MPERG Report 2008-3

Natural Sources of Contaminants In the Yukon

By

EDI Environmental Dynamics Inc.

MPERG is a cooperative working group made up of the Federal and Yukon Governments, Yukon First Nations, mining companies, and non-government organizations for the promotion of research into mining and environmental issues in Yukon.

MPERG (Mining and Petroleum Environment Research Group) reports are available at the Geoscience and Information Sales Outlet, Room 102, Elijah Smith Building, 102-300 Main Street, Whitehorse, Yukon.

Mailing Address:
Box 2703, Whitehorse, Yukon Y1A 2C6
Phone: (867) 667-5200
Fax: (867) 667-5150

The reports are also available electronically at the Yukon Geological Survey website:
http://www.geology.gov.yk.ca/mperg

EDI ENVIRONMENTAL DYNAMICS INC.
Natural Resource Consultants

NATURAL SOURCES OF CONTAMINANTS IN THE YUKON

PREPARED FOR:

MINING AND PETROLEUM ENVIRONMENTAL RESEARCH GROUP

BOX 2703

WHITEHORSE, YT

Y1A 2C6

PREPARED BY:

EDI ENVIRONMENTAL DYNAMICS INC.

402 HAWKINS ST

WHITEHORSE, YT

YIA 1X8

EDI CONTACT:

LYNDSAY DOETZEL, P.BIOL. (867) 393-4882

CATHERINE JACOBSEN, M.SC. (867) 393-4882

BEN SCHONEWILLE, R.P.BIO (867) 393-4882

EDI PROJECT NO.: 07-YC-0022

MARCH 2008

ABSTRACT

This study investigated background levels and uptake rates of organophilic metals, particularly selenium, in ten streams draining portions of the Yukon-Tanana Terrane and Cassiar Platform between Ross River and Watson Lake, Yukon. The study area is suspected to have elevated background metals concentrations and is of interest for mineral exploration and development due to high mineralization. Information on natural metals levels is lacking for this region and for the Yukon in general. Water, sediments, benthic invertebrates and fish (slimy sculpin; *Cottus cognatus*) were sampled and analyzed for metals concentrations. Benthic invertebrates were identified to genus and percent composition of each species in each stream was calculated. The lack of anthropogenic activity in the area indicates that selenium concentrations found in all sample media and natural, background concentrations. Of all the sample media, concentrations of selenium were highest in sediment; however, sediment selenium concentrations were found to be in a range similar to levels documented at the Kudz Ze Kayah and Viceroy Brewery Creek mines in other regions of the Yukon. Selenium concentrations in water generally exceeded CCME guidelines, but also fell within a range similar to the Kudz Ze Kayah and Viceroy Brewery Creek mines. These findings with respect to selenium levels in water and stream sediments highlight the importance of developing site-specific selenium guidelines for management of aquatic systems. The rate of uptake of selenium in benthic invertebrate and fish tissues was greater than that of the other organophilic metals investigated. Selenium concentrations were generally higher in benthic invertebrates than in fish, likely owing to the detritus-feeding and bottom-dwelling life history of these invertebrates. Weak positive trends were noted in the relationship between selenium concentrations in fish and benthic invertebrates, and between fish and the water column. A significant positive relationship was noted between selenium concentrations in fish and stream sediments. These findings are consistent with past studies documenting dietary sources as the most common uptake pathways for selenium, with water comprising a secondary source. Examination of benthic invertebrate community composition revealed commonly abundant species and species typical of fast-flowing streams with high water quality, which is characteristic of the streams in the study area. The findings of this study provide valuable baseline information on background concentrations of metals, particularly selenium, as well as documentation of benthic invertebrate community composition, in an aquatic system that may experience resource development in the future.

ACKNOWLEDGEMENTS

EDI Environmental Dynamics would like to acknowledge the contributions made by others to the project 'Natural Sources of Contaminants in the Yukon'.

Benoit Godin from Environment Canada worked with EDI to design and develop the project. His continued support through the proposal submission, field work and technical advice given during the data analysis and report authoring was greatly appreciated.

The project would not have been possible without the in-kind contributions from Environment Canada including all laboratory analyses, field personnel and field gear.

Thanks to Doug Davidge from Environment Canada together with Matt Power from EDI who completed the field sampling portion of the program.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

1 INTRODUCTION

The Yukon is a highly mineralized area. This has led not only to extensive mining in the Territory, but also to elevated concentrations of metals in terrestrial and aquatic ecosystems. In some locations, natural levels of certain elements have been found to exceed Canadian Council of Ministers of the Environment (CCME) Guidelines for the protection of terrestrial and aquatic life.

Documentation of background levels of metals in the Yukon is limited. No comprehensive database exists and few studies have been completed to assess metal concentrations in the various geological regions of the Yukon. This situation presents difficulties for public and private land managers wishing to understand the existing or potential impacts of mining activity. This solid base of information on natural metal levels is necessary to evaluate the degree to which the concentrations of these elements may be elevated by mining operations, leading to potential contamination of terrestrial and aquatic resources.

In addition to the gap in information on background metal levels, there is also a lack of understanding of the pathways and rates of uptake of potential contaminants in biological systems. Certain metals, hereafter called 'organophilic metals' affiliate more readily with organic matter and are more prone to uptake by biological organisms. These organophilic metals include selenium (Se), vanadium (V), uranium (U), arsenic (As), mercury (Hg) and beryllium (Be). In aquatic ecosystems, organophilic metals may be taken up by aquatic plants or animals and may accumulate at subsequently higher levels in the food chain. Toxicological effects may be experienced at any level of the food chain, depending on contaminant concentrations and the sensitivity of the organism.

Selenium, in particular, has been identified as a useful indicator for the investigation of the uptake and accumulation of organophilic metals in aquatic ecosystems. An essential element for most organisms, selenium becomes toxic at elevated levels. Selenium is mobilized in aquatic systems through several pathways, such as uptake from sediments by rooted aquatic plants, benthic invertebrates and detritus-eating invertebrates (Adams et al., 2000). Accumulation of selenium at higher trophic levels occurs primarily through dietary pathways (Chapman, 2005).

The behaviour of selenium in aquatic systems varies in relation to site-specific factors, such as reduction and oxidation, pH, and biological productivity (Adams et al., 2000). Mining for coal, phosphate, uranium, and various other metals can expedite the release of selenium from rock with elevated background levels (Chapman, 2005). Due to the lack of universally accepted threshold values for selenium concentrations in surface water and sediments, an understanding of site-specific conditions is important for assessing selenium contamination resulting from mining and industrial activity.

The purpose of this study was to investigate natural metal concentrations and the uptake of these metals in aquatic ecosystems in a region of the Yukon as yet undisturbed by mining activity, and suspected to have elevated background metals concentrations. The study region was located within the geological zones of the Tanana Terrane and Cassiar Platform, between Watson Lake and Ross River. This area is of interest for mineral exploration; thus, the results of this study may provide valuable, pre-development baseline information on natural metal levels and biological accumulation in aquatic ecosystems in this region.

The two primary objectives of the study were as follows: 1) to examine natural metal concentrations in stream sediments, surface water, benthic invertebrates and fish, and; 2) to investigate the uptake of metals in the aquatic food chain. Emphasis was placed on analysis of organophilic elements, due to the tendency of these metals to accumulate in biological tissues. Particular focus was placed on the behaviour of selenium (Se) as an indicator of organophilic metal uptake.

A secondary objective of the study was to document the community composition of benthic invertebrates in the study streams. Certain species of benthic invertebrates are known to be intolerant to elevated levels of metals associated with mining activity. Characterizing the pre-disturbance benthic invertebrate community composition in the study area may provide a valuable reference for investigation of potential changes resulting from future development in this region.

2 METHODS

2.1 STUDY AREA

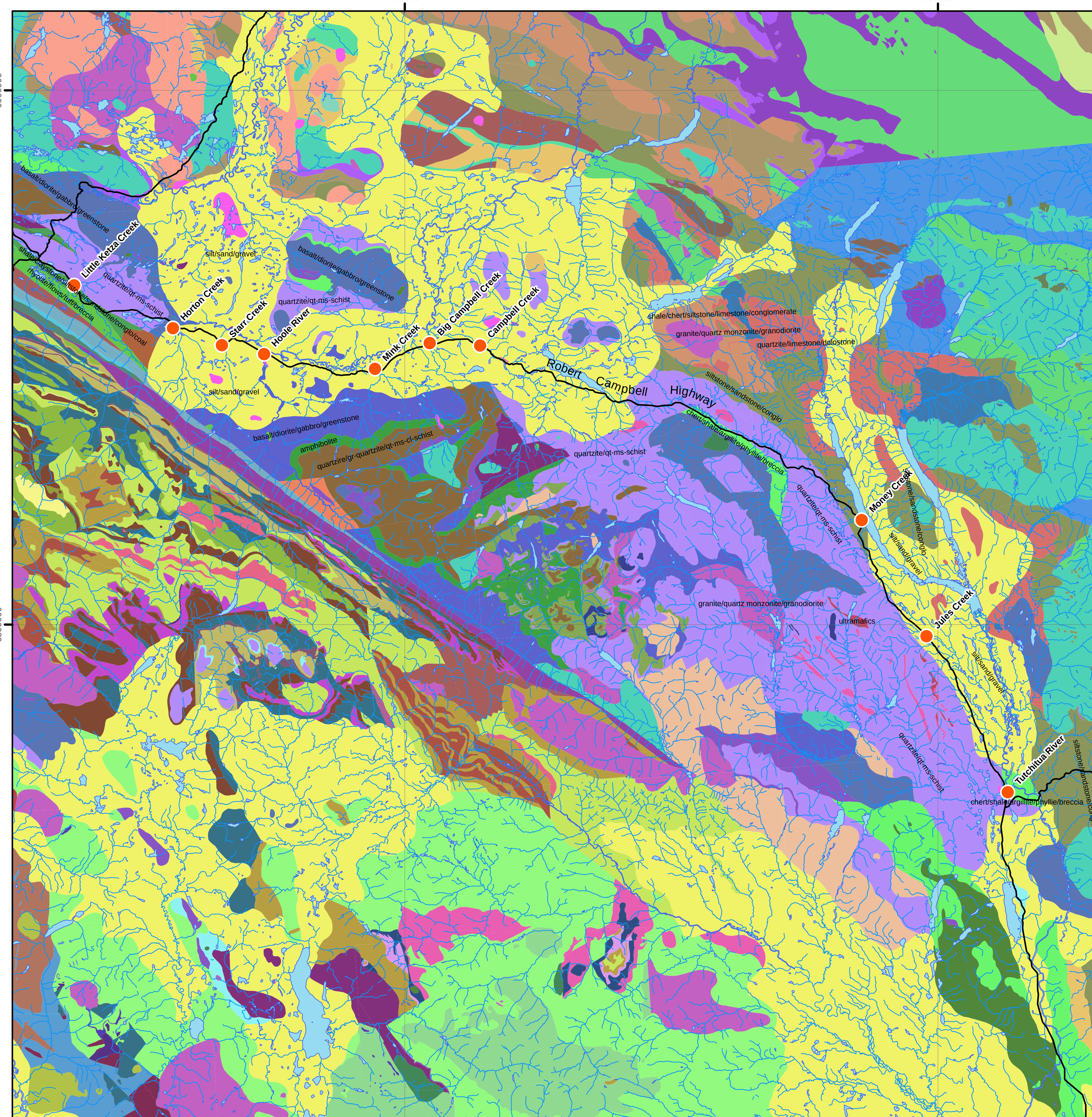
The study area encompassed various tributaries of the Francis, Finlayson and Pelly Rivers, which drain portions of the Yukon Tanana-Terrane and Cassiar Platform between Ross River and Watson Lake. The Yukon-Tanana Terrane is composed of a diversity of metamorphic rock assemblages, while the Cassiar Platform is characterized by sedimentary limestone and sandstone deposits. Both geological regions are within the Omineca Belt, one of the five major morphogeological belts in the Yukon, which is characterized by metamorphosized sedimentary rocks and granites. Exposed bedrock is common in the glaciated portion of the Omineca Belt, which includes the study area (Hart, 1999).

The study area is also within the Interior Hydrologic Region, which drains primarily from the footslopes of the Selwyn Mountains to the east. Streamflow is characterized by rapid snowmelt discharge, peaking in June, with secondary peaks resulting from rainfall events throughout the summer. The mean annual temperature in the region is -5ºC, with a mean January temperature of -20 ºC and a mean July temperature of 15ºC. Permafrost is extensive, but discontinuous, in the region (Yukon Ecoregions Working Group, 2004).

The study area is classified as belonging to the North Yukon-Plateau ecoregion. The terrain in this ecoregion includes rolling uplands and nearly level tablelands dissected by deeply cut, broad, U-shaped valleys. The Tintina Trench, a straight, steep-sided valley ranging from 5-22 km wide, traverses the ecoregion from southeast to northwest (north of the study area). White spruce in a matrix of dwarf willow, birch, shrubs, and occasionally lodgepole pine, forms extensive open forests. Black spruce, scrub willow, birch, and mosses are found on poorly drained sites. Shrub birch occurs with scattered subalpine fir and white spruce in subalpine areas, whereas alpine vegetation consists of mountain avens, dwarf willow, low shrubs, and mosses (Yukon Ecoregions Working Group, 2004).

2.2 STUDY DESIGN

The study was designed to encompass the watercourses draining a portion of the Yukon-Tanana Terrane and Cassiar Platform believed to have high background metals levels. All streams sampled were tributaries to the Francis River, Francis Lake, the Finlayson River or the Pelly River. A total of ten streams were sampled, including the following: Little Ketza Creek, Horton Creek, Starr Creek, Hoole River, Mink Creek, Big Campbell Creek, Campbell Creek, Money Creek, Jules Creek and Tutchitua River. (Figure 1).



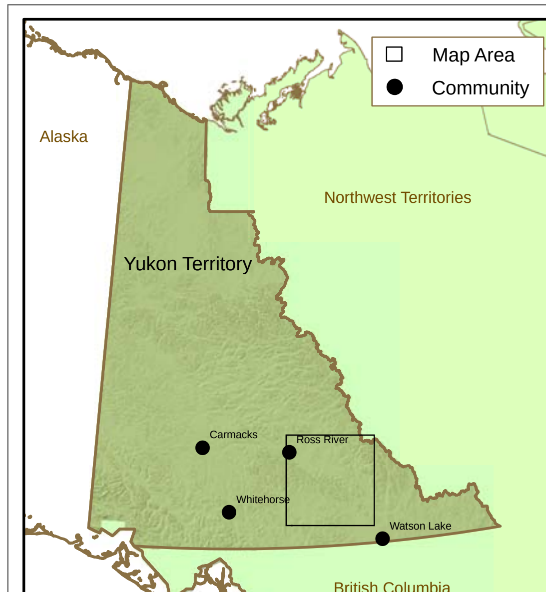


Figure 1. Overview of Study Area Showing Local Bedrock Geology.

Data Input/Drawn By: Matt Power
Date: 20 March 2008
Projection: NAD 1983 UTM Zone 8N
EDI Project No.: 07-YC-0022

Digital Data Sources:

Base Map Files: NTDB Canada 1:250,000
Digital Elevation Model: YG - Geomatics.
Bedrock Geology: YG - Geomatics.

0 4 8 16 24 32 40
Kilometres

EDI ENVIRONMENTAL DYNAMICS INC.
Natural Resource Consultants

The sampling program was designed to enable analysis of natural background levels of metals, as well as uptake and accumulation rates of metals in biological organisms. Sediments and surface water were sampled to capture potential sources of metals, while benthic invertebrates and fish were sampled to assess the uptake and accumulation rates of metals.

Figure 2 illustrates the typical sources and uptake pathways of organophilic metals in aquatic systems. The heaviest arrow indicates the most common uptake pathway, from sediment to benthic invertebrates. Medium weight arrows indicate secondary pathways, from benthic invertebrates to fish and from periphyton to fish. The lightest arrows indicate the least common source of uptake, water.

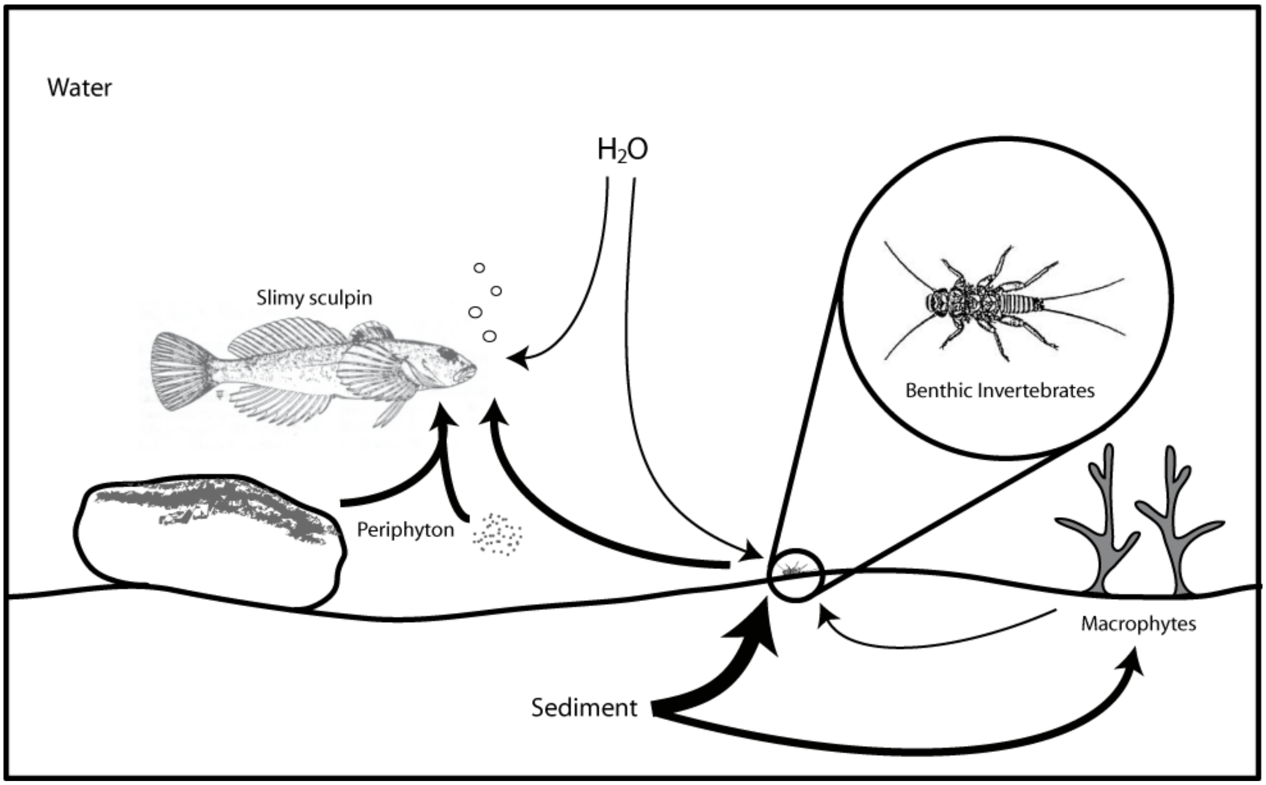


Figure 2. Uptake pathways of organophilic metals in aquatic systems. Heavier arrows indicate the more common pathways.

2.3 SAMPLING METHODS

At each sampling site, stream flow, channel width, wetted width, average channel depth, gradient, temperature, pH, turbidity, and dissolved oxygen measurements were taken, and UTM coordinates were recorded. Composition of the stream bed material and instream vegetation conditions were also documented.

At each sampling site, stream sediments, surface water, benthic invertebrates and fish were collected. Stream sediments were sampled using stainless steel instruments and sieved according to laboratory requirements. Samples were stored cold and transported to the laboratory for analysis.

Water quality samples were collected by taking grab samples at a depth of 30 cm, using laboratory-prescribed containers. Samples were kept cool and transported to the laboratory for analysis.

Benthic invertebrate samples were collected via kick-net sampling (363 μ mesh size), following the methods outlined by Reynoldson et al. (2003). Specimens were stored in 10% formalin for transport to the office and transferred to 70% ethanol within 72 h. Specimens were identified to genus under a microscope. Samples were then transported to the Environment Canada laboratory for long term storage.

Fish sampling was conducted by electrofishing with an effort of 28 to 55 minutes at each sampling site. Fish captured were identified to species, and slimy sculpin (*Cottus cognatus*) were kept for analysis (Appendix A lists species captured at each site). As required, slimy sculpin samples obtained (of similar sizes) from a sampling site were amalgamated into composite samples to achieve the minimum required weight (5 grams) for laboratory analysis. Samples were stored frozen and transported to the laboratory for analysis.

A summary of the sampling locations and the samples collected at each location is shown below in Table 1.

Table 1: Summary of sampling locations.

