Technical Report No. 06-01

Aquatic Biomonitoring At Greens Creek Mine, 2005

by James D. Durst
Laura L. Jacobs

May 2006

Alaska Department of Natural Resources **Office of Habitat Management and Permitting**

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

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EXECUTIVE SUMMARY

The Alaska Department of Fish and Game (ADF&G) Habitat and Restoration Division and the USDA Forest Service, in cooperation with the U.S. Fish and Wildlife Service, began an aquatic biomonitoring program in Greens Creek and Tributary Creek in 2001 and again performed the sampling in 2002. The Alaska Department of Natural Resources Office of Habitat Management and Permitting, as successor to ADF&G Habitat and Restoration Division, conducted the sampling in 2003, 2004, and 2005.

As part of the Kennecott Greens Creek Mining Company Fresh Water Monitoring Program, the Greens Creek Mine Biological Monitoring Program's purpose is to ensure the continued use of Greens Creek and its tributaries by fish and other aquatic species, and to document the continued health of all levels of the aquatic biological community: primary productivity, invertebrate communities, and fish. The intent is that the program will also detect changes in the aquatic communities over time that may result from changes in water quality associated with surface or groundwater inputs to the streams. Elements of the biological monitoring program developed to meet the stated purpose have included surveys of periphyton biomass, benthic macroinvertebrate density and community structure, juvenile fish abundance and distribution, concentrations of select heavy metals in fish tissues, and toxicity testing.

In 2005, the stream reaches downstream of mine facilities (Greens Creek Below Pond D Site 54 and Tributary Creek Site 9) sustain functioning, relatively abundant, and diverse aquatic communities at population levels similar to those at the reference site (Upper Greens Creek Site 48). The general theme of the 2005 biomonitoring sampling was "moderate," with water flows, periphyton densities, benthic invertebrate communities, Dolly Varden densities, and fish tissue metals concentrations generally within the range of values seen in the four previous years of biological monitoring sampling.

Periphyton biomass and community composition continue to appear robust, with a pronounced diatom component and minimal amounts of filamentous green algae or blue-green bacteria. Chlorophyll *a* concentrations were similar between the two Greens Creek sites in 2005, and those sites had significantly less periphyton biomass than in 2003. Tributary Creek Site 9 chlorophyll *a* concentrations in 2005 were intermediate to samples from 2001 through 2004 but not statistically different from values of previous years.

The benthic macroinvertebrate communities at all three sites were taxonomically rich and moderately abundant in 2005, and populations of many disturbance-sensitive taxa were well represented. Benthic macroinvertebrate densities tended to be lower in 2005 than in previous years, but were not statistically different. The two Greens Creek sites had similar benthic macroinvertebrate densities in 2005; the density at Tributary Creek Site 9 was moderate for the years sampled and substantially lower than those at the Greens Creek sites. The percentage of benthic macroinvertebrates at both Greens Creek sites that were Chironomidae decreased in 2005 compared to 2004. Aquatic communities at both Greens Creek sites were dominated by Ephemeroptera (mayflies), with small contributions by Plecoptera (stoneflies) and aquatic Diptera (true flies). At the Tributary Creek site, the community was less dominated by Ephemeroptera, with Plecoptera being a more important component along with numerous non-insect invertebrates. The continuing community differences between the Greens Creek and Tributary Creek sites are likely influenced by differences in physical features, including gradient, stream size, water velocity, and scour patterns in the different sites.

Juvenile fish populations continued to be relatively abundant at each site in 2005, with higher estimated densities for Dolly Varden (*Salvelinus malma*) and coho salmon (*Oncorhynchus kisutch*) than the regional averages for that channel type. Multiple size classes of Dolly Varden were captured at each of the three sites; multiple size classes of coho salmon were captured at Tributary Creek Site 9 while a single size class was captured at Greens Creek Below Pond D Site 54. Dolly Varden capture rates in all three sample reaches were moderate in 2005 compared to previous years' sampling, while coho salmon capture rates were the highest reported at the two sites where they occur. Moderately low water levels somewhat decreased the wetted area available for fish habitat, particularly in Tributary Creek.

Whole body concentrations of metals in fish tissues were generally similar to those found in previous years' samples. Tissues of Dolly Varden from Tributary Creek Site 9 had different metals concentration characteristics than did tissues from Dolly Varden at the two Greens Creek sites (48 and 54) in 2005, although a clear pattern of differential water quality did not emerge between sites upstream and downstream of mine facilities or at sites over time.

The acute toxicity testing element of the biological monitoring program was discontinued after the 2003 sampling year. The results from the 2001 and 2002 toxicity testing, and the 2001 through 2005 periphyton, benthic macroinvertebrate, and juvenile fish biomonitoring program elements, provide no evidence to suggest toxicity of the waters at the three biomonitoring sites.

Overall, the aquatic communities in Upper Greens Creek Site 48, Greens Creek Below Pond D Site 54, and Tributary Creek Site 9 have remained relatively abundant and diverse during the five years of biomonitoring sampling. Differences noted between the stream systems (Greens Creek compared to Tributary Creek) were typically of larger amplitude than were differences between the control and below-mining sites within Greens Creek or over time at the Tributary Creek site. We noted no indications of reduced productivity, community changes, or metals accumulation attributable to operations of the Greens Creek Mine.

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INTRODUCTION

In 2000, an interagency regulatory team made up of representatives from the Alaska Department of Environmental Conservation (ADEC), the Alaska Department of Fish and Game (ADF&G), the Alaska Department of Natural Resources (ADNR), the Alaska Department of Law, the United States Environmental Protection Agency (USEPA), the USDA Forest Service (FS), and the United States Fish and Wildlife Service (FWS) were invited by the Kennecott Greens Creek Mining Company (KGCMC) to conduct a third-party environmental audit of the Greens Creek Mine operations within the Admiralty Island National Monument in southeast Alaska.

From findings of that review, the KGCMC Fresh Water Monitoring Program (FWMP) was updated (KGCMC 2000), including specifications for a biological monitoring program in areas adjacent to the KGCMC surface facilities associated with the mine and mill. This technical report presents results of the fifth year (2005) of the Greens Creek Mine Biological Monitoring Program as specified in the FWMP, conducted by the ADNR Office of Habitat Management and Permitting as successor to the ADF&G Habitat and Restoration Division. The FWMP specifies a review of the biomonitoring program after five years, so this report is inclusive and cumulative. Results from previous years' biomonitoring can be found in Weber Scannell and Paustian (2002), Jacobs et al. (2003), Durst and Townsend (2004), and Durst et al. (2005).

The intent of biological monitoring at Greens Creek Mine is to document the continued use of Greens Creek and Tributary Creek by fish and other aquatic species, and to document the continued health of the aquatic communities. Biomonitoring is designed to detect early changes to the aquatic community that may result from changes in water chemistry through either surface or groundwater inputs to the system.

Results from biomonitoring are typically compared to baseline conditions, or to a reference site that is unaffected if baseline data are unavailable. Each of the Greens Creek Mine biomonitoring sites is evaluated to detect changes or trends over time, with consideration given to any previous monitoring (KGCMC 2000). In addition, the two sites on Greens Creek below mine facilities are compared to a control site upstream of all mine facilities. All biomonitoring at the Greens Creek Mine follows standard protocols acceptable to the USEPA, FS, ADEC, ADF&G, ADNR, and the American Public Health Association (APHA 1992).

PURPOSE

The objective of the Greens Creek Mine Biological Monitoring Program is to establish existing conditions of the aquatic biological communities in selected reaches of Greens Creek and Tributary Creek near the KGCMC surface facilities. Future sampling during the mine life or during reclamation and closure can be compared to the conditions defined under the current biomonitoring program to detect any changes that may have occurred in aquatic communities.

The biological monitoring program for the Greens Creek mine is designed to address the following factors as specified in the Fresh Water Monitoring Program (KGCMC 2000):

- Periphyton biomass, estimated by chlorophyll concentrations;
- Abundance and community structure of benthic macroinvertebrate populations;
- Distribution and abundance of juvenile fish;
- Whole body concentrations of Ag, Cd, Cu, Pb, Se, and Zn in juvenile fish; and
- Standardized laboratory toxicity testing.

LOCATION AND SCHEDULE OF MONITORING

Four of the FWMP sites were selected for the biomonitoring program. Upper Greens Creek Site 48 monitors Greens Creek upstream of all mine and mill activities. Some surface exploration activities have occurred intermittently upstream of this site including exploratory drilling. Biomonitoring at Upper Greens Creek Site 48 annually serves as a control site. Greens Creek Below Pond D Site 54 monitors Greens Creek downstream of all mine and mill facilities. Biomonitoring at Greens Creek Below Pond D Site 54 annually serves as a treatment site. Middle Greens Creek Site 6 (upstream of Site 54 but below Site 48, the mine portal, and several mine facilities), was sampled in 2001 to provide information on baseline conditions (in this instance, baseline is meant to describe the conditions at the beginning of the biomonitoring program) and is sampled on a 5-year schedule. KGCMC monitors the ambient water quality at these and other FWMP sites on a monthly basis, and reports the results of that monitoring under separate cover. Tributary Creek Site 9 monitors Tributary Creek downstream of the dry-stack tailings storage facility. Biomonitoring occurs at Site 9 annually to detect any changes over time. Water quality samples are not currently collected regularly at Tributary Creek Site 9; however, monitoring wells upstream near the dry-stack tailings facility are sampled regularly and reported under separate cover. Figure 1 shows the location of the Greens Creek Mine and the biomonitoring sampling locations.

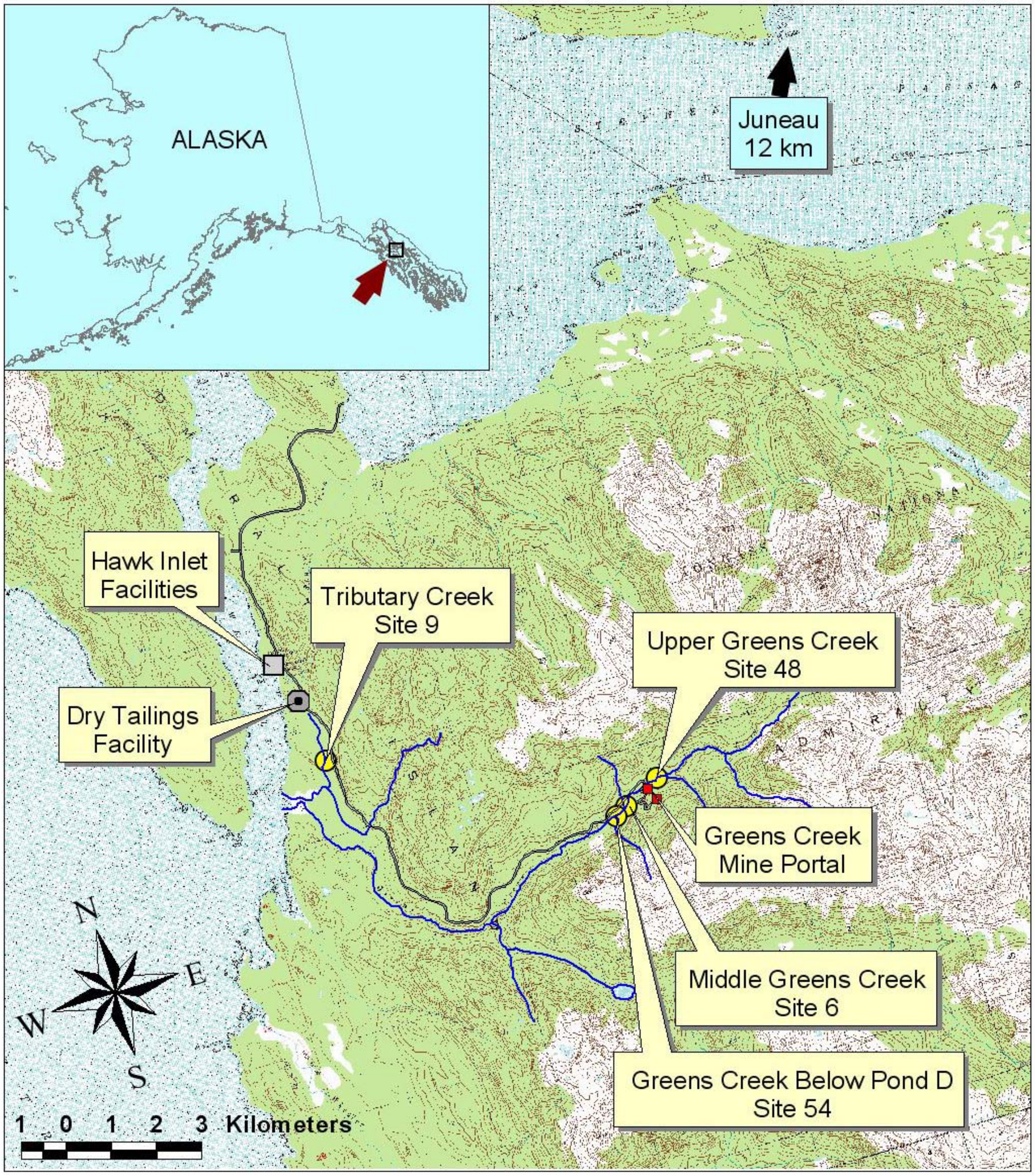

Figure 1. Location of the Greens Creek Mine operation and biomonitoring sampling sites on Admiralty Island in southeast Alaska, southwest of Juneau.

