder (%)	Bedrock (%)	Pool Info Type	Depth (m) Max	Depth (m) Crest	Fish Passage Barriers Type	Fish Passage Barriers T/P
1	BG	0	67	0.5	0.45	0.65	90.0	92.0	0	0	0	100	0					
2	BG	67	46	0.5	0.55	0.75	60.0	62.0	0	0	0	100	0					
3		113																
4																		
5																		
6																		
7																		
8																		
9																		
10																		
11																		
12																		
13																		
14																		
15																		
16																		
17																		
18																		
19																		
20																		

Flow Conditions H = High flow, M = Medium flow, L = Low flow
Habitat Unit Under bankfull conditions: 0 - 2.5 m = > 1 m², 2.5 - 5 m = > 2 m², 5 - 10 m = > 4 m², 10 -15 m = > 6 m², 15 -20 = > 8 m², > 20 m = > 10 m²
Hab Type P = pool, G = glide, R = riffle, C = cascade, O = other, BG = boulder glide
Dist. fr start distance from beginning of the survey to the beginning of the habitat unit being surveyed
Pool Type S = scour, D = dammed, U = unknown
Substrate Sand (silt, clay, fine organic< 2 mm), Gravel (2 - 64 mm), Cobble (64 - 256), Boulders (256 - 4000 mm), Bedrock (>4000 mm)
Fish Passage Barriers IF = Impassible waterfall
BF = Boulder Field, passage through the boulder arrangement is not possible for fish
D = dry channel, no stream flow
NC = no distinct channel, water drains over land
N = no barrier to fish passage through the habitat unit
T/P T = temporary, portion of open water season
P = Permanent, all year round

Stream Crossing ID: 97.2
Survey Date (d/m/y): 4/8/2002
Survey Crew: U/AK/FL/TA
Aerial photo: 0

Hab Unit No.	Banks of Channel L Bank Height (m)	R Bank Height (m)	L Bank Stab	R Bank Stab	Instream Cover Pool %	Boulder %	Instream Veg %	Overhang Veg %	Undercut Bank %	Photos (Role #) (Photo #)
1	0.30	0.30	S	S		100				7-20
2	0.30	0.30	S	S		100				7-19
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										

Comments:

Preliminary Assessment

Spawning:	Rearing:	Over-wintering:	Adult Feeding:	Migration:
2	3	0	1	1

Banks of Channel (Stability) H = highly stable, S = stable, U = unstable
Preliminary Assessment 0 = no habitat present, 1 = poor, 2 = fair, 3 = good, 4 = excellent

Stream Crossing ID: 206.9 **Survey Date (d/m/y):** 3/8/2002
Drainage Area (Km²): **Survey Crew:** SU/AK/TA
Survey Distance (m) 111 **Aerial photo:**

A: Downstream
N: 65° 27.709
W: 110°01.814

B:Upstream
N: 65° 27.758
W: 110°01.775

Approx. Distance from Over-wintering Habitat (Km): 0.1
Temperature (°C): 11.6 **Visibility:**
Channel Velocity (m/s): 0.1 **Conductivity (uS/cm):** 8
Current Flow Conditions: **pH:** 6.46
Discharge estimate (m³/s) 0.018

Barriers to Over-Wintering Habitat:

Weather: Sunny, no wind

Hab Unit No.	Hab Type	Dist. fr start (m)	Length (m)	Slope (%)	Depth (m) Mean	Depth (m) Bank-full	Width (m) Mean	Width (m) Bank-full	Bed Material Sand (%)	Gravel (%)	Cobble (%)	Boulder (%)	Bedrock (%)	Pool Info Type	Depth (m) Max	Depth (m) Crest	Fish Passage Barriers Type	Fish Passage Barriers T/P
1	G	0	30	1.0	1.50	0.30	2.0	3.0	0	55	30	15	0					
2	R	30	5	2.0	0.05	0.25	0.9	2.6	0	70	20	10	0					
3	G	35	32	0.5	0.30	0.50	2.5	3.7	10	70	20	0	0					
4	R	67	15	1.5	0.05	0.20	2.3	2.6	0	25	65	10	0					
5	G	82	9	0.5	0.25	0.40	2.1	3.1	5	20	60	15	0					
6	R	91	6	1.5	0.10	0.20	1.3	2.6	0	20	60	20	0					
7	G	97	14	0.5	0.15	0.25	0.9	2.5	50	5	40	5	0					
8		111																
9																		
10																		
11																		
12																		
13																		
14																		
15																		
16																		
17																		
18																		
19																		
20																		

Flow Conditions H = High flow, M = Medium flow, L = Low flow
Habitat Unit Under bankfull conditions: 0 - 2.5 m = > 1 m², 2.5 - 5 m = > 2 m², 5 - 10 m = > 4 m², 10 -15 m = > 6 m², 15 -20 = > 8 m², > 20 m = > 10 m²
Hab Type P = pool, G = glide, R = riffle, C = cascade, O = other
Dist. fr start distance from beginning of the survey to the beginning of the habitat unit being surveyed
Pool Type S = scour, D = dammed, U = unknown
Substrate Sand (silt, clay, fine organic< 2 mm), Gravel (2 - 64 mm), Cobble (64 - 256), Boulders (256 - 4000 mm), Bedrock (>4000 mm)
Fish Passage Barriers IF = Impassible waterfall
BF = Boulder Field, passage through the boulder arrangement is not possible for fish
D = dry channel, no stream flow
NC = no distinct channel, water drains over land
N = no barrier to fish passage through the habitat unit
T/P T = temporary, portion of open water season
P = Permanent, all year round

Stream Crossing ID: 206.9
Survey Date (d/m/y): 3/8/2002
Survey Crew: SU/AK/TA
Aerial photo: 0

Hab Unit No.	Banks of Channel L Bank Height (m)	R Bank Height (m)	L Bank Stab	R Bank Stab	Instream Cover Pool %	Boulder %	Instream Veg %	Overhang Veg %	Undercut Bank %	Photos (Role #) (Photo #)
1	0.20	0.20	S	S		10	10			
2	0.40	0.50	S	S		10				S-23
3	0.20	0.40	S	S						
4	0.30	0.20	S	S			10			
5	0.25	0.25	S	S		5				
6	0.10	0.10	S	S		10				
7	0.30	0.20	S	S		5	5			
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										

Comments:

Preliminary Assessment

Spawning:	Rearing:	Over-wintering:	Adult Feeding:	Migration:

Banks of Channel (Stability) H = highly stable, S = stable, U = unstable
Preliminary Assessment 0 = no habitat present, 1 = poor, 2 = fair, 3 = good, 4 = excellent

APPENDIX 3.2-2
ELECTROFISHING SURVEY DATA, BATHURST INLET ROAD STREAM CROSSINGS, AUGUST 2002

Appendix 3.2-2
Electrofishing Survey Data, Bathurst Inlet Road Sream Crossings, August 2002

	Stream		Stream characterisitics								Fishing Effort		Number						Total
Date	Crossing (km)	Survey Crew	Temperature (°C)	Conductivity (mS/cm)	pH	Velocity[1] (m/sec)	Flow[2] (m^3/sec)	Flow[3] (m^3/sec)	Habitat Notes[4]	Electrofishing Voltage (V)	Distance (m)	Time (sec)	Arctic grayling	Slimy sculpin	Burbot	Ninespine stickleback	Lake trout	Total	CPUE (fish/sec)
3-Aug-02	208.2	SU/FL/AK/TA	11.1	9	5.7	-	-	0.0000	7	600	200	110	0	2	0	4	0	6	0.055
3-Aug-02	206.9	SU/AK/TA	11.6	8	6.5	0.10	0.0180	-	8	500	111	293	10	0	3	0	0	13	0.044
3-Aug-02	189.6	SU/AK/TA	11.7	15	6.4	0.25	0.0038	-	9	-	400	584	0	0	0	0	0	0	0.000
3-Aug-02	183.6	FL/SU/AK/TA	13.1	9	6.3	-	-	0.0000	10	900	400	481	20	6	0	4	0	30	0.062
3-Aug-02	182.8	FL/SU/AK/TA	20.5	20	6.1	0.10	0.0006	-	11	800	350	174	0	0	0	0	0	0	0.000
3-Aug-02	169.1	SU/AK/TA	12.7	10	6.4	-	-	-	12	1000	200	774	5	1	0	0	0	6	0.008
3-Aug-02	168.3	FL/SU/AK/TA	10.2	20	6.1	-	-	0.0015	13	600	250	155	0	2	0	0	0	2	0.013
3-Aug-02	168.0	FL/SU/AK/TA	17.3	16	6.4	-	-	-	14	400	290	473	0	4	0	0	0	4	0.008
3-Aug-02	167.6	FL/SU/AK/TA	11.7	32	6.1	-	-	0.0002	15	-	370	178	0	0	0	0	0	0	0.000
4-Aug-02	197.4	FL/SU/AK/TA	8.9	23	6.4	-	-	0.0005	16	600	400	207	0	0	0	0	0	0	0.000
4-Aug-02	196.7	FL/SU/AK/TA	6.7	14	6.5	-	-	0.0000	17	700	400	577	0	0	12	0	0	12	0.021
4-Aug-02	159.5	FL/SU/AK/TA	5.7	17	6.0	-	-	0.0015	18	500	400	429	0	0	0	0	0	0	0.000
4-Aug-02	158.2	FL/SU/AK/TA	6.9	25	6.4	-	-	-	19	400	300	203	0	0	0	0	0	0	0.000
4-Aug-02	123.8	FL/SU/AK/TA	7.6	19	5.1	-	-	-	20	400	400	483	0	7	0	0	0	7	0.014
4-Aug-02	117.4	FL/SU/AK/TA	8.3	19	6.3	0.10	0.0003	-	21	700	400	141	0	0	0	0	0	0	0.000
4-Aug-02	113.2	SU/AK/TA	10.5	14	6.4	0.60	0.1800	-	22	500	400	817	0	0	0	0	0	0	0.000
4-Aug-02	106.7	FL/SU/AK/TA	7.7	16	6.3	0.20	0.0150	-	23	1100	400	332	0	0	1	0	0	1	0.003
4-Aug-02	97.2	FL/SU/AK/TA	12.7	45	6.0	-	-	-	24	-	113	460	0	0	0	0	1	1	0.002
5-Aug-02	94.1	FL/SU/AK/TA	7.3	27	6.4	-	-	-	25	800	400	446	0	0	0	0	0	0	0.000
5-Aug-02	92.3	FL/SU/AK/TA	8.7	23	5.9	-	-	-	26	900	200	135	0	0	0	0	0	0	0.000
5-Aug-02	91.4	FL/SU/AK/TA	9.8	36	5.6	0.05	0.0004	-	27	800	80	90	0	0	0	0	0	0	0.000
5-Aug-02	90.3	FL/SU/AK/TA	8.4	39	6.1	0.50	0.0600	-	28	700	50	77	0	0	0	0	0	0	0.000
5-Aug-02	85.0	SU/AK/TA	7.8	46	5.5	-	-	0.0005	29	-	400	313	0	0	0	0	0	0	0.000
5-Aug-02	77.0	FL/SU/AK/TA	11.4	39	6.5	-	-	0.0005	30	500	400	332	0	0	0	0	0	0	0.000
5-Aug-02	76.0	FL/SU/AK/TA	13.3	64	6.8	0.25	0.0080	-	31	600	400	736	18	0	0	0	0	18	0.024
5-Aug-02	74.9	FL/SU/AK/TA	9.4	61	6.4	-	-	-	32	600	310	51	0	0	0	0	0	0	0.000
5-Aug-02	74.1	FL/SU/AK/TA	10.1	91	6.6	-	-	-	33	500	400	132	0	0	0	0	0	0	0.000
5-Aug-02	70.1	FL/SU/AK/TA	10.2	35	6.9	-	-	0.0000	34	600	40	180	0	1	0	0	0	1	0.006
5-Aug-02	69.4	FL/SU/AK/TA	-	-	-	-	-	-	35	600	380	171	0	3	0	0	0	3	0.018
6-Aug-02	39.0	SU/TA	-	-	-	-	-	0.0005	36	300	250	183	0	1	0	0	0	1	0.005
6-Aug-02	35.9	SU/TA	-	-	-	-	-	1.0000	37	700	180	517	0	3	0	0	0	3	0.006
6-Aug-02	33.8	SU/TA	-	-	-	-	-	1.0000	38	400	320	387	0	0	0	0	0	0	0.000
6-Aug-02	14.1	SU/TA	-	-	-	0.30	0.1140	-	39	300	203	314	0	0	0	0	0	0	0.000
6-Aug-02	2.8	SU/TA	-	-	-	-	-	0.0000	40	200	400	220	0	0	0	0	0	0	0.000
7-Aug-02	18.3	SU/TA	-	-	-	-	-	0.0010	41	300	200	92	0	0	0	0	0	0	0.000
Mean			10.4	23	6.3	0.19	0.0076	0.0024		597	297	321							0.002
SD			3.2	-	-	-	-			215	119	208							-
n			28	28	28.0	10	10	15		31	35	35	53	30	16	8	1	108	35
minimum			5.7	8	5.1	0.05	0.0003	0.0000		200	40	51							0.000
maximum			20.5	91	6.9	0.60	0.1800	1.0000		1100	400	817							0.062

[1]Velocity was estimated with the floating chip method

[2]Flow was estimated as the product of velocity, average depth and average width of the habitat unit where velocity was estimated

[3]Flow was estimated by eye by an experienced hydrologist

[4]See Appendix 3.1-3

All means are arithmetic except those for conductivity, velocity, flow and CPUE which were geometric because of their log-normal distribution

SD=standard deviation of a mean and n=number of records. Dashes indicate no data available.

All electrofishing was done with a frequency of 60 Hz and a pulse width of 6 milliseconds.

APPENDIX 3.2-3
HABITAT NOTES FROM ELECTROFISHING SURVEY, BATHURST INLET PORT AND ROAD PROJECT, AUGUST 2002

Appendix 3.2-3
Habitat Notes from Electrofishing Survey, Bathurst Inlet Port and Road Project, August 2002

Stream crossing	Note	Comment
208.2	1	No flow - residual pools only. Intermittent pockets. Lots of dry places. Temporary barriers. Presence of fish indicates access to overwintering habitat.
206.9	2	Average depth was 0.1 m, width was 1.8 m, and average velocity was 0.1 m/sec, giving a stream flow of 0.018 m^3/sec. No barriers. Presence of fish indicates access to overwintering habitat.
189.6	3	No fish caught. There is a fish passage barrier between the small lake and the big lake (downstream). Although there was lots of water in channel, there was no fish. There was also an upstream fish barrier. Average stream width = 0.3 m, average depth = 0.05 m, and velocity = 0.25 m/sec. Permanent barriers. No access to overwintering habitat.
183.6	4	No observed flow. Intermittent connectivity between residual pools. At this flow fish cannot migrate to downstream or upstream lakes. Temporary barriers. Presence of fish indicates access to overwintering habitat.
182.8	5	Temperature is high because it was taken in a standing, shallow pool. Average stream width = 0.3 m, average depth = 0.02 m, and velocity = 0.10 m/sec, giving a flow of 0.0006 m^3/sec. From beginning of stream to end there are only a couple of residual pools. Therefore, not much habitat for fish to stay during summer. The deepest location of stream was 0.10 m.. No fish caught. Temporary barriers. Indeterminate access to overwintering habitat.
169.1	6	Low flow but lots of water. Photo #S1-23. No barriers. Presence of fish indicates access to overwintering habitat.
168.3	7	Flow = 1.5 L/sec. Water went sub-surface about 250 m from start at about latitude 65° 29.642, longitude 109° 14.871. Temporary barrriers. Presence of fish indicates access to overwintering habitat.
168.0	8	No barriers. Presence of fish indicates access to overwintering habitat.
167.6	9	No fish. Very low flow (0.2 L/sec). Water went subsurface at 370 m from start. Temporary barriers. Indeterminate access to overwintering habitat.
197.4	10	There is connection between stream and downstream pond and the big lake but we did not find fish. There was some flow, but not much. However, there was little if any pool habitat, most was glide with some depths only where there was flow. This opposite to "Bathurst 193.4" where there was no flow but relatively deep residual pools. Flow was 0.5 L/sec. No barriers. Indeterminate access to overwintering habitat.
196.7	11	No flow, just standing water. Diverse habitat, lots of cobble and residual pools that are at least 25 cm deep, some 40 cm. Upstream end seems to end, i.e., water must come from below ground. Checked 2 upstream lakes and there is connection and the second upstream lake has deep spots for overwintering (looks like it could be over 2 m deep, as determined by helicopter). Temporary barriers. Presence of fish indicates access to overwintering habitat.
159.5	12	Flow is approximately 1.5 L/sec. No upstream lake, stream starts just after boulder garden. First downstream lake not deep enough for overwintering but second downstream lake likely is, but no fish. Habitat is good - pools and cobble/boulder areas, 30-80 cm deep residual pools. No idea why no fish captured. Permanent upstream barrier. Indeterminate access to overwintering habitat.
158.2	13	At upstream end, water flows subsurface. Water connected to large lake downstream. Temporary upstream barrier. Access to overwintering habitat.
123.8	14	Downstream section is not connected to any lakes, just flows through boulder fields. Upstream connected to a small lake (tiny but deep). Flowing water, distinct channel from lake from 400 to 250 m downstream. First 150 m flows subsurface through willows and boulders. All fish caught near upper section of stream, close to lake. Width was approximately 40 cm. Temporary barriers. Presence of fish indicates access to overwintering habitat.
117.4	15	Average stream width = 0.1 m, average depth = 0.03 m, velocity = 0.1 m/sec. Stream continues upstream of survey point. The upstream lakes are small and do not likely represent overwintering habitat. Downstream lake is small and fairly shallow. After downstream lake is a marsh area with small ponds. No obvious overwintering habitat nearby. No barriers.