Stream	Date Sampled	Sampling Location		Samples Collected			
		Latitude	Longitude	Water	Stream Sediments	Benthic Invertebrates	Fish
Little Ketza Creek	Jul 26/07	N 61.850800	W 132.349300	√	√	√	√
Horton Creek	Jul 26/07	N 61.800150	W 132.031534	√	√	√	√
Starr Creek	Jul 26/07	N 61.767166	W 131.858800	√	√	√	√
Hoole River	Jul 25/07	N 61.748866	W 131.710983	√	√	-	-
Mink Creek	Jul 25/07	N 61.714384	W 131.321716	√	√	√	√
Big Campbell Creek	Jul 25/07	N 61.752384	W 131.120567	√	√	√	√
Campbell Creek	Jul 25/07	N 61.743933	W 130.952900	√	√	√	√
Money Creek	Jul 24/07	N 61.413917	W 129.643933	√	√	√	√
Jules Creek	Jul 24/07	N 61.200150	W 129.453467	√	√	√	-
Tutchitua River	Jul 24/07	N 60.927500	W 129.219167	√	√	√	√

2.4 LABORATORY ANALYSIS

All laboratory analysis was conducted by Environment Canada. Sediment, water, invertebrate and fish analyses were completed for all metals listed in Table 2. Total metals were analyzed in sediments, invertebrates and fish. Total and dissolved metals were analyzed in water samples, as well as the following additional water quality parameters:

- total dissolved solids
- pH
- total suspended solids
- ammonia
- colour
- conductivity
- chloride
- dissolved organic carbon
- turbidity
- sulphate
- hardness
- nitrate
- nitrite
- alkalinity

Table 2: Total and dissolved metals included in analysis of sediment, water, benthic invertebrates and fish.

Element	*Chemical symbol*	**Element**	*Chemical Symbol*
Aluminum	Al	Molybdenum	Mo
Antimony	Sb	Nickel	Ni
Arsenic	As	Phosphorus	P
Barium	Ba	Potassium	K
Beryllium	Be	Selenium	Se
Bismuth	Bi	Silicon	Si
Boron	B	Silver	Ag
Cadmium	Cd	Sodium	Na
Calcium	Ca	Strontium	Sr
Chromium	Cr	Sulfur	S
Cobalt	Co	Tin	Sn
Copper	Cu	Thallium	Tl
Lead	Pb	Titanium	Ti
Lithium	Li	Uranium	U
Magnesium	Mg	Vanadium	V
Manganese	Mn	Zinc	Zn
Mercury	Hg		

2.5 DATA ANALYSIS

Data collected as part of this project was reviewed and compared to applicable guidelines, including the CCME water quality criteria for the protection of aquatic life (CCME 2002), and the British Columbia guideline for selenium in tissues (BC MOE 2001). Relationships between selenium concentrations in media and biota were investigated through simple regression using Minitab Statistical Software (v. 15, 2007).

3 RESULTS

3.1 STREAM CHARACTERISTICS

The 10 watercourses sampled as part of this study were all cold, clear, fast flowing alpine streams. The average channel width at each of the stream sampling locations ranged from a minimum of 4.5 m, Little Ketza Creek to the largest at 46.0 m, Tutchitua River. Dominant substrate material in the majority of the sample streams was gravel and cobble, while in two streams, Hoole River and Little Campbell Creek, the dominant substrate material was boulder. Discharge in the streams ranged from $0.68 m^3/s$ in Horton Creek to $9.15 m^3/s$ in Big Campbell Creek. Detailed physical stream attribute data, including field measured water quality, can be found in Appendix A.

The water in all watercourses sampled was alkaline with pH slightly above 8.0. The concentration of dissolved organic carbon was low in all watercourses, and total dissolved solids (TDS) were low in all streams except Little Ketza Creek, which had a TDS concentration of 781 mg/L. The concentration of total suspended solids was also quite low, often below detection limits in all watercourses. Detailed water quality data can be found in Appendix G.

3.2 CONCENTRATIONS OF ORGANOPHILIC ELEMENTS

Figure 3 to Figure 8 in Sections 3.2.1 to 3.2.6 present the ranges in concentrations of the six organophilic elements among sampling locations and sample media (i.e. fish tissue, benthic invertebrates, stream sediment, and water). It is important to note that the analytical results displayed here are shown in terms of dry weight, with the exception of the metal concentrations in fish tissues, which are shown in wet weight. In addition, the detection limits utilized by the laboratory did not allow for a measurable concentration of beryllium, uranium or vanadium to be found in samples of fish tissue or benthic invertebrates and, as such, levels of these metals are not included in the figures below. In situations where a group of samples were found to be below the detection limits, half of the detection limit was used to illustrate the metal concentration in the following figures. The complete set of analytical data for all parameters (including the organophilic elements) can be found in Appendix C through Appendix G.

3.2.1 SELENIUM

Levels of selenium were somewhat variable between sampling locations; however, Little Ketza Creek, Starr Creek, and to a lesser extent, Horton Creek were found to have the highest concentrations in all sample media (Figure 3). Benthic invertebrates appeared to have the highest concentrations of selenium in comparison to other sample media, with water typically having the lowest concentrations.

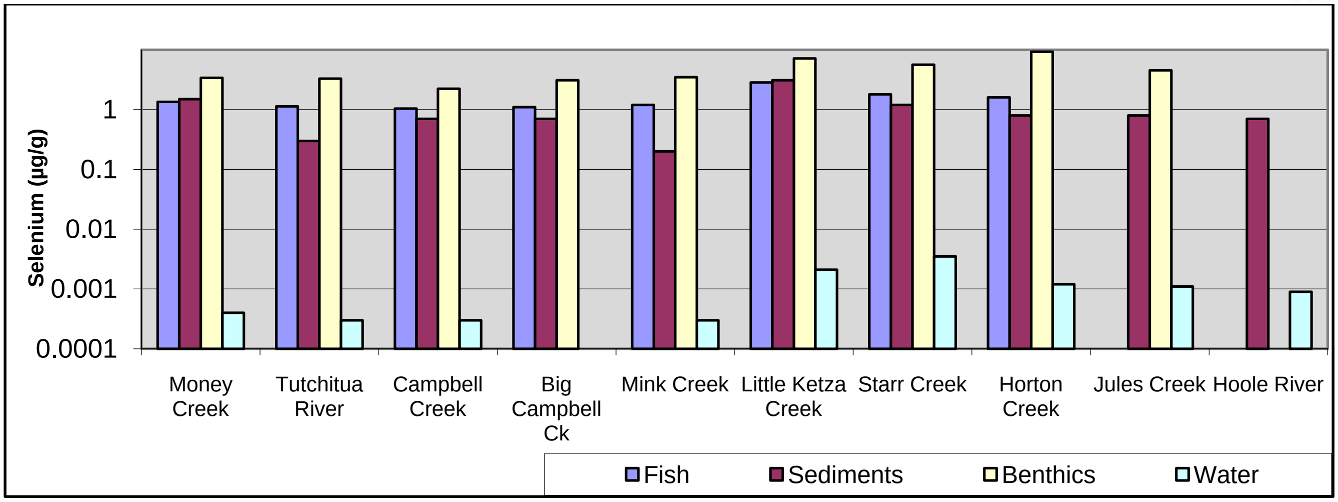


Figure 3: Selenium concentrations for all sample media from all sample locations.

The range of selenium concentrations in the various sample media is shown in the following list:

- Fish (individual) – 1.0 µg/g wet weight (Campbell Creek) to 3.7 µg/g wet weight (Little Ketza Creek).
- Stream Sediments – 0.2 µg/g dry weight (Mink Creek) to 3.1 µg/g dry weight (Little Ketza Creek).
- Benthic Invertebrates – 2.2 µg/g wet weight (Campbell Creek) to 9.3 µg/g wet weight (Horton Creek).
- Water – 0.0001 µg/g (Big Campbell Creek) to 0.0035 µg/g (Starr Creek).

3.2.2 ARSENIC

The highest arsenic concentrations were found in stream sediments, with moderate levels found in benthic invertebrates (Figure 4). Relatively low concentrations were found in water and barely detectable levels were found in fish tissues. As shown in Figure 4, these patterns were relatively consistent among sampling sites.

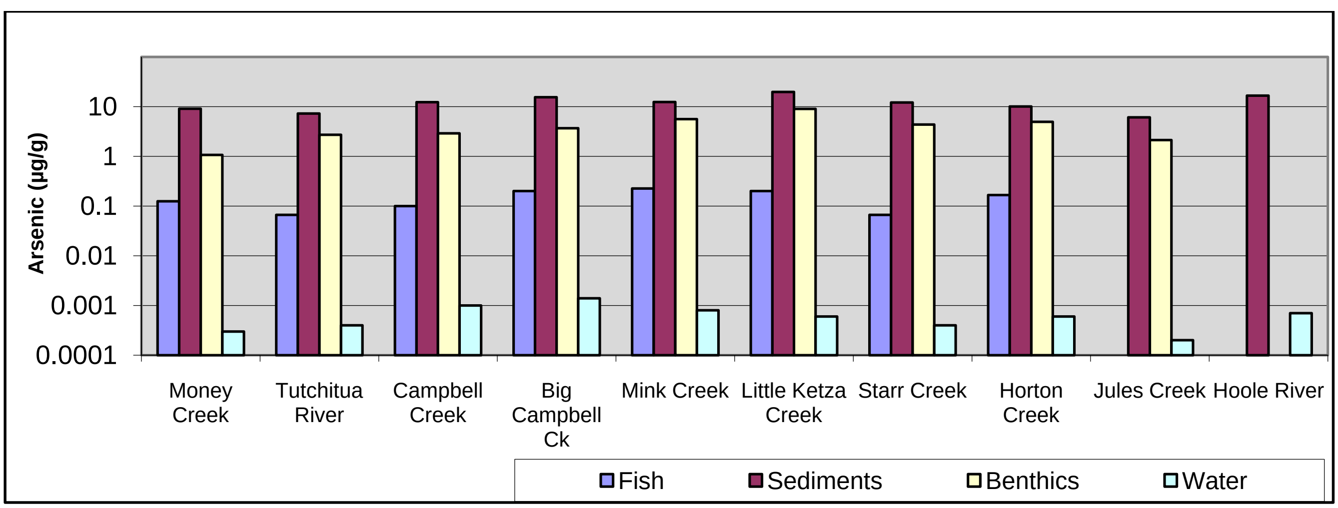


Figure 4: Arsenic concentrations for all sample media from all sample locations.

3.2.3 MERCURY

Concentrations of mercury were found to be quite variable among sample media and sample locations, as indicated in Figure 5; however, benthic invertebrates and stream sediments typically had the highest levels.

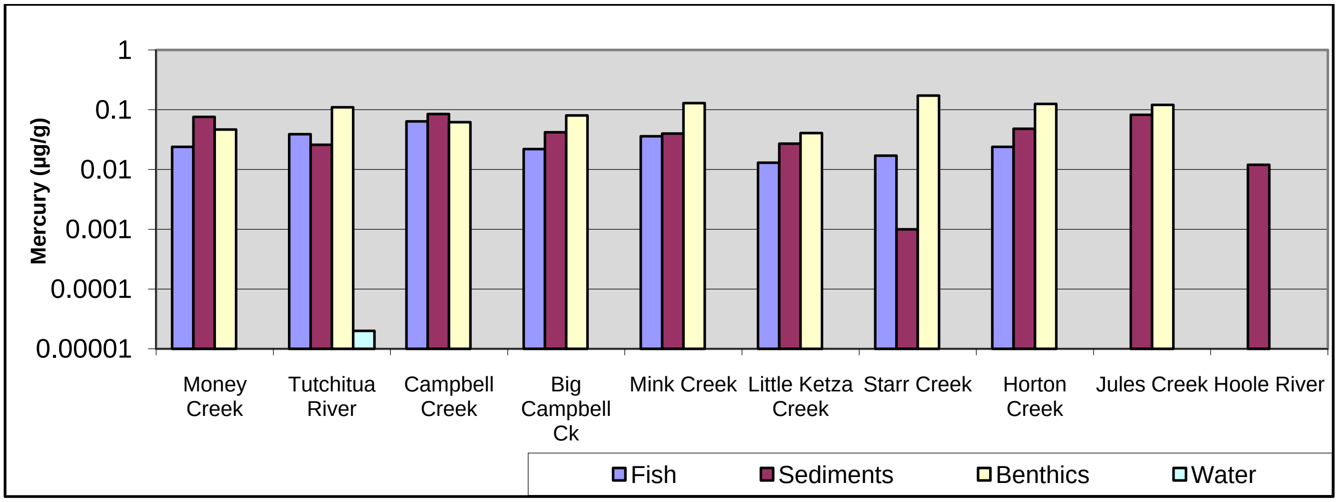


Figure 5: Mercury concentrations for all sample media from all sample locations.

3.2.4 BERYLLIUM

The only notable levels of beryllium found were within the stream sediment media, which had levels that were fairly consistent among sampling locations (Figure 6), ranging from 0.17 µg/g dry weight (Tutchitua River) to 0.40 µg/g dry weight (Money Creek). The concentrations found in water samples were below or very near the detection limit of 0.002 µg/g at all sampling locations.

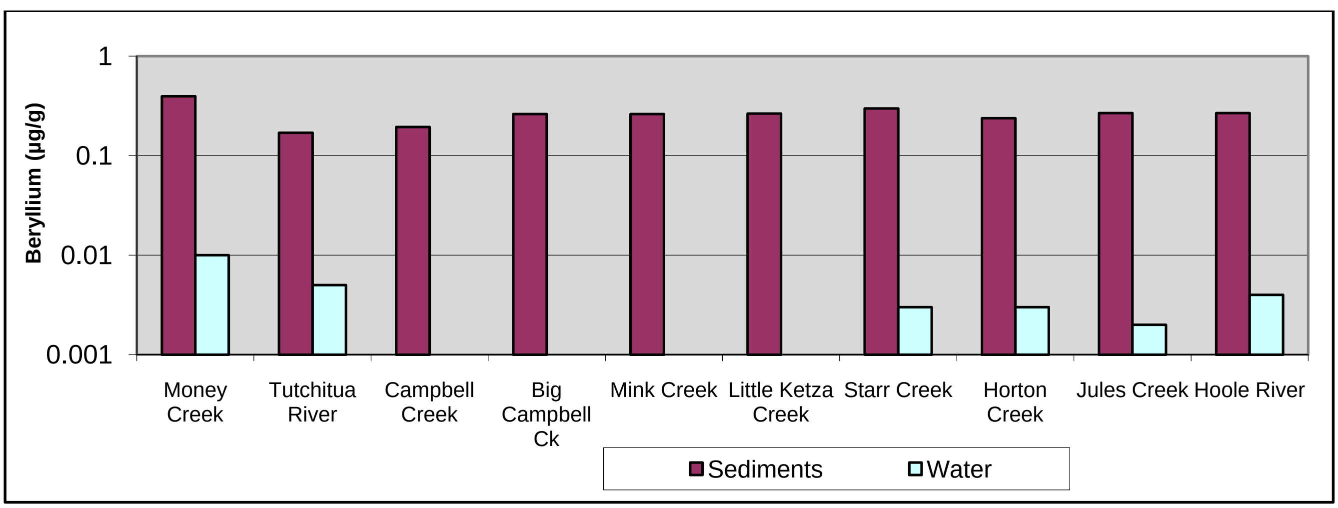


Figure 6: Beryllium concentrations for all sample media from all sample locations.

3.2.5 URANIUM

Uranium concentrations were found to be similar among sample media, with the exception of Little Ketza, Starr and Horton creeks; which showed substantially higher concentrations in water samples (Figure 7). The concentrations of this element were quite variable in water samples, with a range of 0.211 µg/g (Tutchitua River) to 9.98 µg/g (Little Ketza Creek). The concentrations of this element in stream sediment samples were more consistent, with a range of 0.654 µg/g dry weight (Jules Creek) to 1.71 µg/g dry weight (Little Ketza Creek).

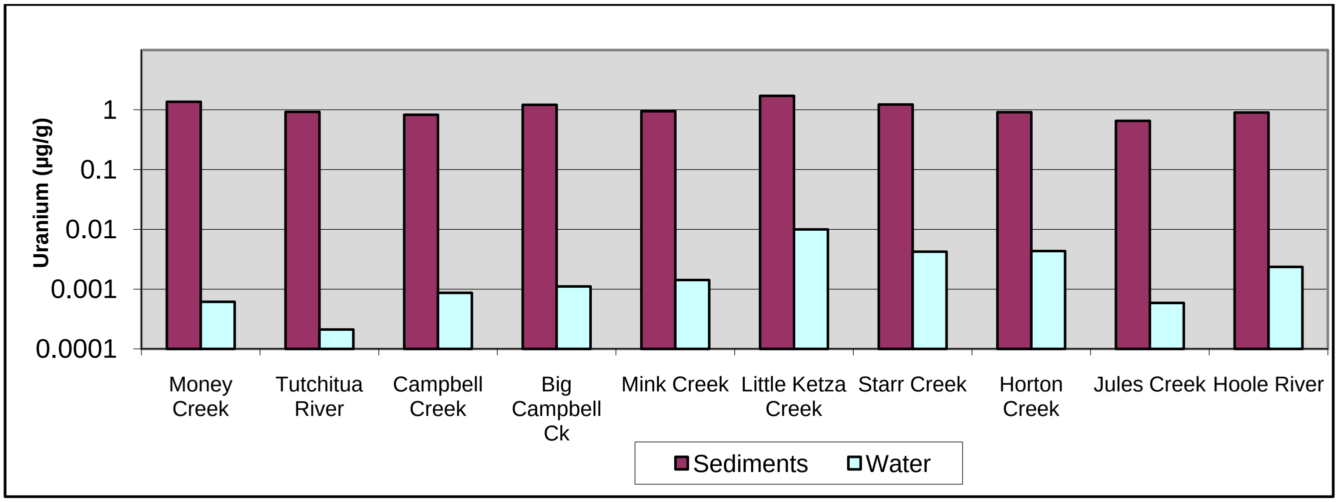


Figure 7: Uranium concentrations for all sample media from all sample locations.

3.2.6 VANADIUM

Similar to beryllium, vanadium was most apparent in the stream sediment media, which had concentrations in the range of 15.3 µg/g dry weight (Tutchitua River) to 31.1 µg/g dry weight (Jules Creek). Levels of this element in water samples were low, ranging from 0.1 µg/g (Big Campbell Creek) to 0.46 µg/g (Money Creek).

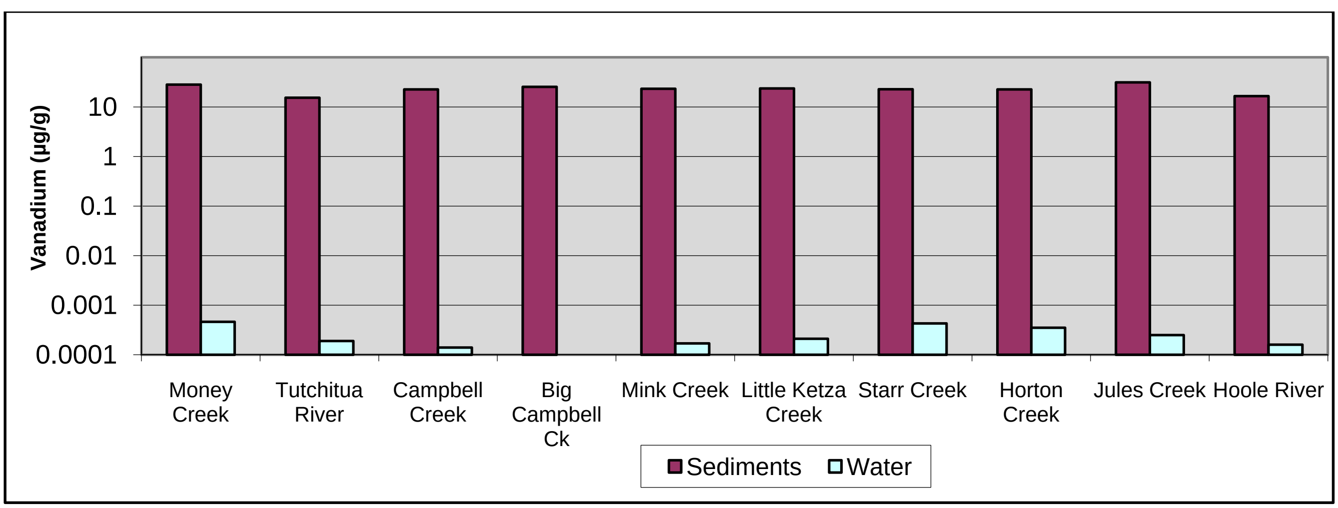


Figure 8: Vanadium concentrations for all sample media from all sample locations.

3.3 RELATIONSHIP BETWEEN SAMPLE MEDIA

Examining the relationship between elemental concentrations in different sample media is valuable because it provides information on movement of organophilic metals, namely selenium, through the aquatic ecosystem. Figure 9 through Figure 13 show the results of regression analyses of selenium concentrations in various sample media. Note that in the figures below, each point represents the mean selenium concentration at a sampling location. For the remaining organophilic elements, similar figures can be found in Appendix H.