METHODS

Sample design and methods followed procedures in the KGCMC Fresh Water Monitoring Program (KGCMC 2000), and as reported for the previous years of this biomonitoring study (Weber Scannell and Paustian 2002, Jacobs et al. 2003, Durst and Townsend 2004, and Durst et al. 2005). Photographs were taken to document site conditions and sampling areas in each survey reach.

Data analyses were performed using hand calculators, Microsoft® Excel 2002, and Statistix® 8 (Analytical Software 2003). Kruskal-Wallis One-Way AOV, a nonparametric alternative to a one-way analysis of variance (ANOVA), was used to test for differences between years and sites (H_0: All of the population distribution functions are identical). All-pairwise comparisons were conducted on the mean ranks for each group to test for homogeneity of rank means between pairs of years or sites when significant or substantial differences were found. Throughout this report, two levels of statistical differences are reported: ***significant differences*** required an $\alpha \leq 0.05$, while ***substantial differences*** required an α value greater than 0.05 but less than or equal to 0.10 ($0.05 < \alpha \leq 0.10$). Groups reported as *not statistically different* were neither significantly different nor substantially different.

SAMPLE SITES

Upper Greens Creek Site 48

Upper Greens Creek Site 48 was selected as an upstream “control” reach site for comparison to downstream "treatment" reaches of Greens Creek adjacent to and downstream from the KGCMC facilities. This site, at approximately 265 m elevation, is upstream of all mining facilities and of all activities except for some isolated exploratory drilling. Site 48 lies approximately 0.8 km upstream of a weir that blocks access to upper Greens Creek by anadromous fish. Because of this barrier, the only salmonid species at this site is resident Dolly Varden (*Salvelinus malma*).

The Upper Greens Creek Site 48 sample reach has a Moderate Width Mixed Control (MM2) channel type (Appendix 1), with an average channel width of 9 m at ordinary high water and a gradient of 2-4 percent. This is a typical stream for the middle to lower portions of moderately sized basins in southeast Alaska (Paustian et al. 1992, Weber Scannell and Paustian 2002). Cobble is the dominant substrate and large woody material has a key role in pool formation and fish habitat cover.

Middle Greens Creek Site 6

Water quality at the Middle Greens Creek Site 6 (upstream of the Bruin Creek confluence) has been monitored under the FWMP since 1978. The site, at approximately 235 m elevation, was located to detect potential effects on Greens Creek from activities in the KGCMC mine, mill, and shop areas. Access of anadromous fish to this stream reach was created by KGCMC in 1989 by installing a fish pass in a waterfall approximately 4.8 km downstream. This site is near the upper limit of anadromous fish, defined by a weir located approximately 0.8 km upstream. Both Dolly Varden and coho salmon (*Oncorhynchus kisutch*) have been captured in this reach.

Biomonitoring information from this site will be used to detect possible changes in aquatic communities that occur from natural causes or as a result of mine activities. Following the sampling schedule presented in the FWMP, biomonitoring data were collected in 2001 for baseline information (Weber Scannell and Paustian 2002) and the site will be sampled again as part of the biomonitoring program in 2006.

Greens Creek Below Pond D Site 54

Greens Creek Below Pond D Site 54 is located approximately 0.4 km downstream of Middle Greens Creek Site 6 and approximately 1.2 km downstream of the weir that limits the upstream migration of anadromous fish in Greens Creek. This site, at approximately 225 m elevation, was located to detect potential effects from production rock storage areas 23 and D in addition to the facilities upstream of Middle Greens Creek Site 48. As such, Greens Creek Below Pond D Site 54 is downstream of all mine facilities along Greens Creek except portions of the B Road. Anadromous fish access to Site 54 was created by KGCMC in 1989 when a fish pass was installed in a waterfall area approximately 4.4 km downstream. Both Dolly Varden and coho salmon have been documented in this reach.

Greens Creek Below Pond D Site 54 has a Moderate Width Mixed Control (MM2) channel type (Appendix 1), with an average channel width of 10 m at ordinary high water and a gradient of 2-4 percent. This is a typical stream for the middle to lower portions of moderately sized basins in southeast Alaska (Paustian et al. 1992, Weber Scannell and Paustian 2002). Cobble is the dominant streambed material and large woody debris is integral to pool formation and fish habitat cover.

Tributary Creek Site 9

Tributary Creek is a small lowland stream with a dense canopy. This site, at approximately 25 m elevation, was previously monitored under the FWMP from 1981 through 1993 and is included in the current biomonitoring program because it is located approximately 1.6 km downstream from the KGCMC dry-stack tailings facilities. As such, it is the closest free-flowing stream reach suitable for biomonitoring to the tailings facilities. Data from this site will be analyzed for trends showing changes over time.

Tributary Creek provides habitat for a variety of fish populations including pink salmon (*Oncorhynchus gorbuscha*), chum salmon (*O. keta*), coho salmon, cutthroat trout (*O. clarki*), rainbow trout (*O. mykiss*), Dolly Varden, and sculpin (*Cottus* sp.). The sample reach in Tributary Creek Site 9 has a Narrow Low Gradient Flood Plain (FP3) Channel Type (Appendix 1), typical of a valley bottom or flat lowlands. At this site, Tributary Creek averages 2-3 m wide with a stream gradient of one percent, and has fine gravel as the dominant substrate (Paustian et al. 1992, Weber Scannell and Paustian 2002).

PERIPHYTON BIOMASS

Rationale

Periphyton, or attached algae, are sensitive to changes in water quality. Their abundance confirms that productivity is occurring at specific locations within a water body.

Sample Collection and Analysis

The method used to collect stream periphyton follows the protocol from the ADF&G (1998) and Barbour et al. (1999). Periphyton was sampled during a period of stable flow. Ten rocks were collected from the stream benthos in each study reach. A 5-cm x 5-cm square of high-density foam was placed on the rock. Using a small toothbrush, all material around the foam square was removed and rinsed away with clean water. The foam was removed from the rock, the rock was brushed with a clean toothbrush, and the loosened periphyton was rinsed onto a 0.45 μm glass fiber filter attached to a vacuum pump. Approximately 1 ml saturated $MgCO_3$ was added to the filter, after extracting as much water as possible, to prevent acidification and conversion of chlorophyll to phaeophytin. The glass filter was wrapped in a large paper filter (to absorb any additional water), placed in a sealed labeled plastic bag, and packed over desiccant. Filters were frozen on site in a lightproof container with desiccant, and then transported to Fairbanks where they were kept frozen until laboratory analysis by OHMP staff.

Methods for extraction and measurement of chlorophyll followed USEPA protocol (USEPA 1997). Filters for each rock sampled were removed from the freezer, cut into small pieces, and placed in a centrifuge tube with 10 ml of 90% buffered acetone. Centrifuge tubes were placed in a metal rack, covered with aluminum foil, and held in a refrigerator for 24 hr. After extraction, samples were centrifuged for 20 minutes at 1,600 rpm and then read on a Shimadzu Spectrophotometer UV-601 at optical density (OD) 664 nm, OD 647 nm, and OD 630 nm. In addition, a reading was taken at OD 750 nm to correct for turbidity. An acetone blank was used to correct for the solvent. Samples were then treated with 0.1 ml of 0.1 N hydrochloric acid to convert chlorophyll to phaeophytin, and read at OD 665 nm and OD 750 nm. Based upon these readings, amounts of chlorophylls *a*, *b*, *c*, and phaeophytin were determined according to Standard Methods (APHA 1992). Chlorophyll *a* is always predominant, and is a useful indicator of biomass. Chlorophylls *b* and *c* are accessory pigments that can provide information on the types of periphyton present.

Periphyton biomass data are presented using Box and Whisker graphs (Velleman and Hoaglin 1981). The box shows the middle half of the data, the intersecting line is the median, the vertical lines at the top and the bottom of the box indicate the range of "typical" data values; values beyond the "whiskers" represent statistical outlier values. "Possible" statistical outliers are data values outside the box by more than 1½ times the size of the box, while "probable" statistical outliers are value outside the box by more than 3 times the size of the box (Analytical Software 2003). We have no knowledge to indicate that these data values are other than extreme values that may be part of the data set's actual distribution, so they were retained and used for data analysis.

BENTHIC MACROINVERTEBRATES

Rationale

Benthic macroinvertebrate abundance and taxonomic richness are useful measures of stream health. Characterizing community structure and abundance of benthic macroinvertebrates at sample sites can show trends in stream health and water quality.

Sample Collection and Analysis

Five benthic samples were collected from each sample site with a modified Hess sampler. We used a stratified random sample design, modified from Barbour et al. (1999). Samples were collected exclusively from riffle areas where the greatest taxonomic richness and densities are typically found. This sample design eliminated variability from sampling pools or other marginal habitats where pollution-sensitive macroinvertebrates are less likely to occur. For each sample, the substrate was first manually disturbed, and then rocks were brushed and removed.

After the larger substrate was removed, the fine gravels were disturbed to a depth of approximately 10-15 cm. Macroinvertebrates disturbed from the stream bottom were collected in a 1-m, 300 µm mesh net and cup attached to the sampler. The sample was removed, placed in pre-labeled 500 ml Nalgene® bottles, and then preserved in 80% denatured ethanol. Macroinvertebrate samples were later sorted from all debris and identified to the lowest practical taxonomic level by an independent contractor.

Analyses included comparisons of density, taxonomic richness, percent community composition, and percent dominant taxon. The latter is a metric intended to identify the absence of environmentally sensitive species or dominance of less sensitive taxa.

JUVENILE FISH POPULATIONS

Rationale

Monitoring juvenile fish populations to determine potential trends in the numbers of Dolly Varden and coho salmon in stream reaches near the surface mine facilities helps evaluate the health of vertebrate populations in the Greens Creek and Tributary Creek drainages.