(continued)

Appendix 3.2-3
Habitat Notes from Electrofishing Survey, Bathurst Inlet Port and Road Project, August 2002 (continued)

Stream crossing	Note	Comment
113.2	16	Average width = 1.2 m, average depth = 0.25 m, and average velocity = 0.6 m/sec. Flow is 0.18 m^3/sec. Lots of flow. Good habitat - lots of deep pools, riffles, boulders, etc., but no fish caught or observed. Stream has lots of aquatic plants and meanders through grassy area. Both upstream lakes are shallower and do not likely represent overwintering habitat. Downstream of sampling areas is a shallow lake and downstream of the first lake is a waterfall that looks like a fish barrier. No access to overwintering habitat.
106.7	17	Depth = 0.15 m, width = 0.5 m, and velocity = 2 m/sec. Therefore, flow is 0.015 m^3/sec. Boulder garden leads to pockets of flow. Pockets were between 5 and 30 m. Access is poor, but possible. Upstream boulder garden has a steep slope but possible access. First upstream lake is shallow but has deep holes. Another boulder garden after the lake. Downstream end is a boulder field with poor connection and difficult access. No bariers. Presence of fish indicates access to overwintering habitat.
97.2	18	Partly cloudy. Photos 7-20 and 7-21 were taken of the site and photo 7-18 of the lake trout. No barriers. Presence of fish indicates access to overwintering habitat.
94.1	19	Good habitat and good flow. Lots of boulders and pools and meanders. Downstream lake is shallow and small. Downstream past first lake is a good channel that has subsurface sections. Upstream is a boulder field with subsurface flow. Upstream lakes are small. Photos S1-19, 20 and 21. Temporary barriers. No access to overwintering habitat.
92.3	20	Upstream lake - couldn't see bottom but the outflow is not connected to other downstream lakes - subsurface. Flow is low - standing pools. Permanent upstream barrier. No access to overwintering habitat.
91.4	21	Downstream lake has deep spot, but there is a steep cascade barrier. Stream goes subsurface upstream of survey zone but flows at surface at higher flows. Therefore, access upstream of the survey zone is a boulder garden. Average stream width = 0.15 m, depth = 0.05 m, and velocity = 0.05 m/sec. Permanent downstream barriers. Indeterminate access to overwintering habitat.
90.3	22	No fish. Habitat is only a standing pool and subsurface flow. Average width = 4 m, depth = 0.03 m, and velocity = 0.5 m/sec. Thus, flow is 0.06 m^3/sec. Upstream lake has deep spot. Downstream barrier (cascade/rock face). Flow from lake is subsurface, it daylights about 25 m upstream of downstream lake and then flows down an impassable rock face barrier. Temporary barriers. No access to overwintering habitat.
85.0	23	Good habitat. Many ponds, boulders and cobble and meanders, etc. Deep pools but no overwintering habitat. Flow is approximately 0.5 L/sec. Downstream lake is shallow and upstream lake is shallow. No barriers. No access to overwintering habitat.
77.0	24	Narrow channel in a grassy area, some gravel and cobble - some pockets - 30 cm pools. Flow is <0.5 L/sec. Found fish in habitat similar to this. There is an upstream lake that is potential overwintering habitat but the outlet of lake is not confined and is likely not possible for fish to move up. Downstream lake to survey stream is connected but there are many marsh areas where flow is unconfined. There is a connection over the marsh at higher flows and stream is connected to stream km 74.0 so we should see fish. Temporary barriers. Indeterminant access to overwintering habitat.
76.0	25	Stream width = 0.8 m, depth = 0.04 m and velocity = 0.25 m/sec. Therefore, flow = 0.008 m^3/sec. Good connection downstream and lake must have deep sections. No barriers. Presence of fish indicates access to overwintering habitat.
74.9	26	Very low flow. Only one or two standing residual pools. There is a barrier upstream and downstream - boulder area where flow is subsurface. Poor habitat. Flow through grassy area with silt upstream in headwater area. Not enough drainage to produce a defined channel. Permanent barriers. No access to overwintering habitat.

(continued)

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Appendix 3.2-3
Habitat Notes from Electrofishing Survey, Bathurst Inlet Port and Road Project, August 2002 (completed)

Stream crossing	Note	Comment
74.1	27	No fish likely because overwintering habitat is too far. Habitat is silt and grass. The stream goes through marshy area. Very low relief. Only a few cobble or boulders observed. Poor habitat. Upstream is headwater - no overwintering habitat. All four downstream lakes are shallow and have no overwintering habitat. No barriers. No access to overwintering habitat.
70.1	28	Just standing water. Not too many residual pools. Some good habitat in downstream section but it was very dry. Survey section is close to large lake. Most of the channel was dry probably due to the steep drop in land, i.e., stream elevation is much higher than the lake elevation. Access to downstream lake is good at higher flows - there is a steep section over much of the stream, fish could potentially access the stream. Temporary barriers. Presence of fish indicates access to overwintering habitat.
69.4	29	Some good habitat with residual pools. Good access to lake. Upstream the stream ends. No barriers. Access to overwintering habitat.
39.0	30	Habitat is mostly isolated pools, a few larger ponds in middle and end of survey. Ponds had thick orange algae/bacterial growth. Downstream lake has deep spots. Flow was <1.5 L/sec. The single SLSC captured was taken in first residual pool upstream of lake. Another SLSC was seen but not captured. Temporary barriers. Presence of fish indicates access to overwintering habitat.
35.9	31	Wide boulder/cobble channel. Lots of flow (approximately 1 m^3/sec). Fished between upstream pond and downstream braided section. Missed 4 to 5 SLSC, but no other fish observed. Upstream lake had some deep spots but I could see to the bottom. There is a connection, therefore could be overwintering habitat. Downstream is a barrier waterfalls. Permanent downstream barrier. Presence of fish indicates access to overwintering habitat.
33.8	32	Good habitat but large section of subsurface flow; connected at higher flows. Upstream is a small waterfall and a small lake with a deep section. Fish could migrate down at high flow and enter the stream. No barriers. Indeterminate access to overwintering habitat.
14.1	33	No fish but good habitat. Average width = 1.9 m, depth = 0.20 m, and velocity = 0.3 m/sec. Therefore, flow is 0.114 m^3/sec. The stream has very good connections up to upstream of the lake, but this is only a temporary barrier. The upstream lake has a deep section but it is far away (~10 km). A potentila reason for no fish is the far distance to overwintering habitat. Photo S1-10 taken at the glide looking upstream and photo #S1-9 taken at first downstream pool looking downstream. Temporary upstream barrier. No access to overwintering habitat.
2.8	34	Standing water. Habitat has deep pools. Upstream there is a headwater zone (no lake) and downstream is the ocean. No barriers. No access to overwintering habitat.
18.3	35	No fish - poor habitat. Survey with the electrofisher was only for 200 m because no confined channel. Downstream lake is deep but passage to survey section is very steep and there is no confined stream for fish. Flow was approximately 1 L/sec. Permanent barriers. No access to overwintering habitat.

APPENDIX 3.2-4
HABITAT VARIABLES OF THE THREE STREAMS SURVEYED IN AUGUST 2002

Appendix 3.2-4

Habitat Data from the Three Streams where Habitat Assessments were Conducted in August 2002

Stream Crossing (km)	Number of Habitat Units	Mean Habitat Length[1] (m)	Mean Wetted Width[2] (m)	Mean Bankfull Width[2] (m)	Total Wetted Surface Area (m^2)	Mean Wetted Depth[3] (m)	Mean Bankfull Depth[3] (m)	Stream Gradient[2] (%)	Glide Habitat[4] (%)	Riffle Habitat[4] (%)	Pool Habitat[4] (%)	Cascades Habitat[4] (%)	Other Habitat[4] (%)
206.9	7	16	2.0	3.1	218	0.57	0.36	0.9	78.6	21.4	0.0	0.0	0.0
97.2	2	57	77.8	79.8	8790	0.48	0.68	0.5	0.0	0.0	0.0	0.0	100.0
14.1	3	68	8.1	9.3	1649	0.67	1.00	0.4	9.4	0.0	90.6	0.0	0.0

Stream Crossing (km)	Sand Substrate[4] (%)	Gravel Substrate[4] (%)	Cobble Substrate[4] (%)	Boulder Substrate[4] (%)	Bedrock Substrate[4] (%)	Left Bank[2] Height (m)	Right Bank[2] Height (m)	Pool Cover[4] (%)	Boulder Cover[4] (%)	Instream Vegetation Cover[4] (%)	Overhanging Vegetation Cover[4] (%)	Undercut Bank Cover[4] (%)	Pool Maximum Depth[1] (m)	Pool Crest Depth[1] (m)
206.9	7	49	36	8	0	0.23	0.27	0	4	5	0	0	-	-
97.2	0	0	0	100	0	0.30	0.30	0	100	0	0	0	-	-
14.1	22	0	64	0	0	0.28	0.32	25	7	19	0	0	0.67	0.20

[1]Average over all habitat units

[2]Average over all habitat units, weighted by habitat unit length

[3]Average over all habitat units, weighted by habitat unit wetted surface area

[4]Percent of total wetted surface area made up of that habitat type

APPENDIX 3.3-1
FISH LENGTH AND WEIGHT, ELECTROFISHING SURVEYS, BATHURST INLET PORT AND ROAD PROJECT, AUGUST 2002

Appendix 3.3-1
Fish Length and Weight from Electrofishing Surveys, Bathurst Inlet Road, August 2002

Date	Stream Crossing (km)	Species	Fork Length (mm)	Weight (g)
3-Aug	208.2	NNST	18	0.08
3-Aug	208.2	NNST	46	0.84
3-Aug	208.2	NNST	49	0.80
3-Aug	208.2	NNST	50	0.84
3-Aug	208.2	SLSC	46	0.74
3-Aug	208.2	SLSC	60	1.80
3-Aug	206.9	ARGR	40	0.60
3-Aug	206.9	ARGR	42	0.70
3-Aug	206.9	ARGR	42	0.62
3-Aug	206.9	ARGR	43	0.69
3-Aug	206.9	ARGR	52	1.40
3-Aug	206.9	ARGR	52	1.64
3-Aug	206.9	ARGR	53	1.40
3-Aug	206.9	ARGR	53	1.71
3-Aug	206.9	ARGR	53	1.50
3-Aug	206.9	ARGR	56	1.72
3-Aug	206.9	BURB	28	0.24
3-Aug	206.9	BURB	37	0.50
3-Aug	206.9	BURB	49	0.90
4-Aug	196.7	BURB	30	0.21
4-Aug	196.7	BURB	31	0.22
4-Aug	196.7	BURB	31	0.23
4-Aug	196.7	BURB	33	0.39
4-Aug	196.7	BURB	34	0.39
4-Aug	196.7	BURB	34	0.42
4-Aug	196.7	BURB	38	0.42
4-Aug	196.7	BURB	40	0.57
4-Aug	196.7	BURB	40	0.58
4-Aug	196.7	BURB	41	0.50
4-Aug	196.7	BURB	42	0.65
4-Aug	196.7	BURB	48	0.81
3-Aug	183.6	ARGR	25	0.14
3-Aug	183.6	ARGR	28	0.17
3-Aug	183.6	ARGR	30	0.33
3-Aug	183.6	ARGR	31	0.27
3-Aug	183.6	ARGR	31	0.29
3-Aug	183.6	ARGR	31	0.18
3-Aug	183.6	ARGR	32	0.27
3-Aug	183.6	ARGR	32	0.24
3-Aug	183.6	ARGR	32	0.30
3-Aug	183.6	ARGR	32	0.23
3-Aug	183.6	ARGR	32	0.24
3-Aug	183.6	ARGR	33	0.35
3-Aug	183.6	ARGR	34	0.32
3-Aug	183.6	ARGR	34	0.34
3-Aug	183.6	ARGR	35	0.25
3-Aug	183.6	ARGR	35	0.21
3-Aug	183.6	ARGR	35	0.30
3-Aug	183.6	ARGR	35	0.30
3-Aug	183.6	ARGR	37	0.58
3-Aug	183.6	ARGR	38	0.23
3-Aug	183.6	NNST	12	0.04
3-Aug	183.6	NNST	16	0.06
3-Aug	183.6	NNST	19	0.06
3-Aug	183.6	NNST	50	0.68
3-Aug	183.6	SLSC	41	1.01
3-Aug	183.6	SLSC	52	1.29

(continued)

Appendix 3.3-1
Fish Length and Weight from Electrofishing Surveys, Bathurst Inlet Road, August 2002 (completed)

Date	Stream Crossing (km)	Species	Fork Length (mm)	Weight (g)
3-Aug	183.6	SLSC	56	1.71
3-Aug	183.6	SLSC	59	1.85
3-Aug	183.6	SLSC	62	2.48
3-Aug	183.6	SLSC	62	2.40
3-Aug	169.1	ARGR	170	62.00
3-Aug	169.1	ARGR	22	0.12
3-Aug	169.1	ARGR	23	0.13
3-Aug	169.1	ARGR	23	0.12
3-Aug	169.1	ARGR	25	-
3-Aug	169.1	SLSC	59	1.82
3-Aug	168.3	SLSC	59	2.00
3-Aug	168.3	SLSC	68	1.90
3-Aug	168.0	SLSC	53	1.46
3-Aug	168.0	SLSC	70	2.96
3-Aug	168.0	SLSC	75	3.27
3-Aug	168.0	SLSC	75	2.95
4-Aug	123.8	SLSC	34	0.37
4-Aug	123.8	SLSC	50	1.07
4-Aug	123.8	SLSC	52	1.17
4-Aug	123.8	SLSC	56	1.87
4-Aug	123.8	SLSC	60	1.80
4-Aug	123.8	SLSC	60	1.72
4-Aug	123.8	SLSC	78	4.28
4-Aug	106.7	BURB	37	0.47
4-Aug	97.2	LKTR	180	120.00
5-Aug	76.0	ARGR	40	0.46
5-Aug	76.0	ARGR	43	0.85
5-Aug	76.0	ARGR	43	0.91
5-Aug	76.0	ARGR	45	0.72
5-Aug	76.0	ARGR	45	1.25
5-Aug	76.0	ARGR	46	0.78
5-Aug	76.0	ARGR	47	0.90
5-Aug	76.0	ARGR	48	-
5-Aug	76.0	ARGR	48	0.84
5-Aug	76.0	ARGR	48	0.82
5-Aug	76.0	ARGR	48	1.17
5-Aug	76.0	ARGR	49	0.94
5-Aug	76.0	ARGR	49	0.92
5-Aug	76.0	ARGR	50	1.08
5-Aug	76.0	ARGR	50	1.24
5-Aug	76.0	ARGR	51	-
5-Aug	76.0	ARGR	51	-
5-Aug	76.0	ARGR	51	1.20
5-Aug	70.1	SLSC	70	4.17
5-Aug	69.4	SLSC	60	2.30
5-Aug	69.4	SLSC	70	3.24
5-Aug	69.4	SLSC	70	3.01
6-Aug	39.0	SLSC	57	1.46
6-Aug	35.9	SLSC	57	1.53
6-Aug	35.9	SLSC	85	5.80
6-Aug	35.9	SLSC	90	6.71
Total			108	

ARGR = Arctic grayling, SLSC = slimy sculpin, BURB = burbot, NNST = ninespine stickleback, LKTR = lake trout

Dashes indicate data not available

Appendix C-8
Freshwater Baseline Study, 2007

Author: **Rescan Environmental Services Ltd.**
Date: **November 2007**



the BATHURST INLET PORT AND ROAD PROJECT

Bathurst Inlet Port and Road Project

Nunavut, Canada

Freshwater Baseline Study, 2007



Prepared by:

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December 2007

EXECUTIVE SUMMARY

Executive Summary

Baseline information on the freshwater environment of the Bathurst Inlet Port and Road Project was collected during June and August, 2007 in order to conduct an environmental impact assessment. This report describes the physical characteristics and the quality of water and sediment of six streams that are crossed by the proposed road between Bathurst Inlet and Contwoyto Lake.

Streams were originally selected for the 2001 aquatics sampling program and were chosen based on their potential as high-quality fish habitat and to represent a wide range of stream sizes. Water samples were collected in 2007, once in June during freshet and in August during low flow, while sediments were sampled once in August.

Most of the general water quality variables did not exceed the CCME guidelines where they were available. The exceptions are several sites that fell below the lower guideline for pH (6.5) and total suspended solids (TSS) values in June and August. Most sites had relatively low metal concentrations. The general exception to this is B6, likely as a result of the high TSS at the time of sampling. CCME guidelines for the protection of aquatic life were exceeded in one or more samples for total aluminium, cadmium, chromium, copper and iron.

Analyses of sediment samples resulted in considerably higher average nutrient values in 2007 than in 2001. The highest average total metal concentrations varied from site to site. B6, the closest site to the proposed port, had relatively low average metal concentrations for several variables. CCME guidelines were exceeded for one or more sediment samples for arsenic, chromium and copper. The distribution of particle size in sediments did not differ considerably between 2001 and 2007. The analyses indicated that on average all stream sites were dominated by sand.

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1. INTRODUCTION

1. Introduction

1.1 Background

The Bathurst Inlet Port and Road Project (the Project) is located in the Kitikmeot region of Nunavut. The proposed marine port is located on the west side of Bathurst Inlet about 40 km south of the community of Bathurst Inlet. The proposed road will begin at the marine port in Bathurst Inlet and continue west to Contwoyto Lake, a distance of approximately 211 km.

The road will be used while the ground is frozen from January to April. Road maintenance activities will occur late in the summer and in early fall. Truck traffic from January to April will primarily carry fuel and cargo to operating mines in the area. Prospective users of the road include EKATI, Diavik, Jericho and Snap Lake diamond mines.

Baseline information on the freshwater environment along the road is required as part of the environmental impact assessment for the Project. Environmental studies for the Project began in 2001 (Rescan, 2007). The data collected in 2007 adds to the water and sediment data for the six sites between the marine port and Contwoyto Lake collected in 2001 (Figure 1.1-1). This report describes the water quality and sediment quality of six streams crossed by the road.

1.2 Objectives

The objectives of the 2007 aquatics study are to characterize the water and sediment quality of six stream sites along the proposed road. This baseline information, in combination with studies from 2001, will provide a reference from which potential impacts of development on these ecosystems may be detected. Surface waters were analyzed for physical characteristics, nutrient concentrations, and total and dissolved metals. Stream sediments were analyzed for physical characteristics, nutrient concentrations, metal concentrations, and grain size.

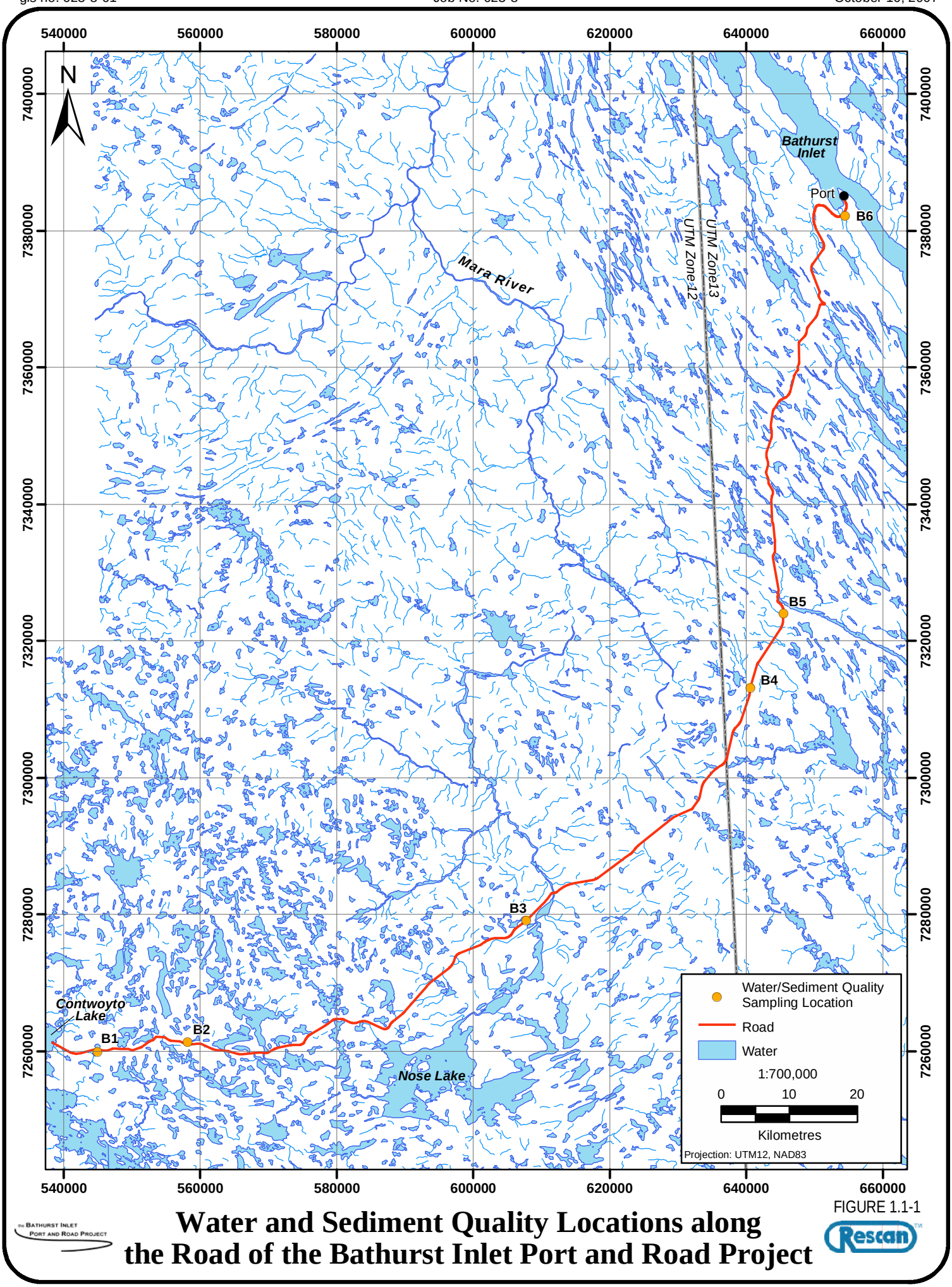


FIGURE 1.1-1

Water and Sediment Quality Locations along the Road of the Bathurst Inlet Port and Road Project

2. MATERIALS AND METHODS

2. Materials and Methods

2.1.1 Study Design

Six streams that cross the road were surveyed for baseline physical data (Table 2.1-1). Sampling locations were similar to locations in 2001 but may have changed slightly based on stream flow and sampling feasibility. Stream locations were selected based on three criteria initially obtained from the fish and fish habitat assessments: presence of Arctic grayling or larger migratory fish, stream size and geographical location. The streams represent a wide range of stream size and were distributed along the entire road between Contwoyto Lake and Bathurst Inlet (Figure 1.1-1).