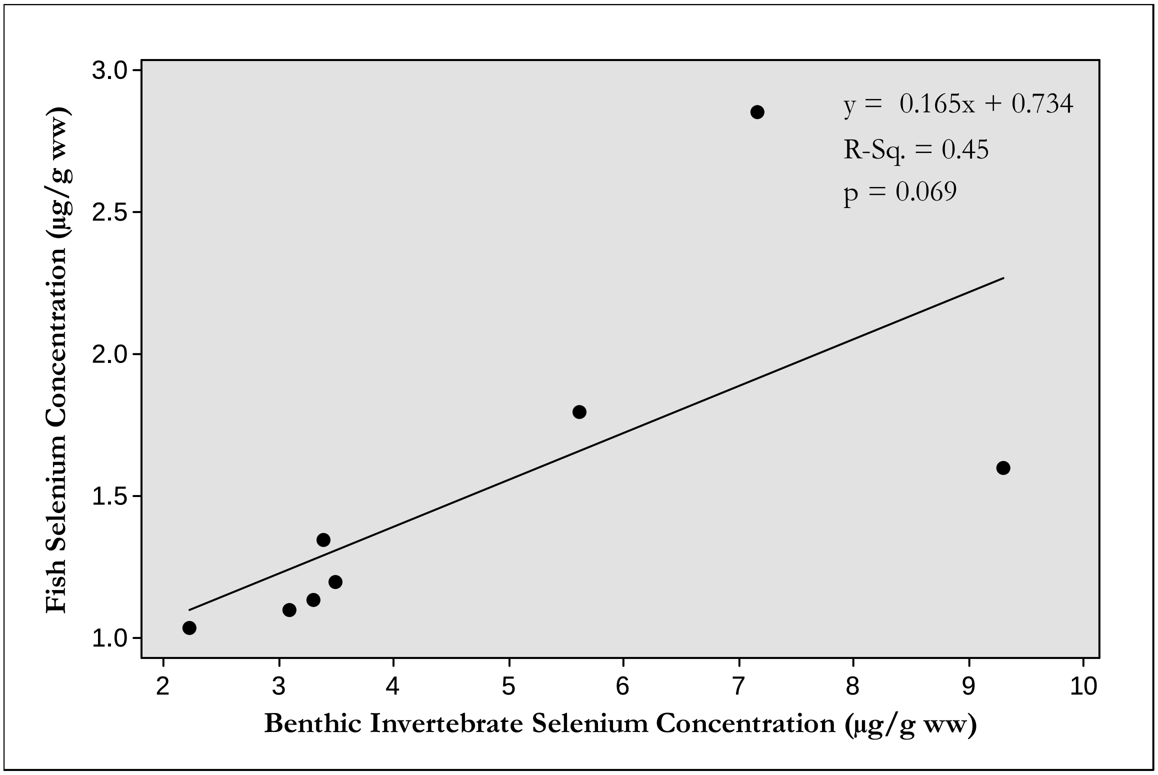


Figure 9: Relationship between selenium concentrations in benthic invertebrates and fish tissue.

As shown in Figure 9, there is a positive trend in the relationship between the selenium concentrations in whole-body fish tissue, and that in benthic invertebrate tissue. The relationship is not a significant one ($p > 0.05$); however, a weakly positive trend was noted. As the selenium concentration in benthic invertebrates increases, so does the selenium concentrations in slimy sculpin tissue.

Relationships were similarly investigated between the following: fish tissue and stream sediment (Figure 10), fish tissue and water (Figure 11), benthic invertebrates and stream sediments (Figure 12), and benthic invertebrates and water (Figure 13). All relationships displayed a positive trend, however, the only statistically significant relationship noted was between the total selenium concentration in whole-body slimy sculpin tissue and sediment ($p = 0.002$). Therefore, as selenium concentration in sediment increased, so did the selenium concentrations in the tissues of fish sampled.

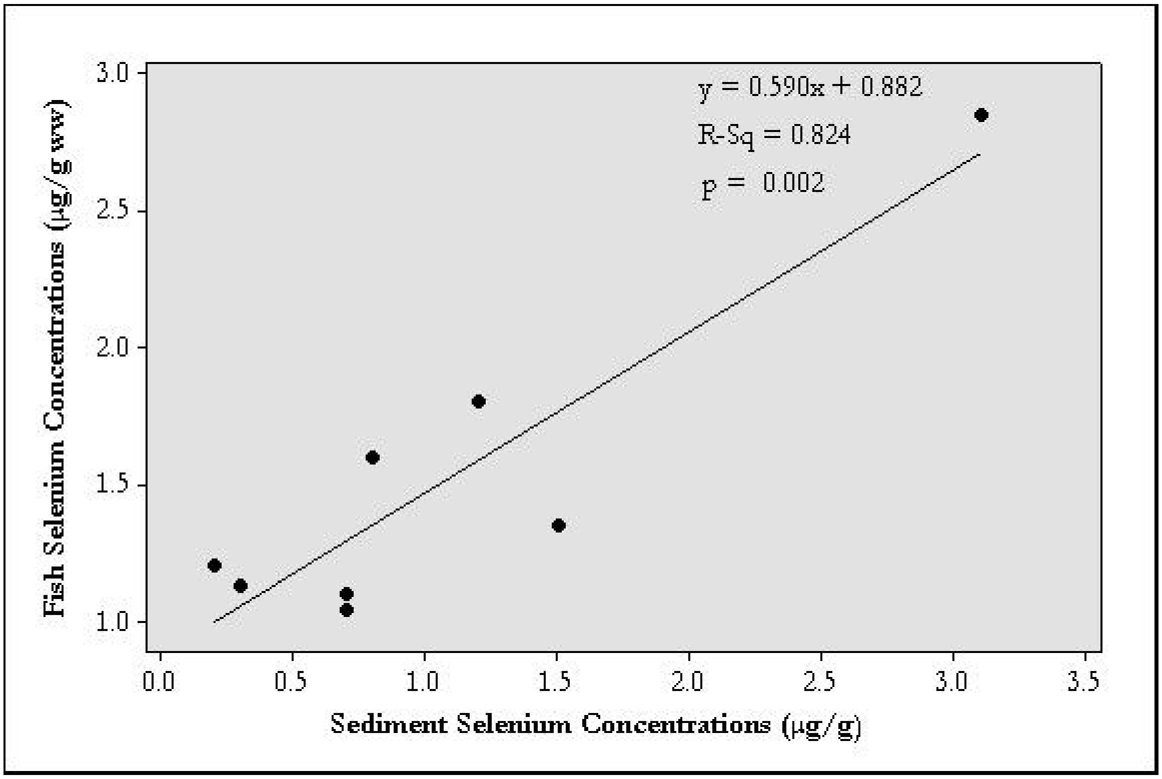


Figure 10: Relationship between total selenium concentrations in stream sediment and fish tissue.

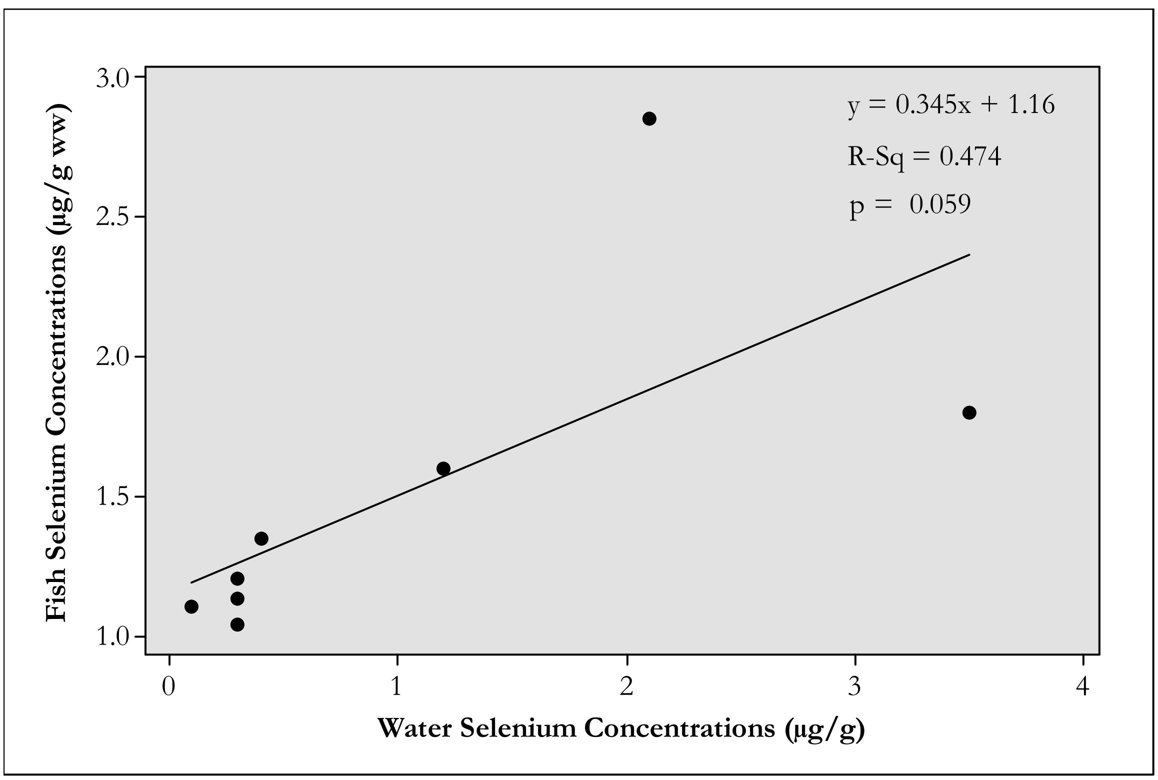


Figure 11: Relationship between total selenium concentrations in water and fish tissue.

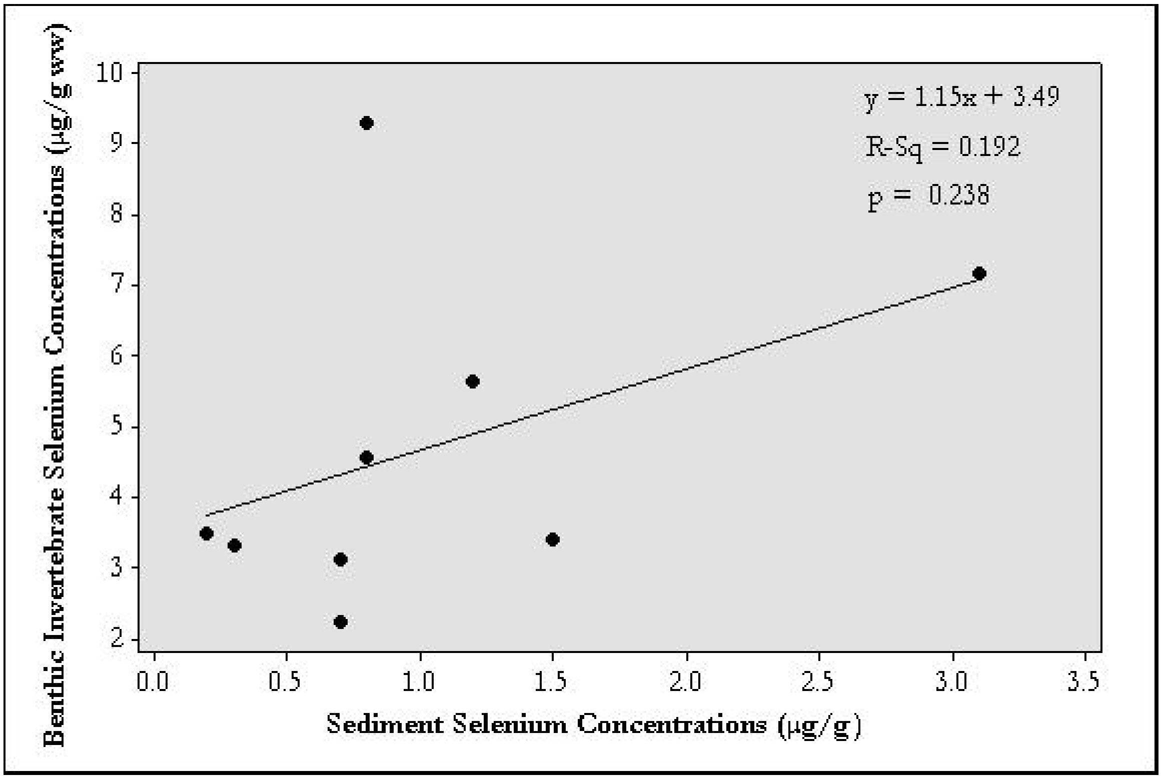


Figure 12: Relationship between total selenium concentrations in stream sediment and benthic invertebrates.

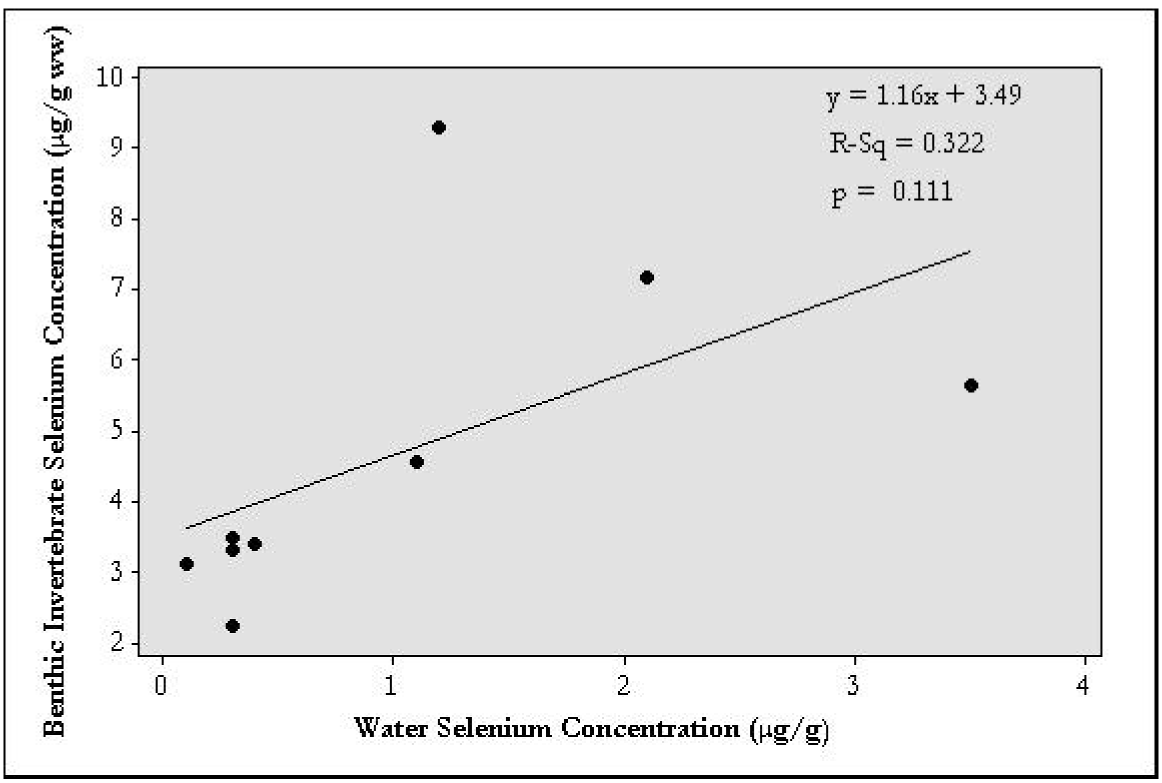


Figure 13: Relationship between total selenium concentrations in water and benthic invertebrates.

3.3.1 BIOCONCENTRATION FACTORS

Bioconcentration factors are a useful tool for assessing the uptake of metals into biota in aquatic ecosystems. Bioconcentration factors illustrate the relationship between metal levels in animal tissues (i.e. fish tissue, benthic invertebrates) and the concentrations of these same metals in possible sources of uptake (i.e. water, stream sediments, benthic invertebrates). Bioconcentration factors for the organophilic metals of interest in this study were calculated using the following formula:

$$\text{Bioconcentration Factor (BCF)} = \frac{\text{Concentration of Chemical in Tissues}}{\text{Exposure Concentration}}$$

Table 3 to

Table 5 below summarize the bioconcentration factors for arsenic, selenium and mercury for all sample locations.

Table 3: Bioconcentration factors for arsenic.

Stream Name	Benthic Invertebrates / Stream Sediments	Fish / Benthic Invertebrates	Fish / Water
Money Creek	0.117	0.117	417
Tutchitua River	0.372	0.025	168
Little Campbell River	0.236	0.034	100
Big Campbell Creek	0.238	0.054	143
Mink Creek	0.453	0.040	281
Little Ketza Creek	0.457	0.022	333
Starr Creek	0.360	0.015	167
Horton Creek	0.489	0.034	278
Average	***0.340***	***0.043***	***236***
Range	***0.117 – 0.489***	***0.015 – 0.117***	***100 - 417***

Table 4: Bioconcentration factors for selenium.

Stream Name	Benthic Invertebrates / Stream Sediments	Fish / Benthic Invertebrates	Fish / Water
Money Creek	2.261	0.398	3375
Tutchitua River	10.982	0.344	3777
Little Campbell River	3.184	0.467	3467
Big Campbell Creek	4.430	0.355	11000
Mink Creek	17.442	0.344	4000
Little Ketza Creek	2.313	0.397	1357
Starr Creek	4.684	0.320	514
Horton Creek	11.628	0.172	1333
Average	***7.115***	***0.350***	***3603***
Range	***2.261 - 17.442***	***0.172 - 0.467***	***514 - 11000***

Table 5: Bioconcentration factors for mercury.

Stream Name	Benthic Invertebrates / Stream Sediments	Fish / Benthic Invertebrates	Fish / Water
Money Creek	0.612	0.516	2400
Tutchitua River	4.211	0.356	1950
Little Campbell River	0.730	1.032	6400
Big Campbell Creek	1.915	0.274	2200
Mink Creek	3.222	0.279	3600
Little Ketza Creek	1.507	0.319	1300
Starr Creek	172.482	0.099	1700
Horton Creek	2.604	0.192	2400
Average	***23.410***	***0.383***	***2744***
Range	***0.612 - 172.482***	***0.099 - 1.032***	***1300 - 6400***

Overall, bioconcentration factors were highest for selenium, followed by mercury and then arsenic. Bioconcentration factors illustrating the relationship between metal concentrations in fish and water were highest overall, followed by bioconcentration factors for sediments and benthic invertebrates. Bioconcentration factors illustrating the relationship between metal concentrations in benthic invertebrates and fish showed the lowest values overall.

The concentration of selenium in benthic invertebrates was, on average, 7.1 times greater than in stream sediments, and at one location (Mink Creek) was 17.4 times greater. The concentration of selenium in fish (slimy sculpin, a benthivorous species) was, on average, only 0.4 times greater than in benthic invertebrates. The concentration of selenium in fish was, on average, 3600 times greater than in water, and at one location (Big Campbell Creek) was 11000 times greater.

The concentration of mercury was, on average, 23 times higher in benthic invertebrates than in stream sediments. However, this mean value was influenced by a high mercury bioconcentration factor of 172.5 at Starr Creek. Excluding this value, the concentration of mercury was between 0.6 and 4.2 times greater in benthic invertebrates than in sediments. The concentration of mercury in slimy sculpin was, on average, 0.38 times the concentrations found in benthic invertebrates. The concentration of mercury in fish was, on average, 2744 times higher than in water, and at one location was 6400 times higher.

Bioconcentration factors for arsenic were lower in all comparisons, but reflected the same trend in relative values as in mercury and selenium. The mean bioconcentration factor for water and fish had the greatest value (236), followed by the mean bioconcentration factor for benthic invertebrates and fish (0.04). The mean bioconcentration factor for benthic invertebrates and stream sediments had the lowest value (0.03).

3.3.2 BENTHIC INVERTEBRATE COMMUNITY COMPOSITION

Fifteen orders of benthic invertebrates were found in the study area. Within these, a total of 81 taxa were identified to genus. Percent composition of each taxum at each location was calculated. Abundance data for all taxa at all streams are presented in Appendix C.

Among all locations, Diptera and Ephemeroptera were the two most common orders of benthic invertebrates present. Within the order Diptera, species of the family Chironomidae were the most abundant in all locations, comprising between 12.77% and 62.59% of the benthic invertebrates sampled in each stream. The three most abundant Chironomidae species were *Cricotopus* sp. (2.44 - 31.29%), *Rheotanytarsus* sp. (0.00 - 21.34%), and *Diamesa* sp. (0.37 - 14.05%). Within the order Ephemeroptera, *Baetis* sp. was particularly abundant in six of nine sampling locations, comprising between 7.48% and 40.43% of the benthic invertebrates samples in these streams.

Several species were abundant in one stream but found rarely or not at all in others. Four species of the order Bassommatophora were found only at Campbell Creek and not at any other location. Of these, *Fossaria modicella* and *Pisidium* sp. were particularly abundant, comprising 15.19% and 24.07%, respectively, of the benthic invertebrates sampled at this site. *Candona* sp. was particularly abundant in Little Ketza Creek, comprising 41.82% of the benthic invertebrates sampled. This species was present, but not abundant, at several other locations.

4 DISCUSSION

There remains a very limited database of information on selenium concentrations in aquatic environments in the Yukon. This store of data is important, particularly in regions currently undergoing exploration and mining, and even more so in highly mineralized areas where mining activity is likely to occur in the future. Mining for a variety of resources, including coal and precious metals, is capable of mobilizing selenium previously trapped in rock, thereby increasing its concentration in the aquatic food web. Therefore, a large store of baseline data, covering a large geological area of the Yukon, would provide a means by which to appraise any increases in selenium concentrations in aquatic environments.