Sample Collection and Analysis

Fish population estimates were made using a modification of Aho (2000) with a three-pass removal method developed by the USFS (Bryant 2000). Fish were trapped using 6.4 mm (1/4 in) square mesh galvanized Gee's minnow traps baited with salmon eggs that had been treated with a povidone-iodine (Betadine®) disinfectant solution. Approximately 25 minnow traps were deployed for each sampling event within each sample reach, which was identified by aluminum tree tags and flagging set by the USFS during previous years' sampling. Sample reaches varied in length among sites because of the different availability of suitable habitat in which to set traps. At Upper Greens Creek Site 48, the 75 m reach sampled in 2001 was shortened to 50 m in 2002 and following years; at Greens Creek Below Pond D Site 54, the same 28 m long reach has been sampled each of the five years; and at Tributary Creek Site 9, the 44 m reach sampled in 2001 was extended to 50 m long for 2002 and following years. Traps were placed throughout the sample section focusing on pools, undercut banks, bank alcoves, under root-wads or logjams, and other habitats where fish were likely to be captured. In higher velocity sites, rounded stream rocks were placed in the traps to keep them in place and to provide cover for fish retained in the traps.

Where possible, natural features such as shallow riffles or small waterfalls over log steps define upper and lower sample reach boundaries to minimize fish movement into the sample section during sampling. To better define reach boundaries, traps were also set above and below each sample reach to serve as "blocks" by capturing potential migrants into the sample reach.

Minnow traps in each sample reach were set for about 1.5 hr, at which time all captured fish were transferred to perforated plastic buckets. Buckets were placed in the stream to keep water aerated and the captured fish in less stressful conditions. The traps were re-baited and reset for another 1.5 hr period. While the second set was fishing, fish captured during the first set were identified to species, counted, measured to fork length, and placed in a mesh holding bag in the stream. The procedure was repeated for the third 1.5 hr trapping period. Block traps were left in place and set for the entire 4.5 hr sampling period. Fish captured in these traps were counted and identified to species.

Fish population estimates were developed using the multiple-pass depletion method of Lockwood and Schneider (2000), an iterative method that produces a maximum likelihood estimate (MLE) of fish numbers with a 95% confidence interval. Six Dolly Varden from the first trapping period at each site were retained for whole body analysis of metals. Fish not retained for the metals analyses were returned to the stream immediately after sampling was completed.

METALS CONCENTRATIONS IN JUVENILE FISH

Rationale

The response time for juvenile fish to accumulate metals is rapid; for example, ADF&G has documented metals accumulation in juvenile Dolly Varden within five to six weeks after dispersing from their overwintering grounds to mineralized and unmineralized tributaries (Weber Scannell and Ott 2001). Should changes occur at the Greens Creek Mine that result in higher concentrations of metals in the creek, tissue sampling of juvenile fish should reflect these changes.

Sample Collection and Analysis

Six moderate-sized (target size range 95-125 mm fork length) juvenile Dolly Varden captured in baited minnow traps at each sample site were collected for whole body metals analysis. Collected fish were measured to fork length, individually packed in clean, pre-labeled bags, placed in an acid-washed cooler, and frozen on-site until transport to Fairbanks. We followed the techniques of Crawford and Luoma (1993) for minimizing contamination of the samples. In Fairbanks, the fish were weighed without removal from the bags (we corrected for the weight of the sample bag). The fish were submitted to a private analytical laboratory, where they were digested, dried, and analyzed for silver (Ag), cadmium (Cd), copper (Cu), lead (Pb) , selenium (Se), and zinc (Zn) on a dry-weight basis, with percent total solids also reported. In 2000, samples from Greens Creek Below Pond D Site 54 and Tributary Creek Site 9 both contained a mixture of coho salmon and Dolly Varden. In 2001 through 2005, all fish retained for metals analysis were Dolly Varden, although samples from Site 54 and Site 9 potentially contained a mixture of resident and anadromous forms.

Samples were numbered following the convention established by ADF&G in 2001: Date/StreamCode/SpeciesCode/AgeCode/SampleNumber. For example, one fish sample was labeled 072205GC48DVJ01 where 072205 represents July 22, 2005; GC48 represents Upper Greens Creek 48; DV represents Dolly Varden; J represents juvenile; and 01 represents sample replicate number 1.

Quality Control / Quality Assurance of Laboratory Analysis

The analytical laboratory (Columbia Analytical Services, Inc. in Kelso, Washington) provided Tier II quality assurance/quality control validation information for each analyte including matrix spikes, standard reference materials, laboratory calibration data, sample blanks, and sample duplicates.

TOXICITY TESTING

Rationale

Toxicity tests are designed to measure the combined toxic effects of all constituents in a particular sample, because some substances can be toxic in amounts that are below detection limits. This is particularly true when multiple toxic components synergistically cause toxicity, although each component may individually be below a detection limit.

Sample Collection and Analysis

The toxicity testing component of the Greens Creek Biomonitoring Program was suspended after the 2003 biomonitoring sampling period. Results from 2001 and 2002 provided no indication of toxicity, operational difficulties with the analytic method identified in the FWMP made further toxicity testing problematic, and continuation of the other components of the biological monitoring program were considered adequate to track the health of the stream systems and to detect toxicity should it occur (McGee and Marthaller 2004).

RESULTS AND DISCUSSION

Water levels appeared moderately low at the Greens Creek sites and low at the Tributary Creek site during sampling in 2005. The stream discharges during the biomonitoring sampling period in 2005 appeared to be higher than in 2003 or 2004 but much lower than in 2001 or 2002. These observations are confirmed by gage data obtained by KGCMC from the U.S. Geological Survey's Station 15101490, located just upstream of the mine portal road bridge between Greens Creek sites 48 and 54 (Table 1).

Table 1. Mean daily discharge in Greens Creek during biomonitoring sampling periods.

Water Year	Sampling Dates	Discharge, cubic feet/sec	Discharge, cubic meters/sec
2001	July 23	72	2.04
	July 24	73	2.07
2002	July 23	91	2.58
	July 24	123	3.48
2003	July 22	16	0.45
	July 23	15	0.42
2004	July 21	25	0.70
	July 22	22	0.62
2005	July 22	33	0.93
	July 23	29	0.82

UPPER GREENS CREEK SITE 48

Upper Greens Creek Site 48 (Figure 2) was sampled in the afternoon of 22 July 2005. The weather was partly cloudy with light winds. There was no evidence of high flow or other disturbance events. The water temperature was 10°C and the air temperature 18°C. Because Upper Greens Creek Site 48 serves as a control site for comparisons with Middle Greens Creek Site 6 and Greens Creek Below Pond D Site 54, biomonitoring primarily documents any changes at this site over time.

Periphyton Biomass

Concentrations of chlorophyll *a*, an estimate of periphyton biomass, in Upper Greens Creek Site 48 were significantly[1] different between years when 2001 through 2005 were analyzed together. The moderate values in 2005 were higher than those of 2001 and 2002 and lower than those of 2003 and 2004 (Appendix 2). Multiple pairwise comparisons showed that the 2005 values were significantly different only from the high values of 2003. The Box and Whisker output plot from Statistix is shown in Figure 3.

In the periphyton community at Site 48, the significantly higher proportions of chlorophyll *c* than chlorophyll *b* in all five years sampled (Figure 4), indicated communities dominated by diatoms. Low to undetectable concentrations of chlorophyll *b* indicate low populations amounts of filamentous green algae or blue-green bacteria.

Figure 2. Upper Greens Creek Site 48, 22 July 2005.

[1] Throughout this report, ***significant differences*** required an $\alpha \leq 0.05$ while ***substantial differences*** required $0.05 < \alpha \leq 0.10$.

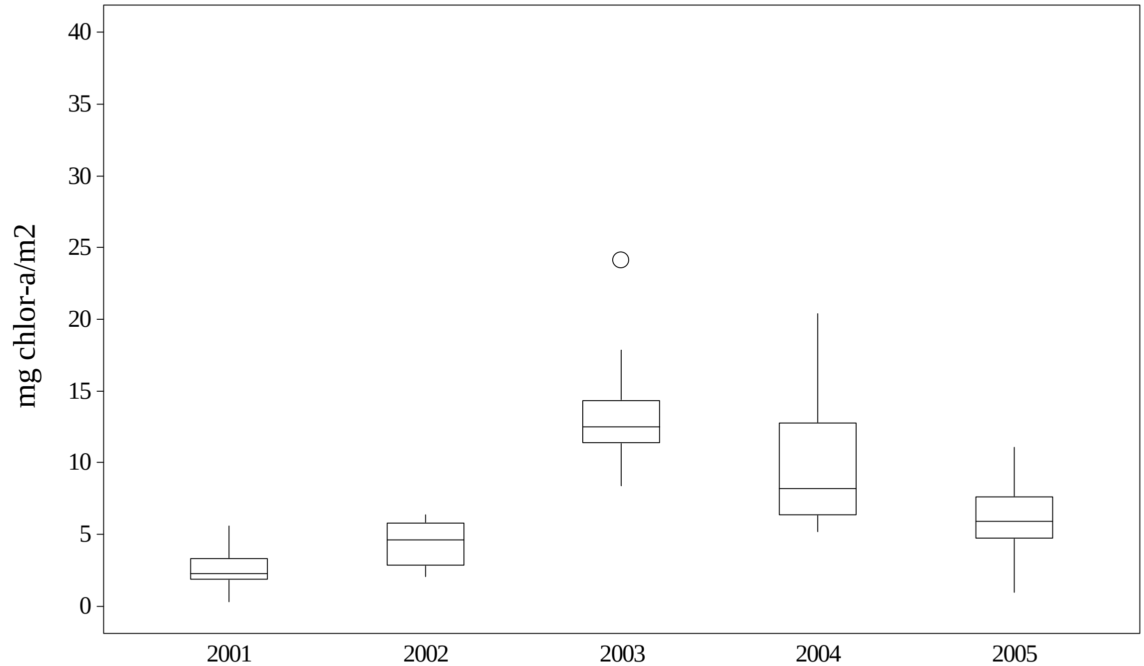

Figure 3. Estimated periphyton biomass densities at Upper Greens Creek Site 48 in 2001 through 2005 (n = 10 samples each year). Box encompasses middle half of data; horizontal line is median value. One probable outlier value (○) was identified in the 2003 data set.

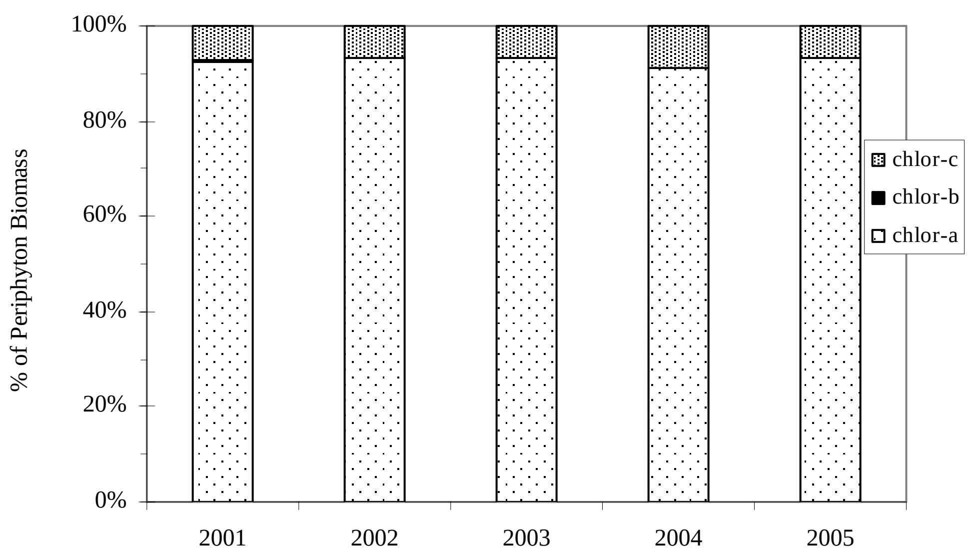

Figure 4. Proportions of chlorophylls *a*, *b*, and *c* in Upper Greens Creek Site 48 samples in 2001 through 2005.