Table 2.1-1
Co-ordinates and Variables Measured at Stream Sampling Stations, June/August 2007

2001 Station ID	2007 Station ID	GPS Co-ordinates (UTM)			Date Sampled	Variables Measured
		Easting	Northing	Zone		
Bathurst km 203.6	B1	544966	7259896	12	June 24 / August 18, 2007	Water quality/Water and sediment quality
Bathurst km 189.8	B2	558085	7261386	12	June 24 / August 18, 2007	Water quality/Water and sediment quality
Bathurst km 132.0	B3	607859	7279197	12	June 24 / August 18, 2007	Water quality/Water and sediment quality
Bathurst km 82.1	B4	367594	7312496	13	June 24 / August 18, 2007	Water quality/Water and sediment quality
Bathurst km 70.4	B5	373143	7323064	13	June 24 / August 18, 2007	Water quality/Water and sediment quality
Bathurst km 2.5	B6	387880	7380208	13	June 24 / August 18, 2007	Water quality/Water and sediment quality

2.1.2 Water Quality

One water sample was collected per site on June 24 and another on August 18, using standardized methods (RISC, 1997). Water samples were analyzed for general physico-chemical variables, anions, nutrients, total cyanide, total organic carbon (TOC), and total and dissolved metals at the lowest feasible detection limits by ALS Environmental Services of Vancouver, B.C.

For each sample, the scientist stood facing upstream and triple-rinsed the bottle and cap prior to filling. Preservatives were added for total metals (ultra-pure nitric acid), TOC (hydrochloric acid), and total cyanides (NaOH). No air bubbles were left in any of the bottles. A list of all routine chemistry variables is presented along with general method detection limits (MDL) in Table 2.1-2.

Table 2.1-2
Water Quality Variables and Method Detection Limits, 2007

Variable	Detection Limit (mg/L)	Variable	Detection Limit (mg/L)
Physical/Dissolved Anions		**Total and Dissolved Metals**	
Colour (C.U.)	5	Aluminum	0.001
Conductivity (µmhos/cm)	2	Antimony	0.0001
pH (pH units)	0.01	Arsenic	0.0001
Total Suspended Solids	3	Barium	0.00005
Turbidity (NTU)	0.1	Beryllium	0.0005
Total Organic Carbon	0.5	Bismuth	0.0005
Total Dissolved Solids	1	Boron	0.01
Hardness	0.5	Cadmium	0.00005
Total Alkalinity (as $CaCO_3$)	1	Calcium	0.02
Acidity	1	Chromium	0.0005
Bromide	0.05	Cobalt	0.0001
Chloride	0.5	Copper	0.0001
Fluoride	0.02	Iron	0.03
Sulphate	0.5	Lead	0.00005
Nutrients		Lithium	0.005
Ammonia Nitrogen	0.005	Magnesium	0.005
Nitrate	0.005	Manganese	0.00005
Nitrite	0.001	Mercury	0.00001
Total Kjeldahl Nitrogen	0.05	Molybdenum	0.00005
Total Nitrogen	0.02	Nickel	0.0005
Total Phosphorus	0.002	Phosphorous	0.3
Cyanides		Potassium	0.05
Total Cyanide	0.005	Selenium	0.001
		Silicon	0.05
		Silver	0.00001
		Sodium	2
		Strontium	0.0001
		Thallium	0.0001
		Tin	0.0001
		Titanium	0.01
		Uranium	0.00001
		Vanadium	0.001
		Zinc	0.001

C.U. = Colour Units
NTU = Nephelometric Turbidity Units

All analytical results are presented in appendices (listed in Section 3.1). Variables of particular interest and all those with guidelines have been presented graphically. Within this appendix the available CCME guidelines are summarized and samples exceeding these guidelines are highlighted. The analyzed data were then summarized for each variable by site and grouped from west to east. Some variables could not be measured reliably below a specified detection limit and are reported by the analytical laboratory as below that detection limit. When required for the

purpose of statistical analyses and graphical presentation, these values (called non-detects) were replaced with half of the detection limit.

2.1.3 Sediment Quality

Sediment was collected at all six stream sites once, in August, 2007. Three composite samples were collected at each site. Methods for stream sediment sampling were standardized (RISC, 1998) and involved the use of a stainless steel bowl and spoon to collect multiple grab samples within or alongside stream stations. Sediment was spooned from the top 5 cm at three to four locations along the streams within 10 to 20 m. Sediment was then carefully spooned into clean, pre-labelled Whirl-Pak bags, sealed (no air bubbles), and kept cool in the dark until analysis by ALS Environmental Services of Vancouver. This was done at three distinct areas per site (different braids, or different stretches of the main channel), covering a total stretch of 50 to 250 m, depending on site width and access, and resulted in three separate replicates per site.

All sediment samples were analyzed for moisture, particle size, nutrients, TOC, and total metals using the lowest feasible detection limit. A list of sediment test variables is presented in Table 2.1-3. Non-detects were replaced by half of the detection limit. Data are summarized by site, and compared to CCME sediment quality guidelines (CCME, 2003). The CCME guidelines include the Interim Sediment Quality Guideline (ISQG) and the Probable Effect Level (PEL).

Table 2.1-3
Sediment Quality Variables and Detection Limits, 2007

Variable		Detection Limit (mg/kg dry weight)	Variable		Detection Limit (mg/kg dry weight)
Physical Tests			Lithium	T-Li	2
Moisture		0.10%	Magnesium	T-Mg	50
Particle Size		0.10%	Manganese	T-Mn	1
Nutrients			Mercury	T-Hg	0.005
Available Phosphorus		1	Molybdenum	T-Mo	4
Total Nitrogen		0.01%	Nickel	T-Ni	5
Total Metals			Phosphorus	T-P	50
Aluminum	T-Al	50	Potassium	T-K	200
Antimony	T-Sb	20	Selenium	T-Se	50
Arsenic	T-As	0.5	Silver	T-Ag	2
Barium	T-Ba	1	Sodium	T-Na	200
Beryllium	T-Be	0.5	Strontium	T-Sr	0.5
Bismuth	T-Bi	20	Thallium	T-Tl	50
Cadmium	T-Cd	0.1	Tin	T-Sn	10
Calcium	T-Ca	50	Titanium	T-Ti	1
Chromium	T-Cr	2	Vanadium	T-V	2
Cobalt	T-Co	2	Zinc	T-Zn	1
Copper	T-Cu	1	**Organic Parameters**		
Iron	T-Fe	50	Total Organic Carbon	(%)	0.05
Lead	T-Pb	2			

2.1.4 Quality Assurance and Quality Control (QA/QC)

A separate set of bottles for field and travel blanks were included as part of the field QA/QC program. The travel blank bottles were filled with deionised water in the lab and remained closed throughout the field trip. This allowed assessment of contamination associated with transportation. The field blank bottles were also filled with deionised water, but were opened in the field and preserved as required for certain analyses. This allowed assessment of contamination associated with field sampling (airborne contamination, contamination of the lid/bottle, *etc.*) and preservation procedures. All data for field and travel QA/QC are reported in appendices. The frequency of detection of a concentration for a water quality variable above the method detection limit (MDL) was noted for both travel and field blanks, indicating possible contamination.

For quality assurance/quality control purposes, a minimum of 10% of the water samples were randomly collected in duplicate in order to assess the magnitude of variability within a site. For each pair of QA/QC field duplicate water samples, the relative percent differences (RPD) were calculated,

where: $RPD = 100 \mid rep1 - rep2 \mid /[(rep1 + rep2)/2]$

The RPD between the duplicates is a measure of the variability inherent in field sampling (environmental heterogeneity, sampler handling leading to contamination).

Additionally, one sediment replicate sample was sub-sampled in the lab for QA/QC purposes to ensure that sample homogenization was thorough. The Relative Percent Difference (RPD) statistic was used to assess the degree of homogenization.

Also, RPD values less than 20% were not considered notable. The B.C. provincial government suggests that any field duplicates with RPD values exceeding 20% should be noted and data should be interpreted accordingly (BCMWLAP, 2005). The results of RPD calculations were examined in order to detect patterns of high variation for multiple variables within sample pairs, indicating possible contamination during field sampling.

Analyses were conducted utilizing the lowest possible detection limit. For some samples, detection limits were greater due to interference from high conductivity, high TSS, or a high metal value. These samples must be diluted resulting in a higher detection limit.

3. RESULTS AND DISCUSSION

3. Results and Discussion

3.1.1 Water Quality

All analytical results for June and August stream water quality data, including highlighted samples that exceed CCME guidelines, are shown in Appendix 3.1-1. Water quality samples were collected from all six stream sites. Where possible, comparisons between the 2007 and 2001 data for these sites are discussed below.

3.1.1.1 Physical Variables and Nutrients

Key variables (pH, conductivity, nitrate, total phosphate, and total suspended solids) are presented graphically and discussed below. Within each figure, sites are shown from west to east along the road. If available, CCME guidelines are indicated.

The pH was similar across stream sites, although slightly higher at B6 (which was also the case in 2001) (Figure 3.1-1). Values ranged from 6.1 to 7.6 in 2007, which is generally lower than the range of values for 2001. All sites except B6 fell below the CCME lower guideline of 6.5 in one or both months. Conductivity across stream sites ranged from 9.2 to 265 µS/cm (Figure 3.1-1). Similar to the pattern seen with pH, B6 had much higher conductivity than other sites in 2001, although it was almost double (490 µS/cm) the August 2007 value.

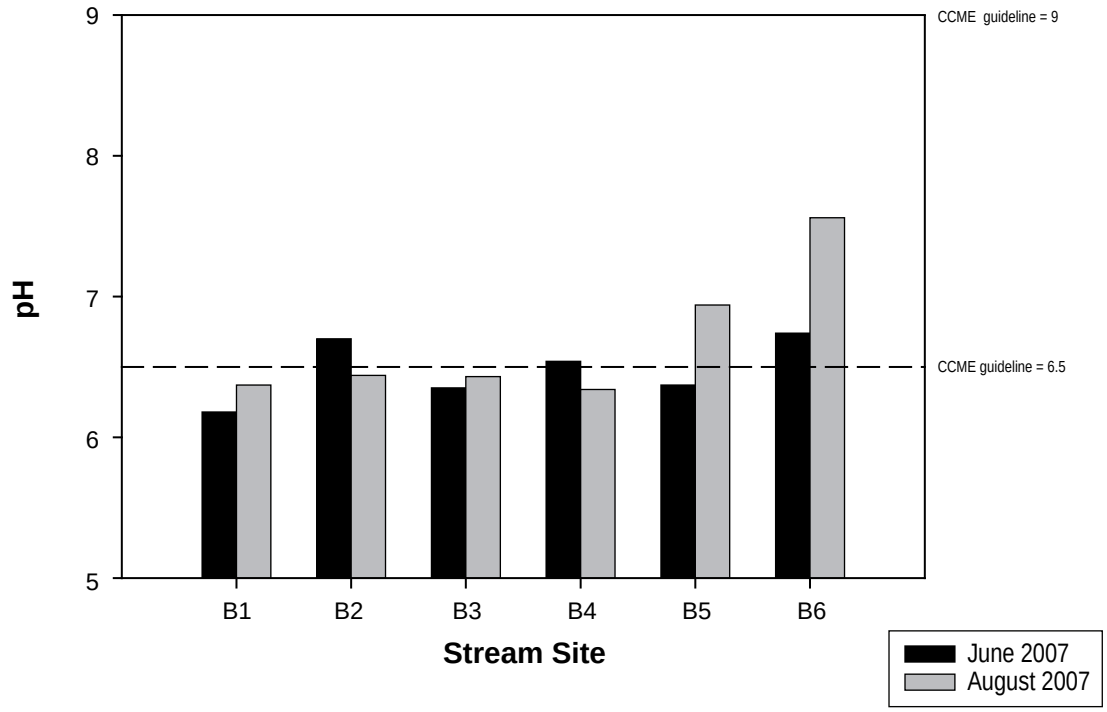
Nitrate concentrations were generally low at most sites (Figure 3.1-2). All samples collected during June and the August sample for B1 were below detection (0.005 mg/L). B3 had the highest value at 0.035 mg/L (August). All sites were well below the CCME guideline of 2.93 mg/L.

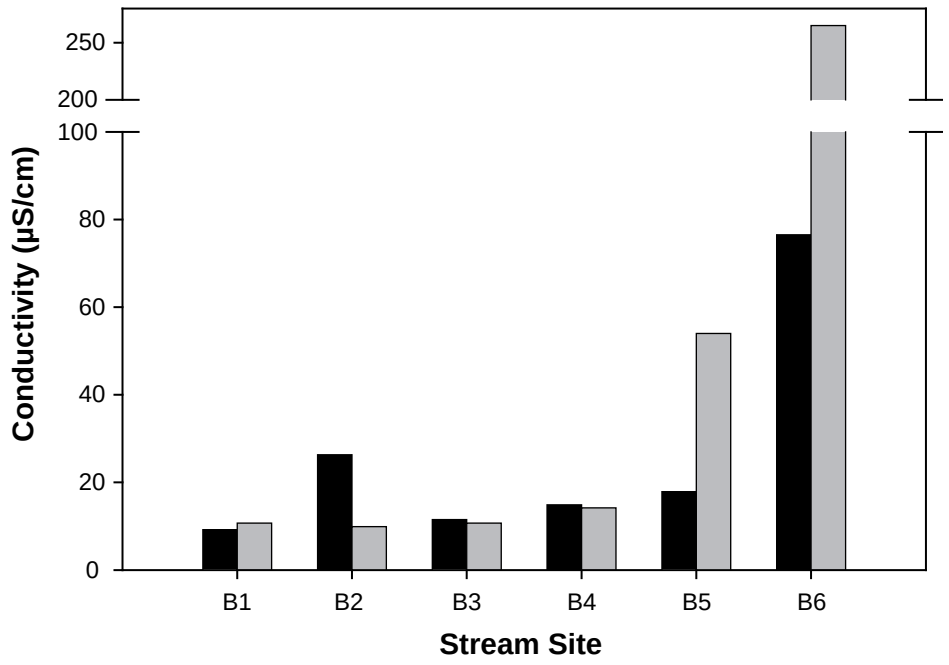
Total phosphate (TP) concentrations ranged from 0.005 (B3 August) to 0.106 (B6 June) mg/L (Figure 3.1-2). The relatively high concentrations at B6 are likely correlated with the high total suspended solids (TSS) at this site.

In 2001, the TSS values at all sites were below detection, except for B6 which was at the detection limit of 3 mg/L. The TSS values in 2007 ranged from below detection at most sites to 427 mg/L in June at B6 (Figure 3.1-2). This considerably high TSS value is probably the reason relatively high values of several water nutrients and metals are found at this site. Plate 3.1-1 illustrates the low clarity and the high suspended solids load carried by the B6 stream at the time of sampling. B1, with comparatively clear water, is also shown.

3.1.1.2 Total Metals

Several metals (antimony, beryllium, boron, cadmium, lead, mercury, molybdenum, selenium and silver) had at least 80% of samples below detection limits and are not discussed unless a sample exceeded the CCME guideline *(i.e.* cadmium). Of the remaining total metals, key variables are presented graphically and discussed below. Dissolved metals are not presented (but analytical results are available in Appendix 3.1-1) since no CCME guidelines are available for those variables. Most sites, except B6 and in some cases B5, had relatively low total metal concentrations. Several metals, such as cadmium, chromium and lead were below analytical detection limits at many sites.





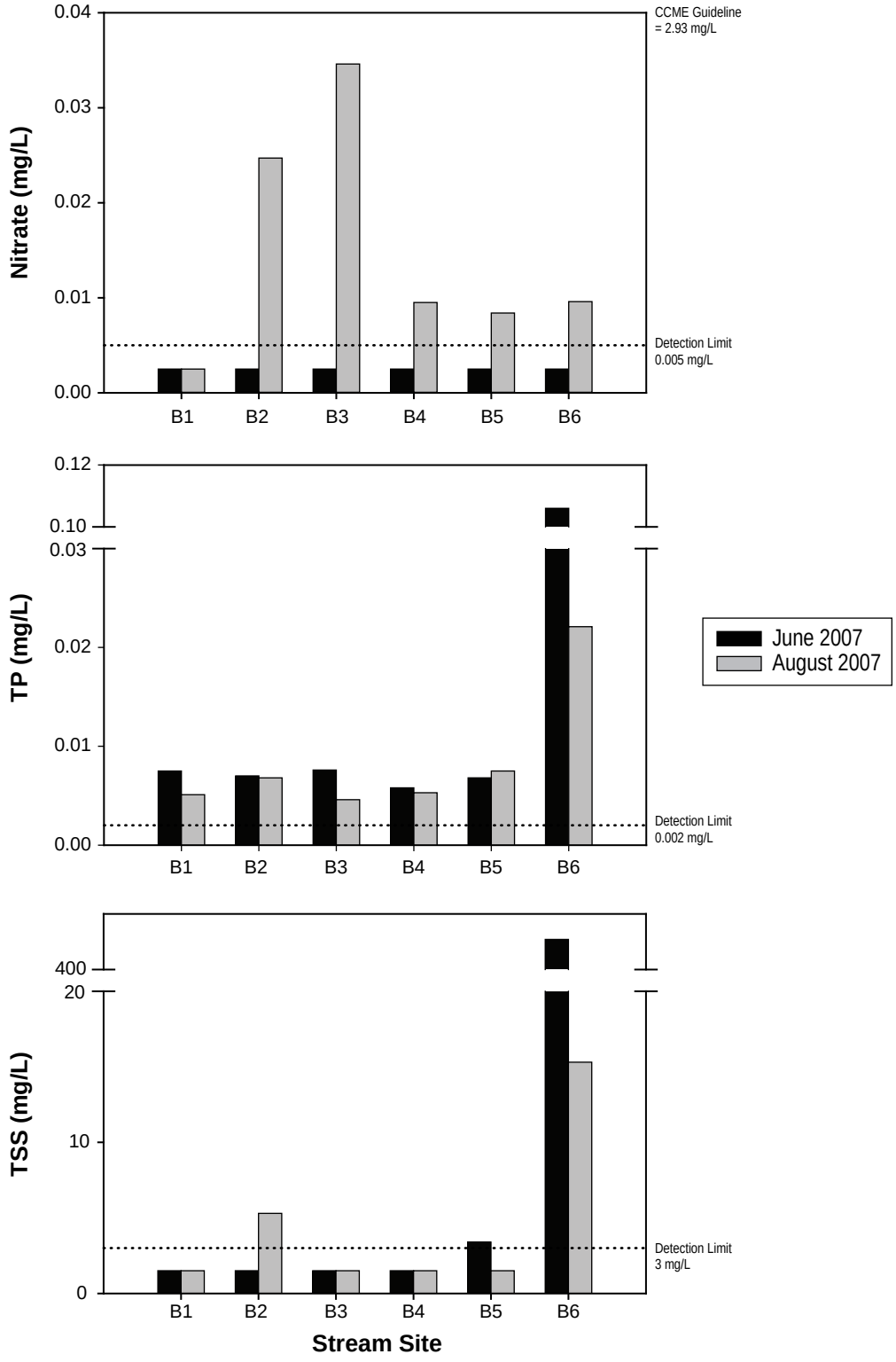
Notes: Dotted line denotes detection limits.
Dashed line denotes guideline values, where available.