The sampling sites chosen for this study were all located on fast-flowing, clear water streams with low turbidity. Past research has shown that fine organic sediments (including those produced by deposition and decay of particulate matter and plant and animal tissue) are rare in this type of system because they are continuously flushed. Therefore, there is little opportunity for a contaminated surface layer of sediment to build up, and rooted plants are scarce. Concentrations of selenium in stream sediments in this study ranged from 0.2 μg/g in Mink Creek to a high of 3.1 μg/g in Little Ketza Creek. Little Ketza Creek was one of the smaller watercourses sampled, and was flowing at a slightly slower rate than the others, which could possibly have led to higher selenium concentrations through greater deposition of organic matter. Also, there is some variation in bedrock geology between sampling locations (Figure 1). Little Ketza Creek is located in a regions dominated by shale/claystone/siltstone/sandstone/conglomerate/coal, while the majority of other sites site on geology dominated by silt/sand/gravel. This difference in bedrock may help explain variations in selenium concentration, particularly as selenium has been associated with coal in the past. (Chapman 2005). There is some data available from both the Kudz Ze Kayah (KZK) mine site (Cominco Ltd., 1998) as well as Viceroy Brewery Creek (Viceroy Minerals Corporation, 2003). Unfortunately, these mine sites were sampled only after exploration and/or mining activities were initiated. However, sediment concentrations at the KZK mine site ranged from 0.76 to 3.46 μg/g (1997), while Brewery Creek concentrations ranged from 0.80 to 3.13 μg/g; selenium concentrations quite similar in value and range to those found as part of this current study.

Concentrations of total selenium in the water column of streams sampled as part of this study ranged from undetectable (< 0.2 μg/L) to a high of 3.5 μg/L; and many exceeded the CCME water quality criteria (1.0 μg/L). The highest concentrations were noted in Starr, Horton and Little Ketza creeks; again these creeks were the smallest among those sampled. The concentrations of total and dissolved metals are nearly equal in all sites; this likely occurs because these are fast-slowing clear water streams with a negligible amount of suspended particulate matter. Water column concentrations of total selenium in streams sampled as part of the KZK program had a mean total selenium concentration of 0.4 μg/L, while concentrations of selenium in water from the Brewery Creek mine ranged from 0.5 to 1.60 μg/L (2002 data). Therefore, concentrations at the KZK and Brewery Creek sites were lower than in those stream sampled as part of this study. This, however, it not surprising as some variation is expected throughout the Territory, depending on the degree of mineralization, and the bedrock characteristics of a given area. Some water samples from all areas exceeded the CCME selenium criteria for the protection of aquatic life. Federal guidelines, developed by CCME are designed to be generic, and protective of all water bodies/watercourses, including the most sensitive. The selenium guideline was derived using data from water in reservoirs in much warmer climates, mostly from the United States. Warmer water leads to greater uptake of selenium into biological tissues. The aquatic ecosystems sampled here are very different, being fast-flowing cold water streams, which do not promote the same rapid uptake of selenium into biota. It has long been recognized that proper management of selenium concentration in aquatic systems requires site-specific guidelines. Both KZK and Brewery Creek were required by the Yukon Water Board to set site-specific guidelines, and both arrived at the same value: 3.8 μg/L total selenium in water. Total selenium concentrations in all water samples taken as part of this study fell below this guideline value.

Selenium concentrations in slimy sculpin in the streams sampled as part of this study ranged from 1.0 μg/g wet weight in Campbell Creek to 3.7 μg/g wet weight in Little Ketza Creek. All fish samples met or exceeded the BC tissue guideline for selenium (1.0 μg/g wet weight). The slimy sculpin sampled from Finlayson Creek as part of the KZK study had selenium concentrations that ranged from 0.6 to 1.3 μg/g wet weight, slightly lower than what was found in this study; the same trend as seen in the water column data. Very few slimy sculpin were sampled as part of the Brewery Creek assessment, and of those sampled all had selenium concentrations that were below the detection limit (0.4 μg/g wet weight).

Selenium concentrations were generally higher in benthic invertebrates than in fish. This is expected due to the fact that benthic invertebrates are bottom-dwellers, living in constant contact with stream sediments; therefore, they acquire selenium through both ingestion and absorption. Slimy sculpin, on the other hand, do not burrow within the stream sediment and they take up very little selenium from the water column through respiration; therefore they are largely exposed to selenium through the benthos, which they consume. The selenium concentrations in the benthos are therefore diluted throughout the fish tissue, or excreted, resulting in fish selenium concentrations that are slightly lower than those seen in the benthos. Periphyton samples were collected as part of this study; however, the mass collected was not sufficient to allow for metals analysis. Such information would be valuable in the future as it would provide another dietary source from which fish species ingest selenium.

Relationships between selenium concentrations in the various media/biota were investigated. There were positive trends between total selenium concentrations in the whole-body fish samples and concentrations in both stream sediments and the water column. The relationship between selenium concentrations in fish tissue and those in stream sediments was the only statistically significant relationship found. Positive relationships were also noted between selenium concentrations in benthic invertebrates and those in stream sediments and the water column, however, these relationships were notably weaker. This study was somewhat weakened by the sample size. More samples would increase statistical power, and likely strengthen these relationships.

Bioconcentration factors (BCFs) were highest for selenium, followed by mercury and arsenic. Therefore, the proportion of selenium being taken up by biota from the aquatic environment is greater than other organophilic metals. It has been determined by past studies that selenium is preferentially taken up by biota through diet rather than by absorption from water (see, for example, Adams et al. 2000; Chapman, 2005). Selenium concentrations in slimy sculpin tissue were, on average, 0.35 times that of selenium concentrations in benthic invertebrates. This is likely due to the dilution of selenium from benthic invertebrate tissue into fish tissue. The selenium concentration in fish tissue was on average 3.6 times greater than that in the water column. It is difficult to determine the source of the majority of selenium in the fish tissue; however, it is known that uptake of organophilic metals is through diet rather than through passive uptake from water. Selenium concentrations in benthic invertebrate tissue seem to be acquired mostly from sediments. The BCF of selenium from sediment into benthic invertebrates was 7.1, the highest BFC seen in this study. However, this was expected since benthic invertebrates both live in sediment, and consume detritus material within the sediment, therefore maximizing their exposure. It would be useful to conduct selenium analysis in periphyton as part of a future study as periphyton provides an additional dietary source of selenium for slimy sculpin that was not investigated by this study.

Finally, a secondary objective of this study was to identify and document the community composition of benthic invertebrates in the study streams effort. Various benthic invertebrate species react differently to changes in water quality and quantity (flow rates), whether due to natural or anthropogenic causes. Creating a database that includes the benthic invertebrate species present and relative percentages of different species in each of the study streams will allow comparisons to be made with future data. Changes in composition can help interpret changes in the watercourse itself. Currently, Diptera and Ephemeroptera are the most common orders of benthic invertebrates found in all the streams. While Diptera are very common, and can tolerate less than ideal conditions with respect to water quality and contaminants, Ephemeroptera (mayflies) are indicators of excellent stream quality. As stream quality decreases, through changes in water quality or stream flow, diversity of mayflies decreases. They are known to be particularly sensitive to mining waste.

5 CONCLUSIONS

The data collected as part of this study is an excellent beginning to the creation of a database of selenium concentrations in aquatic systems in mineralized regions of the Yukon. Some conclusions can be made from the data collected as part of this study:

- Total selenium concentrations in fish exceed the BC tissue guideline, and total selenium concentration in water exceeded the CCME guideline for the protection of aquatic life in nearly all samples. These guidelines were designed with data from aquatic systems very different with respect to stream hydraulics and water quality; it is likely that they are too conservative for most watercourses in the Yukon Territory.

- Sediment acts as the store of selenium, and benthic invertebrates aid in the movement of the metal from sediment into the food web.

- Benthic invertebrates sampled appear to take up selenium very efficiently from the sediment, whereas fish take up selenium from both water, and from diet, through benthic invertebrates.

- Further data collection, including metals analysis in periphyton may help complete this picture.

- Valuable data on the community composition and abundance of benthic invertebrates in a series of streams in the Finlayson Region of the Yukon have been collected and documented. This data will be useful for comparison purposes to track any potential changes should any of this area be affected by future mining or other anthropologic activities.

6 LITERATURE CITED

Adams, W., Toll, J., Brix, K., Tear, L., and D. DeForest. 2000. Site-specific approaches for setting water quality criteria for selenium: differences between lotic and lentic systems. Proceedings of the 24th annual British Columbia Mine Reclamation Symposium, Williams Lake, BC.

Ministry of Water, Land, and Air Protection (now Ministry of Environment). 2001. British Columbia approved water quality guidelines (criteria): 1998 edition, updated August 24, 2001. Victoria, BC.

Canadian Council of Ministers of the Environment (CCME). 2002. Canadian water quality guidelines for the protection of aquatic life: Summary table. In: Canadian environmental quality guidelines, CCME, Winnipeg, Manitoba. (http://www2.ec.gc.ca/ceqg-rcge/water.pdf)

Chapman, P. 2005. Selenium monitoring and management – new mines. Golder Associates, North Vancouver, BC.

Cominco Ltd. 1998. Kudz Ze Kayah Water License Application.

Hart, C. 1999. The Geological Framework of the Yukon Territory. Yukon Geological Survey [online]. Available from http://geology.yk.net/publications/summaries/framework.html

Minitab Inc. 2007. Minitab Statistical Software, Version 15.0, State College, PA, USA.

Reynoldson, T., Logan, C., Pascoe, T., and S. Thompson. 2003. Canadian aquatic biomonitoring network (CABIN) Invertebrate Biomonitoring Field and Laboratory Manual. National Water Research Institute, Environment Canada.

Viceroy Minerals Corporation. 2003. Viceroy Minerals Corporation; Site Specific Selenium Criteria Report. Addendum to: 2001 Decommissioning and Reclamation Plan. February 2003.

Yukon Ecoregions Working Group, 2004. Yukon Plateau-North. *In*: Ecoregions of the Yukon Territory: Biophysical properties of Yukon landscapes, C.A.S. Smith, J.C. Meikle and C.F. Roots (eds.), Agriculture and Agri-Food Canada, PARC Technical Bulletin No. 04-01, Summerland, British Columbia, p. 63-72.

Appendix A. Physical Stream Data

Stream Name	Date	Average Channel Width (m)	Average Wetted Width (m)	Average Residual Pool Depth (m)	Average Gradient (%)	Bed Material		Water Quality			
						Dom.	Sub Dom.	Temp (°C)	pH	Conductivity	Turbidity
Horton Creek	26-Jul-07	14.2	10.2	0.2	3.5	gravel	cobble	10.29	7.98	753	clear
Starr Creek	26-Jul-07	10.8	6.5	0.4	2	cobble	boulder	7.32	8.05	745	lightly turbid
Big Campbell Creek	25-Jul-07	27.0	25.4	NA	1	cobble	boulder	14.46	7.71	602	clear
Jules Creek	24-Jul-07	7.9	5.1	0.9	2	gravel	fines	4.9	7.55	473	clear
Mink Creek	25-Jul-07	15.3	11.7	0.6	1	gravel	cobble	11.52	7.71	656	clear
Hoole River	25-Jul-07	30.0	25.0	1.2	2	boulder	cobble	12.93	8	712	lightly turbid
Tutchitua River	24-Jul-07	46.0	45.0	1.0	1	gravel	boulder	10.42	7	439	lightly turbid
Money Creek	24-Jul-07	DNS	0.5	DNS	3	cobble	gravel	11.31	7.89	465	clear
Little Ketza Creek	26-Jul-07	4.5	2.8	0.2	2	cobble	gravel	10.31	7.72	1101	lightly turbid
Little Campbell Creek	25-Jul-07	11.3	8.5	0.6	1.5	boulder	cobble	15.6	7.89	708	clear

Stream Name	Fish Sampling						Estimated Discharge (m^3/s)	Comments
	Method	Effort (mins)	Effort (m)	CCG Captured	CH Captured	BB Captured		
Horton Creek	electrofishing	40	100	18	3	0	0.68	
Starr Creek	electrofishing	50	60	7	2	0	3.6	
Big Campbell Creek	electrofishing	NA	300	9	6	0	9.15	
Jules Creek	electrofishing	37	120	0	0	0	3.4	
Mink Creek	electrofishing	53	150	24	2	1	5.9	
Hoole River	electrofishing	70	40	0	3	0	DNS	could not accurately measure stream attributes due to large size of stream (estimates only)
Tutchitua River	electrofishing	34	35	6	0	0	DNS	could not accurately measure stream attributes due to large size of stream (estimates only)
Money Creek	electrofishing	NA	200	11	0	0	DNS	
Little Ketza Creek	electrofishing	40	90	19	9	0	0.37	1 unidentified whitefish observed
Little Campbell Creek	electrofishing	29	30	16	0	0	1.67	

Appendix B. Photo documentation

Photo A: Downstream view of Little Ketza Creek in the vicinity of the Campbell Highway Crossing.

Photo B: Upstream view of Horton Creek in the vicinity of the Campbell Highway Crossing.

Photo C: Upstream view of Starr Creek in the vicinity of the Campbell Highway Crossing.

Photo D: Upstream view of the Hoole Creek in the vicinity of the Campbell Highway Crossing.

Photo E: Upstream view of Mink Creek in the vicinity of the Campbell Highway Crossing.

Photo F: Downstream view of Big Campbell Creek in the vicinity of the Campbell Highway Crossing.

Photo G: Upstream view of (Little) Campbell Creek in the vicinity of the Campbell Highway Crossing.

Photo H: Upstream view of Money Creek in the vicinity of the Campbell Highway Crossing.

Photo I: Downstream view of Jules Creek in the vicinity of the Campbell Highway Crossing.

Photo J: Downstream view of the Tutchitua River in the vicinity of the Campbell Highway Crossing.

Appendix C. Benthic Invertebrate Community Data

Stream	Sampler Mesh Size (um)	Individuals per Replicate	Abundance per Replicate (%)	Invertebrate Taxa Identification	Phylum	Class	Order	Family	Genus	species
Tuchitua River	363	6	1.43	Ameletus sp	Arthropoda	Insecta	Ephemeroptera	Siphlonuridae	Ameletus	
Tuchitua River	363	52	12.38	Baetis sp	Arthropoda	Insecta	Ephemeroptera	Baetidae	Baetis	
Tuchitua River	363	1	0.24	Brillia sp	Arthropoda	Insecta	Diptera	Chironomidae	Brillia	
Tuchitua River	363	1	0.24	Capnia sp	Arthropoda	Insecta	Plecoptera	Capniidae	Capnia	
Tuchitua River	363	1	0.24	Cardiocladius sp	Arthropoda	Insecta	Diptera	Chironomidae	Cardiocladius	
Tuchitua River	363	3	0.71	Chelifera sp	Arthropoda	Insecta	Diptera	Empididae	Chelifera	
Tuchitua River	363	45	10.71	Chironomidae	Arthropoda	Insecta	Diptera	Chironomidae		
Tuchitua River	363	37	8.81	Cinygmula sp	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Cinygmula	
Tuchitua River	363	1	0.24	Corynoneura sp	Arthropoda	Insecta	Diptera	Chironomidae	Corynoneura	
Tuchitua River	363	55	13.10	Cricotopus sp	Arthropoda	Insecta	Diptera	Chironomidae	Cricotopus	
Tuchitua River	363	1	0.24	Deuterophlebia sp	Arthropoda	Insecta	Diptera	Deuterophelbiidae	Deuterophlebia	
Tuchitua River	363	12	2.86	Diamesa sp	Arthropoda	Insecta	Diptera	Chironomidae	Diamesa	
Tuchitua River	363	17	4.05	Drunella doddsi	Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Drunella	Drunella doddsi
Tuchitua River	363	10	2.38	Epeorus (Iron) sp	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Epeorus	
Tuchitua River	363	9	2.14	Ephemerellidae	Arthropoda	Insecta	Ephemeroptera	Ephemerellidae		
Tuchitua River	363	6	1.43	Eukiefferiella sp	Arthropoda	Insecta	Diptera	Chironomidae	Eukiefferiella	
Tuchitua River	363	1	0.24	Euryhapsis sp	Arthropoda	Insecta	Diptera	Chironomidae	Euryhapsis	
Tuchitua River	363	10	2.38	Glossosoma sp	Arthropoda	Insecta	Trichoptera	Glossosomatidae	Glossosoma	
Tuchitua River	363	1	0.24	Hexatoma sp	Arthropoda	Insecta	Diptera	Tipulidae	Hexatoma	
Tuchitua River	363	6	1.43	Hydracarina	Arthropoda	Arachnida	Hydracarina			
Tuchitua River	363	1	0.24	Hydroptila sp	Arthropoda	Insecta	Trichoptera	Hydroptilidae	Hydroptila	
Tuchitua River	363	1	0.24	Hydrovatus sp	Arthropoda	Insecta	Coleoptera	Dytiscidae	Hydrovatus	
Tuchitua River	363	10	2.38	Lebertia sp	Arthropoda	Arachnida	Trombidiformes	Lebertiidae	Lebertia	
Tuchitua River	363	1	0.24	Nematoda	Nematoda					
Tuchitua River	363	3	0.71	Neumania sp	Arthropoda	Arachnida	Trombidiformes	Unionicolidae	Neumania	
Tuchitua River	363	1	0.24	Pericoma sp	Arthropoda	Insecta	Diptera	Psychodidae	Pericoma	
Tuchitua River	363	2	0.48	Plecoptera	Arthropoda	Insecta	Plecoptera			
Tuchitua River	363	5	1.19	Polycelis coronata	Platyhelminthes	Turbellaria	Tricladida	Planariidae	Polycelis	Polycelis coronata
Tuchitua River	363	4	0.95	Pseudostenophylax sp	Arthropoda	Insecta	Trichoptera	Limnephilidae	Pseudostenophylax	
Tuchitua River	363	61	14.52	Rheotanytarsus sp	Arthropoda	Insecta	Diptera	Chironomidae	Rheotanytarsus	
Tuchitua River	363	1	0.24	Rhithrogena sp	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Rhithrogena	
Tuchitua River	363	1	0.24	Rhyacophila acropedes	Arthropoda	Insecta	Trichoptera	Rhyacophilidae	Rhyacophila	Rhyacophila acropedes
Tuchitua River	363	1	0.24	Simulium sp	Arthropoda	Insecta	Diptera	Simuliidae	Simulium	
Tuchitua River	363	5	1.19	Skwala parallela	Arthropoda	Insecta	Plecoptera	Perlodidae	Skwala	Skwala parallela
Tuchitua River	363	8	1.90	Sperchon sp	Arthropoda	Arachnida	Trombidiformes	Sperchonidae	Sperchon	
Tuchitua River	363	9	2.14	Sweltsa sp	Arthropoda	Insecta	Plecoptera	Chloroperlidae	Sweltsa	
Tuchitua River	363	4	0.95	Thienemanniella sp	Arthropoda	Insecta	Diptera	Chironomidae	Thienemanniella	
Tuchitua River	363	5	1.19	Torrenticola sp	Arthropoda	Arachnida	Trombidiformes	Torrenticolidae	Torrenticola	
Tuchitua River	363	2	0.48	Trichoptera	Arthropoda	Insecta	Trichoptera			