Benthic Macroinvertebrates

The density of benthic macroinvertebrates in Upper Greens Creek Site 48 samples in 2005 was moderate between the lower values of 2001 and 2002 and the higher values of 2003 and 2004, but was not statistically different[2] from any other year (Table 2, Figure 5). The same was true of taxonomic richness (Appendix 3).

Table 2. Summary of benthic macroinvertebrate samples at Upper Greens Creek Site 48 in 2001 through 2005.

Year	Mean Density (aqua. invert./m^2)	Taxonomic Richness	Mean Taxa Per Sample
2001	2368	25	11.8
2002	1408	26	13.0
2003	4734	27	17.6
2004	3358	30	19.4
2005	2792	29	15.8

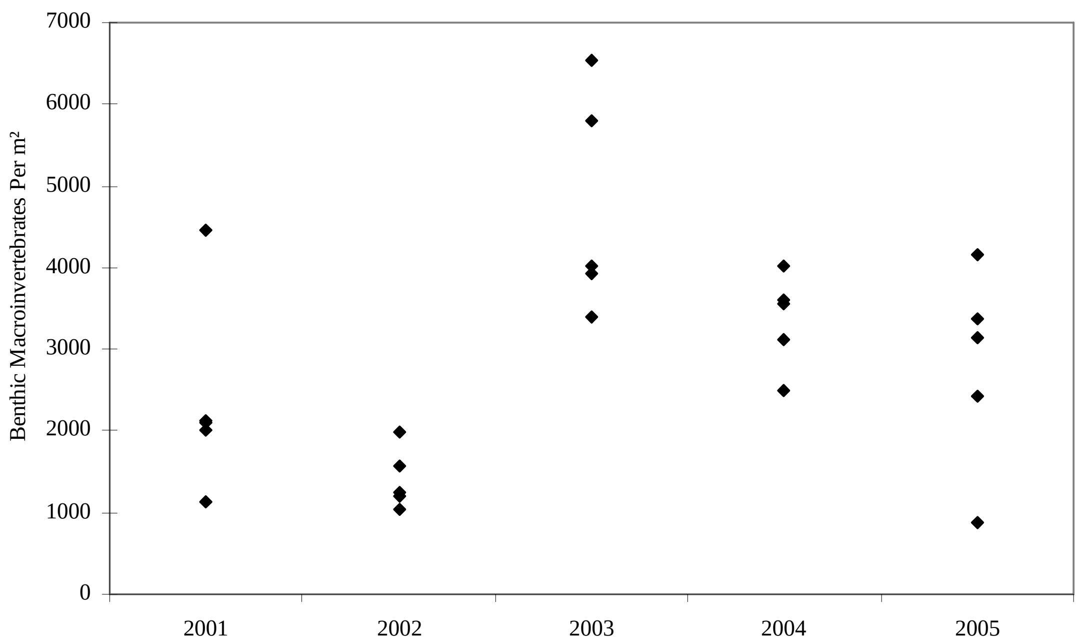

Figure 5. Density of benthic macroinvertebrates (n = 5 samples each year) at Upper Greens Creek Site 48 in 2001 through 2005.

[2] Throughout this report, groups reported as *not statistically different* were neither significantly different nor substantially different.

Invertebrate communities were somewhat different among the five years sampled, with relatively low but somewhat different proportions of Chironomidae occurring each year (Figure 6). The numbers of Chironomidae in 2005 samples were similar to those found in 2003, and less than in 2004. The EPT taxa (Ephemeroptera [mayflies], Plecoptera [stoneflies], and Trichoptera [caddisflies]) continued to be most prevalent, with relatively low proportions of aquatic invertebrates present from the CO taxa (Chironomidae [midge larvae] and Oligochaeta [aquatic worms]). Given that most of the EPT taxa are sensitive to decreased water quality, especially metals, the high proportion found at this baseline site signifies clean or healthy water quality conditions for aquatic life. This view is bolstered by the low proportion of the more disturbance tolerant CO taxa.

At Upper Greens Creek Site 48, mayflies (Ephemeroptera) dominated the benthic macroinvertebrate samples (Figure 7, Table 3). Common taxa in the five years sampled include the mayflies Baetidae: *Baetis*, Ephemerellidae: *Drunella*, and Heptgeniidae: *Epeorus* and *Rhithrogena*. *Baetis* are rated "moderately sensitive" to decreased water quality, *Drunella* are "very to extremely sensitive," *Epeorus* are "sensitive," and *Rhithrogena* are "very sensitive" (Barbour et al. 1999). In all five years, pollution-sensitive taxa dominated the invertebrate community at Upper Greens Creek Site 48, and many species of mayflies, stoneflies, caddisflies, and true flies represent a complex community. Appendix 3 lists the benthic macroinvertebrate taxa found at Upper Greens Creek Site 48 in 2001 through 2005.

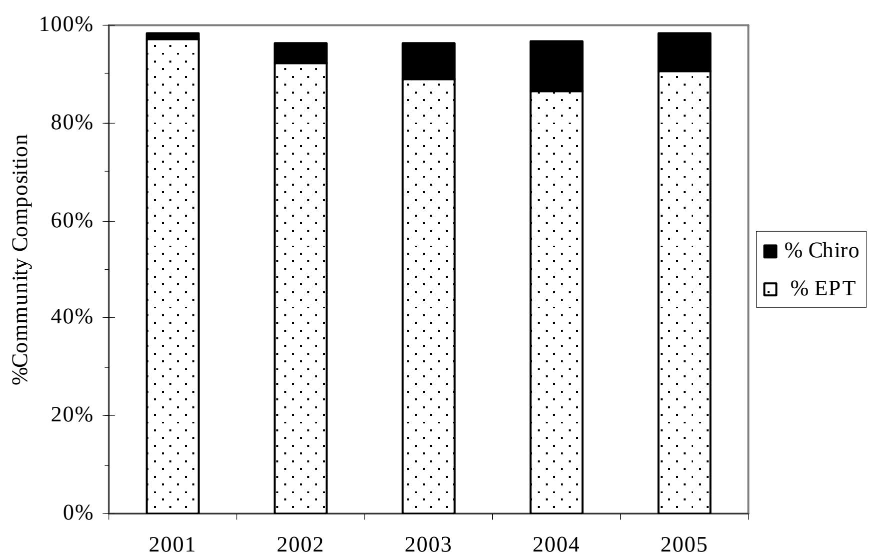

Figure 6. Proportions of EPT taxa and Chironomidae in Upper Greens Creek Site 48 samples in 2001 through 2005.

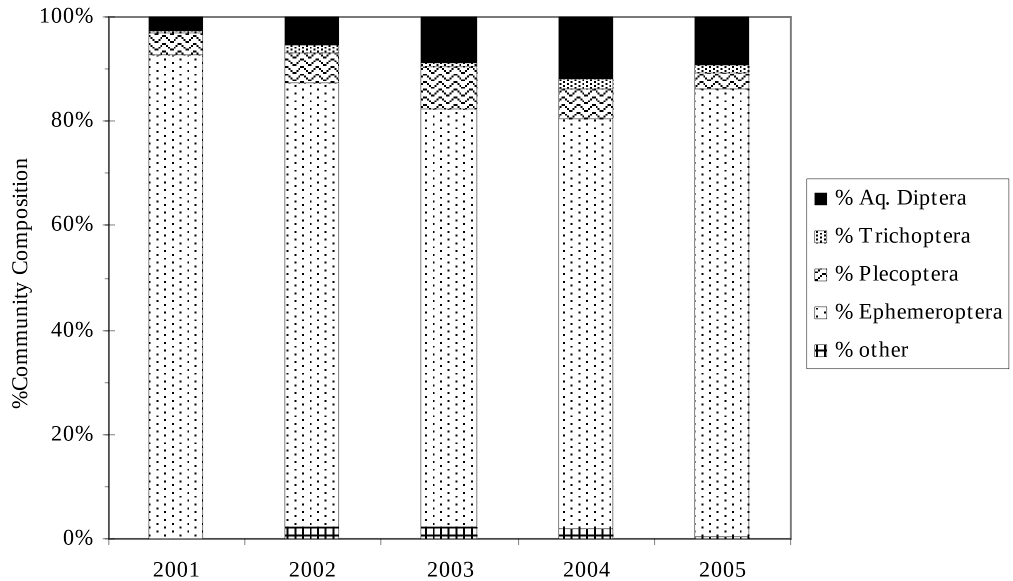

Figure 7. Community composition of benthic macroinvertebrates at Upper Greens Creek Site 48 in 2001 through 2005.

Table 3. Common taxa (>5.0% of aquatic invertebrates) found in Upper Greens Creek Site 48 samples in 2001 through 2005. The percent dominant taxon each year is bold.

Order	Family	Genus	2001	2002	2003	2004	2005
Ephemeroptera	Baetidae	*Baetis*	26%	22%	19%	23%	20%
	Ephemerellidae	*Drunella*	-	7%	**27%**	**24%**	26%
	Heptageniidae	*Cinygmula*	8%	-	-	6%	6%
		Epeorus	**38%**	**27%**	16%	12%	**27%**
		Rhithrogena	16%	**27%**	12%	12%	5%
Diptera	Chironomidae		-	-	7%	11%	8%

Juvenile Fish Populations

The 2005 juvenile fish survey captured 212 Dolly Varden in 29 minnow traps within the same 50-m reach at Upper Greens Creek Site 48 as sampled in 2002, 2003, and 2004. Three “block” traps were set downstream of this reach, and two upstream; they captured 32 additional Dolly Varden that are not included in the reported results. The estimated 2005 population size for the reach, based on a 3-pass removal, was 246 Dolly Varden with an approximate density of 0.65 fish/m² of wetted stream surface area. This was significantly less fish than in 2003, similar to the 2004 estimate, and significantly more fish than in 2002 (Table 4, Appendix 4). The density estimate for 2005 is intermediate between the higher values for 2003 and 2004 and the considerably lower value for 2002.

Table 4. Juvenile fish population estimates for Upper Greens Creek Site 48 based on minnow trapping in 2001 through 2005.

Year Sampled	Fish Species	No. Fish Caught	FLength, mm	Popn Estimate, fish (95% CI)	Sample Reach, m	Density, fish/m^2
2001	DV	68	50-140*	144 (84-448)	72	0.2
2002	DV	126	45-160*	145 (134-173)	50	0.23
2003	DV	285	54-180	333 (305-361)	50	0.9**
2004	DV	244	54-158	255 (246-264)	50	0.88
2005	DV	212	50-149	246 (222-264)	50	0.65

* Lengths represent upper end of 5-mm summary intervals reported by USFS.
** Based on estimated wetted area value.

Fork lengths of captured Dolly Varden represent a wide range of fish sizes. We have no validation data to correlate fish lengths with age such as scale or otolith analyses, but the length frequency plots (Figure 8) suggest that multiple age classes of Dolly Varden were captured in all five years of biomonitoring.

Metals Concentrations in Juvenile Fish

Median concentrations of metals in Upper Greens Creek Site 48 juvenile Dolly Varden tissues in 2005 were generally similar to those found in samples from the previous four years of biomonitoring at this site (Figure 9, Appendix 5). For comparison testing, silver concentrations reported as not detected were assumed to be at the detection level of 0.02 mg Ag/kg. Concentrations of cadmium were substantially less in 2005 than in 2002, and concentrations of lead were significantly higher in 2005 than in 2001 and 2003. The mean rank scores for silver, copper, selenium, and zinc concentrations in 2005 were not statistically different from those of previous years.