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Stream Water pH and Conductivity, June and August 2007

FIGURE 3.1-1

Rescan™



Notes: Dotted line denotes detection limits.
Dashed line denotes guideline values, where available.

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Stream Water Nitrate, Total Phosphate (TP) and Total Suspended Solids (TSS), June and August 2007

FIGURE 3.1-2

Rescan™





Plate 3.1-1. Visible high turbidity and TSS at B6 and the relatively clear waters of B1.

Total aluminium ranged from 0.016 (B3 August) to 1.75 mg/L (B6 June) with both months at B6 exceeding the CCME guideline of 0.10 mg/L (Figure 3.1-3). Total arsenic at B6 (August) was below the detection limit (0.001 mg/L) but B3 (August) had an even lower concentration of 0.0001 mg/L (Figure 3.1-3). Detection limits vary as a result of variable water quality (*i.e.* high TSS). The highest concentration of total arsenic was at B6 (June, 0.0008 mg/L). All sites were well below the CCME guideline of 0.005 mg/L.

As previously mentioned, most total cadmium and chromium samples were below or close to their respective detection limits of 0.000017 and 0.0001 mg/L (Figure 3.1-4). The only total cadmium values that were above analytical detection (B2, August; B6, June) also exceeded the CCME guideline, which is dependent on hardness. At site B6, both June and August total chromium concentrations exceeded the CCME guideline (0.001 mg/L) with the highest concentration occurring in June (4.92 mg/L). All other sites showed much lower chromium values.

Total copper concentrations ranged from 0.0006 (B2 August) to 0.006 mg/L (B6 June) (Figure 3.1-5). There is a gradual increase in copper concentrations visible moving east towards Bathurst Inlet. Both June and August values at B5 and B6 exceeded the CCME guideline, which is dependant on hardness. Concentrations of total iron ranged from 0.05 (B2 June) to 2.27 mg/L (B6 June) (Figure 3.1-5). The CCME guideline (0.3 mg/L) was exceeded by B1 (August) and B6 (June and August).

Total nickel and total zinc concentrations are well below the CCME guidelines (Figure 3.1-6). Generally, June samples had higher concentrations than August samples. Total nickel concentrations ranged from 0.0005 (B2 August) to 0.0036 mg/L (B5 August). Total zinc concentrations ranged from below detection limit (0.001 mg/L) at B3 (August) to 0.0077 mg/L (B6 June).

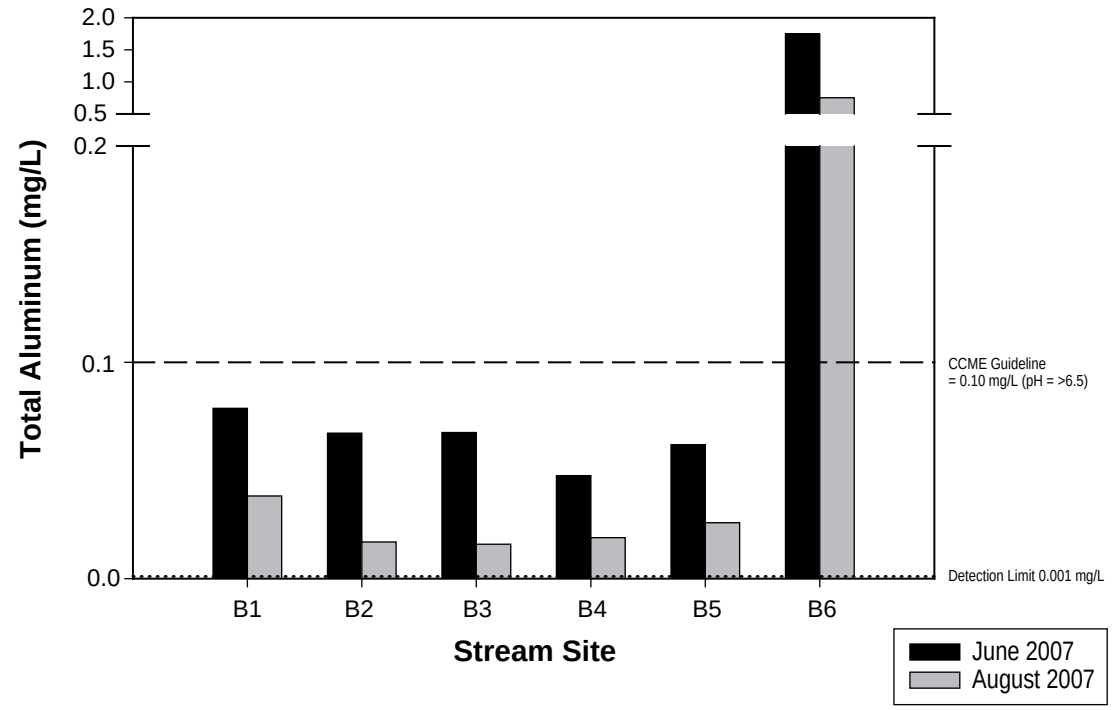
3.1.1.3 Quality Assurance and Quality Control (QA/QC)

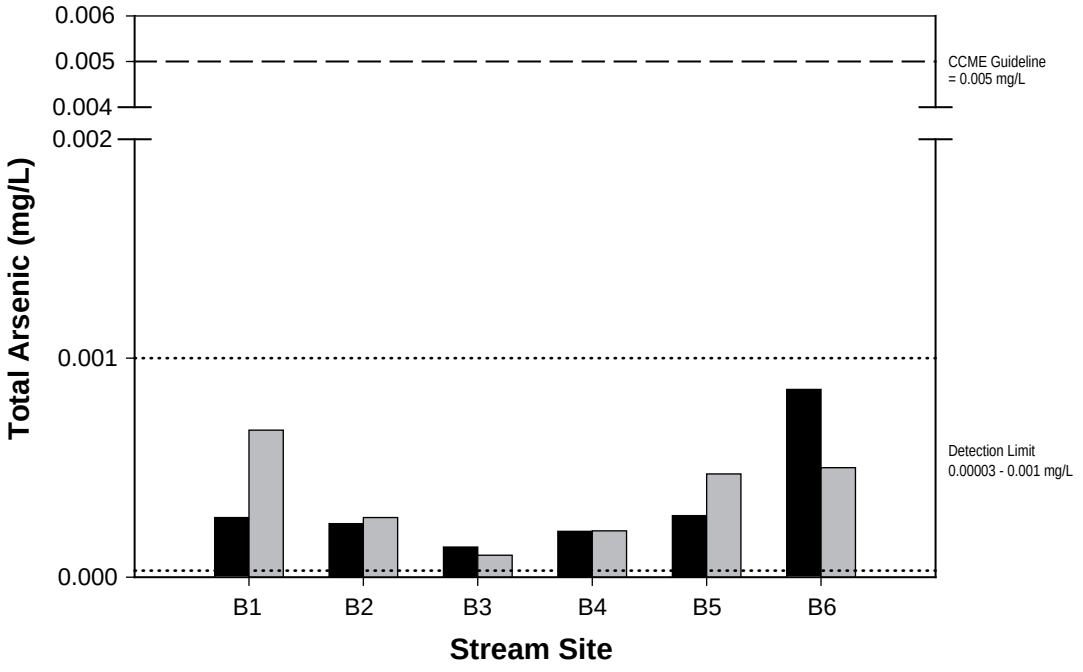
Field and travel blank data are presented in Appendix 3.1-1. Field and travel blank data were all below analytical detection limits, with the exception of nitrate in the August field blank, where value was < 2 times the MDL.

The RPD between the replicates is a measure of the variability inherent in field sampling (environmental heterogeneity, sampler handling leading to contamination). The RPD analyses of QA/QC field duplicate data for streams are reported in Appendix 3.1-2. Thirty-three (June) and twenty-three (August) of the 80 (41 and 29%) analyzed duplicates were below detection limits and no RPD values were calculated. Of the remaining results, 97% (June) and 95% (August) of the calculated RPD values were not greater than the 20% threshold indicated in British Columbian guidelines (BCMWLAP, 2005).

3.1.2 Sediment Quality

All analytical results for stream sediment data, including highlighted samples that exceed CCME guidelines, are shown in Appendix 3.1-3. All six stream sites were sampled for sediment quality compared to 2001 when sediment was only available at three sites (B1, B5 and B6). Where 2007 and 2001 data for these sites are considerably different, it is noted in the text for the variable of concern.





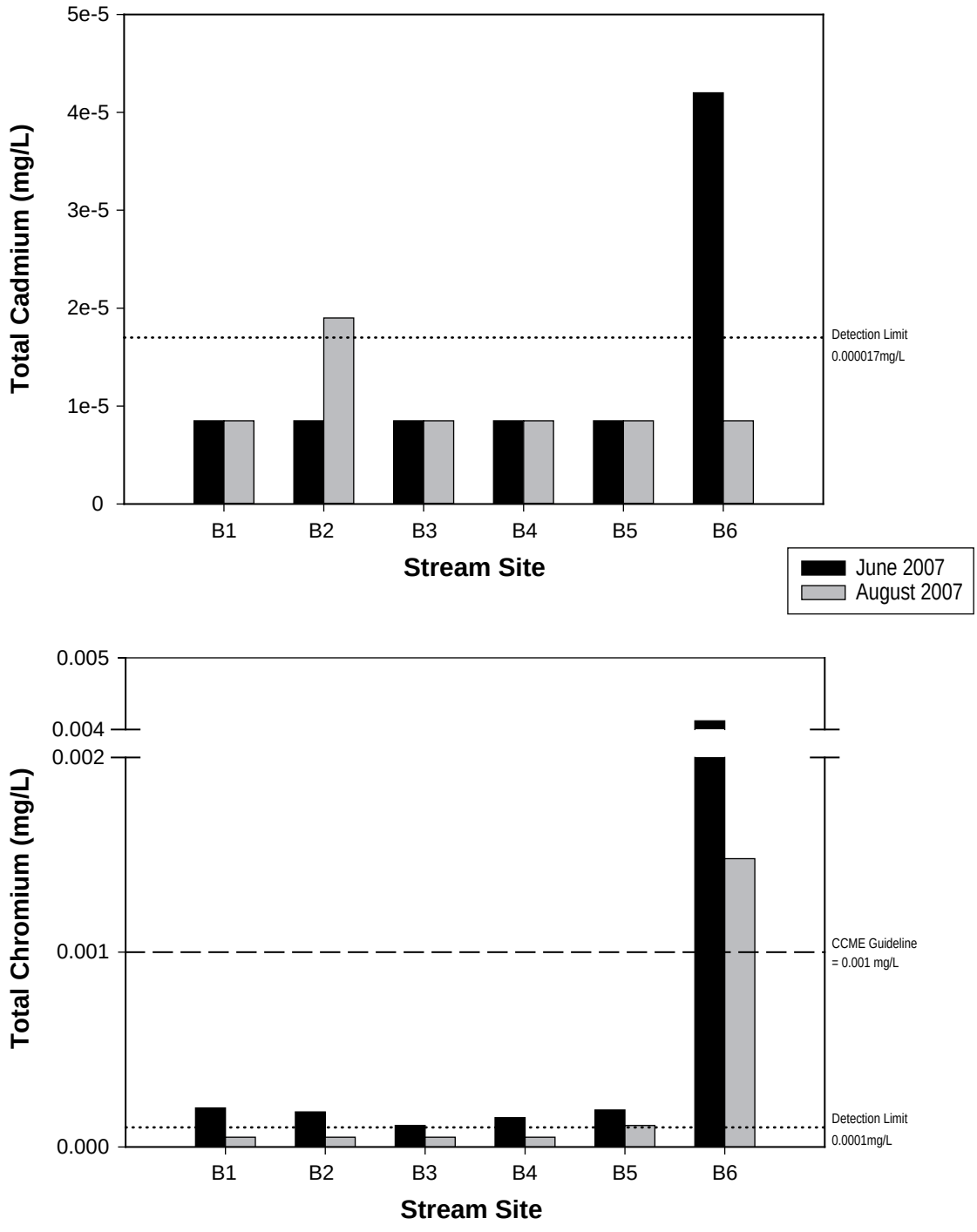
Notes: Dotted line denotes detection limits.
Dashed line denotes guideline values, where available.

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Stream Water Total Aluminum and Total Arsenic, June and August 2007

FIGURE 3.1-3

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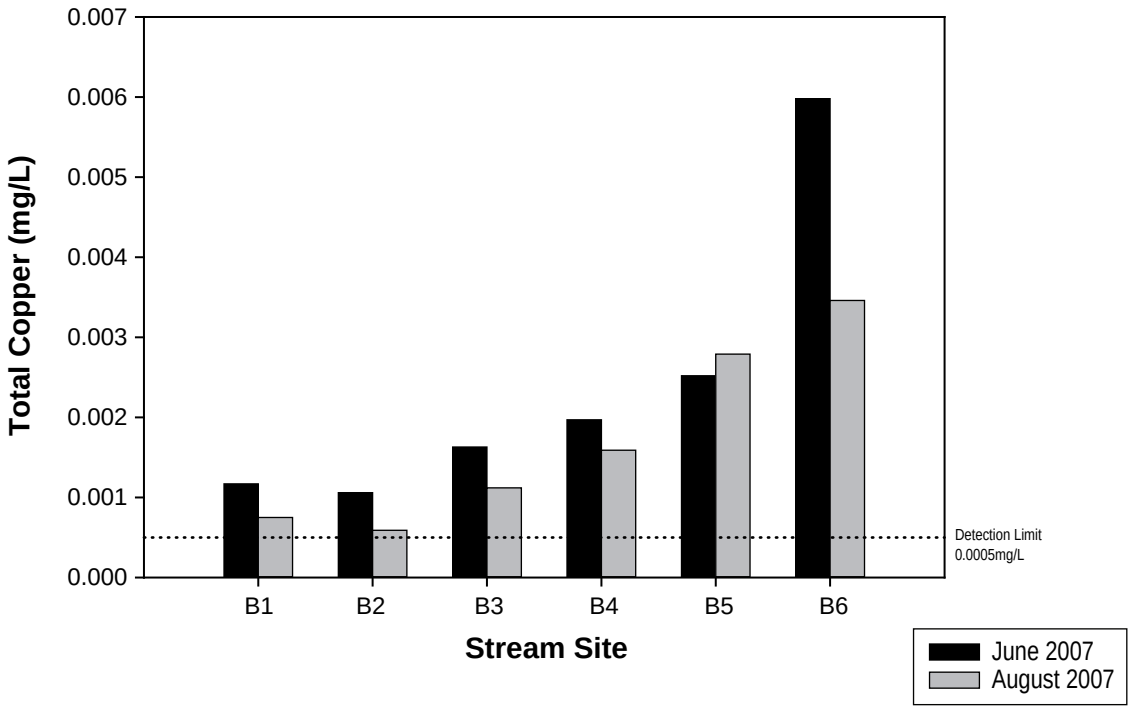
Notes: Dotted line denotes detection limits.
Dashed line denotes guideline values, where available.
CCME cadmium guideline depends on hardness.

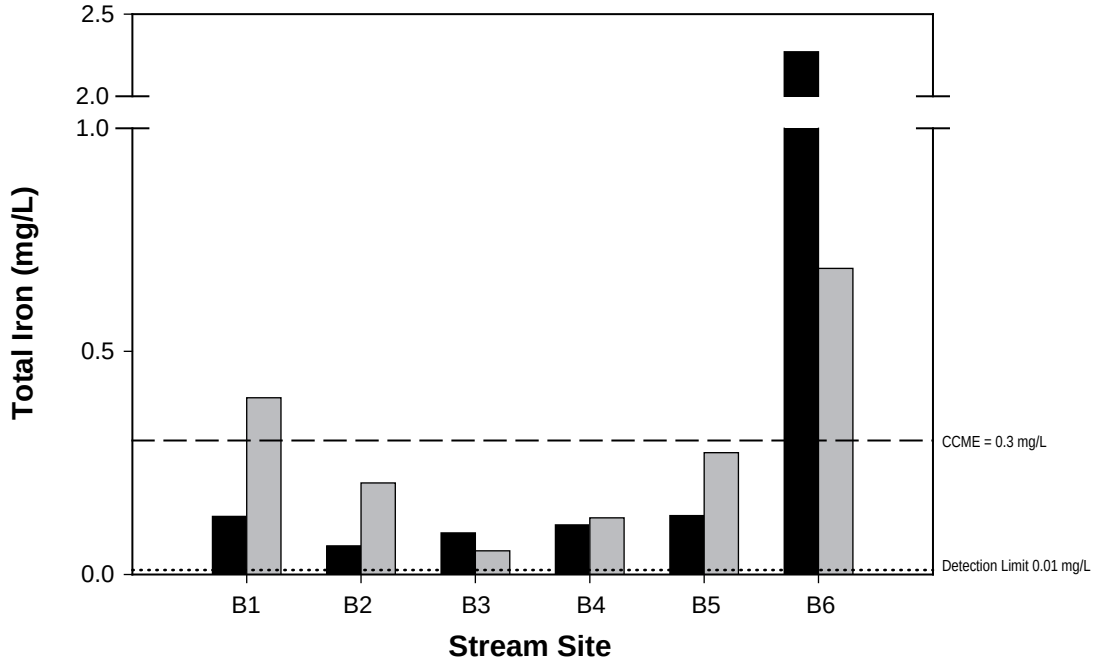
the BATHURST INLET PORT AND ROAD PROJECT

Stream Water Total Cadmium and Total Chromium, June and August 2007

FIGURE 3.1-4

Rescan™





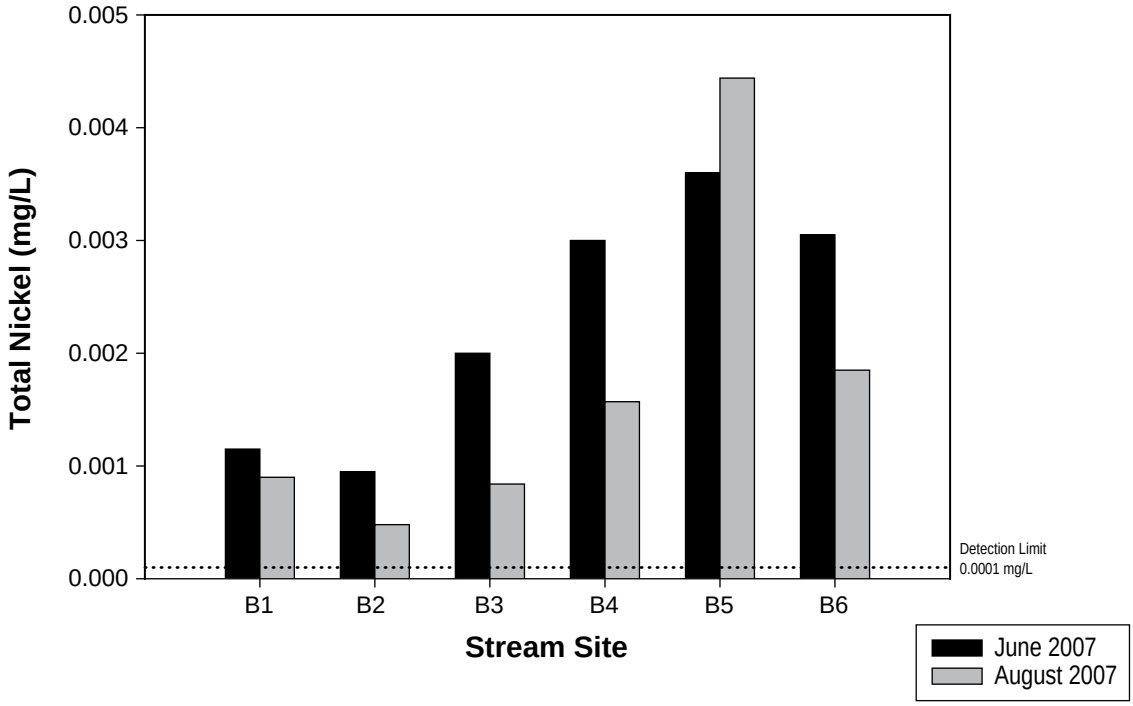
Notes: Dotted line denotes detection limits.
Dashed line denotes guideline values, where available.
CCME total copper guideline depends on hardness.