Stream	Sampler Mesh Size (um)	Individuals per Replicate	Abundance per Replicate (%)	Invertebrate Taxa Identification	Phylum	Class	Order	Family	Genus	species
Tuchitua River	363	4	0.95	Unionicola sp	Arthropoda	Arachnida	Trombidiformes	Unionicolidae	Unionicola	
Tuchitua River	363	16	3.81	Zapada sp	Arthropoda	Insecta	Plecoptera	Nemouridae	Zapada	
Jules Creek	363	12	4.65	Ameletus sp	Arthropoda	Insecta	Ephemeroptera	Siphlonuridae	Ameletus	
Jules Creek	363	69	26.74	Baetis sp	Arthropoda	Insecta	Ephemeroptera	Baetidae	Baetis	
Jules Creek	363	1	0.39	Brillia sp	Arthropoda	Insecta	Diptera	Chironomidae	Brillia	
Jules Creek	363	1	0.39	Candona sp	Arthropoda	Crustacea	Cladocopina	Candoniidae	Candona	
Jules Creek	363	1	0.39	Capnia sp	Arthropoda	Insecta	Plecoptera	Capniidae	Capnia	
Jules Creek	363	9	3.49	Chironomidae	Arthropoda	Insecta	Diptera	Chironomidae		
Jules Creek	363	69	26.74	Cinygmula sp	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Cinygmula	
Jules Creek	363	2	0.78	Cnephia sp	Arthropoda	Insecta	Diptera	Simuliidae	Cnephia	
Jules Creek	363	18	6.98	Cricotopus sp	Arthropoda	Insecta	Diptera	Chironomidae	Cricotopus	
Jules Creek	363	16	6.20	Diamesa sp	Arthropoda	Insecta	Diptera	Chironomidae	Diamesa	
Jules Creek	363	1	0.39	Drunella doddsi	Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Drunella	Drunella doddsi
Jules Creek	363	7	2.71	Epeorus (Iron) sp	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Epeorus	
Jules Creek	363	4	1.55	Eukiefferiella sp	Arthropoda	Insecta	Diptera	Chironomidae	Eukiefferiella	
Jules Creek	363	4	1.55	Lebertia sp	Arthropoda	Arachnida	Trombidiformes	Lebertiidae	Lebertia	
Jules Creek	363	8	3.10	Mallochohelea sp	Arthropoda	Insecta	Diptera	Ceratopogonidae	Mallochohelea	
Jules Creek	363	2	0.78	Prosimulium sp	Arthropoda	Insecta	Diptera	Simuliidae	Prosimulium	
Jules Creek	363	2	0.78	Rheotanytarsus sp	Arthropoda	Insecta	Diptera	Chironomidae	Rheotanytarsus	
Jules Creek	363	1	0.39	Rhithrogena sp	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Rhithrogena	
Jules Creek	363	9	3.49	Simulium sp	Arthropoda	Insecta	Diptera	Simuliidae	Simulium	
Jules Creek	363	2	0.78	Sperchon sp	Arthropoda	Arachnida	Trombidiformes	Sperchonidae	Sperchon	
Jules Creek	363	7	2.71	Sweltsa sp	Arthropoda	Insecta	Plecoptera	Chloroperlidae	Sweltsa	
Jules Creek	363	2	0.78	Thienemanniella sp	Arthropoda	Insecta	Diptera	Chironomidae	Thienemanniella	
Jules Creek	363	3	1.16	Tubificidae	Annelida	Clitellata	Haplotaxida	Tubificidae		
Jules Creek	363	1	0.39	Unionicola sp	Arthropoda	Arachnida	Trombidiformes	Unionicolidae	Unionicola	
Jules Creek	363	7	2.71	Zapada sp	Arthropoda	Insecta	Plecoptera	Nemouridae	Zapada	
Money Creek	363	2	0.55	Ameletus sp	Arthropoda	Insecta	Ephemeroptera	Siphlonuridae	Ameletus	
Money Creek	363	1	0.28	Antocha sp	Arthropoda	Insecta	Diptera	Tipulidae	Antocha	
Money Creek	363	59	16.25	Baetis sp	Arthropoda	Insecta	Ephemeroptera	Baetidae	Baetis	
Money Creek	363	3	0.83	Beloneuria sp	Arthropoda	Insecta	Plecoptera	Perlidae	Beloneuria	
Money Creek	363	1	0.28	Brachycentrus sp	Arthropoda	Insecta	Trichoptera	Brachycentridae	Brachycentrus	
Money Creek	363	4	1.10	Brillia sp	Arthropoda	Insecta	Diptera	Chironomidae	Brillia	
Money Creek	363	1	0.28	Cardiocladius sp	Arthropoda	Insecta	Diptera	Chironomidae	Cardiocladius	
Money Creek	363	6	1.65	Chelifera sp	Arthropoda	Insecta	Diptera	Empididae	Chelifera	
Money Creek	363	23	6.34	Chironomidae	Arthropoda	Insecta	Diptera	Chironomidae		
Money Creek	363	7	1.93	Cinygmula sp	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Cinygmula	
Money Creek	363	84	23.14	Cricotopus sp	Arthropoda	Insecta	Diptera	Chironomidae	Cricotopus	
Money Creek	363	1	0.28	Deuterophlebia sp	Arthropoda	Insecta	Diptera	Deuterophelbiidae	Deuterophlebia	

Stream	Sampler Mesh Size (um)	Individuals per Replicate	Abundance per Replicate (%)	Invertebrate Taxa Identification	Phylum	Class	Order	Family	Genus	species
Money Creek	363	51	14.05	Diamesa sp	Arthropoda	Insecta	Diptera	Chironomidae	Diamesa	
Money Creek	363	4	1.10	Diptera	Arthropoda	Insecta	Diptera			
Money Creek	363	1	0.28	Drunella doddsi	Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Drunella	Drunella doddsi
Money Creek	363	1	0.28	Enchytraeidae	Annelida	Clitellata	Haplotaxida	Enchytraeidae		
Money Creek	363	18	4.96	Epeorus (Iron) sp	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Epeorus	
Money Creek	363	5	1.38	Drunella flavilinea	Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Drunella	Drunella flavilinea
Money Creek	363	6	1.65	Ephemerellidae	Arthropoda	Insecta	Ephemeroptera	Ephemerellidae		
Money Creek	363	6	1.65	Eukiefferiella sp	Arthropoda	Insecta	Diptera	Chironomidae	Eukiefferiella	
Money Creek	363	1	0.28	Euryhapsis sp	Arthropoda	Insecta	Diptera	Chironomidae	Euryhapsis	
Money Creek	363	4	1.10	Lebertia sp	Arthropoda	Arachnida	Trombidiformes	Lebertiidae	Lebertia	
Money Creek	363	1	0.28	Megarcys sp	Arthropoda	Insecta	Plecoptera	Perlodidae	Megarcys	
Money Creek	363	6	1.65	Micrasema sp	Arthropoda	Insecta	Trichoptera	Brachycentridae	Micrasema	
Money Creek	363	6	1.65	Nematoda	Nematoda					
Money Creek	363	6	1.65	Polycelis coronata	Platyhelminthes	Turbellaria	Tricladida	Planariidae	Polycelis	Polycelis coronata
Money Creek	363	2	0.55	Prosimulium sp	Arthropoda	Insecta	Diptera	Simuliidae	Prosimulium	
Money Creek	363	3	0.83	Pseudostenophylax sp	Arthropoda	Insecta	Trichoptera	Limnephilidae	Pseudostenophylax	
Money Creek	363	25	6.89	Rheotanytarsus sp	Arthropoda	Insecta	Diptera	Chironomidae	Rheotanytarsus	
Money Creek	363	1	0.28	Rhyacophila acropedes	Arthropoda	Insecta	Trichoptera	Rhyacophilidae	Rhyacophila	Rhyacophila acropedes
Money Creek	363	1	0.28	Rhyacophila sp	Arthropoda	Insecta	Trichoptera	Rhyacophilidae	Rhyacophila	
Money Creek	363	7	1.93	Simulium sp	Arthropoda	Insecta	Diptera	Simuliidae	Simulium	
Money Creek	363	2	0.55	Sweltsa sp	Arthropoda	Insecta	Plecoptera	Chloroperlidae	Sweltsa	
Money Creek	363	4	1.10	Thienemanniella sp	Arthropoda	Insecta	Diptera	Chironomidae	Thienemanniella	
Money Creek	363	4	1.10	Trichoptera	Arthropoda	Insecta	Trichoptera			
Money Creek	363	1	0.28	Tubificidae	Annelida	Clitellata	Haplotaxida	Tubificidae		
Money Creek	363	1	0.28	Unionicola sp	Arthropoda	Arachnida	Trombidiformes	Unionicolidae	Unionicola	
Money Creek	363	4	1.10	Zapada sp	Arthropoda	Insecta	Plecoptera	Nemouridae	Zapada	
Campbell Creek	363	1	0.19	Antocha sp	Arthropoda	Insecta	Diptera	Tipulidae	Antocha	
Campbell Creek	363	7	1.30	Baetis sp	Arthropoda	Insecta	Ephemeroptera	Baetidae	Baetis	
Campbell Creek	363	1	0.19	Brachycentrus sp	Arthropoda	Insecta	Trichoptera	Brachycentridae	Brachycentrus	
Campbell Creek	363	1	0.19	Brillia sp	Arthropoda	Insecta	Diptera	Chironomidae	Brillia	
Campbell Creek	363	3	0.56	Candona sp	Arthropoda	Crustacea	Cladocopina	Candoniidae	Candona	
Campbell Creek	363	5	0.93	Cardiocladius sp	Arthropoda	Insecta	Diptera	Chironomidae	Cardiocladius	
Campbell Creek	363	2	0.37	Chelifera sp	Arthropoda	Insecta	Diptera	Empididae	Chelifera	
Campbell Creek	363	27	5.00	Chironomidae	Arthropoda	Insecta	Diptera	Chironomidae		
Campbell Creek	363	71	13.15	Cricotopus sp	Arthropoda	Insecta	Diptera	Chironomidae	Cricotopus	
Campbell Creek	363	2	0.37	Diamesa sp	Arthropoda	Insecta	Diptera	Chironomidae	Diamesa	
Campbell Creek	363	2	0.37	Dicranota sp	Arthropoda	Insecta	Diptera	Tipulidae	Dicranota	
Campbell Creek	363	1	0.19	Drunella grandis	Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Drunella	Drunella grandis
Campbell Creek	363	4	0.74	Ecclisomyia sp	Arthropoda	Insecta	Trichoptera	Limnephilidae	Ecclisomyia	

Stream	Sampler Mesh Size (um)	Individuals per Replicate	Abundance per Replicate (%)	Invertebrate Taxa Identification	Phylum	Class	Order	Family	Genus	species
Campbell Creek	363	1	0.19	Empididae	Arthropoda	Insecta	Diptera	Empididae		
Campbell Creek	363	8	1.48	Enchytraeidae	Annelida	Clitellata	Haplotaxida	Enchytraeidae		
Campbell Creek	363	1	0.19	Ephemerellidae	Arthropoda	Insecta	Ephemeroptera	Ephemerellidae		
Campbell Creek	363	6	1.11	Eukiefferiella sp	Arthropoda	Insecta	Diptera	Chironomidae	Eukiefferiella	
Campbell Creek	363	1	0.19	Euryhapsis sp	Arthropoda	Insecta	Diptera	Chironomidae	Euryhapsis	
Campbell Creek	363	82	15.19	Fossaria modicella	Mollusca	Gastropoda	Basommatophora	Lymnaeidae	Fossaria	Fossaria modicella
Campbell Creek	363	4	0.74	Gyraulus parvus	Mollusca	Gastropoda	Basommatophora	Planorbidae	Gyraulus	Gyraulus parvus
Campbell Creek	363	9	1.67	Helisoma sp	Mollusca	Gastropoda	Basommatophora	Planorbidae	Helisoma	
Campbell Creek	363	3	0.56	Hydracarina	Arthropoda	Arachnida	Hydracarina			
Campbell Creek	363	14	2.59	Hydroptila sp	Arthropoda	Insecta	Trichoptera	Hydroptilidae	Hydroptila	
Campbell Creek	363	3	0.56	Lebertia sp	Arthropoda	Arachnida	Trombidiformes	Lebertiidae	Lebertia	
Campbell Creek	363	1	0.19	Micrasema sp	Arthropoda	Insecta	Trichoptera	Brachycentridae	Micrasema	
Campbell Creek	363	3	0.56	Nais sp	Annelida	Clitellata	Haplotaxida	Naididae	Nais	
Campbell Creek	363	1	0.19	Nematoda	Nematoda					
Campbell Creek	363	2	0.37	Neumania sp	Arthropoda	Arachnida	Trombidiformes	Unionicolidae	Neumania	
Campbell Creek	363	1	0.19	Oxyethira sp	Arthropoda	Insecta	Trichoptera	Hydroptilidae	Oxyethira	
Campbell Creek	363	20	3.70	Paraleptophlebia sp	Arthropoda	Insecta	Ephemeroptera	Leptophlebiidae	Paraleptophlebia	
Campbell Creek	363	18	3.33	Pericoma sp	Arthropoda	Insecta	Diptera	Psychodidae	Pericoma	
Campbell Creek	363	3	0.56	Physella gyrina	Mollusca	Gastropoda	Basommatophora	Physidae	Physella	Physella gyrina
Campbell Creek	363	130	24.07	Pisidium sp	Mollusca	Bivalvia	Veneroida	Pisidiidae	Pisidium	Pisidium subtruncatum
Campbell Creek	363	20	3.70	Rheotanytarsus sp	Arthropoda	Insecta	Diptera	Chironomidae	Rheotanytarsus	
Campbell Creek	363	2	0.37	Simulium sp	Arthropoda	Insecta	Diptera	Simuliidae	Simulium	
Campbell Creek	363	1	0.19	Skwala parallela	Arthropoda	Insecta	Plecoptera	Perlodidae	Skwala	Skwala parallela
Campbell Creek	363	4	0.74	Sperchon sp	Arthropoda	Arachnida	Trombidiformes	Sperchonidae	Sperchon	
Campbell Creek	363	1	0.19	Staphylinidae	Arthropoda	Insecta	Coleoptera	Staphylinidae		
Campbell Creek	363	7	1.30	Sweltsa sp	Arthropoda	Insecta	Plecoptera	Chloroperlidae	Sweltsa	
Campbell Creek	363	1	0.19	Synorthocladius sp	Arthropoda	Insecta	Diptera	Chironomidae	Synorthocladius	
Campbell Creek	363	6	1.11	Thienemanniella sp	Arthropoda	Insecta	Diptera	Chironomidae	Thienemanniella	
Campbell Creek	363	2	0.37	Thienemannimyia sp	Arthropoda	Insecta	Diptera	Chironomidae	Thienemannimyia	
Campbell Creek	363	3	0.56	Trichoptera	Arthropoda	Insecta	Trichoptera			
Campbell Creek	363	38	7.04	Tubificidae	Annelida	Clitellata	Haplotaxida	Tubificidae		
Campbell Creek	363	3	0.56	Unionicola sp	Arthropoda	Arachnida	Trombidiformes	Unionicolidae	Unionicola	
Campbell Creek	363	11	2.04	Valvata sincera	Mollusca	Gastropoda	Mesogastropoda	Valvatidae	Valvata	Valvata sincera
Campbell Creek	363	3	0.56	Zapada sp	Arthropoda	Insecta	Plecoptera	Nemouridae	Zapada	
Big Campbell Creek	363	1	0.61	Ameletus sp	Arthropoda	Insecta	Ephemeroptera	Siphlonuridae	Ameletus	
Big Campbell Creek	363	1	0.61	Antocha sp	Arthropoda	Insecta	Diptera	Tipulidae	Antocha	
Big Campbell Creek	363	32	19.51	Baetis sp	Arthropoda	Insecta	Ephemeroptera	Baetidae	Baetis	
Big Campbell Creek	363	1	0.61	Brachycentrus sp	Arthropoda	Insecta	Trichoptera	Brachycentridae	Brachycentrus	
Big Campbell Creek	363	1	0.61	Brillia sp	Arthropoda	Insecta	Diptera	Chironomidae	Brillia	

Stream	Sampler Mesh Size (um)	Individuals per Replicate	Abundance per Replicate (%)	Invertebrate Taxa Identification	Phylum	Class	Order	Family	Genus	species
Big Campbell Creek	363	1	0.61	Capnia sp	Arthropoda	Insecta	Plecoptera	Capniidae	Capnia	
Big Campbell Creek	363	3	1.83	Cardiocladius sp	Arthropoda	Insecta	Diptera	Chironomidae	Cardiocladius	
Big Campbell Creek	363	5	3.05	Chironomidae	Arthropoda	Insecta	Diptera	Chironomidae		
Big Campbell Creek	363	26	15.85	Cinygmula sp	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Cinygmula	
Big Campbell Creek	363	4	2.44	Cricotopus sp	Arthropoda	Insecta	Diptera	Chironomidae	Cricotopus	
Big Campbell Creek	363	1	0.61	Deuterophlebia sp	Arthropoda	Insecta	Diptera	Deuterophelbiidae	Deuterophlebia	
Big Campbell Creek	363	3	1.83	Diamesa sp	Arthropoda	Insecta	Diptera	Chironomidae	Diamesa	
Big Campbell Creek	363	6	3.66	Drunella doddsi	Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Drunella	Drunella doddsi
Big Campbell Creek	363	1	0.61	Drunella grandis	Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Drunella	Drunella grandis
Big Campbell Creek	363	1	0.61	Enchytraeidae	Annelida	Clitellata	Haplotaxida	Enchytraeidae		
Big Campbell Creek	363	1	0.61	Epeorus (Iron) sp	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Epeorus	
Big Campbell Creek	363	2	1.22	Drunella flavilinea	Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Drunella	Drunella flavilinea
Big Campbell Creek	363	3	1.83	Ephemerellidae	Arthropoda	Insecta	Ephemeroptera	Ephemerellidae		
Big Campbell Creek	363	1	0.61	Eukiefferiella sp	Arthropoda	Insecta	Diptera	Chironomidae	Eukiefferiella	
Big Campbell Creek	363	1	0.61	Euryhapsis sp	Arthropoda	Insecta	Diptera	Chironomidae	Euryhapsis	
Big Campbell Creek	363	1	0.61	Hexatoma sp	Arthropoda	Insecta	Diptera	Tipulidae	Hexatoma	
Big Campbell Creek	363	1	0.61	Hydracarina	Arthropoda	Arachnida	Hydracarina			
Big Campbell Creek	363	4	2.44	Lebertia sp	Arthropoda	Arachnida	Trombidiformes	Lebertiidae	Lebertia	
Big Campbell Creek	363	1	0.61	Nematoda	Nematoda					
Big Campbell Creek	363	1	0.61	Perlidae	Arthropoda	Insecta	Plecoptera	Perlidae		
Big Campbell Creek	363	35	21.34	Rheotanytarsus sp	Arthropoda	Insecta	Diptera	Chironomidae	Rheotanytarsus	
Big Campbell Creek	363	6	3.66	Simulium sp	Arthropoda	Insecta	Diptera	Simuliidae	Simulium	
Big Campbell Creek	363	5	3.05	Sperchon sp	Arthropoda	Arachnida	Trombidiformes	Sperchonidae	Sperchon	
Big Campbell Creek	363	6	3.66	Sweltsa sp	Arthropoda	Insecta	Plecoptera	Chloroperlidae	Sweltsa	
Big Campbell Creek	363	2	1.22	Thienemanniella sp	Arthropoda	Insecta	Diptera	Chironomidae	Thienemanniella	
Big Campbell Creek	363	1	0.61	Torrenticola sp	Arthropoda	Arachnida	Trombidiformes	Torrenticolidae	Torrenticola	
Big Campbell Creek	363	3	1.83	Unionicola sp	Arthropoda	Arachnida	Trombidiformes	Unionicolidae	Unionicola	
Big Campbell Creek	363	3	1.83	Zapada sp	Arthropoda	Insecta	Plecoptera	Nemouridae	Zapada	
Mink Creek	363	1	0.68	Antocha sp	Arthropoda	Insecta	Diptera	Tipulidae	Antocha	
Mink Creek	363	11	7.48	Baetis sp	Arthropoda	Insecta	Ephemeroptera	Baetidae	Baetis	
Mink Creek	363	7	4.76	Cardiocladius sp	Arthropoda	Insecta	Diptera	Chironomidae	Cardiocladius	
Mink Creek	363	2	1.36	Chelifera sp	Arthropoda	Insecta	Diptera	Empididae	Chelifera	
Mink Creek	363	17	11.56	Chironomidae	Arthropoda	Insecta	Diptera	Chironomidae		
Mink Creek	363	10	6.80	Cinygmula sp	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Cinygmula	
Mink Creek	363	46	31.29	Cricotopus sp	Arthropoda	Insecta	Diptera	Chironomidae	Cricotopus	
Mink Creek	363	1	0.68	Cypria sp	Arthropoda	Crustacea	Podocopa	Cyprididae	Cypria	
Mink Creek	363	2	1.36	Deuterophlebia sp	Arthropoda	Insecta	Diptera	Deuterophelbiidae	Deuterophlebia	
Mink Creek	363	4	2.72	Diamesa sp	Arthropoda	Insecta	Diptera	Chironomidae	Diamesa	
Mink Creek	363	8	5.44	Drunella doddsi	Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Drunella	Drunella doddsi