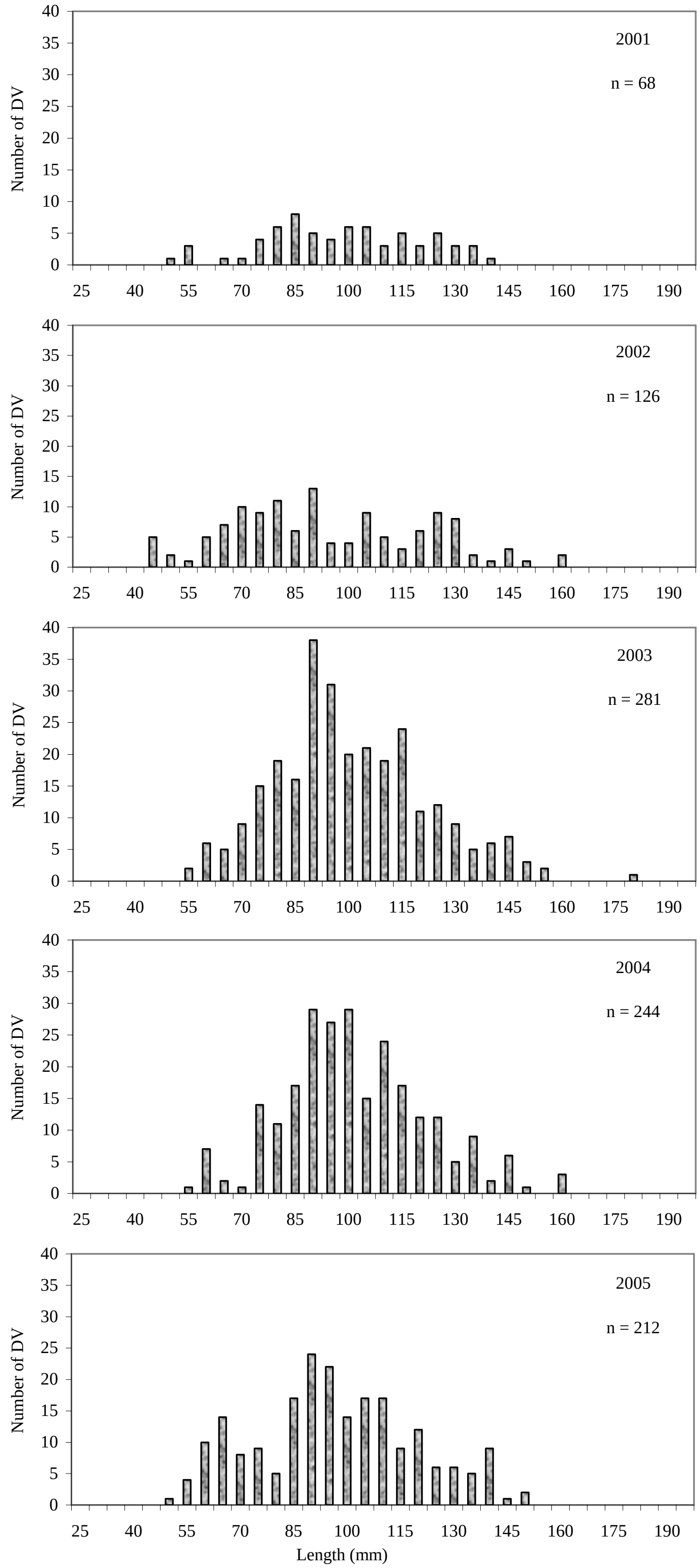

Figure 8. Length frequencies of Dolly Varden captured at Upper Greens Creek Site 48 in 2001 through 2005.

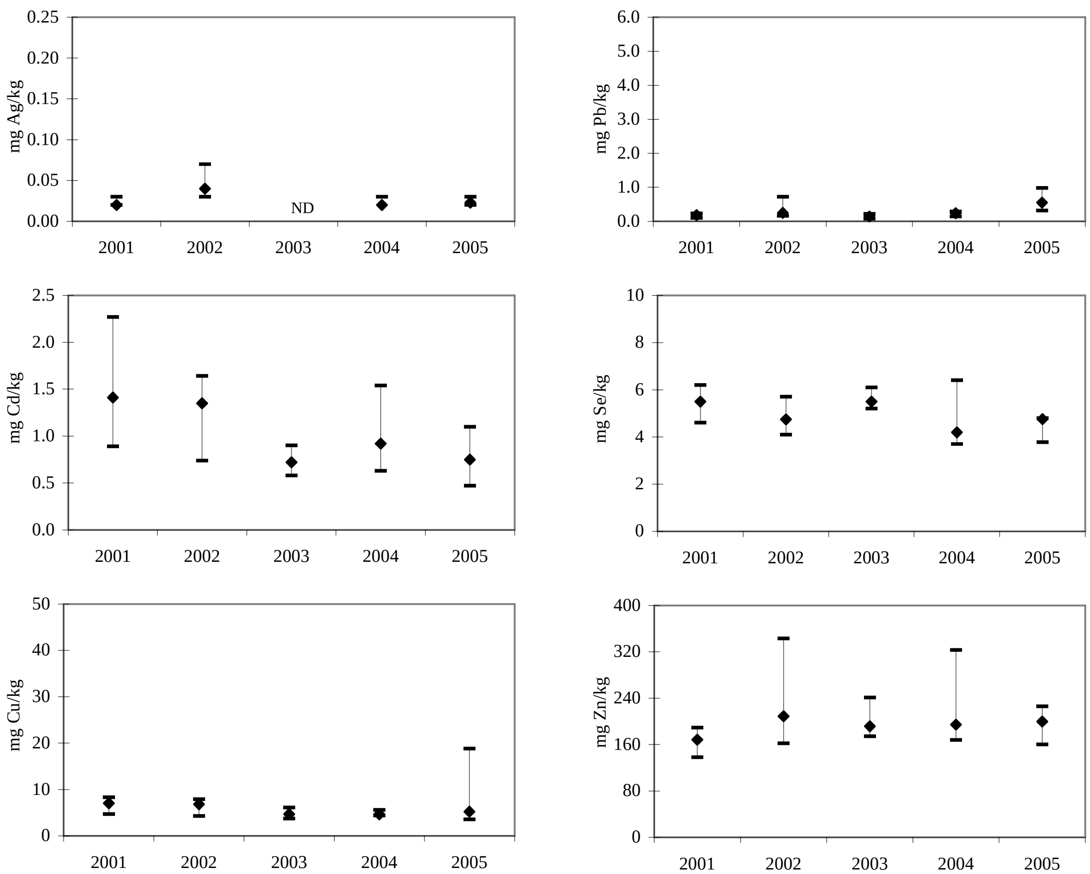

Figure 9. Whole body metals concentrations (medians and ranges) in Dolly Varden captured at Upper Greens Creek Site 48 in 2001 through 2005. ND = Not Detected at reporting limit for Ag of 0.02 mg/kg.

Summary

The moderately abundant periphyton and benthic macroinvertebrate communities, prevalence of disturbance-sensitive invertebrate species, and relatively stable metals concentrations in Dolly Varden over time in Upper Greens Creek Site 48 samples signify a functioning and apparently healthy aquatic community. The Dolly Varden population density and size distribution is within expectations for this type of stream channel reach with a downstream barrier to anadromous fish.

GREENS CREEK BELOW POND D SITE 54

Greens Creek Below Pond D Site 54 (Figure 10) was sampled in the morning of 22 July 2005. The weather was clearing after a rainy night. There was no evidence of recent high flow events. The water temperature was 9.0°C and the air temperature was 15.5°C.

Figure 10. Greens Creek Below Pond D Site 54, 22 July 2005.

Periphyton Biomass

Concentrations of chlorophyll *a*, an estimate of periphyton biomass, in Greens Creek Below Pond D Site 54 were significantly different between years when 2001 through 2005 were taken together. The 2005 values were higher than those for 2001 and lower than those for 2002, 2003, and 2004, but only significantly different from the high values of 2003. The Box and Whisker output plot from Statistix is shown in Figure 11.

The periphyton community at Greens Creek Below Pond D Site 54 had a significantly higher proportion of chlorophyll *c* than chlorophyll *b* in all five years sampled (Figure 12), indicating communities dominated by diatoms. Low to undetectable concentrations of chlorophyll *b* indicate low populations amounts of filamentous green algae or blue-green bacteria.

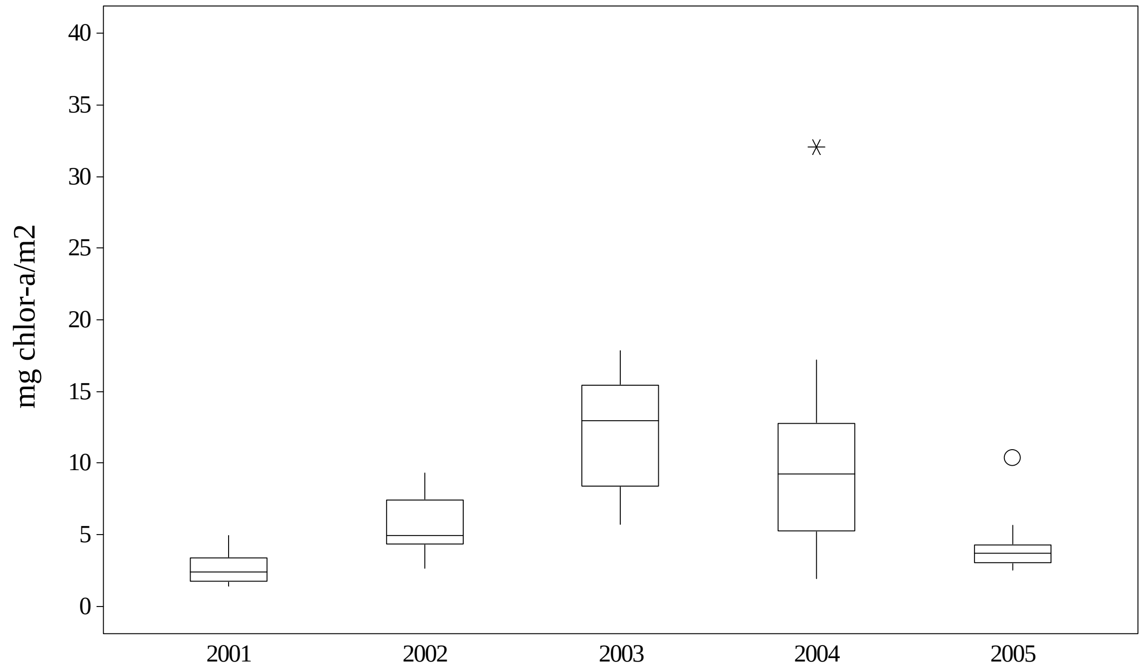

Figure 11. Estimated periphyton biomass densities at Greens Creek Below Pond D Site 54 in 2001 through 2005 (n = 10 samples each year). Box encompasses middle half of data; horizontal line is median value. One possible outlier value (*) was identified in the 2004 data set, and one probable outlier value (○) was identified in the 2005 data set.