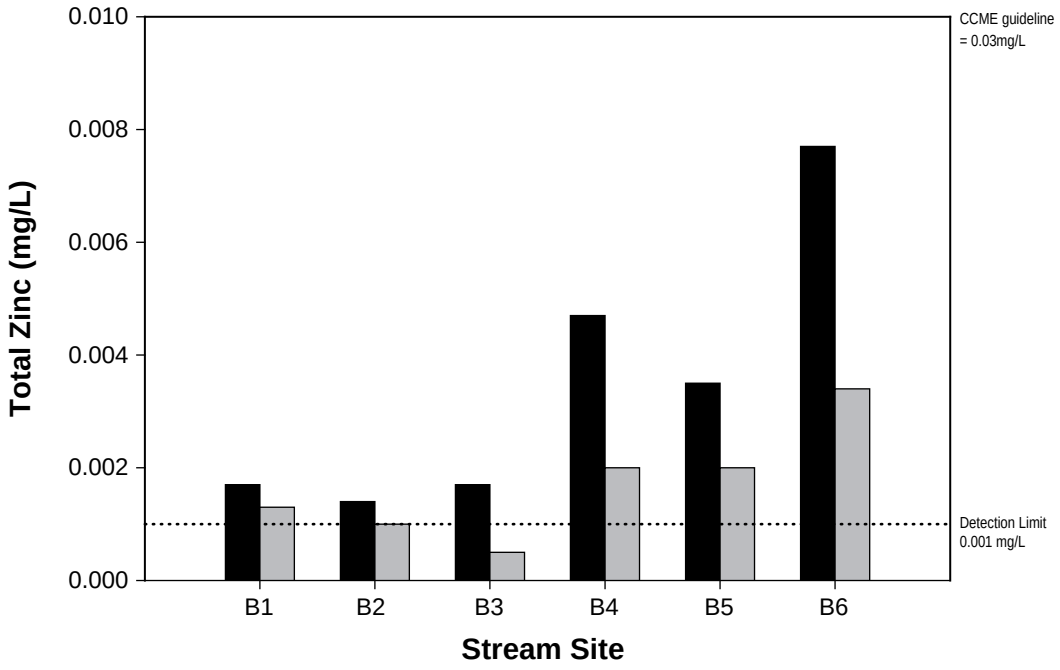
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Stream Water Total Copper and Total Iron, June and August 2007

FIGURE 3.1-5

Rescan™





Notes: Dotted line denotes detection limits.
Nickel CCME guidelines depend on hardness (0.025 mg/L at hardness 0.60mg/L).

the BATHURST INLET PORT AND ROAD PROJECT

Stream Water Total Nickel and Total Zinc, June and August 2007

FIGURE 3.1-6

Rescan™

3.1.2.1 Nutrients and Total Organic Carbon (TOC)

Average available phosphate ranged from below the detection limit (1 mg/kg) to 20.3 mg/kg, total nitrogen ranged from 0.03 to 0.47%, and TOC ranged from 0.35 to 6.0% (Figure 3.1-7). Available phosphate is five times greater in 2007 compared to 2001 for B1 (20 mg/L), primarily because of a high value of one replicate in 2007 (56 mg/kg). This replicate in B1 also caused the relatively high average TOC values compared to those in 2001, which were an order of magnitude lower.

3.1.2.2 Total Metals

Of the total metals analyzed, several variables were consistently below detection limits, including cadmium and lead. The remaining variables with CCME guidelines (arsenic, chromium, copper, mercury and zinc) and several other metals of interest (aluminum, iron and nickel) are presented graphically (Figures 3.1-8 to 3.1-11).

The highest average total metal concentrations varied from site to site. B6, at the proposed port, consistently had the lowest average metal concentrations for all variables except copper, where B1 was the lowest and mercury, where B5 was below detection (0.005 mg/kg). Total metals with values below detection were arsenic (5 mg/kg) and mercury (B5 and B6 in both cases). In 2001 all mercury values were below detection limits while in 2007 B4 was found to have the highest average total mercury concentration at 0.04 mg/kg.

Average total aluminum values range from 5,040 to 11,933 mg/kg. Average total iron values ranged from 10,113 to 36,833 mg/kg. Average total nickel values ranged from 7.1 to 25.3 mg/kg. Average total zinc values ranged from 15.6 to 56.0 mg/kg.

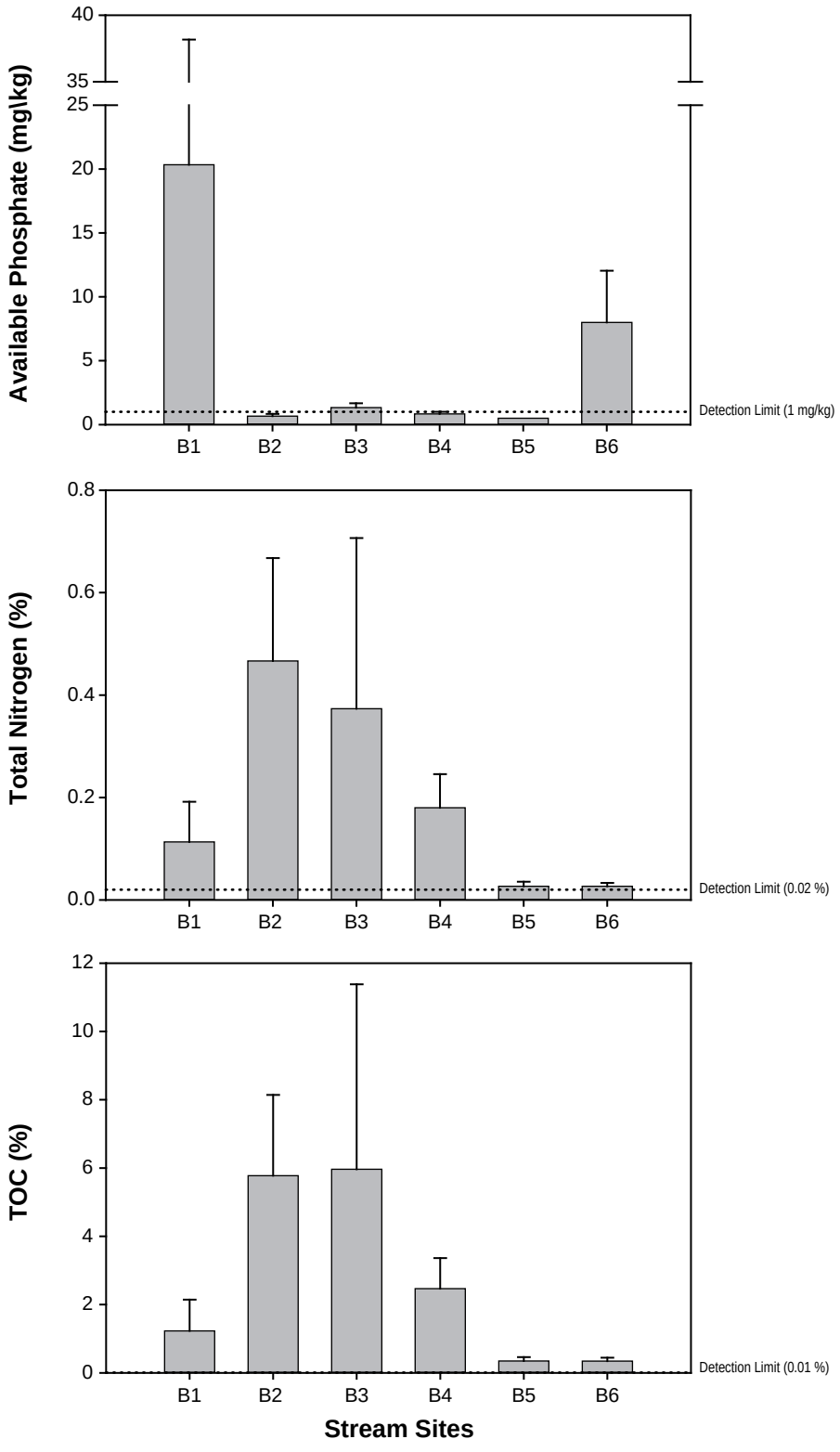
In 2001, all total arsenic samples were well below the PEL guideline (17 mg/kg) whereas, in 2007, both B1 and B2 exceeded this guideline. In the case of B1, this was the result of one replicate having an exceedingly high concentration. Average total chromium and total copper values were all well below the PEL guideline (as was the case in 2001), with the exception of B4 and B5 which exceeded the ISQG for chromium (37.3 mg/kg). All other variables are below guideline values.

3.1.2.3 Particle Size

The distribution of particle size in sediments did not differ considerably between 2001 and 2007. Analyses indicated that all stream sites were dominated by sand (46 to 84%), with smaller proportions of silt (5 to 32%), gravel (1 to 29%), and clay (1.5 to 5.0%) (Figure 3.1-12). Particle size analyses are indicative of the energy of water flow in the area of the sediment sample. The predominance of larger particle sizes in the sediment, such as sand and gravel, indicates a higher energy flow regime relative to sediment that contains high proportions of smaller particle sizes.

3.1.2.4 Quality Assurance and Quality Control (QA/QC)

The calculated RPD for sediment duplicate variables can be found in Appendix 3.1-4. Of the 40 variables analyzed, 40% had an RPD of zero. Of the remaining variables 97.5% had a RPD less than 20% indicating that the samples were efficiently homogenised.



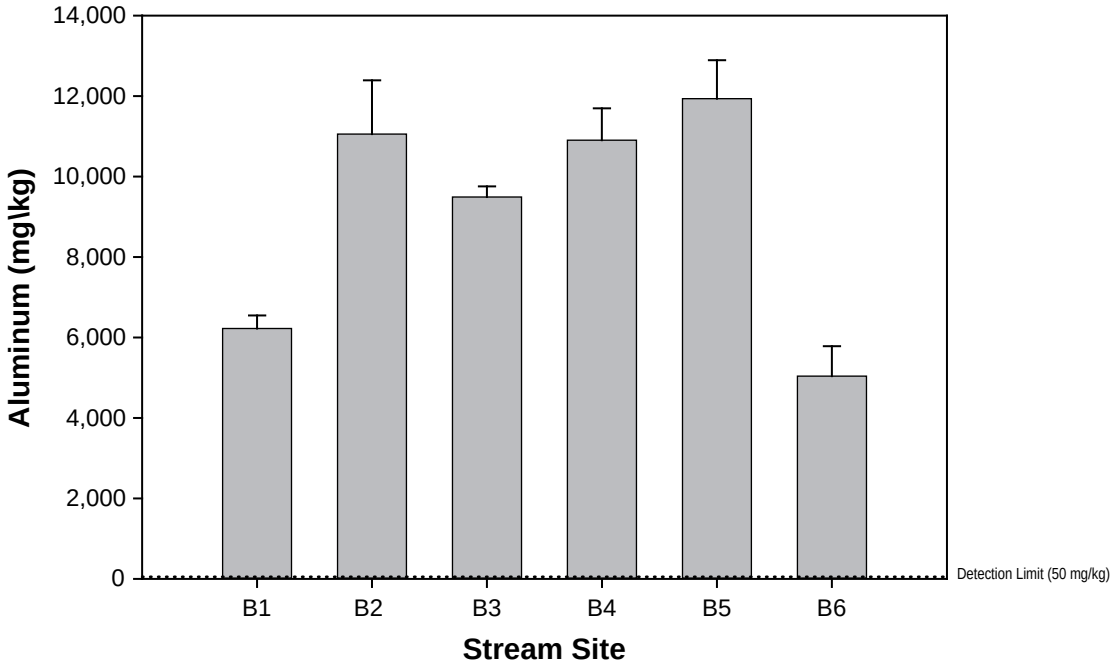
Notes: Error bars represent standard error of the mean.
Dotted line denotes detection limits.

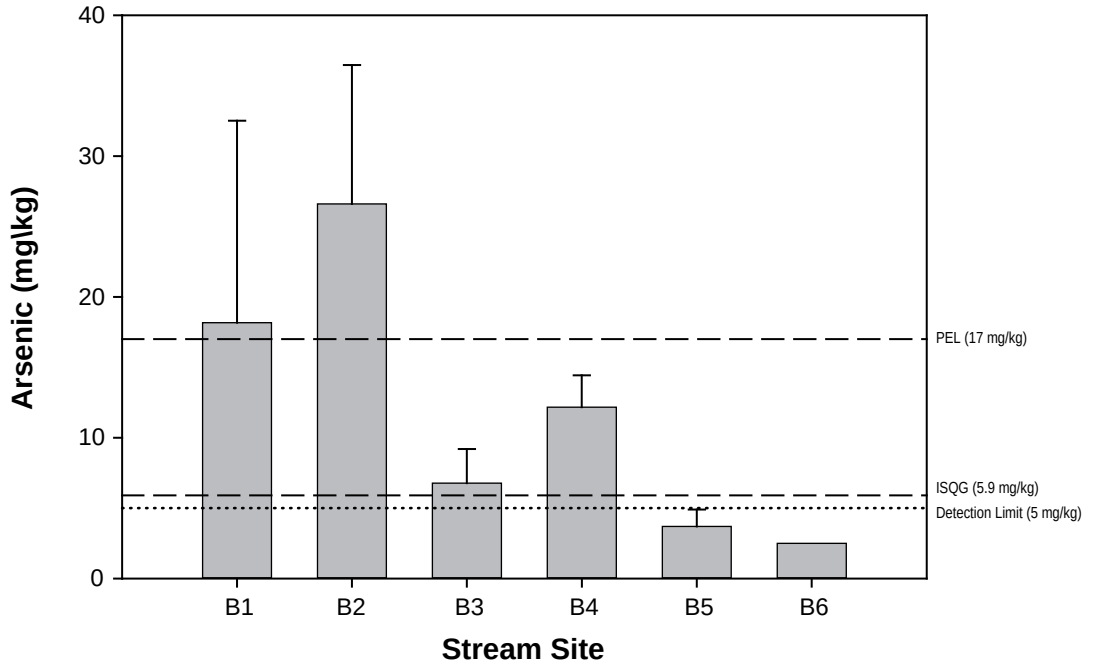
the BATHURST INLET PORT AND ROAD PROJECT

Available Phosphate, Total Nitrogen and Total Organic Carbon (TOC) in Stream Sediments, August 2007

FIGURE 3.1-7

Rescan™





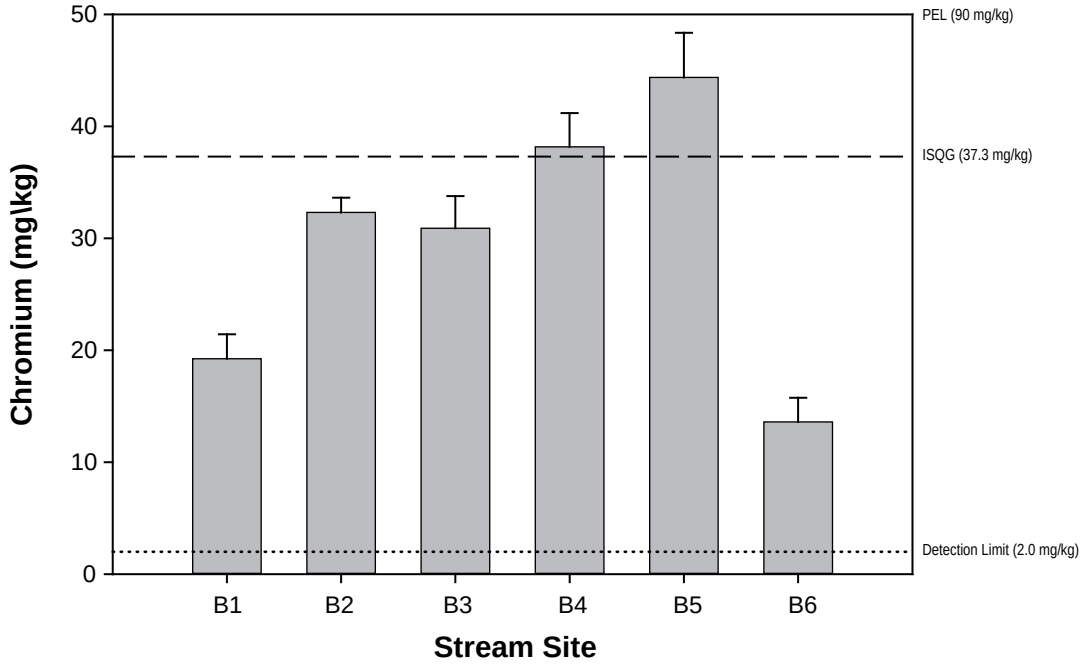
Notes: Error bars represent standard error of the mean.
Dotted line denotes detection limits.
Dashed line denotes guideline values, where available.