Stream	Sampler Mesh Size (um)	Individuals per Replicate	Abundance per Replicate (%)	Invertebrate Taxa Identification	Phylum	Class	Order	Family	Genus	species
Mink Creek	363	1	0.68	Enchytraeidae	Annelida	Clitellata	Haplotaxida	Enchytraeidae		
Mink Creek	363	2	1.36	Eukiefferiella sp	Arthropoda	Insecta	Diptera	Chironomidae	Eukiefferiella	
Mink Creek	363	1	0.68	Euryhapsis sp	Arthropoda	Insecta	Diptera	Chironomidae	Euryhapsis	
Mink Creek	363	4	2.72	Glossosoma sp	Arthropoda	Insecta	Trichoptera	Glossosomatidae	Glossosoma	
Mink Creek	363	1	0.68	Hydracarina	Arthropoda	Arachnida	Hydracarina			
Mink Creek	363	2	1.36	Kincaidiana hexatheca	Annelida	Clitellata	Lumbriculida	Lumbriculidae	Kincaidiana	Kincaidiana hexatheca
Mink Creek	363	1	0.68	Lebertia sp	Arthropoda	Arachnida	Trombidiformes	Lebertiidae	Lebertia	
Mink Creek	363	1	0.68	Mallochohelea sp	Arthropoda	Insecta	Diptera	Ceratopogonidae	Mallochohelea	
Mink Creek	363	12	8.16	Rheotanytarsus sp	Arthropoda	Insecta	Diptera	Chironomidae	Rheotanytarsus	
Mink Creek	363	1	0.68	Simulium sp	Arthropoda	Insecta	Diptera	Simuliidae	Simulium	
Mink Creek	363	1	0.68	Skwala parallela	Arthropoda	Insecta	Plecoptera	Perlodidae	Skwala	Skwala parallela
Mink Creek	363	2	1.36	Sperchon sp	Arthropoda	Arachnida	Trombidiformes	Sperchonidae	Sperchon	
Mink Creek	363	3	2.04	Thienemanniella sp	Arthropoda	Insecta	Diptera	Chironomidae	Thienemanniella	
Mink Creek	363	2	1.36	Tubificidae	Annelida	Clitellata	Haplotaxida	Tubificidae		
Mink Creek	363	1	0.68	Unionicola sp	Arthropoda	Arachnida	Trombidiformes	Unionicolidae	Unionicola	
Mink Creek	363	3	2.04	Zapada sp	Arthropoda	Insecta	Plecoptera	Nemouridae	Zapada	
Starr Creek	363	1	1.75	Agathon sp	Arthropoda	Insecta	Diptera	Blephariceridae	Agathon	
Starr Creek	363	3	5.26	Baetis sp	Arthropoda	Insecta	Ephemeroptera	Baetidae	Baetis	
Starr Creek	363	1	1.75	Capnia sp	Arthropoda	Insecta	Plecoptera	Capniidae	Capnia	
Starr Creek	363	1	1.75	Chelifera sp	Arthropoda	Insecta	Diptera	Empididae	Chelifera	
Starr Creek	363	3	5.26	Chironomidae	Arthropoda	Insecta	Diptera	Chironomidae		
Starr Creek	363	7	12.28	Cricotopus sp	Arthropoda	Insecta	Diptera	Chironomidae	Cricotopus	
Starr Creek	363	5	8.77	Diamesa sp	Arthropoda	Insecta	Diptera	Chironomidae	Diamesa	
Starr Creek	363	23	40.35	Drunella doddsi	Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Drunella	Drunella doddsi
Starr Creek	363	3	5.26	Epeorus (Iron) sp	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Epeorus	
Starr Creek	363	1	1.75	Kincaidiana hexatheca	Annelida	Clitellata	Lumbriculida	Lumbriculidae	Kincaidiana	Kincaidiana hexatheca
Starr Creek	363	1	1.75	Polycelis coronata	Platyhelminthes	Turbellaria	Tricladida	Planariidae	Polycelis	Polycelis coronata
Starr Creek	363	1	1.75	Rhithrogena sp	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Rhithrogena	
Starr Creek	363	1	1.75	Rhyacophila angelita	Arthropoda	Insecta	Trichoptera	Rhyacophilidae	Rhyacophila	Rhyacophila angelita
Starr Creek	363	1	1.75	Rhyacophila hyalinata	Arthropoda	Insecta	Trichoptera	Rhyacophilidae	Rhyacophila	Rhyacophila hyalinata
Starr Creek	363	1	1.75	Skwala parallela	Arthropoda	Insecta	Plecoptera	Perlodidae	Skwala	Skwala parallela
Starr Creek	363	1	1.75	Sperchon sp	Arthropoda	Arachnida	Trombidiformes	Sperchonidae	Sperchon	
Starr Creek	363	1	1.75	Sweltsa sp	Arthropoda	Insecta	Plecoptera	Chloroperlidae	Sweltsa	
Starr Creek	363	2	3.51	Zapada sp	Arthropoda	Insecta	Plecoptera	Nemouridae	Zapada	
Horton Creek	363	5	2.66	Arctopsyche sp	Arthropoda	Insecta	Trichoptera	Hydropsychidae	Arctopsyche	
Horton Creek	363	76	40.43	Baetis sp	Arthropoda	Insecta	Ephemeroptera	Baetidae	Baetis	
Horton Creek	363	1	0.53	Candona sp	Arthropoda	Crustacea	Cladocopina	Candoniidae	Candona	
Horton Creek	363	1	0.53	Cardiocladius sp	Arthropoda	Insecta	Diptera	Chironomidae	Cardiocladius	
Horton Creek	363	2	1.06	Chelifera sp	Arthropoda	Insecta	Diptera	Empididae	Chelifera	

Stream	Sampler Mesh Size (um)	Individuals per Replicate	Abundance per Replicate (%)	Invertebrate Taxa Identification	Phylum	Class	Order	Family	Genus	species
Horton Creek	363	7	3.72	Chironomidae	Arthropoda	Insecta	Diptera	Chironomidae		
Horton Creek	363	1	0.53	Cinygmula sp	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Cinygmula	
Horton Creek	363	11	5.85	Cricotopus sp	Arthropoda	Insecta	Diptera	Chironomidae	Cricotopus	
Horton Creek	363	1	0.53	Diamesa sp	Arthropoda	Insecta	Diptera	Chironomidae	Diamesa	
Horton Creek	363	1	0.53	Dicranota sp	Arthropoda	Insecta	Diptera	Tipulidae	Dicranota	
Horton Creek	363	1	0.53	Diptera	Arthropoda	Insecta	Diptera			
Horton Creek	363	6	3.19	Drunella doddsi	Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Drunella	Drunella doddsi
Horton Creek	363	1	0.53	Enchytraeidae	Annelida	Clitellata	Haplotaxida	Enchytraeidae		
Horton Creek	363	1	0.53	Ephemerellidae	Arthropoda	Insecta	Ephemeroptera	Ephemerellidae		
Horton Creek	363	2	1.06	Eukiefferiella sp	Arthropoda	Insecta	Diptera	Chironomidae	Eukiefferiella	
Horton Creek	363	3	1.60	Hydracarina	Arthropoda	Arachnida	Hydracarina			
Horton Creek	363	3	1.60	Nais sp	Annelida	Clitellata	Haplotaxida	Naididae	Nais	
Horton Creek	363	1	0.53	Nematoda	Nematoda					
Horton Creek	363	1	0.53	Neumania sp	Arthropoda	Arachnida	Trombidiformes	Unionicolidae	Neumania	
Horton Creek	363	1	0.53	Plecoptera	Arthropoda	Insecta	Plecoptera			
Horton Creek	363	1	0.53	Rhyacophila acropedes	Arthropoda	Insecta	Trichoptera	Rhyacophilidae	Rhyacophila	Rhyacophila acropedes
Horton Creek	363	5	2.66	Simulium sp	Arthropoda	Insecta	Diptera	Simuliidae	Simulium	
Horton Creek	363	2	1.06	Skwala parallela	Arthropoda	Insecta	Plecoptera	Perlodidae	Skwala	Skwala parallela
Horton Creek	363	1	0.53	Sperchon sp	Arthropoda	Arachnida	Trombidiformes	Sperchonidae	Sperchon	
Horton Creek	363	1	0.53	Sweltsa sp	Arthropoda	Insecta	Plecoptera	Chloroperlidae	Sweltsa	
Horton Creek	363	1	0.53	Synorthocladius sp	Arthropoda	Insecta	Diptera	Chironomidae	Synorthocladius	
Horton Creek	363	1	0.53	Taenionema sp	Arthropoda	Insecta	Plecoptera	Taeniopterygidae	Taenionema	
Horton Creek	363	1	0.53	Thienemanniella sp	Arthropoda	Insecta	Diptera	Chironomidae	Thienemanniella	
Horton Creek	363	2	1.06	Tubificidae	Annelida	Clitellata	Haplotaxida	Tubificidae		
Horton Creek	363	2	1.06	Wiedemannia sp	Arthropoda	Insecta	Diptera	Empididae	Wiedemannia	
Horton Creek	363	45	23.94	Zapada sp	Arthropoda	Insecta	Plecoptera	Nemouridae	Zapada	
Little Ketza Creek	363	6	1.82	Arctopsyche sp	Arthropoda	Insecta	Trichoptera	Hydropsychidae	Arctopsyche	
Little Ketza Creek	363	7	2.12	Baetis sp	Arthropoda	Insecta	Ephemeroptera	Baetidae	Baetis	
Little Ketza Creek	363	138	41.82	Candona sp	Arthropoda	Crustacea	Cladocopina	Candoniidae	Candona	
Little Ketza Creek	363	1	0.30	Chelifera sp	Arthropoda	Insecta	Diptera	Empididae	Chelifera	
Little Ketza Creek	363	28	8.48	Chironomidae	Arthropoda	Insecta	Diptera	Chironomidae		
Little Ketza Creek	363	2	0.61	Cinygmula sp	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Cinygmula	
Little Ketza Creek	363	41	12.42	Cricotopus sp	Arthropoda	Insecta	Diptera	Chironomidae	Cricotopus	
Little Ketza Creek	363	2	0.61	Cypria sp	Arthropoda	Crustacea	Podocopa	Cyprididae	Cypria	
Little Ketza Creek	363	50	15.15	Diamesa sp	Arthropoda	Insecta	Diptera	Chironomidae	Diamesa	
Little Ketza Creek	363	7	2.12	Dicosmoecus sp	Arthropoda	Insecta	Trichoptera	Limnephilidae	Dicosmoecus	
Little Ketza Creek	363	3	0.91	Enchytraeidae	Annelida	Clitellata	Haplotaxida	Enchytraeidae		
Little Ketza Creek	363	1	0.30	Epeorus (Iron) sp	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Epeorus	
Little Ketza Creek	363	11	3.33	Eukiefferiella sp	Arthropoda	Insecta	Diptera	Chironomidae	Eukiefferiella	

Stream	Sampler Mesh Size (um)	Individuals per Replicate	Abundance per Replicate (%)	Invertebrate Taxa Identification	Phylum	Class	Order	Family	Genus	species
Little Ketza Creek	363	1	0.30	Euryhapsis sp	Arthropoda	Insecta	Diptera	Chironomidae	Euryhapsis	
Little Ketza Creek	363	2	0.61	Hydracarina	Arthropoda	Arachnida	Hydracarina			
Little Ketza Creek	363	1	0.30	Lebertia sp	Arthropoda	Arachnida	Trombidiformes	Lebertiidae	Lebertia	
Little Ketza Creek	363	3	0.91	Nais sp	Annelida	Clitellata	Haplotaxida	Naididae	Nais	
Little Ketza Creek	363	1	0.30	Prosimulium sp	Arthropoda	Insecta	Diptera	Simuliidae	Prosimulium	
Little Ketza Creek	363	1	0.30	Rheotanytarsus sp	Arthropoda	Insecta	Diptera	Chironomidae	Rheotanytarsus	
Little Ketza Creek	363	9	2.73	Rhyacophila acropedes	Arthropoda	Insecta	Trichoptera	Rhyacophilidae	Rhyacophila	Rhyacophila acropedes
Little Ketza Creek	363	2	0.61	Simulium sp	Arthropoda	Insecta	Diptera	Simuliidae	Simulium	
Little Ketza Creek	363	1	0.30	Skwala parallela	Arthropoda	Insecta	Plecoptera	Perlodidae	Skwala	Skwala parallela
Little Ketza Creek	363	1	0.30	Sperchon sp	Arthropoda	Arachnida	Trombidiformes	Sperchonidae	Sperchon	
Little Ketza Creek	363	4	1.21	Taenionema sp	Arthropoda	Insecta	Plecoptera	Taeniopterygidae	Taenionema	
Little Ketza Creek	363	6	1.82	Tubificidae	Annelida	Clitellata	Haplotaxida	Tubificidae		
Little Ketza Creek	363	1	0.30	Zapada sp	Arthropoda	Insecta	Plecoptera	Nemouridae	Zapada	

Appendix D. Fish Laboratory Results

Sample ID	Sample Type	Units	Moisture	Aluminum	Antimony	Arsenic	Barium	Berylium	Boron	Cadmium	Cadmium	Calcium
Money Creek 1	sculpin - whole	µg/g ww	73.737	13	< 4	0.2	10.7	< 0.08	< 0.8	0.37	0.4	30100
Money Creek 2	sculpin - whole	µg/g ww	76.937	16	< 4	< 0.1	6.7	< 0.08	< 0.8	0.19	< 0.4	16200
Tutchitua River 1	sculpin - whole	µg/g ww	77.791	19	< 4	0.1	7.42	< 0.08	4	0.07	< 0.4	17200
Tutchitua River 2	sculpin - whole	µg/g ww	77.012	< 4	< 4	< 0.1	3.53	< 0.08	2.1	0.05	< 0.4	7890
Tutchitua River 3	sculpin - whole	µg/g ww	72.651	12	< 4	< 0.1	6.17	< 0.08	< 0.8	0.1	< 0.4	12100
Little Campbell River 1	sculpin - whole	µg/g ww	73.664	< 4	< 4	0.1	4.65	< 0.08	< 0.8	0.11	< 0.4	12200
Little Campbell River 2	sculpin - whole	µg/g ww	71.178	5	< 4	0.1	4.66	< 0.08	< 0.8	0.1	< 0.4	10400
Little Campbell River 3	sculpin - whole	µg/g ww	76.931	< 4	< 4	0.1	6.5	< 0.08	< 0.8	0.11	< 0.4	14300
Little Campbell River 4	sculpin - whole	µg/g ww	73.840	4	< 4	0.1	4.3	< 0.08	< 0.8	0.09	< 0.4	10300
Little Campbell River 5	sculpin - whole	µg/g ww	75.787	23	< 4	0.1	4.35	< 0.08	< 0.8	0.07	< 0.4	8560
Big Campbell Creek 1	sculpin - whole	µg/g ww	77.012	4	< 4	0.2	3.56	< 0.08	< 0.8	0.11	< 0.4	9350
Big Campbell Creek 2	sculpin - whole	µg/g ww	72.345	< 4	< 4	0.2	5.2	< 0.08	< 0.8	0.13	< 0.4	16100
Mink Creek 1	sculpin - whole	µg/g ww	78.808	17	< 4	0.2	5.85	< 0.08	< 0.8	0.09	< 0.4	13100
Mink Creek 2	sculpin - whole	µg/g ww	81.032	7	< 4	0.2	5.51	< 0.08	< 0.8	0.15	< 0.4	13600
Mink Creek 3	sculpin - whole	µg/g ww	74.453	28	< 4	0.3	8.44	< 0.08	< 0.8	0.14	< 0.4	21000
Mink Creek 4	sculpin - whole	µg/g ww	75.038	12	< 4	0.2	6.99	< 0.08	< 0.8	0.09	< 0.4	17200
Mink Creek Burbot 1	burbot - whole	µg/g ww	80.873	< 4	< 4	0.6	2.8	< 0.08	< 0.8	0.03	< 0.4	8120
Little Ketza Creek 1	sculpin - whole	µg/g ww	72.205	12	< 4	0.2	2.77	< 0.08	< 0.8	0.14	< 0.4	13400
Little Ketza Creek 2	sculpin - whole	µg/g ww	76.743	8	< 4	0.2	2.39	< 0.08	< 0.8	0.1	< 0.4	12900
Little Ketza Creek 3	sculpin - whole	µg/g ww	76.800	8	< 4	0.2	2.14	< 0.08	< 0.8	0.1	< 0.4	9670
Little Ketza Creek 4	sculpin - whole	µg/g ww	78.500	< 4	< 4	0.1	1.94	< 0.08	< 0.8	0.11	< 0.4	16600
Little Ketza Creek 5	sculpin - whole	µg/g ww	75.842	11	< 4	0.2	2.49	< 0.08	< 0.8	0.13	< 0.4	13500
Little Ketza Creek 6	sculpin - whole	µg/g ww	77.784	6	< 4	0.2	1.96	< 0.08	< 0.8	0.11	< 0.4	11300
Little Ketza Creek 7	sculpin - whole	µg/g ww	73.636	32	< 4	0.3	5.59	< 0.08	< 0.8	0.27	< 0.4	15600
Little Ketza Creek 8	sculpin - whole	µg/g ww	75.841	10	< 4	0.2	2.09	< 0.08	< 0.8	0.14	< 0.4	12200
Starr Creek 1	sculpin - whole	µg/g ww	74.689	29	< 4	0.1	3.91	< 0.08	< 0.8	0.21	< 0.4	11100
Starr Creek 2	sculpin - whole	µg/g ww	78.018	6	< 4	< 0.1	3.34	< 0.08	< 0.8	0.21	< 0.4	12500
Starr Creek 3	sculpin - whole	µg/g ww	76.042	27	< 4	< 0.1	3.28	< 0.08	< 0.8	0.14	< 0.4	10300
Horton Creek 1	sculpin - whole	µg/g ww	73.701	13	< 4	0.2	3.78	< 0.08	< 0.8	0.13	< 0.4	11600
Horton Creek 2	sculpin - whole	µg/g ww	76.489	13	< 4	0.2	4.32	< 0.08	< 0.8	0.15	< 0.4	14000
Horton Creek 3	sculpin - whole	µg/g ww	71.889	4	< 4	0.1	2.5	< 0.08	< 0.8	0.1	< 0.4	10500
Horton Creek 4	sculpin - whole	µg/g ww	77.692	12	< 4	0.2	4.14	< 0.08	< 0.8	0.19	< 0.4	13400
Horton Creek 5	sculpin - whole	µg/g ww	77.838	6	< 4	0.1	2.4	< 0.08	< 0.8	0.1	< 0.4	8860
Horton Creek 6	sculpin - whole	µg/g ww	75.778	17	< 4	0.2	2.93	< 0.08	< 0.8	0.13	< 0.4	8620
Detection limits				4	4	0.1	0.08	0.08	0.8	0.01	0.4	80

Sample ID	Sample Type	Units	Chromium	Cobalt	Copper	Iron	Lead	Magnesium	Manganese	Mercury	Molybdenum	Nickel
Money Creek 1	sculpin - whole	μg/g ww	< 0.4	< 0.4	6.2	60.3	< 0.01	733	14.4	0.023	< 0.8	< 2
Money Creek 2	sculpin - whole	μg/g ww	< 0.4	< 0.4	4.1	50	< 0.01	517	7.88	0.025	< 0.8	< 2
Tutchitua River 1	sculpin - whole	μg/g ww	< 0.4	< 0.4	3.8	55.4	0.09	505	18.2	0.047	< 0.8	< 2
Tutchitua River 2	sculpin - whole	μg/g ww	< 0.4	< 0.4	2.2	23.7	< 0.01	611	7.79	0.035	< 0.8	< 2
Tutchitua River 3	sculpin - whole	μg/g ww	< 0.4	< 0.4	14.3	54.5	< 0.01	422	12.8	0.036	< 0.8	< 2
Little Campbell River 1	sculpin - whole	μg/g ww	< 0.4	< 0.4	2.4	19.6	0.09	397	40.8	0.031	< 0.8	< 2
Little Campbell River 2	sculpin - whole	μg/g ww	< 0.4	< 0.4	4.7	26.5	< 0.01	357	25.4	0.083	< 0.8	< 2
Little Campbell River 3	sculpin - whole	μg/g ww	< 0.4	< 0.4	3.5	23.1	< 0.01	413	39.3	0.065	< 0.8	< 2
Little Campbell River 4	sculpin - whole	μg/g ww	< 0.4	< 0.4	1.3	23.2	< 0.01	388	36.7	0.039	< 0.8	< 2
Little Campbell River 5	sculpin - whole	μg/g ww	< 0.4	< 0.4	1.4	46.2	< 0.01	329	28.1	0.101	< 0.8	< 2
Big Campbell Creek 1	sculpin - whole	μg/g ww	< 0.4	< 0.4	4	24.2	< 0.01	326	7.42	0.028	< 0.8	< 2
Big Campbell Creek 2	sculpin - whole	μg/g ww	< 0.4	< 0.4	1.8	26.9	< 0.01	496	11.6	0.015	< 0.8	< 2
Mink Creek 1	sculpin - whole	μg/g ww	< 0.4	< 0.4	1.2	53.8	< 0.01	409	13.8	0.035	< 0.8	< 2
Mink Creek 2	sculpin - whole	μg/g ww	< 0.4	< 0.4	1.7	40.9	< 0.01	419	15.2	0.036	< 0.8	< 2
Mink Creek 3	sculpin - whole	μg/g ww	< 0.4	< 0.4	2.1	93.6	0.01	549	20.7	0.048	< 0.8	< 2
Mink Creek 4	sculpin - whole	μg/g ww	< 0.4	< 0.4	1.4	41.6	< 0.01	489	23.7	0.023	< 0.8	< 2
Mink Creek Burbot 1	burbot - whole	μg/g ww	< 0.4	< 0.4	0.9	19.2	< 0.01	367	4.79	0.017	< 0.8	< 2
Little Ketza Creek 1	sculpin - whole	μg/g ww	< 0.4	< 0.4	1.2	106	0.01	413	54.8	0.012	< 0.8	< 2
Little Ketza Creek 2	sculpin - whole	μg/g ww	< 0.4	< 0.4	1.4	59.6	< 0.01	385	33	0.013	< 0.8	< 2
Little Ketza Creek 3	sculpin - whole	μg/g ww	< 0.4	< 0.4	1.2	84.1	< 0.01	314	46	0.016	< 0.8	< 2
Little Ketza Creek 4	sculpin - whole	μg/g ww	< 0.4	< 0.4	1	44.1	< 0.01	441	46.2	0.009	< 0.8	< 2
Little Ketza Creek 5	sculpin - whole	μg/g ww	< 0.4	< 0.4	1.1	86.6	< 0.01	392	32.1	0.011	< 0.8	< 2
Little Ketza Creek 6	sculpin - whole	μg/g ww	< 0.4	< 0.4	1.2	69.1	< 0.01	363	28.6	0.018	< 0.8	< 2
Little Ketza Creek 7	sculpin - whole	μg/g ww	< 0.4	< 0.4	1.7	232	0.13	467	60.8	0.013	< 0.8	< 2
Little Ketza Creek 8	sculpin - whole	μg/g ww	< 0.4	< 0.4	1.1	70	< 0.01	389	24.1	0.013	< 0.8	< 2
Starr Creek 1	sculpin - whole	μg/g ww	< 0.4	< 0.4	1	88.6	0.04	405	4.42	0.012	< 0.8	< 2
Starr Creek 2	sculpin - whole	μg/g ww	< 0.4	< 0.4	0.8	34.4	0.04	369	4.61	0.028	< 0.8	< 2
Starr Creek 3	sculpin - whole	μg/g ww	< 0.4	< 0.4	1	75.5	0.03	372	3.6	0.01	< 0.8	< 2
Horton Creek 1	sculpin - whole	μg/g ww	< 0.4	< 0.4	1.7	72.2	< 0.01	379	10.8	0.027	< 0.8	< 2
Horton Creek 2	sculpin - whole	μg/g ww	< 0.4	< 0.4	1.3	64.6	0.01	422	16.6	0.033	< 0.8	< 2
Horton Creek 3	sculpin - whole	μg/g ww	< 0.4	< 0.4	1	36.1	< 0.01	501	10.5	0.017	< 0.8	< 2
Horton Creek 4	sculpin - whole	μg/g ww	< 0.4	< 0.4	1.1	66	0.02	564	14.6	0.025	< 0.8	< 2
Horton Creek 5	sculpin - whole	μg/g ww	< 0.4	< 0.4	1	47.3	< 0.01	538	8.28	0.026	< 0.8	< 2
Horton Creek 6	sculpin - whole	μg/g ww	< 0.4	< 0.4	1.2	95	0.02	350	10.9	0.018	< 0.8	< 2
Detection limits			0.4	0.4	0.4	0.4	0.01	8	0.08	0.002	0.8	2