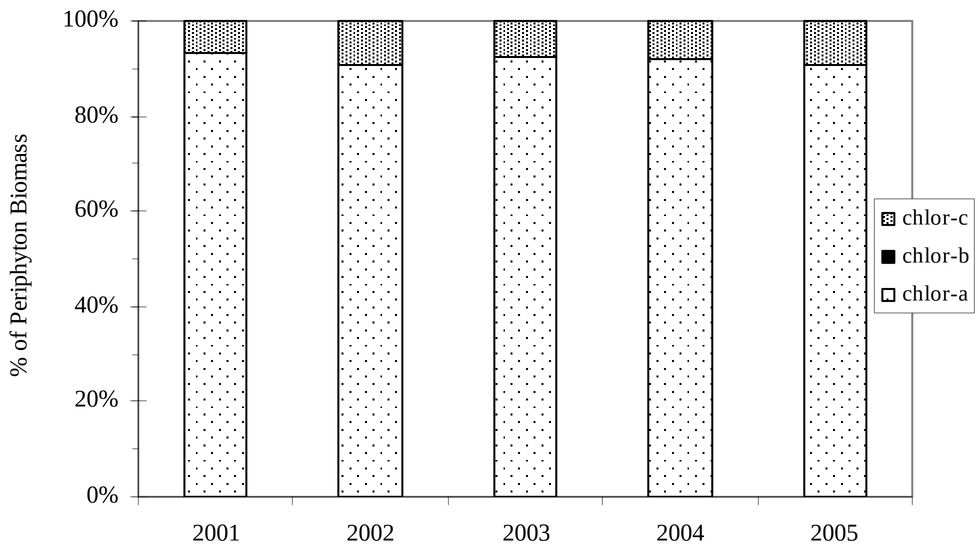

Figure 12. Proportions of chlorophylls *a*, *b*, and *c* in Greens Creek Below Pond D Site 54 samples in 2001 through 2005.

Benthic Macroinvertebrates

The average density of benthic macroinvertebrates (both median and mean) in Greens Creek Below Pond D Site 54 samples in 2005 was the lowest of the five years sampled, but not statistically so (Table 5, Figure 13). Taxonomic richness was similar during the five years sampled, also with no statistical differences between years.

Table 5. Summary of benthic macroinvertebrate samples at Greens Creek Below Pond D Site 54 in 2001 through 2005.

Year	Mean Density (aqua. invert./m^2)	Taxonomic Richness	Mean Taxa Per Sample
2001	3564	28	15.2
2002	2932	30	13.8
2003	4670	26	16.2
2004	3934	31	19.0
2005	2786	25	14.8

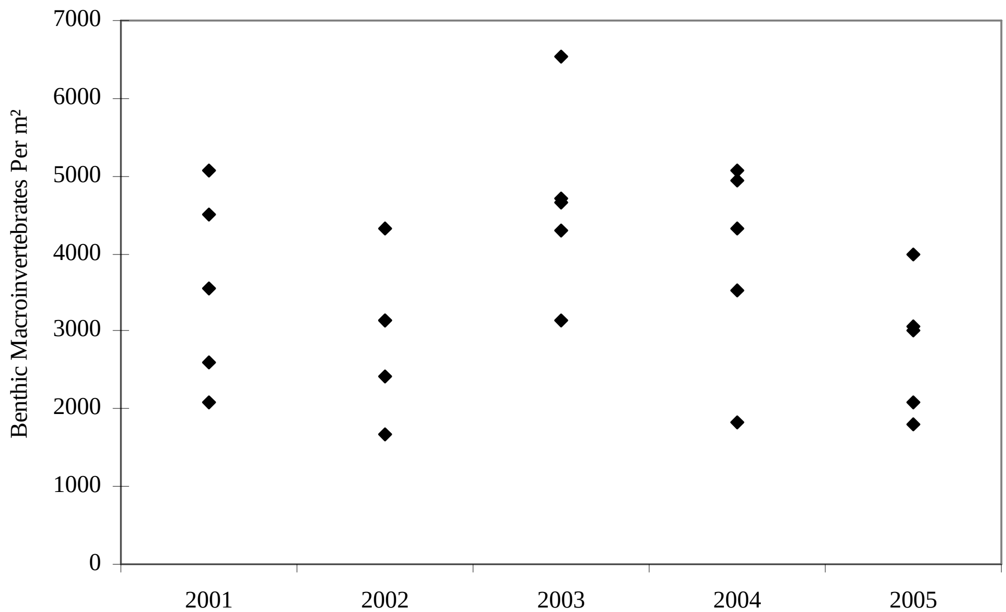

Figure 13. Density of benthic macroinvertebrates (n = 5 samples each year) at Greens Creek Below Pond D Site 54 in 2001 through 2005.

Invertebrate communities in Greens Creek Site 54 continued to be dominated by EPT taxa (Figure 14). In each of the five years sampled, Ephemeroptera were the most commonly collected order (Figure 15). In 2005, the Ephemeroptera were dominated by Baetidae: *Baetis,* Ephemerella: *Drunella*, and Heptageniidae: *Cinygmula*, and *Epeorus.* *Baetis* are rated "moderately sensitive" to decreased water quality, *Drunella* are "very to extremely sensitive," *Epeorus* are "sensitive," and *Rhithrogena* are "very sensitive" (Barbour et al. 1999). The dominance of the benthic macroinvertebrate community by pollution-sensitive taxa (Table 6), combined with the mixture of many species of mayflies, stoneflies, caddisflies, and true flies (Appendix 3) suggests a complex and productive aquatic ecosystem at this site.

Table 6. Common taxa (>5.0% of aquatic invertebrates) found in Greens Creek Below Pond D Site 54 samples in 2001 through 2005. The percent dominant taxon each year is bold.

Order	Family	Genus	2001	2002	2003	2004	2005
Ephemeroptera	Baetidae	*Baetis*	14%	15%	9%	15%	14%
	Ephemerellidae	*Drunella*	7%	19%	**38%**	**38%**	**39%**
	Heptageniidae	*Cinygmula*	18%	5%	8%	6%	6%
		Epeorus	**53%**	**43%**	17%	12%	25%
		Rhithrogena	-	10%	13%	9%	-
Diptera	Chironomidae		-	-	6%	8%	-

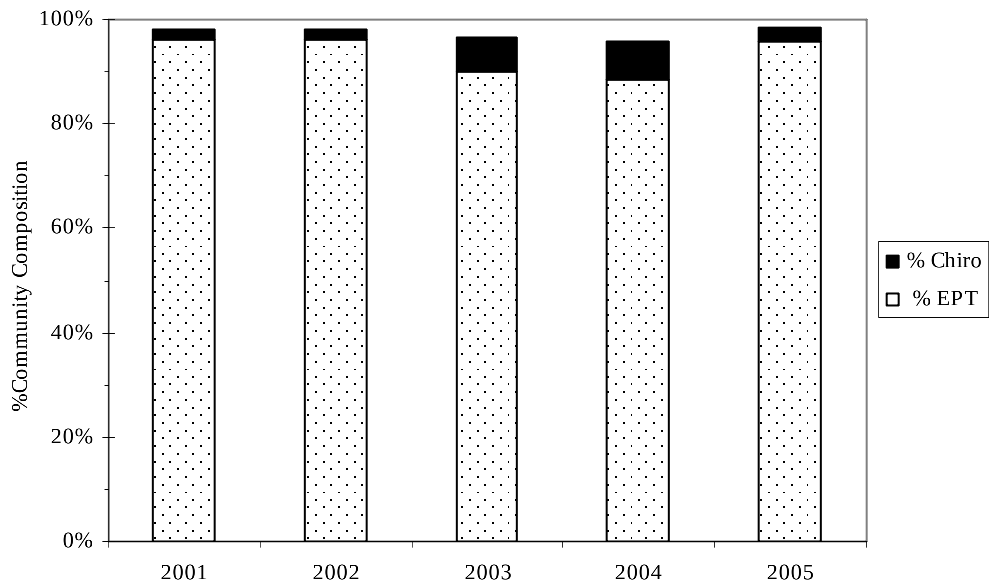

Figure 14. Proportions of EPT taxa and Chironomidae in Greens Creek Below Pond D Site 54 samples in 2001 through 2005.

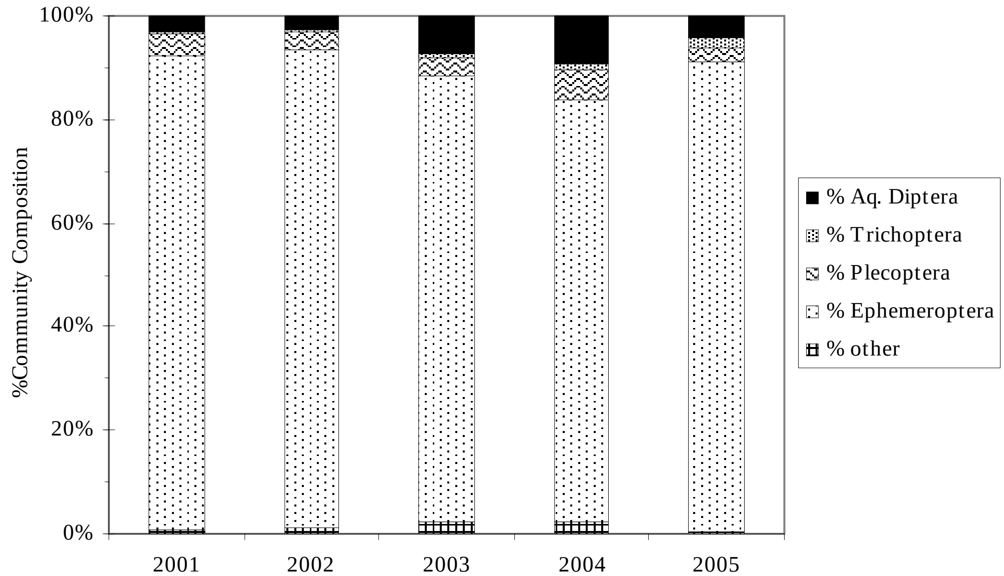

Figure 15. Community composition of benthic macroinvertebrates at Greens Creek Below Pond D Site 54 in 2001 through 2005.

Juvenile Fish Populations

The 2005 juvenile fish survey at Greens Creek Below Pond D Site 54 captured 61 coho salmon and 213 Dolly Varden in 25 minnow traps in the same 28-m reach as sampled in the three previous years (Table 7). Four "block" traps were used immediately downstream of the sample reach and three upstream; they captured an additional 5 coho salmon and 43 Dolly Varden that are not included in the reported results. The estimated 2005 population sizes for the reach, based on a 3-pass removal, was 67 coho salmon with an approximate density of 0.31 fish/m^2, and 255 Dolly Varden with an approximate density of 1.17 fish/m^2 of wetted stream surface area (Table 7). The estimated population of juvenile coho salmon in the Greens Creek Below Pond D Site 54 sample reach in 2005 was significantly higher than in 2002, 2003, or 2004 (Table 7, Appendix 4). The estimated populations of Dolly Varden were much larger than those for coho each of the years sampled but showed a different trend, with a moderate population estimate for 2005 that was significantly different only from the lower 2001 value.

Table 7. Juvenile fish population estimates for Greens Creek Below Pond D Site 54 based on minnow trapping in 2001-2005.

Year Sampled	Fish Species	No. Fish Caught	FLength mm	Popn Estimate, fish (95% CI)	Sample Reach, m	Density, fish/m^2
2001	DV	138	30-165*	164 (150-200)	28	0.6
2002	DV	271	33-160	293 (282-315)	28	1.0
2003	DV	232	51-184	331 (275-387)	28	1.8**
2004	DV	201	52-161	234 (211-257)	28	1.57
2005	DV	213	52-146	255 (227-283)	28	1.17
2001	CO	>0	---	---	28	---
2002	CO	21	55-85	21 (21)	28	0.07
2003	CO	8	44-52	8 (8)	28	0.04**
2004	CO	24	70-95	31 (20-42)	28	0.21
2005	CO	61	66-93	67 (59-75)	28	0.31

* Lengths represent upper end of 5-mm summary intervals reported by USFS.
** Based on estimated wetted area value.

We have no validation data to correlate fish lengths with age such as scale or otolith analyses, but the wide range of size classes shown in the length frequency plots (Figure 16) suggest that multiple age classes of Dolly Varden were captured in all five years of biomonitoring.

Juvenile coho salmon caught at the Greens Creek Below Pond D Site 54 in 2005 were similar in size to those captured in 2004; the data from 2002, 2003, 2004, and 2005 appear to show a single age class (Figure 17). The USFS reported too few coho juveniles captured in 2001 for a meaningful length frequency analysis.