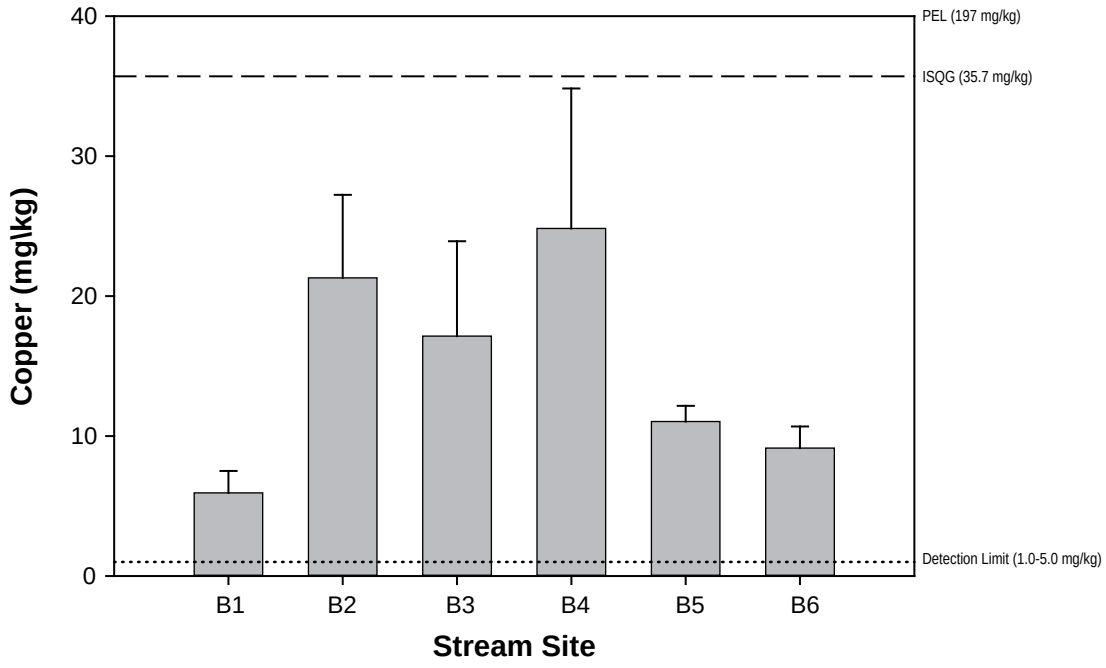
the BATHURST INLET PORT AND ROAD PROJECT

Total Aluminum and Total Arsenic in Stream Sediments, August 2007

FIGURE 3.1-8

Rescan™





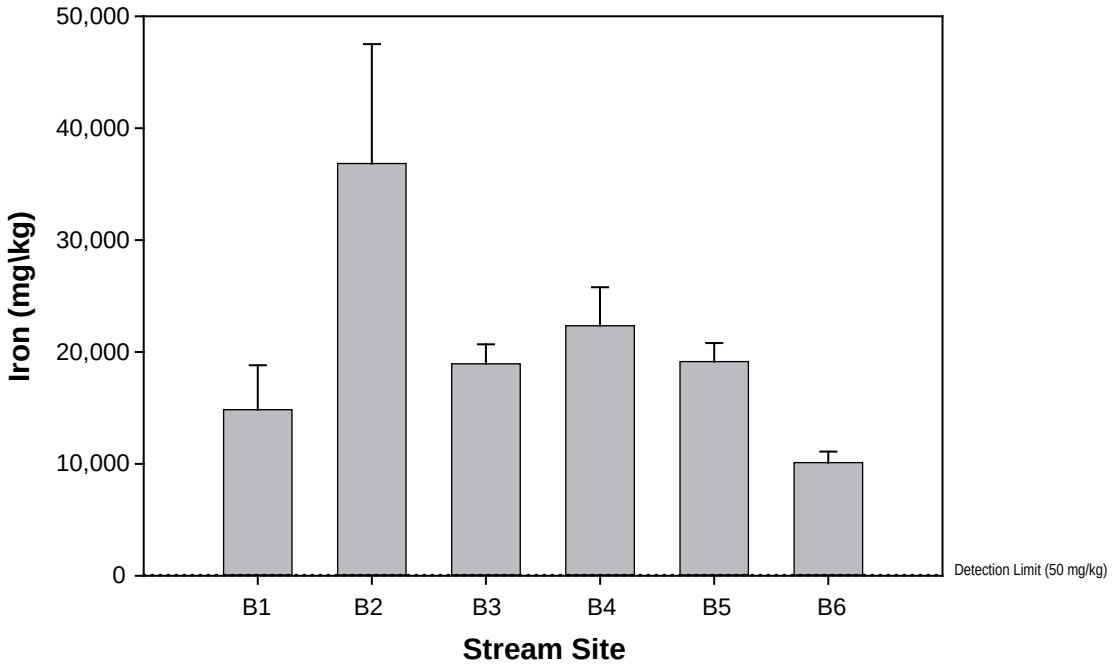
Notes: Error bars represent standard error of the mean.
Dotted line denotes detection limits.
Dashed line denotes guideline values, where available.

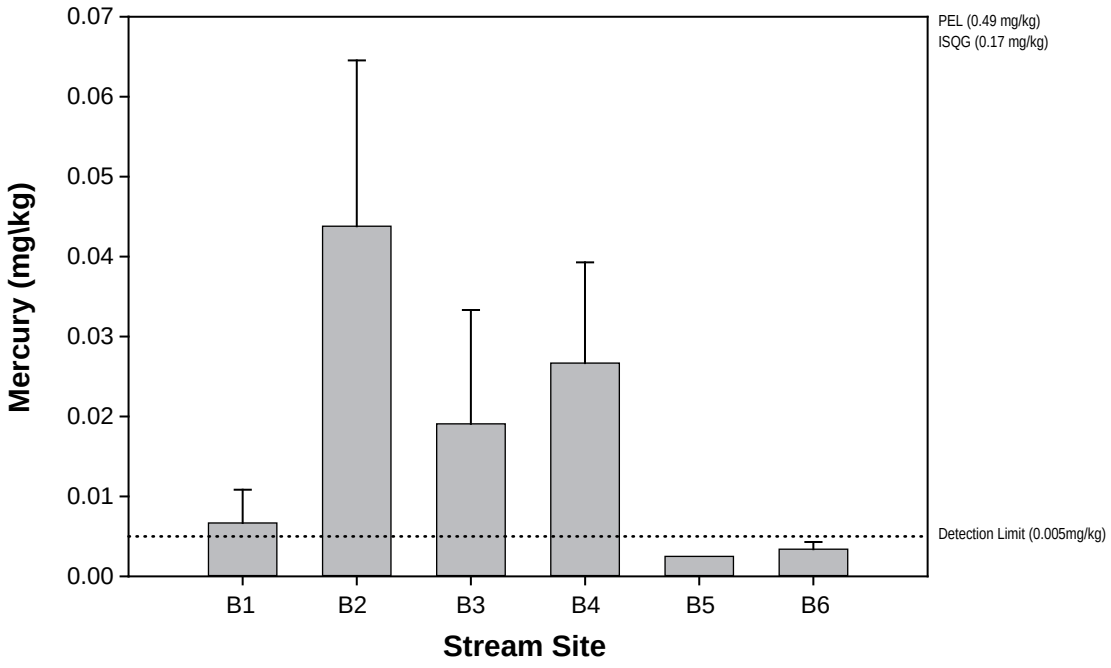
the BATHURST INLET PORT AND ROAD PROJECT

Total Chromium and Total Copper in Stream Sediments, August 2007

FIGURE 3.1-9

Rescan™





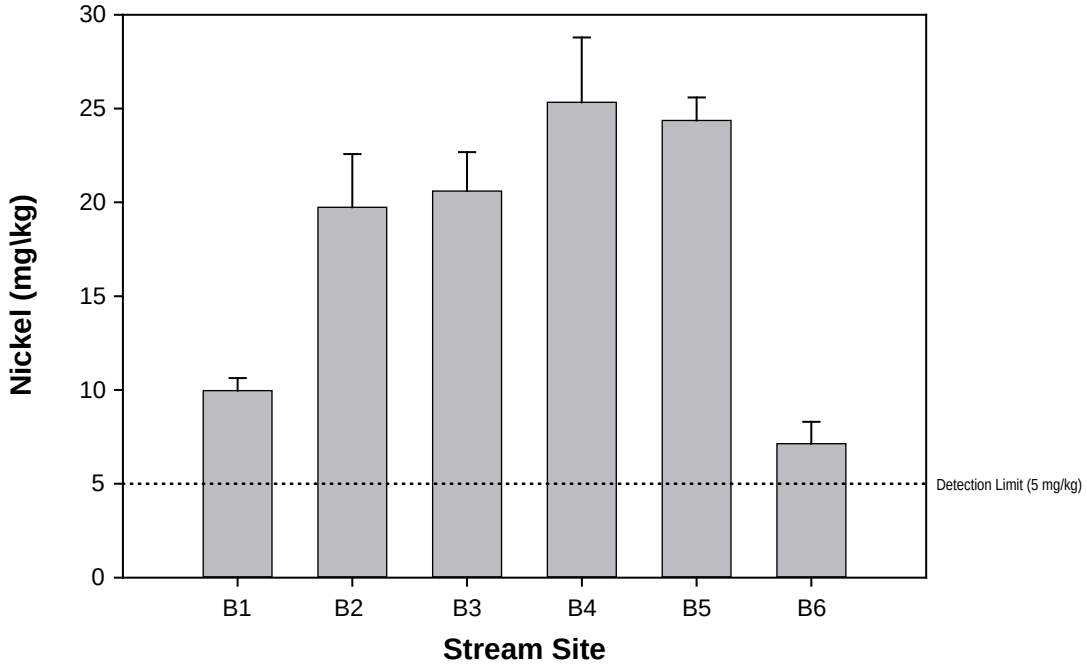
Notes: Error bars represent standard error of the mean.
Dotted line denotes detection limits.
Dashed line denotes guideline values, where available.

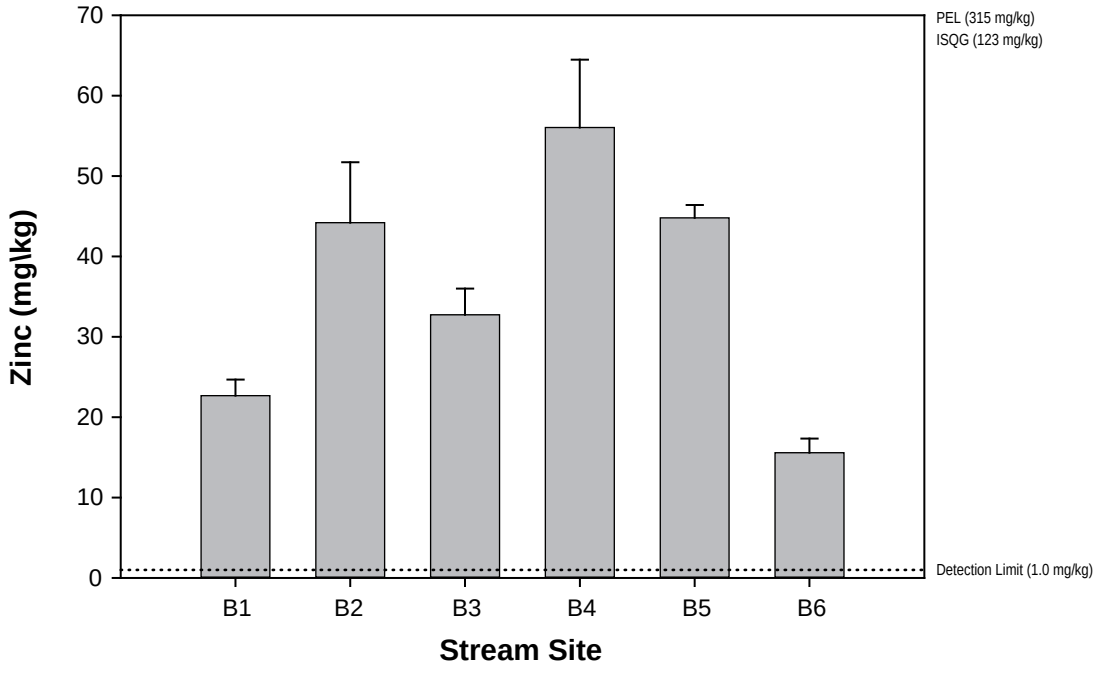
the BATHURST INLET PORT AND ROAD PROJECT

Total Iron and Total Mercury in Stream Sediments, August 2007

FIGURE 3.1-10

Rescan™





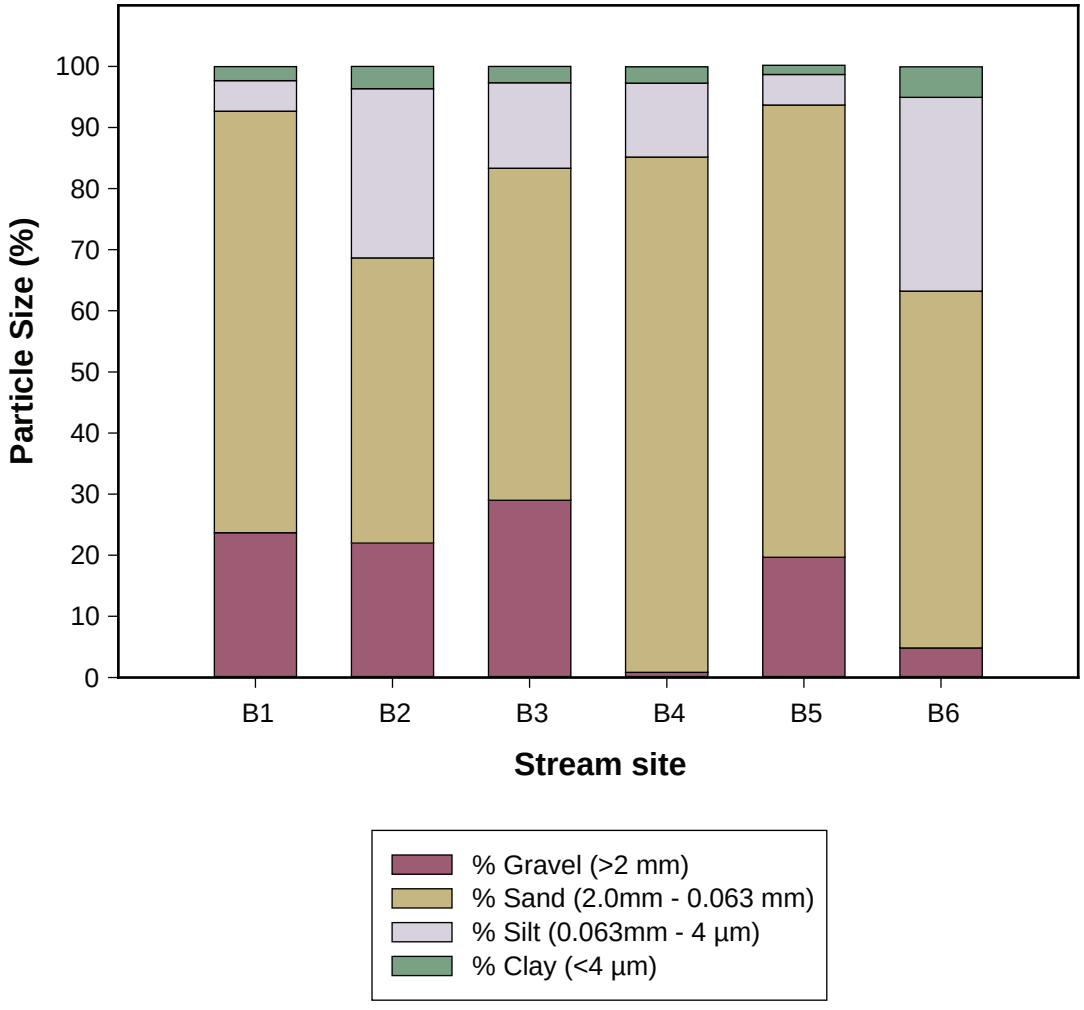
Notes: Error bars represent standard error of the mean.
Dotted line denotes detection limits.
Dashed line denotes guideline values, where available.

the BATHURST INLET PORT AND ROAD PROJECT

Total Nickel and Total Zinc in Stream Sediments, August 2007

FIGURE 3.1-11

Rescan™



the Bathurst Inlet Port and Road Project

Average Particle Size Distribution of Stream Sediment, August 2007

FIGURE 3.1-12

Rescan™

4. SUMMARY

4. Summary

4.1.1 Stream Water Quality

Several of the general water quality variables were below detection limits and similar to 2001 values in analyzed samples. Where they were available most samples did not exceed the CCME guidelines for general variables. Exceptions include several sites that fell below the lower guideline for pH (6.5) and high TSS values in June and August at B6.

Several total metals (antimony, beryllium, boron, cadmium, lead, mercury, molybdenum, selenium and silver) had at least 80% of samples below detection limits. Most sites, except B6 and in some cases B5, had relatively low total metal concentrations. Many of the total metals had their highest concentrations at B6, likely as a result of the high TSS at this site. Guidelines for total metals were exceeded in one or more samples for total aluminium, cadmium, chromium, copper and iron.

4.1.2 Stream Sediment Quality

Available phosphate and TOC were considerably higher in 2007 than in 2001 at some sites. Several metals were not detected at any sites, including cadmium and lead. B6, near the proposed port, had relatively low average metal concentrations for several variables. CCME guidelines were exceeded in one or more samples for arsenic, chromium and copper. The distribution of particle size in sediments did not differ considerably between 2001 and 2007. Analyses indicated that on average all stream sites were dominated by sand.

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RISC. 1998. *Lake and Stream Bottom Sediment Sampling Manual*. Province of British Columbia, Resources Information Standards Committee. Victoria, BC.