Sample ID	Sample Type	Units	Phosphorus	Potassium	Selenium	Silicon	Silver	Sodium	Strontium	Sulfur	Tin	Titanium	Vanadium
Money Creek 1	sculpin - whole	µg/g ww	19600	3010	1.4	20	< 0.8	1340	29.9	3140	5	0.3	< 0.8
Money Creek 2	sculpin - whole	µg/g ww	11300	2740	1.3	20	< 0.8	1050	18.6	2350	< 4	0.3	< 0.8
Tutchitua River 1	sculpin - whole	µg/g ww	12400	2210	1.1	29	< 0.8	929	17.9	2310	4	1.1	< 0.8
Tutchitua River 2	sculpin - whole	µg/g ww	6340	2380	1.1	< 4	< 0.8	981	8.26	1650	5	< 0.2	< 0.8
Tutchitua River 3	sculpin - whole	µg/g ww	8370	2290	1.2	15	< 0.8	810	13.1	2220	4	0.5	< 0.8
Little Campbell River 1	sculpin - whole	µg/g ww	8270	2170	1.1	4	< 0.8	987	16.9	2070	< 4	< 0.2	< 0.8
Little Campbell River 2	sculpin - whole	µg/g ww	6780	2450	1	9	< 0.8	1060	13.9	2280	5	< 0.2	< 0.8
Little Campbell River 3	sculpin - whole	µg/g ww	8960	2100	1	6	< 0.8	949	19.8	2040	< 4	< 0.2	< 0.8
Little Campbell River 4	sculpin - whole	µg/g ww	7290	2330	1.1	7	< 0.8	932	13.7	2060	< 4	< 0.2	< 0.8
Little Campbell River 5	sculpin - whole	µg/g ww	6080	2180	1	34	< 0.8	942	11.2	2040	< 4	0.5	< 0.8
Big Campbell Creek 1	sculpin - whole	µg/g ww	6710	2210	1.1	7	< 0.8	862	11.6	2100	5	< 0.2	< 0.8
Big Campbell Creek 2	sculpin - whole	µg/g ww	10400	2740	1.1	5	< 0.8	1060	20.5	2170	< 4	< 0.2	< 0.8
Mink Creek 1	sculpin - whole	µg/g ww	8540	1950	1.1	24	< 0.8	797	17.7	1920	< 4	0.6	< 0.8
Mink Creek 2	sculpin - whole	µg/g ww	8900	2130	1.2	9	< 0.8	878	18.4	1970	< 4	< 0.2	< 0.8
Mink Creek 3	sculpin - whole	µg/g ww	12800	2660	1.3	28	< 0.8	1130	28.1	2330	< 4	0.4	< 0.8
Mink Creek 4	sculpin - whole	µg/g ww	11400	2430	1.2	17	< 0.8	1040	26	2150	5	0.3	< 0.8
Mink Creek Burbot 1	burbot - whole	µg/g ww	6530	2910	1	5	< 0.8	1070	15.7	1920	< 4	0.2	< 0.8
Little Ketza Creek 1	sculpin - whole	µg/g ww	8780	2640	3.7	22	< 0.8	1050	14.3	2300	< 4	0.3	< 0.8
Little Ketza Creek 2	sculpin - whole	µg/g ww	8230	2350	2.5	16	< 0.8	893	17.2	2130	< 4	< 0.2	< 0.8
Little Ketza Creek 3	sculpin - whole	µg/g ww	6520	2420	2.8	16	< 0.8	964	10.8	2290	< 4	< 0.2	< 0.8
Little Ketza Creek 4	sculpin - whole	µg/g ww	10600	2270	2.6	7	< 0.8	1030	18.9	2290	< 4	< 0.2	< 0.8
Little Ketza Creek 5	sculpin - whole	µg/g ww	8400	2410	2.4	17	< 0.8	981	14.5	2240	< 4	0.2	< 0.8
Little Ketza Creek 6	sculpin - whole	µg/g ww	7600	2510	2.7	12	< 0.8	989	13.6	2420	< 4	< 0.2	< 0.8
Little Ketza Creek 7	sculpin - whole	µg/g ww	10100	2370	3.4	52	< 0.8	969	18.9	2320	< 4	0.7	< 0.8
Little Ketza Creek 8	sculpin - whole	µg/g ww	7900	2580	2.7	17	< 0.8	1030	14.3	2340	< 4	0.2	< 0.8
Starr Creek 1	sculpin - whole	µg/g ww	7430	2430	1.8	40	< 0.8	907	12	2230	< 4	0.8	< 0.8
Starr Creek 2	sculpin - whole	µg/g ww	8240	2150	2.2	7	< 0.8	941	13.7	2280	4	< 0.2	< 0.8
Starr Creek 3	sculpin - whole	µg/g ww	7120	2130	1.4	36	< 0.8	808	11.6	2140	< 4	0.7	< 0.8
Horton Creek 1	sculpin - whole	µg/g ww	7800	2150	1.6	22	< 0.8	936	14.9	2210	< 4	0.6	< 0.8
Horton Creek 2	sculpin - whole	µg/g ww	8690	2050	1.7	21	< 0.8	917	18.2	2040	< 4	0.5	< 0.8
Horton Creek 3	sculpin - whole	µg/g ww	7270	2420	1.3	7	< 0.8	1010	12.9	2050	< 4	< 0.2	< 0.8
Horton Creek 4	sculpin - whole	µg/g ww	8580	2150	1.7	21	< 0.8	940	17.5	1900	< 4	0.4	< 0.8
Horton Creek 5	sculpin - whole	µg/g ww	6520	2330	1.6	12	< 0.8	874	10.9	2120	< 4	< 0.2	< 0.8
Horton Creek 6	sculpin - whole	µg/g ww	6800	2030	1.7	27	< 0.8	791	11.4	2200	< 4	0.7	< 0.8
Detection limits			8	8	0.2	4	0.8	8	0.08	4	4	0.2	0.8

Sample ID	Sample Type	Units	Zinc
Money Creek 1	sculpin - whole	µg/g ww	38.6
Money Creek 2	sculpin - whole	µg/g ww	31.1
Tutchitua River 1	sculpin - whole	µg/g ww	37.1
Tutchitua River 2	sculpin - whole	µg/g ww	37.3
Tutchitua River 3	sculpin - whole	µg/g ww	30.9
Little Campbell River 1	sculpin - whole	µg/g ww	30.7
Little Campbell River 2	sculpin - whole	µg/g ww	39.8
Little Campbell River 3	sculpin - whole	µg/g ww	35.8
Little Campbell River 4	sculpin - whole	µg/g ww	28.3
Little Campbell River 5	sculpin - whole	µg/g ww	39.5
Big Campbell Creek 1	sculpin - whole	µg/g ww	27.2
Big Campbell Creek 2	sculpin - whole	µg/g ww	37.7
Mink Creek 1	sculpin - whole	µg/g ww	33.6
Mink Creek 2	sculpin - whole	µg/g ww	35.3
Mink Creek 3	sculpin - whole	µg/g ww	50.6
Mink Creek 4	sculpin - whole	µg/g ww	34
Mink Creek Burbot 1	burbot - whole	µg/g ww	15.9
Little Ketza Creek 1	sculpin - whole	µg/g ww	31.6
Little Ketza Creek 2	sculpin - whole	µg/g ww	36.7
Little Ketza Creek 3	sculpin - whole	µg/g ww	39
Little Ketza Creek 4	sculpin - whole	µg/g ww	31.3
Little Ketza Creek 5	sculpin - whole	µg/g ww	41
Little Ketza Creek 6	sculpin - whole	µg/g ww	38.3
Little Ketza Creek 7	sculpin - whole	µg/g ww	45.9
Little Ketza Creek 8	sculpin - whole	µg/g ww	37.6
Starr Creek 1	sculpin - whole	µg/g ww	40.5
Starr Creek 2	sculpin - whole	µg/g ww	60.8
Starr Creek 3	sculpin - whole	µg/g ww	37.2
Horton Creek 1	sculpin - whole	µg/g ww	47.2
Horton Creek 2	sculpin - whole	µg/g ww	46.1
Horton Creek 3	sculpin - whole	µg/g ww	38.5
Horton Creek 4	sculpin - whole	µg/g ww	49
Horton Creek 5	sculpin - whole	µg/g ww	37.7
Horton Creek 6	sculpin - whole	µg/g ww	38.2
Detection limits			0.2

Appendix E. Benthic Invertebrate Laboratory Results

Site Name	Units	Moisture	Aluminum	Antimony	Arsenic	Barium	Beryllium	Boron	Cadmium	Calcium	Chromium	Cobalt
Tuchitua River	ug/g (dw)		< 3000	< 3000	2.8	120	< 50	< 500	2.46	9340	< 300	< 300
Jules Creek	ug/g (dw)		1290	< 900	2.2	123	< 20	< 200	4.85	6470	< 90	< 90
Money Creek	ug/g (dw)	3.1	< 600	< 600	1.1	87	< 10	< 100	1.83	6191	< 60	< 60
Campbell Creek	ug/g (dw)		669	< 400	3	100	< 9	< 90	0.91	171205	< 40	< 40
Big Campbell Creek	ug/g (dw)		< 3000	< 3000	3.8	< 50	< 50	< 500	3.27	7140	< 300	< 300
Mink Creek	ug/g (dw)		< 6000	< 6000	5.8	< 100	< 100	< 1000	1.45	11421	< 600	< 600
Starr Creek	ug/g (dw)		< 1000	< 1000	4.5	< 200	< 200	< 2000	1.65	12700	< 1000	< 1000
Horton Creek	ug/g (dw)		< 4000	< 4000	5.1	97.5	< 70	< 700	4.84	12760	< 400	< 400
Little Ketza Creek	ug/g (dw)		3390	< 500	9.3	257	< 9	< 90	4.23	21150	< 50	< 50
Detection limits			variable	variable	variable	variable	variable	variable	variable	variable	variable	variable

Site Name	Units	Copper	Iron	Lead	Magnesium	Manganes	Mercury	olybdenu	Nickel	Phosphoru	Potassium	Selenium
Tuchitua River	ug/g (dw)	85.1	2600	3.37	< 5000	474	0.113	< 500	< 1000	8690	< 5000	3.4
Jules Creek	ug/g (dw)	55.9	3550	1.83	3040	554	0.124	< 200	< 400	7960	< 2000	4.7
Money Creek	ug/g (dw)	44.8	1360	1.13	1920	221	0.048	< 100	< 300	9380	< 1000	3.5
Campbell Creek	ug/g (dw)	27	1680	1.14	1590	1160	0.064	< 90	< 200	8600	< 900	2.3
Big Campbell Creek	ug/g (dw)	65.9	1974	2.59	< 5000	265	0.083	< 500	< 1000	6876	< 5000	3.2
Mink Creek	ug/g (dw)	84	3068	4.01	6983	402	0.133	< 1000	< 3000	8213	3904	3.6
Starr Creek	ug/g (dw)	94.1	2280	29.2	7610	299	0.178	< 2000	< 5000	8960	4730	5.8
Horton Creek	ug/g (dw)	71.9	4745	4.39	< 7000	390	0.129	< 700	< 2000	11260	< 7000	9.6
Little Ketza Creek	ug/g (dw)	30.6	18800	5.62	5050	4350	0.042	< 90	< 200	8530	< 900	7.4
Detection limits		variable	variable	variable	variable	variable	variable	variable	variable	variable	variable	variable

Site Name	Units	Silicon	Silver	Sodium	Stronitum	Sulfur	Tin	Titanium	Vanadium	Zinc
Tuchitua River	ug/g (dw)	< 3000	< 500	38500	< 50	6190	< 3000	< 100	< 500	181
Jules Creek	ug/g (dw)	< 900	< 200	19200	22	5140	< 900	< 40	< 200	145
Money Creek	ug/g (dw)	< 600	< 100	13000	23	5320	< 600	< 30	< 100	517
Campbell Creek	ug/g (dw)	401	< 90	9500	213	2550	< 400	< 20	< 90	61.1
Big Campbell Creek	ug/g (dw)	< 3000	< 500	39875	< 50	5865	< 3000	< 100	< 500	201
Mink Creek	ug/g (dw)	< 6000	< 1000	91820	< 100	6790	< 6000	< 300	< 1000	91.3
Starr Creek	ug/g (dw)	2680	< 2000	109000	< 200	8260	< 1000	< 500	< 2000	135
Horton Creek	ug/g (dw)	< 4000	< 700	63153	< 70	7369	< 4000	< 200	< 700	338
Little Ketza Creek	ug/g (dw)	810	< 90	13100	71	2970	< 500	47	< 90	320
Detection limits		variable	variable	variable	variable	variable	variable	variable	variable	variable

Appendix F. Stream Sediment Laboratory Results

Stream	Watershed	Al (ug/g)	Sb (ug/g)	As (ug/g)	Ba (ug/g)	Be (ug/g)	Bi (ug/g)	B (ug/g)	Cd (ug/g)	Ca (ug/g)	Cr (ug/g)	Co (ug/g)	Cu (ug/g)	Fe (ug/g)	Pb (ug/g)	Li (ug/g)	Mg (ug/g)	Mn (ug/g)	Hg (ug/g)	Mo (ug/g)	Ni (ug/g)	P (ug/g)
Tuchitua River	Frances River	7530	0.254	7.3	136	0.17	0.06	1	0.28	3370	21.5	7.54	17.3	17800	8.09	7.78	8020	437	0.026	0.49	44.4	456
Jules Creek	Frances River	12200	0.344	6.1	771	0.268	0.04	2	0.66	4060	29.8	12.1	27.4	30400	5.99	11.6	10300	1125	0.082	2.14	67	1020
Money Creek	Frances Lake	12500	0.338	9.1	1630	0.395	0.1	2	0.83	6670	23.3	10.8	39.4	30400	11.2	13.5	11800	848	0.076	3.47	57.4	1190
Campbell Creek	Big Campbell Creek	5560	0.252	12.3	414	0.194	0.03	2	0.28	7880	7.8	4.84	12.2	15100	5.31	6.45	3570	1086	0.085	0.82	22.3	2640
Big Campbell Creek	Pelly River	9770	0.333	15.5	283	0.262	0.16	< 1	0.39	20200	6.9	9.93	101	26000	7.93	15.2	9190	497	0.042	1.07	31.2	2320
Mink Creek	Pelly River	6970	0.263	12.4	340	0.262	0.04	2	0.35	7320	4.1	6.14	14.5	17900	6.02	9.63	6000	412	0.04	0.55	27.4	1430
Hoole River	Pelly River	5910	1.5	16.7	201	0.268	0.03	1	0.89	54800	< 0.2	6.81	16.1	20000	7.86	9.31	12400	375	0.012	2.21	27.4	1300
Starr Creek	Pelly River	6490	1	12.1	360	0.298	0.04	1	2.17	57500	< 0.2	7.54	23.4	23600	16.9	7.93	15200	276	< 0.002	3.43	30.9	1510
Horton Creek	Pelly River	3690	0.854	10.1	352	0.238	< 0.02	< 1	0.74	50700	< 0.2	5.57	13.8	17800	9.72	5.35	12500	439	0.048	1.93	25.3	1470
Little Ketza Creek	Pelly River	5410	1.2	19.7	896	0.265	0.11	1	3.65	25800	< 0.2	19.2	33.5	29900	11.1	6.04	6310	4867	0.027	5.65	96.5	894

Stream	Watershed	K (ug/g)	Se (ug/g)	Si (ug/g)	Ag (ug/g)	Na (ug/g)	Sr (ug/g)	S (ug/g)	Tl (ug/g)	Sn (ug/g)	Ti (ug/g)	U (ug/g)	V (ug/g)	Zn (ug/g)
Tuchitua River	Frances River	693	0.3	610	0.08	111	23.1	150	0.048	0.12	296	0.925	15.3	68.3
Jules Creek	Frances River	886	0.8	823	0.12	40	35.8	258	0.083	< 0.05	205	0.654	31.1	103
Money Creek	Frances Lake	1160	1.5	928	0.23	48	47.7	880	0.167	< 0.05	150	1.36	28.1	117
Campbell Creek	Big Campbell Creek	754	0.7	528	0.13	33	47.1	222	0.051	< 0.05	47.3	0.829	22.5	58.4
Big Campbell Creek	Pelly River	587	0.7	630	0.12	34	72.5	1140	0.055	0.09	90	1.21	25.3	69.8
Mink Creek	Pelly River	549	0.2	575	0.08	56	58	181	0.043	0.06	105	0.946	23.1	57.3
Hoole River	Pelly River	438	0.7	557	0.17	103	135	315	0.049	0.07	83.2	0.899	16.5	113
Starr Creek	Pelly River	599	1.2	591	0.24	60	193	417	0.079	< 0.05	39.7	1.23	22.7	158
Horton Creek	Pelly River	471	0.8	456	0.14	34	173	221	0.051	< 0.05	40.6	0.911	22.5	109
Little Ketza Creek	Pelly River	675	3.1	567	0.32	49	95.5	670	0.121	0.05	74.5	1.71	23.6	319

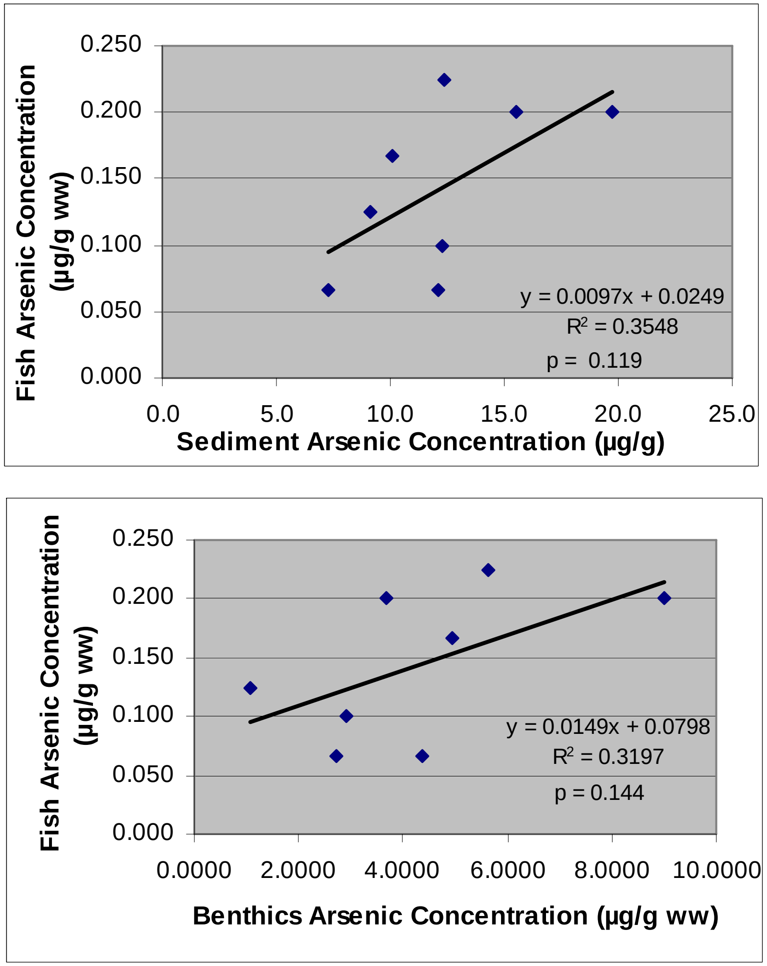
Appendix G. Water Laboratory Results

Stream	Watershed	Alkalinity to pH 4.5 mg CaCO3 / L	True Color (Col. Unit)	Dissolved Organic Carbon (mg/L)	Hardness CaMg diss. (mg CaCO3 / L)	Hardness CaMg extr. (mg CaCO3 / L)	Hardness Total diss. (mg CaCO3 / L)	Hardness Total extr. (mg CaCO3 / L)	Chloride (mg/L)	Sulphate (mg/L)	pH	TDS (mg/L)	TSS (mg/L)	Conductivity (uS/cm)	Nitrogen, Ammonia as N (mg/L)	Nitrogen, Nitrite as N (mg/L)	Nitrogen, Nitrate + Nitrite as N (mg/L)	Phosphorus, Total as P (mg/L)	Turbidity (NTU)
Tuchitua River	Frances River	60.7	12.5	2.3	67.4	72.8	67.7	73.6	< 0.1	15.7	8.05	83	< 5	139	< 0.002	< 0.002	0.007	0.006	0.78
Jules Creek	Frances River	96.1	12.5	2.9	138	143	138	144	< 0.1	50	8.12	188	< 5	269	< 0.002	< 0.002	0.046	0.005	0.76
Money Creek	Frances Lake	73.4	12.5	3	79	88.1	79.3	89.1	< 0.1	18.1	8.16	106	17	168	0.002	< 0.002	0.003	0.022	3.9
Campbell Creek	Big Campbell Creek	164	20	8.6	172	187	173	188	0.1	28	8.3	220	< 5	329	< 0.002	< 0.002	0.002	0.006	0.64
Big Campbell Creek	Pelly River	87.8	7.5	2.4	92.7	99.8	93	100	< 0.1	16	8.25	116	< 5	187	< 0.002	< 0.002	0.013	< 0.002	0.25
Mink Creek	Pelly River	177	12.5	4.8	176	187	177	188	< 0.1	17.2	8.34	211	< 5	334	< 0.002	< 0.002	0.016	0.004	0.41
Hoole River	Pelly River	144	2.5	< 0.5	194	199	194	200	< 0.1	66	8.41	258	< 5	368	0.002	< 0.002	0.024	0.002	0.84
Starr Creek	Pelly River	221	5	1	325	329	325	329	< 0.1	114	8.42	450	6	583	< 0.002	< 0.002	0.058	0.009	2.9
Horton Creek	Pelly River	259	7.5	2.1	306	309	307	310	0.2	70	8.42	386	10	550	< 0.002	< 0.002	0.025	0.013	1.37
Little Ketza Creek	Pelly River	250	10	2.7	552	535	553	536	< 0.1	288	8.29	781	7	916	0.003	< 0.002	0.007	0.007	3.57