Metals Concentrations in Juvenile Fish

Concentrations of metals in juvenile Dolly Varden tissues at Greens Creek Below Pond D Site 54 in 2005 were similar to or less than those found in the previous five years' samples (Figure 18, Appendix 5). Concentrations of silver in 2005 samples were significantly less than in 2000[3]; concentrations of lead in 2005 were significantly less than in 2000 and substantially less than in 2002; and concentrations of selenium in 2005 were significantly less than in 2003. The mean rank scores for whole body concentrations of cadmium, copper, and zinc in 2005 were not statistically different from those of previous years.

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[3] Note that the fish collected for metals testing in 2000 were coho salmon, while those collected in 2001 through 2005 were Dolly Varden.

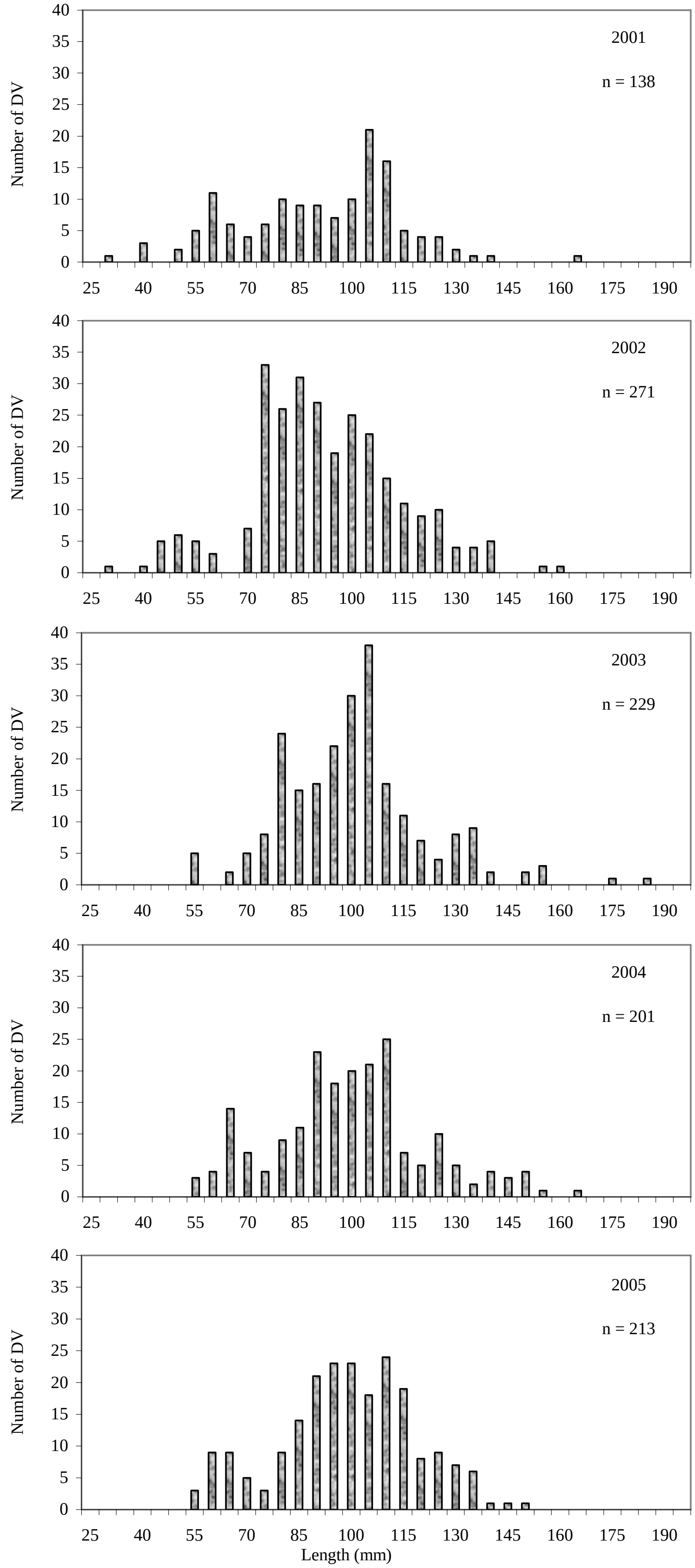

Figure 16. Length frequencies of Dolly Varden captured at Greens Creek Below Pond D Site 54 in 2001 through 2005.

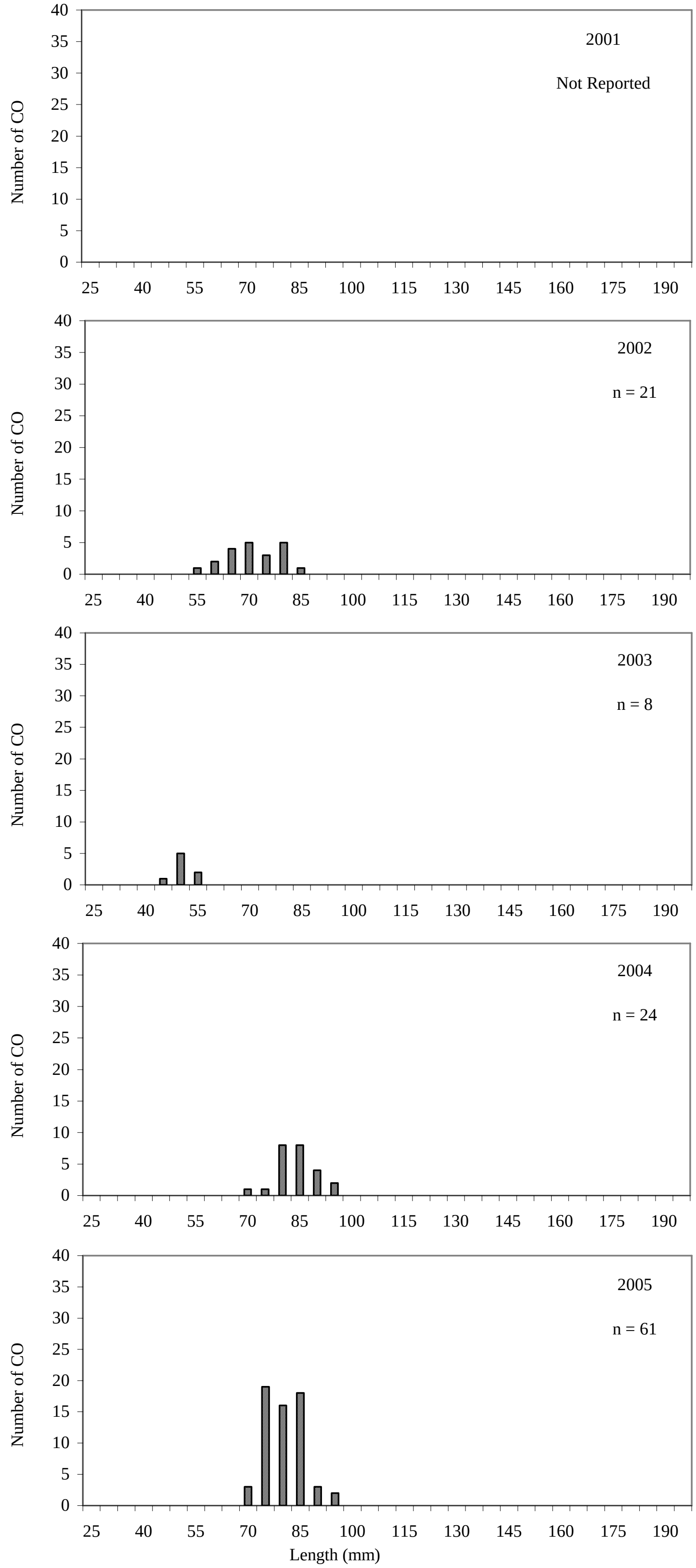

Figure 17. Length frequencies of juvenile coho salmon captured at Greens Creek Below Pond D Site 54 in 2001 through 2005.

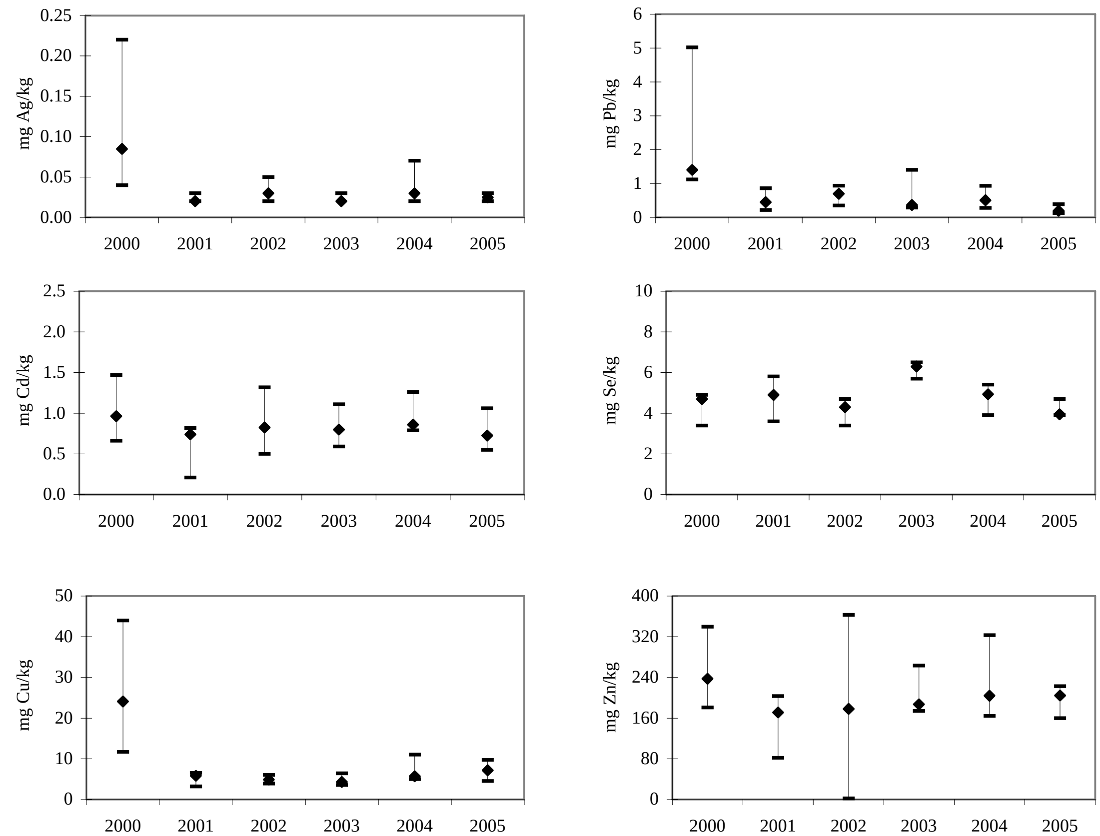

Figure 18. Whole body metals concentrations (medians and ranges) in fish captured at Greens Creek Below Pond D Site 54 in 2000 through 20054. The six fish sampled were coho salmon in 2000, and Dolly Varden in other years.

Summary

The moderately abundant periphyton and benthic macroinvertebrate communities, prevalence of disturbance-sensitive invertebrate species, and relatively stable metals concentrations in Dolly Varden over time in Greens Creek Below Pond D Site 54 samples signify a functioning and apparently healthy aquatic community. The Dolly Varden and coho salmon population densities and size distributions were within expectations for this type of stream channel reach with access to anadromous fish.

TRIBUTARY CREEK SITE 9

Tributary Creek Site 9 (Figure 19) was sampled in the morning of 23 July 2005. The weather was mostly cloudy but dry. The water temperature was 12°C and the air temperature 16°C. Water levels were fairly low as is typical for this site during biomonitoring sampling.