APPENDIX 3.1-1
ANALYTICAL RESULTS FOR WATER QUALITY

Appendix 3.1-1
Analytical Results for Water Quality

RESULTS OF ANALYSIS									
Sample ID		**B1-203.6**	**B2-189.8**	**B3-132.0**	**B4-82.1**	**B5-70.4**	**B6-2.5**	**TRAVEL BLANK**	**FIELD BLANK**
Date Sampled		**24-JUN-07**	**24-JUN-07**	**24-JUN-07**	**24-JUN-07**	**24-JUN-07**	**24-JUN-07**	**24-JUN-07**	**24-JUN-07**
ALS Sample ID	**Available**	**L522538-1**	**L522538-2**	**L522538-3**	**L522538-4**	**L522538-5**	**L522538-6**	**L522538-7**	**L522538-8**
Matrix	**CCME Guideline**	**Water**	**Water**	**Water**	**Water**	**Water**	**Water**	**Water**	**Water**
Physical Tests									
Anion Sum		<0.1	<0.1	<0.1	0.1	0.2	0.7	<0.1	<0.1
Cation Sum		0.1	0.1	0.1	0.2	0.2	0.7	<0.1	<0.1
Cation - Anion Balance		13.7	15.3	16.3	10.2	9.8	3.3	0	0
Hardness (as $CaCO_3$)		3.27	3.99	3.96	5.77	7.86	19	<0.50	<0.50
Conductivity		9.2	26.3	11.5	14.9	17.9	76.5	<2.0	<2.0
pH	6.5 - 9	6.18	6.70	6.35	6.54	6.37	6.74	5.57	5.58
Total Dissolved Solids		12.3	12.8	12.3	13.7	15.5	44.9	<1.0	<1.0
Total Suspended Solids		<3.0	<3.0	<3.0	<3.0	3.4	427	<3.0	<3.0
Turbidity		1.65	0.89	1.25	1.20	1.45	32.4	<0.10	<0.10
Anions and Nutrients									
Ammonia as N		0.0326	0.0278	0.0206	0.0249	0.0275	<0.0050	<0.0050	<0.0050
Alkalinity, Bicarbonate (as $CaCO_3$)		2.9	2.7	2.7	3.6	4.8	17.7	<2.0	<2.0
Alkalinity, Carbonate (as $CaCO_3$)		<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Alkalinity, Hydroxide (as $CaCO_3$)		<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Alkalinity, Total (as $CaCO_3$)		2.9	2.7	2.7	3.6	4.8	17.7	<2.0	<2.0
Bromide (Br)		<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Chloride (Cl)		<0.50	<0.50	<0.50	<0.50	<0.50	11.6	<0.50	<0.50
Fluoride (F)		<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Sulfate (SO_4)		1.10	1.75	1.55	2.56	2.78	0.97	<0.50	<0.50
Nitrate (as N)	2.93	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Nitrite (as N)		<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Total Kjeldahl Nitrogen		0.352	0.348	0.319	0.545	0.331	0.422	<0.050	<0.050
Total Nitrogen		-	-	-	-	-	-	-	-
Ortho Phosphate as P		<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Total Phosphate as P		0.0075	0.0070	0.0076	0.0058	0.0068	0.106	<0.0020	<0.0020
Available Phosphate-P		-	-	-	-	-	-	-	-
Total Metals									
Aluminum (Al)-Total	0.10*	0.0787	0.0672	0.0675	0.0476	0.0619	1.75	<0.0010	<0.0010
Antimony (Sb)-Total		<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Arsenic (As)-total	0.005	0.000272	0.000244	0.000137	0.000209	0.000281	0.000857	<0.000030	<0.000030
Barium (Ba)-Total		0.00338	0.00365	0.00345	0.00322	0.00276	0.0472	<0.000050	<0.000050
Beryllium (Be)-total		<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Boron (B)-total		<0.0010	<0.0010	<0.0010	<0.0010	0.0011	0.0133	<0.0010	<0.0010
Cadmium (Cd)-Total	**A**	<0.000017	<0.000017	<0.000017	<0.000017	<0.000017	0.000042	<0.000017	<0.000017
Calcium (Ca)-Total		0.683	0.814	0.703	1.03	1.68	4.92	<0.020	<0.020
Chromium (Cr)-Total	0.001	0.00020	0.00018	0.00011	0.00015	0.00019	0.00412	<0.00010	<0.00010
Cobalt (Co)-Total		0.00033	<0.00010	0.00060	0.00050	0.00060	0.00125	<0.00010	<0.00010
Copper (Cu)-Total	**B**	0.00117	0.00106	0.00163	0.00197	0.00252	0.00598	<0.00050	<0.00050
Iron (Fe)-Total	0.30	0.130	0.064	0.093	0.111	0.132	2.27	<0.010	<0.010
Lead (Pb)-Total	0.002*	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	0.00145	<0.000050	<0.000050
Magnesium (Mg)-Total		0.364	0.455	0.501	0.745	0.910	3.19	<0.010	<0.010
Manganese (Mn)-Total		0.00886	0.00142	0.0200	0.0164	0.00611	0.0283	<0.000050	<0.000050
Mercury (Hg)-Total	0.000026	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020
Molybdenum (Mo)-Total		<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	0.000097	<0.000050	<0.000050
Nickel (Ni)-Total	0.025*	0.00115	0.00095	0.00200	0.00300	0.00360	0.00305	<0.00010	<0.00010
Potassium (K)-Total		0.326	0.437	0.451	0.511	0.399	1.44	<0.050	<0.050
Selenium (Se)-Total	0.001	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	0.00025	<0.00010	<0.00010
Silicon (Si)-Total		0.376	0.422	0.381	0.273	0.356	3.31	<0.050	<0.050
Silver (Ag)-Total	0.0001	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Sodium (Na)-Total		0.490	0.525	0.471	0.432	0.346	7.95	<0.010	<0.010
Strontium (Sr)-Total		0.00481	0.00565	0.00467	0.00437	0.00489	0.0154	<0.00010	<0.00010
Uranium (U)-Total		0.000027	0.000019	0.000019	0.000028	0.000020	0.000340	<0.000010	<0.000010
Vanadium (V)-Total		0.000169	0.000137	0.000082	0.000099	0.000158	0.00538	<0.000050	<0.000050
Zinc (Zn)-Total	0.03	0.0017	0.0014	0.0017	0.0047	0.0035	0.0077	<0.0010	<0.0010
Dissolved Metals									
Aluminum (Al)-Dissolved		0.0693	0.0613	0.0603	0.0373	0.0396	0.0716	-	-
Antimony (Sb)-Dissolved		<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	-	-
Arsenic (As)-Dissolved		0.000274	0.000242	0.000129	0.000190	0.000257	0.000148	-	-
Barium (Ba)-Dissolved		0.00332	0.00353	0.00346	0.00319	0.00251	0.0187	-	-
Beryllium (Be)-Dissolved		<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	-	-
Boron (B)-Dissolved		<0.0010	<0.0010	<0.0010	0.0011	0.0010	0.0112	-	-
Cadmium (Cd)-Dissolved		<0.000017	<0.000017	<0.000017	<0.000017	<0.000017	<0.000017	-	-
Calcium (Ca)-Dissolved		0.709	0.837	0.735	1.05	1.68	3.90	-	-
Chromium (Cr)-Dissolved		0.00019	0.00015	<0.00010	<0.00010	<0.00010	<0.00010	-	-
Cobalt (Co)-Dissolved		0.00022	<0.00010	0.00012	0.00010	<0.00010	<0.00010	-	-
Copper (Cu)-Dissolved		0.00115	0.00104	0.00162	0.00182	0.00228	0.00180	-	-
Iron (Fe)-Dissolved		0.032	0.035	0.026	0.030	0.035	0.062	-	-
Lead (Pb)-Dissolved		<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	0.000062	-	-
Magnesium (Mg)-Dissolved		0.364	0.461	0.517	0.764	0.889	2.26	-	-
Manganese (Mn)-Dissolved		0.00662	0.000834	0.00616	0.00683	0.000388	0.000310	-	-
Mercury (Hg)-Dissolved		<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	-	-
Molybdenum (Mo)-Dissolved		<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	0.000068	-	-
Nickel (Ni)-Dissolved		0.00118	0.00099	0.00206	0.00290	0.00337	0.00067	-	-
Potassium (K)-Dissolved		0.335	0.440	0.471	0.525	0.390	0.853	-	-
Selenium (Se)-Dissolved		<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	-	-
Silicon (Si)-Dissolved		0.377	0.425	0.340	0.267	0.319	0.677	-	-
Silver (Ag)-Dissolved		<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	-	-
Sodium (Na)-Dissolved		0.499	0.530	0.495	0.449	0.341	7.73	-	-
Strontium (Sr)-Dissolved		0.00493	0.00574	0.00486	0.00447	0.00484	0.0104	-	-
Uranium (U)-Dissolved		0.000024	0.000019	0.000017	0.000025	0.000013	0.000082	-	-
Vanadium (V)-Dissolved		0.000138	0.000139	0.000082	0.000062	0.000103	0.000276	-	-
Zinc (Zn)-Dissolved		0.0021	0.0017	0.0020	0.0043	0.0031	<0.0010	-	-
Organic Parameters									
Total Organic Carbon		7.42	7.10	6.81	6.13	6.44	6.81	<0.50	<0.50

(continued)

< = Less than the detection limit indicated.

Results are expressed as milligrams per dry kilogram except where noted.

Shaded values indicate CCME guideline exceeded.

A - for cadium guideline = 0.001 *$10^{(0.86[\log(\text{hardness})] - 3.2)}$ mg/L

B - for copper: CCME = 0.002 mg/L at 0-120 mg/L [CaCO3], 0.003mg/L at 120 - 180 mg/L [CaCO3], 0.004 mg/L at >180 mg/L [CaCO3]

***for aluminum: pH>6.5**

***for nickel: CCME guideline = 0.025 mg/L at 0-60 mg/L [CaCO3], 0.065mg/L at 60 - 120 mg/L [CaCO3], 0.110 mg/L at 120 - 180 mg/L [CaCO3], 0.150 mg/L at > 180 mg/L [CaCO3]**

***for lead: 0.002 for hardness between 0-60 [CaCO3]**

Table of Contents

Appendix 3.1-1
Analytical Results for Water Quality (completed)

RESULTS OF ANALYSIS										
Sample ID		**B3 DUPLICATE**	**B1**	**B2**	**B3**	**B4**	**B5**	**B6**	**B6 REP2**	**FIELD BLANK**
Date Sampled		**24-JUN-07**	**18-AUG-07**	**18-AUG-07**	**18-AUG-07**	**18-AUG-07**	**18-AUG-07**	**18-AUG-07**	**18-AUG-07**	**18-AUG-07**
ALS Sample ID	**Available**	**L522538-9**	**L544578-1**	**L544578-2**	**L544578-3**	**L544578-4**	**L544578-5**	**L544578-6**	**L544578-7**	**L544578-8**
Matrix	**CCME Guideline**	**Water**	**Water**	**Water**	**Water**	**Water**	**Water**	**Water**	**Water**	**Water**
Physical Tests										
Anion Sum		<0.1	<0.1	<0.1	<0.1	0.1	0.5	2.4	2.4	<0.1
Cation Sum		0.1	0.1	0.1	0.1	0.1	0.5	2.5	2.5	<0.1
Cation - Anion Balance		21.4	18.9	11.1	15.9	9.6	2.7	1.1	2.4	66.2
Hardness (as $CaCO_3$)		4.19	3.68	3.35	3.6	4.98	22.7	56	55.9	-
Conductivity		11.2	10.7	9.9	10.7	14.2	54.0	265	265	<2.0
pH	6.5 - 9	6.12	6.37	6.44	6.43	6.34	6.94	7.56	7.63	5.67
Total Dissolved Solids		12.4	9.1	7.8	8.1	9.6	34	139	138	<1.0
Total Suspended Solids		<3.0	<3.0	5.3	<3.0	<3.0	<3.0	15.3	16.7	<3.0
Turbidity		1.29	0.67	0.73	0.37	0.46	0.92	23.8	24.3	<0.10
Anions and Nutrients										
Ammonia as N		0.0200	0.0120	0.0182	0.0092	0.0166	0.0250	<0.0050	<0.0050	<0.0050
Alkalinity, Bicarbonate (as $CaCO_3$)		2.6	3.6	3.0	2.2	2.0	11.8	37.9	37.6	<2.0
Alkalinity, Carbonate (as $CaCO_3$)		<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Alkalinity, Hydroxide (as $CaCO_3$)		<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Alkalinity, Total (as $CaCO_3$)		2.6	3.6	3.0	2.2	2.0	11.8	37.9	37.6	<2.0
Bromide (Br)		<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	0.079	0.078	<0.050
Chloride (Cl)		<0.50	<0.50	<0.50	<0.50	<0.50	1.25	52.6	51.6	<0.50
Fluoride (F)		<0.020	0.025	0.020	<0.020	0.020	0.022	0.033	0.032	<0.020
Sulfate (SO_4)		1.48	0.58	0.94	1.53	3.06	10.3	7.52	7.35	<0.50
Nitrate (as N)	2.93	<0.0050	<0.0050	0.0247	0.0346	0.0095	0.0084	0.0096	0.0133	0.0061
Nitrite (as N)		<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Total Kjeldahl Nitrogen		0.326	0.237	0.211	0.194	0.208	0.410	0.291	0.271	<0.050
Total Nitrogen		-	0.237	0.235	0.229	0.218	0.419	0.301	0.284	<0.060
Ortho Phosphate as P		<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	0.0016	0.0012	<0.0010
Total Phosphate as P		0.0096	0.0051	0.0068	0.0046	0.0053	0.0075	0.0221	0.0210	<0.0020
Available Phosphate-P		-	-	-	-	-	-	-	-	-
Total Metals										
Aluminum (Al)-Total	0.10*	0.0714	0.0382	0.0169	0.0159	0.0189	0.0258	0.751	0.690	<0.0010
Antimony (Sb)-Total		<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Arsenic (As)-total	0.005	0.000149	0.000671	0.000272	0.000100	0.000211	0.000471	<0.0010	0.00061	<0.000030
Barium (Ba)-Total		0.00367	0.00302	0.00221	0.00240	0.00198	0.00426	0.0257	0.0250	<0.000050
Beryllium (Be)-total		<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Boron (B)-total		<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	0.0177	0.0182	<0.0010
Cadmium (Cd)-Total	A	<0.000017	<0.000017	0.000019	<0.000017	<0.000017	<0.000017	<0.000017	<0.000017	<0.000017
Calcium (Ca)-Total		0.730	0.784	0.664	0.617	0.830	4.40	11.2	11.4	<0.060
Chromium (Cr)-Total	0.001	0.00011	<0.00010	<0.00010	<0.00010	<0.00010	0.00011	0.00148	0.00138	<0.00010
Cobalt (Co)-Total		0.00063	0.00020	0.00012	0.00011	0.00015	0.00030	0.00037	0.00036	<0.00010
Copper (Cu)-Total	B	0.00174	0.00075	0.00059	0.00112	0.00159	0.00279	0.00346	0.00357	<0.00050
Iron (Fe)-Total	0.30	0.090	0.396	0.205	0.053	0.127	0.273	0.686	0.598	<0.010
Lead (Pb)-Total	0.002*	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	0.000342	0.000328	<0.000050
Magnesium (Mg)-Total		0.523	0.435	0.404	0.491	0.717	2.85	7.74	7.84	<0.010
Manganese (Mn)-Total		0.0213	0.00291	0.00412	0.00427	0.00432	0.00393	0.0139	0.0142	<0.000050
Mercury (Hg)-Total	0.000026	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020
Molybdenum (Mo)-Total		<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	0.000183	0.000166	<0.000050
Nickel (Ni)-Total	0.025*	0.00211	0.00090	0.00048	0.00084	0.00157	0.00444	0.00185	0.00173	<0.00010
Potassium (K)-Total		0.489	0.258	0.350	0.389	0.337	0.500	1.81	1.81	<0.050
Selenium (Se)-Total	0.001	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.0010	<0.0010	<0.00010
Silicon (Si)-Total		0.400	0.380	0.186	0.179	0.098	0.128	2.81	2.50	<0.050
Silver (Ag)-Total	0.0001	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Sodium (Na)-Total		0.492	0.655	0.457	0.516	0.384	0.933	29.5	29.2	<0.070
Strontium (Sr)-Total		0.00496	0.00528	0.00483	0.00422	0.00369	0.0123	0.0357	0.0358	<0.00010
Uranium (U)-Total		0.000019	0.000013	<0.000010	<0.000010	0.000013	0.000013	0.000315	0.000318	<0.000010
Vanadium (V)-Total		0.000076	0.000214	0.000054	<0.000050	<0.000050	0.000166	0.0015	0.0017	<0.000050
Zinc (Zn)-Total	0.03	0.0019	0.0013	0.0010	<0.0010	0.0020	0.0020	0.0034	0.0041	<0.0020
Dissolved Metals										
Aluminum (Al)-Dissolved		0.0614	0.0244	0.0088	0.0109	0.0057	0.0090	0.577	0.556	-
Antimony (Sb)-Dissolved		<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	-
Arsenic (As)-Dissolved		0.000144	0.000666	0.000248	0.000108	0.000169	0.000419	0.00058	0.00057	-
Barium (Ba)-Dissolved		0.00357	0.00295	0.00215	0.00240	0.00183	0.00415	0.0224	0.0222	-
Beryllium (Be)-Dissolved		<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	-
Boron (B)-Dissolved		<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	0.0181	0.0174	-
Cadmium (Cd)-Dissolved		<0.000017	<0.000017	<0.000017	<0.000017	<0.000017	<0.000017	<0.000017	<0.000017	-
Calcium (Ca)-Dissolved		0.790	0.741	0.669	0.618	0.817	4.38	10.2	10.3	-
Chromium (Cr)-Dissolved		<0.00010	0.00011	<0.00010	<0.00010	<0.00010	0.00024	0.00123	0.00119	-
Cobalt (Co)-Dissolved		<0.00010	<0.00010	<0.00010	0.00021	<0.00010	<0.00010	0.00012	0.00011	-
Copper (Cu)-Dissolved		0.00165	<0.00050	<0.00050	0.00088	0.00117	0.00219	0.00258	0.00253	-
Iron (Fe)-Dissolved		0.025	0.278	0.138	0.027	0.032	0.133	0.395	0.321	-
Lead (Pb)-Dissolved		<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	0.000145	0.000130	-
Magnesium (Mg)-Dissolved		0.539	0.444	0.409	0.500	0.714	2.85	7.39	7.31	-
Manganese (Mn)-Dissolved		0.00595	0.00116	0.000266	0.000739	0.000721	0.000140	0.00223	0.00229	-
Mercury (Hg)-Dissolved		<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	-
Molybdenum (Mo)-Dissolved		<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	0.000158	0.000150	-
Nickel (Ni)-Dissolved		0.00208	0.00087	0.00040	0.00078	0.00141	0.00414	0.00099	0.00096	-
Potassium (K)-Dissolved		0.505	0.269	0.346	0.405	0.326	0.508	1.65	1.66	-
Selenium (Se)-Dissolved		<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.0010	<0.0010	-
Silicon (Si)-Dissolved		0.338	0.409	0.186	0.192	0.109	0.123	3.13	2.83	-
Silver (Ag)-Dissolved		<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	-
Sodium (Na)-Dissolved		0.500	0.678	0.460	0.526	0.384	0.945	28.0	28.7	-
Strontium (Sr)-Dissolved		0.00509	0.00533	0.00481	0.00427	0.00365	0.0124	0.0335	0.0339	-
Uranium (U)-Dissolved		0.000015	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	0.000235	0.000246	-
Vanadium (V)-Dissolved		0.000080	0.000133	<0.000050	<0.000050	<0.000050	<0.000050	<0.0010	<0.0010	-
Zinc (Zn)-Dissolved		0.0018	0.0020	<0.0010	<0.0010	0.0019	0.0013	<0.0010	<0.0010	-
Organic Parameters										
Total Organic Carbon		6.99	3.95	2.91	3.01	3.02	6.46	7.66	7.75	<0.50

< = Less than the detection limit indicated.

Results are expressed as milligrams per dry kilogram except where noted.

Shaded values indicate CCME guideline exceeded.