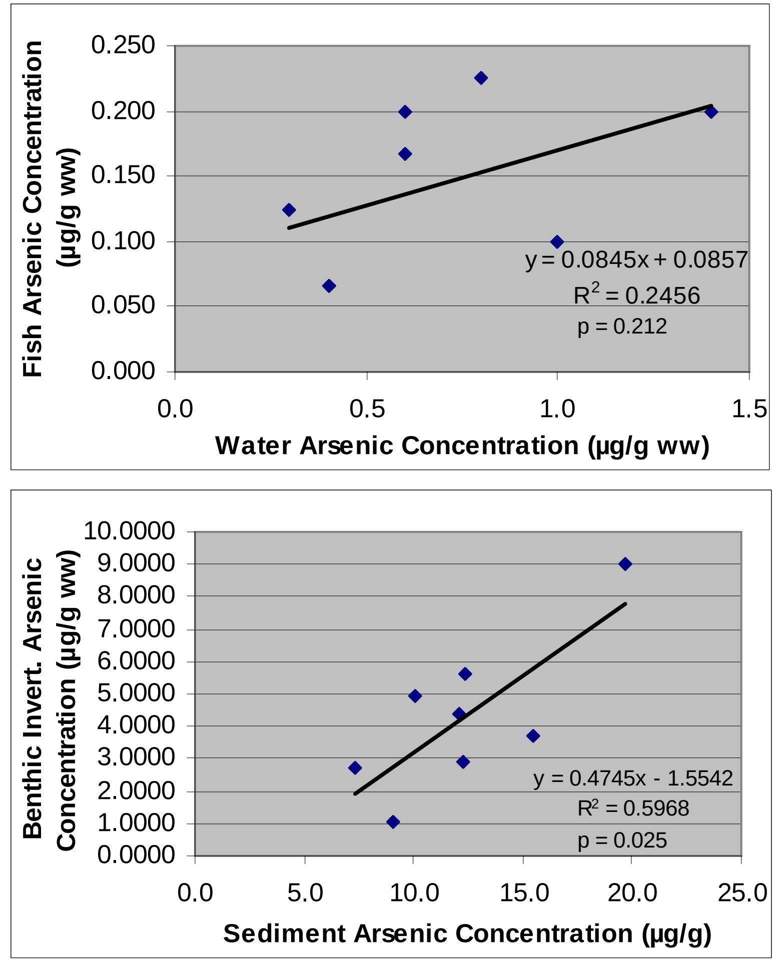
Stream	DISSOLVED METALS																																
	Al (ug/L)	Sb (ug/L)	As (ug/L)	Ba (ug/L)	Be (ug/L)	Bi (ug/L)	B (ug/L)	Cd (ug/L)	Ca (ug/L)	Cr (ug/L)	Co (ug/L)	Cu (ug/L)	Pb (ug/L)	Li (ug/L)	Mg (ug/L)	Mn (ug/L)	Hg (ug/L)	Mo (ug/L)	Ni (ug/L)	P (ug/L)	K (ug/L)	Se (ug/L)	Si (ug/L)	Ag (ug/L)	Na (ug/L)	Sr (ug/L)	S (ug/L)	Tl (ug/L)	Tin (Sn)	Ti (ug/L)	U (ug/L)	V (ug/L)	Zn (ug/L)
Tuchitua River	11.7	0.064	0.6	70.8	< 0.002	< 0.02	< 0.01	0.01	18.7	1.0	0.049	1.47	0.02	0.65	5.1	7.05	<0.02	0.50	2.28	< 0.1	0.6	0.7	3.11	< 0.02	1	81.9	4.91	0.008	< 0.01	0.002	0.204	0.06	3.8
Jules Creek	6.3	0.123	0.2	80.9	< 0.002	< 0.02	< 0.01	0.02	39.2	0.9	0.070	1.11	0.05	1.26	9.7	16.2	<0.02	0.91	2.46	< 0.1	0.4	1.4	2.52	< 0.02	1.1	173	16.4	0.002	< 0.01	0.002	0.554	0.05	3.3
Money Creek	11.3	0.06	0.3	53.9	0.003	< 0.02	0.07	0.02	20.3	0.7	0.047	0.87	0.04	1.97	6.9	2.02	<0.02	0.55	1.61	< 0.1	0.8	0.5	3.80	< 0.02	1.3	104	6.07	0.004	< 0.01	0.002	0.563	0.08	4.4
Campbell Creek	3.2	0.088	1.2	84.1	< 0.002	< 0.02	0.05	< 0.001	45.3	0.9	0.068	0.8	0.02	2.19	14.3	15.5	<0.02	0.83	2.22	< 0.1	1.0	0.3	3.68	< 0.02	2.1	257	8.51	< 0.002	< 0.01	0.002	0.812	0.18	4.3
Big Campbell Creek	3.6	0.037	1.6	44.4	< 0.002	< 0.02	0.02	< 0.001	27.9	0.8	0.043	0.48	0.05	2.27	5.6	1.13	<0.02	0.62	1.43	< 0.1	1.4	< 0.2	2.62	< 0.02	1.2	156	5.18	< 0.002	< 0.01	0.002	1.06	< 0.05	5.6
Mink Creek	2.9	0.101	0.9	108	< 0.002	< 0.02	< 0.01	< 0.001	50.2	0.7	0.070	0.86	< 0.01	3.44	12.4	5.48	<0.02	0.71	2.16	< 0.1	0.9	0.3	4.04	< 0.02	2	289	5.74	< 0.002	0.02	0.002	1.34	0.09	2.8
Hoole River	9.5	0.149	0.8	86.6	< 0.002	< 0.02	< 0.01	0.05	48.8	0.6	0.060	2.7	0.06	4.05	17.5	1.95	<0.02	0.93	2.49	< 0.1	0.5	1.2	2.50	< 0.02	1.3	225	20.7	< 0.002	< 0.01	0.002	2.21	0.06	6.5
Starr Creek	7.8	0.176	0.4	89.7	< 0.002	< 0.02	< 0.01	0.1	76.9	0.6	0.105	0.59	0.03	4.79	32.3	4.1	<0.02	1.39	3.91	< 0.1	0.7	4.6	2.77	< 0.02	2.4	357	38.8	0.003	< 0.01	0.002	4.06	0.09	6.4
Horton Creek	1.9	0.185	0.6	84.3	< 0.002	< 0.02	< 0.01	0.02	69.2	0.7	0.121	0.49	< 0.01	5.13	32.4	16.7	<0.02	2.33	3.16	< 0.1	1.1	1.4	4.64	< 0.02	4.4	372	21.7	0.004	< 0.01	0.002	4.2	0.11	2.8
Little Ketza Creek	2.3	0.282	0.6	60	< 0.002	< 0.02	< 0.01	0.07	138	0.8	0.342	0.55	< 0.01	6.24	50.6	80.2	<0.02	2.71	7.79	< 0.1	1.0	2.8	3.41	< 0.02	1.7	644	102	0.002	< 0.01	0.002	9.93	0.18	4.8

Stream	TOTAL METALS																																	
	Al (ug/L)	Sb (ug/L)	As (ug/L)	Ba (ug/L)	Be (ug/L)	Bi (ug/L)	B (ug/L)	Cd (ug/L)	Ca (ug/L)	Cr (ug/L)	Co (ug/L)	Cu (ug/L)	Fe (ug/L)	Pb (ug/L)	Li (ug/L)	Mg (ug/L)	Mn (ug/L)	Hg (ug/L)	Mo (ug/L)	Ni (ug/L)	P (ug/L)	K (ug/L)	Se (ug/L)	Si (ug/L)	Ag (ug/L)	Na (ug/L)	Sr (ug/L)	S (ug/L)	Tl (ug/L)	Sn (ug/L)	Ti (ug/L)	U (ug/L)	V (ug/L)	Zn (ug/L)
Tuchitua River	95.8	0.069	0.4	66.1	0.005	< 0.02	<0.01	0.03	20.2	1.0	0.090	2.31	0.14	0.08	0.73	4.9	14.10	0.02	0.53	2.46	0.4	0.6	0.3	2.99	0.04	0.9	88.9	4.43	0.005	0.45	0.003	0.211	0.19	2.9
Jules Creek	78.6	0.123	0.2	78.5	0.002	< 0.02	<0.01	0.02	38.9	1.2	0.116	2.25	0.13	0.07	1.35	9.2	20.60	< 0.02	0.94	2.98	0.6	0.5	1.1	2.45	0.03	1	206	14.3	0.005	0.73	0.002	0.587	0.25	7
Money Creek	154	0.082	0.3	60.6	0.01	< 0.02	<0.01	0.05	22.1	1.0	0.132	2.77	0.29	0.19	2.06	7.1	8.24	< 0.02	0.66	2.42	0.4	0.9	0.4	3.79	0.04	1.3	116	5.48	0.013	0.58	0.004	0.615	0.46	7
Campbell Creek	27.4	0.089	1	80.6	< 0.002	< 0.02	<0.01	< 0.01	47.3	0.8	0.077	2.75	0.06	0.06	2.09	14.3	24.90	< 0.02	0.85	2.42	0.7	1.0	0.3	3.51	0.03	2	299	7.93	0.002	0.71	< 0.002	0.868	0.14	3.8
Big Campbell Creek	37.7	0.044	1.4	41.8	< 0.002	< 0.02	<0.01	< 0.01	28.6	0.8	0.067	2.43	< 0.05	0.06	2.15	5.5	3.17	< 0.02	0.64	4.69	0.5	1.4	< 0.2	2.49	0.03	1.1	176	4.78	0.003	0.7	< 0.002	1.11	0.1	4.4
Mink Creek	40	0.101	0.8	104	< 0.002	< 0.02	<0.01	0.01	52	1.0	0.097	2.64	0.08	0.1	3.06	12.4	8.82	< 0.02	0.77	3.08	0.7	0.9	0.3	3.83	0.03	2	325	5.24	0.003	0.76	0.003	1.42	0.17	3.8
Hoole River	51.5	0.15	0.7	84.1	0.004	< 0.02	<0.01	0.05	48.4	0.8	0.100	1.33	0.1	0.15	3.57	17.3	4.49	< 0.02	1.00	2.82	0.7	0.5	0.9	2.36	0.04	1.2	255	17.8	0.003	0.56	< 0.002	2.35	0.16	5.8
Starr Creek	117	0.183	0.4	91.5	0.003	< 0.02	<0.01	0.12	77	0.8	0.193	1.4	0.2	0.34	4.24	30.6	8.01	< 0.02	1.47	4.41	1.0	0.5	3.5	2.72	0.03	2.3	415	34.5	0.005	0.22	0.003	4.24	0.43	7.7
Horton Creek	83.9	0.197	0.6	84.9	0.003	< 0.02	<0.01	0.04	67.5	0.7	0.189	1.31	0.21	0.14	4.49	30.3	20.70	< 0.02	2.44	3.50	0.9	1.0	1.2	4.28	< 0.02	4	429	18.5	0.003	0.22	0.002	4.35	0.35	3.7
Little Ketza Creek	49.6	0.284	0.6	60.9	< 0.002	< 0.02	<0.01	0.12	132	0.7	0.422	1.38	0.43	0.1	5.42	48.4	90.20	< 0.02	2.76	8.73	1.2	0.9	2.1	3.14	0.02	1.6	751	90.6	0.003	0.24	< 0.002	9.98	0.21	8.1

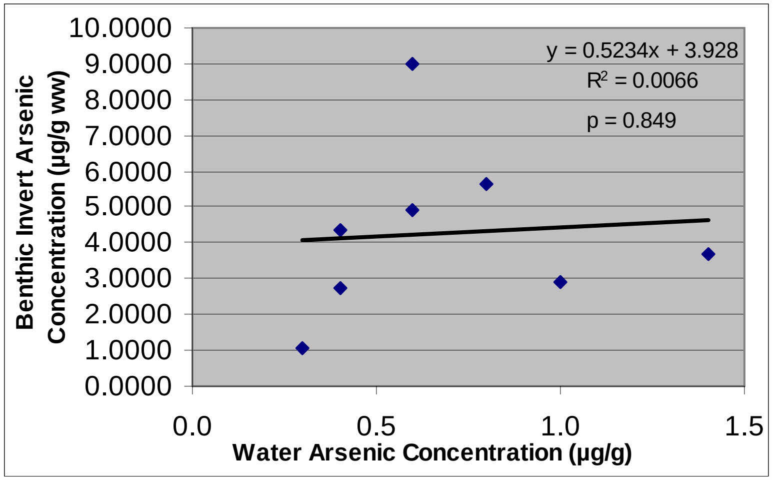
Appendix H. Sample Media Regressions

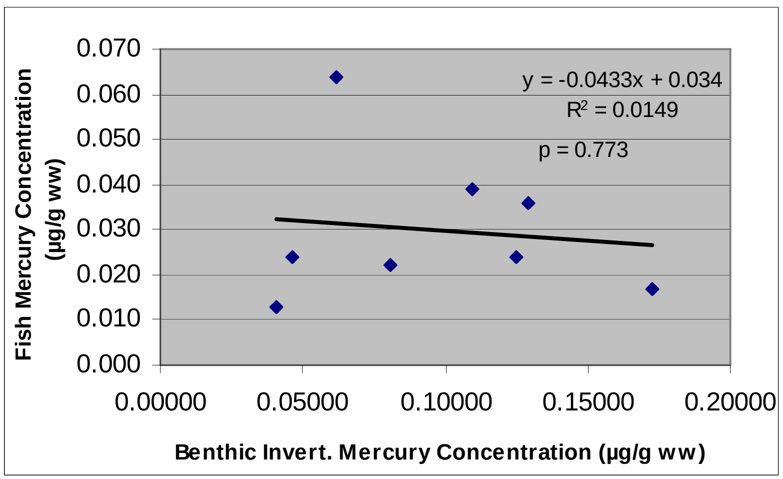


Relationship between arsenic concentrations in fish and sediment (top) and fish and benthic invertebrates (bottom).

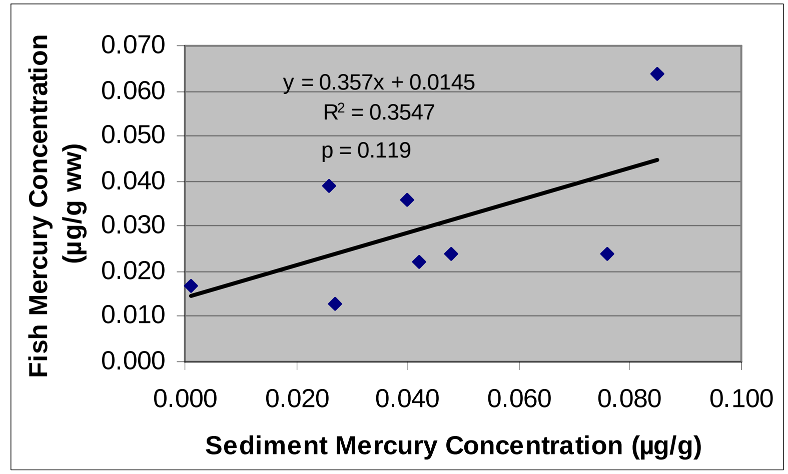


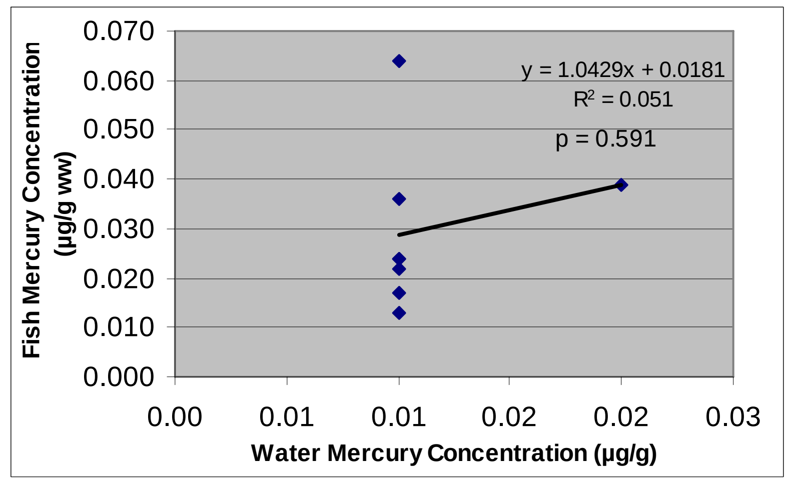
Relationship between arsenic concentrations in water and fish (top) and in benthic invertebrates and sediment (bottom).



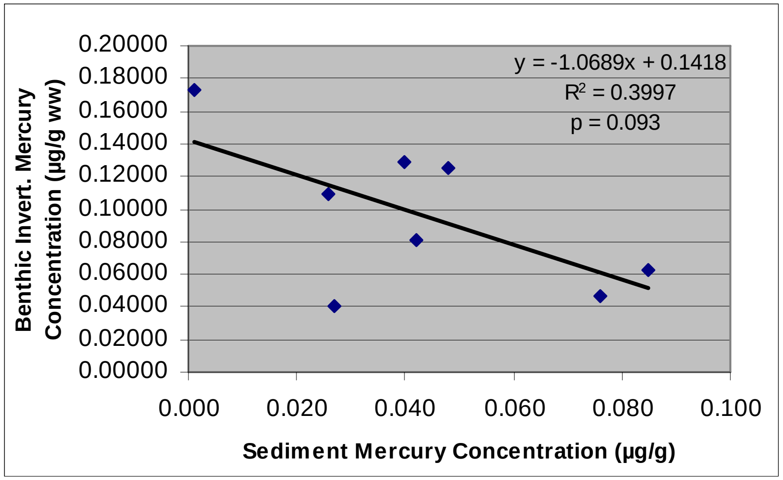


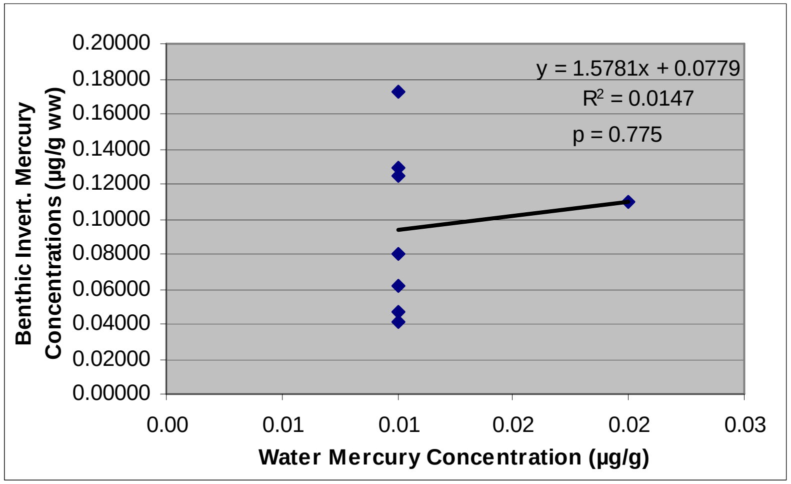
Relationship between arsenic concentrations in water and benthic invertebrates (top). Relationship between mercury concentrations in water and fish (bottom).





Relationship between mercury concentrations in fish and sediment (top) and between fish and water (bottom).





Relationship between mercury concentrations in benthic invertebrates and sediment (top) and between benthic invertebrates and water (bottom).