A - for cadium guideline = 0.001 *10$^{(0.86[\log(\text{hardness})] - 3.2)}$ mg/L

B - for copper: CCME = 0.002 mg/L at 0-120 mg/L [CaCO3], 0.003mg/L at 120 - 180 mg/L [CaCO3], 0.004 mg/L at >180 mg/L [CaCO3]

***for aluminum: pH>6.5**

***for nickel: CCME guideline = 0.025 mg/L at 0-60 mg/L [CaCO3], 0.065mg/L at 60 - 120 mg/L [CaCO3], 0.110 mg/L at 120 - 180 mg/L [CaCO3], 0.150 mg/L at > 180 mg/L [CaCO3]**

***for lead: 0.002 for hardness between 0-60 [CaCO3]**

APPENDIX 3.1-2
RELATIVE PERCENT DIFFERENCE ANALYSIS RESULTS FOR STREAM WATER QUALITY

Table of Contents

Appendix 3.1-2
Relative Percent Difference Analyses for Stream Water Quality Results

Sample ID	B3-132.0	B3 Duplicate	RPD%	B6	B6 REP2	RPD%
Date Sampled	24-Jun-07	24-Jun-07		18-Aug-07	18-Aug-07	
Time Sampled	00:00	00:00		00:00	00:00	
ALS Sample ID	L522538-3	L522538-9		L544578-6	L544578-7	
Matrix	Water	Water		Water	Water	
Physical Tests						
Anion Sum	<0.1	<0.1	0.0	2.4	2.4	0.0
Cation Sum	0.1	0.1	0.0	2.5	2.5	0.0
Cation - Anion Balance	16.3	21.4	27.1	1.1	2.4	74.3
Hardness (as $CaCO_3$)	3.96	4.19	5.6	56	55.9	0.2
Conductivity	11.5	11.2	2.6	265	265	0.0
pH	6.35	6.12	3.7	7.56	7.63	0.9
Total Dissolved Solids	12.3	12.4	0.8	139	138	0.7
Total Suspended Solids	<3.0	<3.0	0.0	15.3	16.7	8.7
Turbidity	1.25	1.29	3.1	23.8	24.3	2.1
Anions and Nutrients						
Ammonia as N	0.0206	0.0200	3.0	<0.0050	<0.0050	0.0
Alkalinity, Bicarbonate (as $CaCO_3$)	2.7	2.6	3.8	37.9	37.6	0.8
Alkalinity, Carbonate (as $CaCO_3$)	<2.0	<2.0	0.0	<2.0	<2.0	0.0
Alkalinity, Hydroxide (as $CaCO_3$)	<2.0	<2.0	0.0	<2.0	<2.0	0.0
Alkalinity, Total (as $CaCO_3$)	2.7	2.6	3.8	37.9	37.6	0.8
Bromide (Br)	<0.050	<0.050	0.0	0.079	0.078	1.3
Chloride (Cl)	<0.50	<0.50	0.0	52.6	51.6	1.9
Fluoride (F)	<0.020	<0.020	0.0	0.033	0.032	3.1
Sulfate (SO_4)	1.55	1.48	4.6	7.52	7.35	2.3
Nitrate (as N)	<0.0050	<0.0050	0.0	0.0096	0.0133	32.3
Nitrite (as N)	<0.0010	<0.0010	0.0	<0.0010	<0.0010	0.0
Total Kjeldahl Nitrogen	0.319	0.326	2.2	0.291	0.271	7.1
Total Nitrogen	-	-	-	0.301	0.284	5.8
Ortho Phosphate as P	<0.0010	<0.0010	0.0	0.0016	0.0012	28.6
Total Phosphate as P	0.0076	0.0096	23.3	0.0221	0.0210	5.1
Total Metals						
Aluminum (Al)-Total	0.0675	0.0714	5.6	0.751	0.690	8.5
Antimony (Sb)-Total	<0.00010	<0.00010	0.0	<0.00010	<0.00010	0.0
Arsenic (As)-total	0.000137	0.000149	8.4	<0.0010	0.00061	0.0
Barium (Ba)-Total	0.00345	0.00367	6.2	0.0257	0.0250	2.8
Beryllium (Be)-total	<0.00020	<0.00020	0.0	<0.00020	<0.00020	0.0
Boron (B)-total	<0.0010	<0.0010	0.0	0.0177	0.0182	2.8
Cadmium (Cd)-Total	<0.000017	<0.000017	0.0	<0.000017	<0.000017	0.0
Calcium (Ca)-Total	0.703	0.730	3.8	11.2	11.4	1.8
Chromium (Cr)-Total	0.00011	0.00011	0.0	0.00148	0.00138	7.0
Cobalt (Co)-Total	0.00060	0.00063	4.9	0.00037	0.00036	2.7
Copper (Cu)-Total	0.00163	0.00174	6.5	0.00346	0.00357	3.1
Iron (Fe)-Total	0.093	0.090	3.3	0.686	0.598	13.7
Lead (Pb)-Total	<0.000050	<0.000050	0.0	0.000342	0.000328	4.2
Magnesium (Mg)-Total	0.501	0.523	4.3	7.74	7.84	1.3
Manganese (Mn)-Total	0.0200	0.0213	6.3	0.0139	0.0142	2.1
Mercury (Hg)-Total	<0.000020	<0.000020	0.0	<0.000020	<0.000020	0.0
Molybdenum (Mo)-Total	<0.000050	<0.000050	0.0	0.000183	0.000166	9.7
Nickel (Ni)-Total	0.00200	0.00211	5.4	0.00185	0.00173	6.7
Potassium (K)-Total	0.451	0.489	8.1	1.81	1.81	0.0
Selenium (Se)-Total	<0.00010	<0.00010	0.0	<0.0010	<0.0010	0.0
Silicon (Si)-Total	0.381	0.400	4.9	2.81	2.50	11.7
Silver (Ag)-Total	<0.00010	<0.00010	0.0	<0.00010	<0.00010	0.0
Sodium (Na)-Total	0.471	0.492	4.4	29.5	29.2	1.0
Strontium (Sr)-Total	0.00467	0.00496	6.0	0.0357	0.0358	0.3
Uranium (U)-Total	0.000019	0.000019	0.0	0.000315	0.000318	0.9
Vanadium (V)-Total	0.000082	0.000076	7.6	0.0015	0.0017	12.5
Zinc (Zn)-Total	0.0017	0.0019	11.1	0.0034	0.0041	18.7
Dissolved Metals						
Aluminum (Al)-Dissolved	0.0603	0.0614	1.8	0.577	0.556	3.7
Antimony (Sb)-Dissolved	<0.00010	<0.00010	0.0	<0.00010	<0.00010	0.0
Arsenic (As)-Dissolved	0.000129	0.000144	11.0	0.00058	0.00057	1.7
Barium (Ba)-Dissolved	0.00346	0.00357	3.1	0.0224	0.0222	0.9
Beryllium (Be)-Dissolved	<0.00020	<0.00020	0.0	<0.00020	<0.00020	0.0
Boron (B)-Dissolved	<0.0010	<0.0010	0.0	0.0181	0.0174	3.9
Cadmium (Cd)-Dissolved	<0.000017	<0.000017	0.0	<0.000017	<0.000017	0.0
Calcium (Ca)-Dissolved	0.735	0.790	7.2	10.2	10.3	1.0
Chromium (Cr)-Dissolved	<0.00010	<0.00010	0.0	0.00123	0.00119	3.3
Cobalt (Co)-Dissolved	0.00012	<0.00010	0.0	0.00012	0.00011	8.7
Copper (Cu)-Dissolved	0.00162	0.00165	1.8	0.00258	0.00253	2.0
Iron (Fe)-Dissolved	0.026	0.025	3.9	0.395	0.321	20.7
Lead (Pb)-Dissolved	<0.000050	<0.000050	0.0	0.000145	0.000130	10.9
Magnesium (Mg)-Dissolved	0.517	0.539	4.2	7.39	7.31	1.1
Manganese (Mn)-Dissolved	0.00616	0.00595	3.5	0.00223	0.00229	2.7
Mercury (Hg)-Dissolved	<0.000020	<0.000020	0.0	<0.000020	<0.000020	0.0
Molybdenum (Mo)-Dissolved	<0.000050	<0.000050	0.0	0.000158	0.000150	5.2
Nickel (Ni)-Dissolved	0.00206	0.00208	1.0	0.00099	0.00096	3.1
Potassium (K)-Dissolved	0.471	0.505	7.0	1.65	1.66	0.6
Selenium (Se)-Dissolved	<0.00010	<0.00010	0.0	<0.0010	<0.0010	0.0
Silicon (Si)-Dissolved	0.340	0.338	0.6	3.13	2.83	10.1
Silver (Ag)-Dissolved	<0.00010	<0.00010	0.0	<0.00010	<0.00010	0.0
Sodium (Na)-Dissolved	0.495	0.500	1.0	28.0	28.7	2.5
Strontium (Sr)-Dissolved	0.00486	0.00509	4.6	0.0335	0.0339	1.2
Uranium (U)-Dissolved	0.000017	0.000015	12.5	0.000235	0.000246	4.6
Vanadium (V)-Dissolved	0.000082	0.000080	2.5	<0.0010	<0.0010	0.0
Zinc (Zn)-Dissolved	0.0020	0.0018	10.5	<0.0010	<0.0010	0.0
Organic Parameters						
Total Organic Carbon	6.81	6.99	2.6	7.66	7.75	1.2

< = Less than the detection limit indicated.

Results are expressed as milligrams per litre except where noted.

Values in red indicate an RPD greater than 20%.

APPENDIX 3.1-3
ANALYTICAL RESULTS FOR SEDIMENT

Appendix 3.1-3
Analytical Results for Sediment

Sample ID			B1			B2			B3		
Replicate	Available		1	2	3	1	2	3	1	2	3
Date Sampled	CCME Guidelines		18-AUG-07	18-Aug-07	18-Aug-07	18-AUG-07	18-Aug-07	18-Aug-07	18-AUG-07	18-Aug-07	18-Aug-07
Nature	ISQG	PEL	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment
% Moisture			88.1	27.4	25.2	79.4	82.7	28.2	85.4	21.2	30.5
pH			5.29	6.30	6.47	5.30	5.61	5.66	5.17	6.50	6.16
Available Phosphate-P			56	3	2	<1	<1	1	2	1	1
Total Organic Carbon			3.06	0.34	0.29	8.55	7.71	1.07	16.8	0.44	0.65
Sulfur (S)-Total			400	<100	<100	900	700	100	2000	<100	100
Total Nitrogen by LECO			0.27	0.04	0.03	0.72	0.61	0.07	1.04	0.03	0.05
Aluminum (Al)			6120	6830	5720	11800	12900	8460	9030	9950	9490
Antimony (Sb)			<10	<10	<10	<10	<10	<10	<10	<10	<10
Arsenic (As)	5.9	17	46.8	5.2	<5	37.4	35.5	**6.9**	**10.9**	**6.9**	<5
Barium (Ba)			32.2	27.5	21.7	51.7	60.7	33.5	44.7	43.1	35.4
Beryllium (Be)			<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Bismuth (Bi)			<20	<20	<20	<20	<20	<20	<20	<20	<20
Cadmium (Cd)	0.6	3.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Calcium (Ca)			1100	1080	898	1740	2170	1440	1220	1160	1110
Chromium (Cr)	37.3	90.0	17.2	23.6	16.9	32.3	34.6	30.0	25.6	35.4	31.7
Cobalt (Co)			3.3	3.3	3.1	14.1	22.4	5.7	15.0	17.1	9.6
Copper (Cu)	35.7	197.0	9.0	5.0	3.8	24.2	29.8	9.9	30.7	10.2	10.5
Iron (Fe)			22700	11800	10000	39400	53900	17200	22300	18000	16500
Lead (Pb)	35	91.3	<30	<30	<30	<30	<30	<30	<30	<30	<30
Lithium (Li)			14.0	18.2	14.5	20.1	21.4	21.0	13.0	19.8	19.6
Magnesium (Mg)			3320	4740	3680	5340	5860	5940	4150	7220	6640
Manganese (Mn)			97.3	118	99.4	302	582	189	319	494	262
Mercury (Hg)	0.17	0.486	0.0150	<0.005	<0.005	0.0613	0.0676	<0.005	0.0474	<0.005	0.0073
Molybdenum (Mo)			<4	<4	<4	<4	<4	<4	<4	<4	<4
Nickel (Ni)			9.8	11.2	8.9	21.4	23.6	14.2	24.7	19.1	18.0
Phosphorus (P)			407	302	191	711	814	404	528	312	304
Potassium (K)			790	1160	890	1020	1150	1250	770	1610	1300
Selenium (Se)			<3.0	<5.0	<2.0	<3.0	<2.0	<3.0	<3.0	<3.0	<3.0
Silver (Ag)			<2	<2	<2	<2	<2	<2	<2	<2	<2
Sodium (Na)			100	100	100	100	100	100	100	100	100
Strontium (Sr)			8.73	5.51	4.98	11.1	14.4	6.41	8.16	5.86	5.62
Thallium (Tl)			<1	<1	<1	<1	<1	<1	<1	<1	<1
Tin (Sn)			<5	<5	<5	<5	<5	<5	<5	<5	<5
Titanium (Ti)			263	269	231	416	434	358	280	362	323
Vanadium (V)			31.9	19.6	16.9	46.6	51.9	29.1	26.0	29.6	27.4
Zinc (Zn)	123.0	315.0	25.1	24.2	18.7	48.5	54.5	29.6	39.1	30.7	28.4
Particle Size											
% Gravel (>2mm)			12	24	35	4	8	54	6	42	39
% Sand (2.0mm – 0.063mm)			78	71	60	43	59	38	56	51	56
% Silt (0.063mm – 4um)			8	4	3	46	30	7	32	6	4
% Clay (<4um)			3	2	2	7	3	1	6	1	1

< = Less than the detection limit indicated. **(continued)**

Results are expressed as milligrams per dry kilogram except where noted.

Total Organic Carbon results are expressed as percent, dry weight basis.

Bolded and outlined values indicate ISQG guideline exceeded.

Shaded values indicate PEL guideline exceeded.

Appendix 3.1-3
Analytical Results for Sediment (completed)

				B4			B5			B6	
Replicate	**Available**		**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
Date Sampled	**CCME Guidelines**		**18-AUG-07**	**18-Aug-07**	**18-Aug-07**	**18-AUG-07**	**18-Aug-07**	**18-Aug-07**	**18-AUG-07**	**18-Aug-07**	**18-Aug-07**
Nature	**ISQG**	**PEL**	**Sediment**	**Sediment**	**Sediment**	**Sediment**	**Sediment**	**Sediment**	**Sediment**	**Sediment**	**Sediment**
% Moisture			35.3	81.6	82.5	43.6	21.8	27.5	36.4	27.0	29.5
pH			5.89	5.30	5.22	6.18	6.81	6.60	7.70	7.52	7.90
Available Phosphate-P			1	1	<1	<1	<1	<1	3	5	16
Total Organic Carbon			0.68	3.24	3.48	0.54	0.14	0.36	0.54	0.29	0.20
Sulfur (S)-Total			100	600	400	200	100	100	400	300	300
Total Nitrogen by LECO			0.05	0.26	0.23	0.04	<0.02	0.03	0.04	0.02	0.02
Aluminum (Al)			12100	11200	9410	10200	12100	13500	4590	6490	4040
Antimony (Sb)			<10	<10	<10	<10	<10	<10	<10	<10	<10
Arsenic (As)	5.9	17	**9.2**	**10.7**	**16.6**	<5	<5	**6.1**	<5	<5	<5
Barium (Ba)			20.7	37.6	26.4	24.0	24.4	30.1	37.9	47.8	33.1
Beryllium (Be)			<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Bismuth (Bi)			<20	<20	<20	<20	<20	<20	<20	<20	<20
Cadmium (Cd)	0.6	3.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Calcium (Ca)			957	1280	1010	1260	1520	1350	2920	3250	2540
Chromium (Cr)	37.3	90.0	**43.5**	**37.9**	33.1	37.1	**45.2**	**50.8**	12.7	17.7	10.4
Cobalt (Co)			6.8	9.5	8.5	10.5	9.4	9.7	3.1	4.2	2.8
Copper (Cu)	35.7	197.0	8.8	**43.2**	22.5	12.7	8.9	11.5	8.7	12.0	6.7
Iron (Fe)			21900	28500	16600	16100	19500	21800	9670	12000	8670
Lead (Pb)	35	91.3	<30	<30	<30	<30	<30	<30	<30	<30	<30
Lithium (Li)			25.1	19.6	18.2	22.4	27.2	30.3	8.6	12.2	7.7
Magnesium (Mg)			8880	6490	5670	7300	9110	10000	3800	5060	3430
Manganese (Mn)			204	159	137	179	225	221	103	127	83.7
Mercury (Hg)	0.17	0.486	0.0055	0.0491	0.0254	<0.005	<0.005	<0.005	<0.005	0.0052	<0.005
Molybdenum (Mo)			<4	<4	<4	<4	<4	<4	<4	<4	<4
Nickel (Ni)			21.3	32.2	22.5	23.3	23.0	26.8	6.5	9.4	5.5
Phosphorus (P)			283	686	328	315	379	362	417	449	366
Potassium (K)			730	750	440	320	510	760	900	1310	820
Selenium (Se)			<2.0	<3.0	<3.0	<3.0	<4.0	<2.0	<3.0	<3.0	<3.0
Silver (Ag)			<2	<2	<2	<2	<2	<2	<2	<2	<2
Sodium (Na)			100	100	100	100	100	100	100	220	760
Strontium (Sr)			4.88	6.80	4.89	5.29	6.37	4.90	12.5	16.5	12.5
Thallium (Tl)			<1	<1	<1	<1	<1	<1	<1	<1	<1
Tin (Sn)			<5	<5	<5	<5	<5	<5	<5	<5	<5
Titanium (Ti)			319	309	314	273	346	340	287	350	251
Vanadium (V)			30.8	32.2	25.3	23.2	27.9	34.5	19.6	23.9	16.8
Zinc (Zn)	123.0	315.0	47.2	72.9	48.0	42.6	43.9	47.9	14.5	19.0	13.2
Particle Size											
% Gravel (>2mm)			<1	1	1	12	30	17	<1	13	1
% Sand (2.0mm – 0.063mm)			95	80	78	84	63	76	52	50	73
% Silt (0.063mm – 4um)			3	16	18	3	6	6	41	32	22
% Clay (<4um)			2	3	3	1	2	2	7	4	4

< = Less than the detection limit indicated.

Results are expressed as milligrams per dry kilogram except where noted.

Total Organic Carbon results are expressed as percent, dry weight basis.

Bolded and outlined values indicate ISQG guideline exceeded.

Shaded values indicate PEL guideline exceeded.

APPENDIX 3.1-4
RELATIVE PERCENT DIFFERENCE ANALYSIS RESULTS FOR STREAM SEDIMENT

Appendix 3.1-4
Relative Percent Difference Analysis Results for Stream Sediment

Sample ID	Replicate 1	Replicate 2	RPD %
Date Sampled	18-AUG-07	18-AUG-07	
Particle Size			
% Gravel (>2mm)	54	54	**0.0**
% Sand (2.0mm – 0.063mm)	38	41	**7.6**
% Silt (0.063mm – 4um)	7	4	**54.5**
% Clay (<4um)	1	1	**0.0**
Organic Parameters			
Organic Carbon	0.65	0.59	**9.7**
Physical Tests			
% Moisture	35.3	36.6	**3.6**
pH	7.52	7.54	**0.3**
Anions and Nutrients			
Available Phosphate-P	<1	<1	**0.0**
Metals			
Aluminum (Al)	6490	6640	**2.3**
Antimony (Sb)	<10	<10	**0.0**
Arsenic (As)	<5.0	<5.0	**0.0**
Barium (Ba)	47.8	50.1	**4.7**
Beryllium (Be)	<0.50	<0.50	**0.0**
Bismuth (Bi)	<20	<20	**0.0**
Cadmium (Cd)	<0.50	<0.50	**0.0**
Calcium (Ca)	3250	3320	**2.1**
Chromium (Cr)	17.7	17.7	**0.0**
Cobalt (Co)	4.2	4.4	**4.7**
Copper (Cu)	12.0	12.0	**0.0**
Iron (Fe)	12000	12100	**0.8**
Lead (Pb)	<30	<30	**0.0**
Lithium (Li)	12.2	12.6	**3.2**
Magnesium (Mg)	5060	5160	**2.0**
Manganese (Mn)	127	128	**0.8**
Mercury (Hg)	0.0052	0.0061	**15.9**
Molybdenum (Mo)	<4.0	<4.0	**0.0**
Nickel (Ni)	9.4	9.1	**3.2**
Phosphorus (P)	449	445	**0.9**
Potassium (K)	1310	1330	**1.5**
Selenium (Se)	<3.0	<3.0	**0.0**
Silver (Ag)	<2.0	<2.0	**0.0**
Sodium (Na)	220	230	**4.4**
Strontium (Sr)	16.5	16.4	**0.6**
Thallium (Tl)	<1.0	<1.0	**0.0**
Tin (Sn)	<5.0	<5.0	**0.0**
Titanium (Ti)	350	351	**0.3**
Vanadium (V)	23.9	24.7	**3.3**
Zinc (Zn)	19.0	18.8	**1.1**

Results are expressed as milligrams per dry kilogram except where noted.

< = Less than the detection limit indicated.

Values in red indicate an RPD greater than 20%.