Figure 19. Tributary Creek Site 9, 23 July 2005.

Periphyton Biomass

Concentrations of chlorophyll *a*, an estimate of periphyton biomass, at Tributary Creek Site 9 were not statistically different among the five years sampled. The value from one sample in 2005 was much higher than were the other nine, as was also the case in 2004. Median biomass in 2005 was greater than that in 2001 and less than those in 2002, 2003, and 2004. The Box and Whisker output plot from Statistix is shown in Figure 20. Tributary Creek Site 9 samples contained significantly higher proportions of chlorophyll *c* than chlorophyll *b* in all years but 2002, when the chlorophyll *c* proportions were actually higher than those for chlorophyll *c* but not statistically different (Figure 21). The four years with a significantly higher proportion of chlorophyll *c* than chlorophyll *b* indicate communities dominated by diatoms, while the year with higher concentrations of chlorophyll *b* than chlorophyll *c* indicate elevated populations of filamentous green algae or blue-green bacteria.

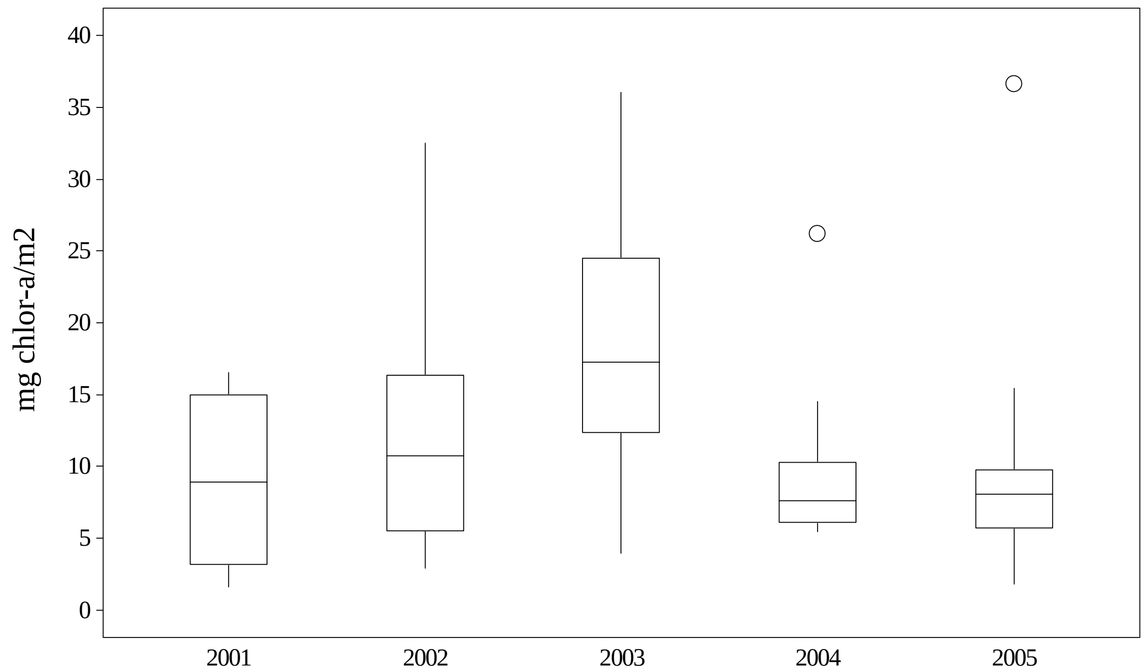

Figure 20. Estimated periphyton biomass densities at Tributary Creek Site 9 in 2001 through 2005 (n = 10 samples each year). Box encompasses middle half of data; horizontal line is median value. One probable outlier value (○) was identified in the 2004 and 2005 data sets.

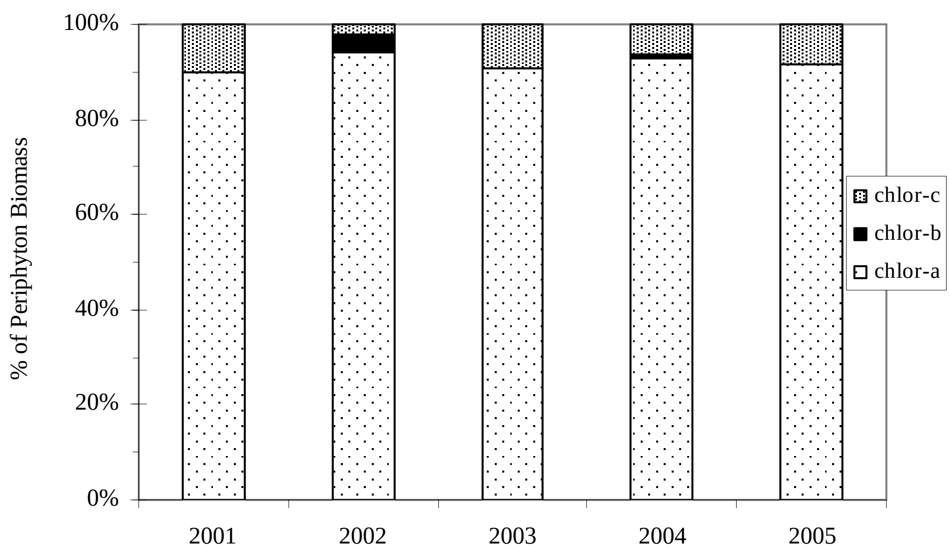

Figure 21. Proportions of chlorophylls *a*, *b*, and *c* in Tributary Creek Site 9 samples in 2001 through 2005.

Benthic Macroinvertebrates

The average density of benthic macroinvertebrates (both median and mean) in 2005 Tributary Creek Site 9 samples was moderately low compared to previous years (Table 8, Figure 22), but only significantly different from the high densities of 2003. Taxonomic richness, as expressed by number of taxa in samples, showed a similar pattern to that of density, although there were no statistical differences between richness in 2005 and that in preview years.

Table 8. Summary of benthic macroinvertebrate samples at Tributary Creek Site 9 in 2001 through 2005.

Year	Mean Density (aqua. invert./m^2)	Taxonomic Richness	Mean Taxa Per Sample
2001	1018	21	13.6
2002	1496	24	15.2
2003	5032	36	21.0
2004	2064	26	13.8
2005	1056	30	14.2

The EPT taxa continued to be the majority component of the Tributary Creek Site 9 benthic macroinvertebrate community. Chironomidae remained a relatively small, stable component at the Tributary Creek site (Figure 23).

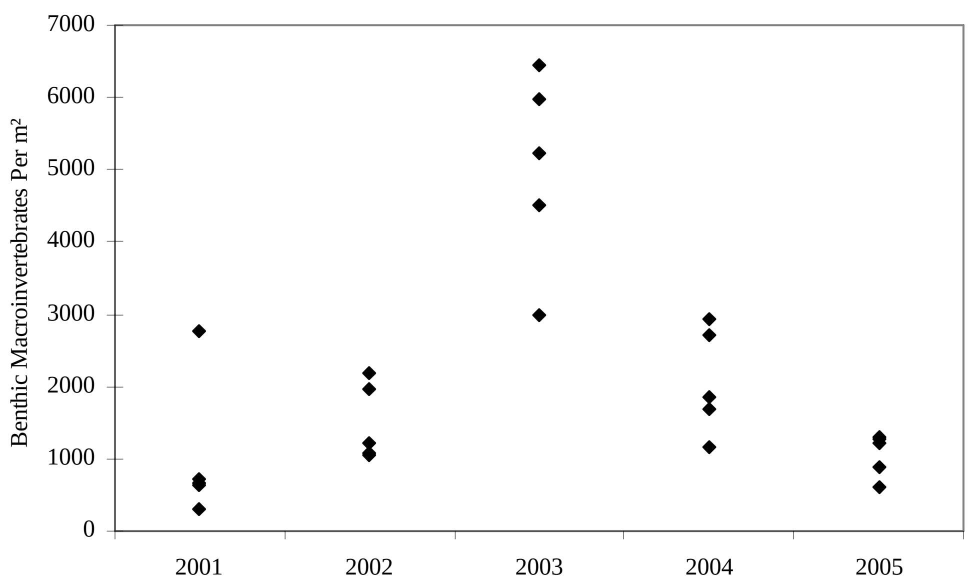

Figure 22. Density of benthic macroinvertebrates (n = 5 samples each year) at Tributary Creek Site 9 in 2001 through 2005.

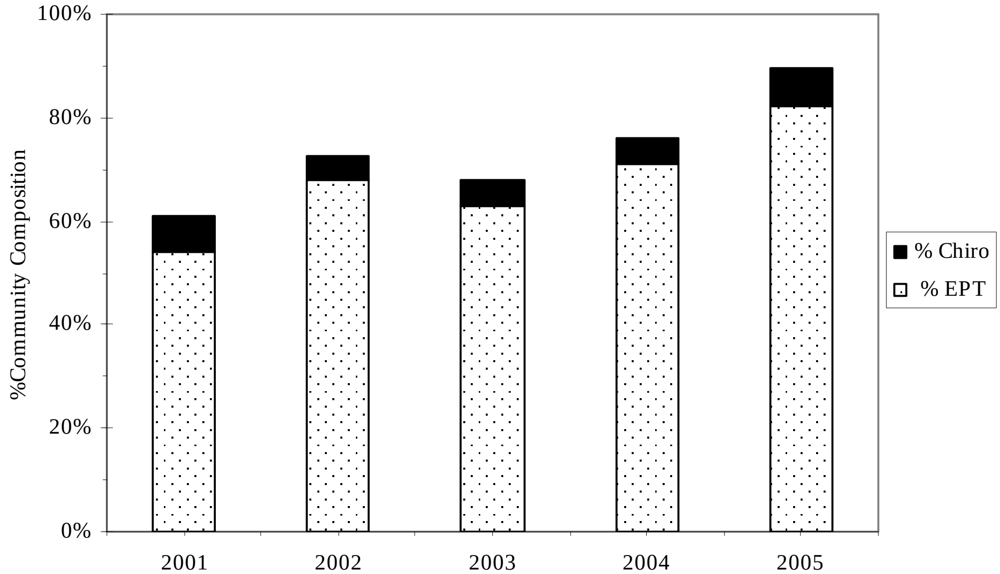

Figure 23. Proportions of EPT taxa and Chironomidae in Tributary Creek Site 9 samples in 2001 through 2005.

In the five years of benthic macroinvertebrate community sampling at Tributary Creek Site 9, the community has tended to be more diverse than at the Greens Creek sites, with more taxa being common in the samples. The 2005 Tributary Creek Site 9 samples were more diverse than those from 2004, and less diverse than in 2001 and 2003 (Table 9).

Table 9. Common taxa (>5.0% of aquatic invertebrates) found in Tributary Creek Site 9 samples in 2001 through 2005. The dominant taxon percent each year is bold.

Order	Family	Genus	2001	2002	2003	2004	2005
Ephemeroptera	Baetidae	*Baetis*	8%	16%	6%	-	7%
	Heptageniidae	*Cinygma*	-	-	-	-	8%
		Cinygmula	17%	**24%**	**20%**	5%	-
	Leptophlebiidae	*Paraleptophlebia*	13%	13%	10%	**43%**	**36%**
Plecoptera	Chloroperlidae	*Suwallia*	7%	-	-	-	7%
		Sweltsa	-	6%	-	-	-
		Neaviperla	-	-	7%	-	-
	Nemouridae	*Zapada*	-	-	15%	-	8%
Diptera	Chironomidae		7%	-	-	5%	8%
	Simuliidae	*Simulium*	8%	-	-	-	-
Acarina			-	6%	-	-	-
Oligochaeta			8%	-	14%	11%	-
Ostracoda			**18%**	-	8%	-	-
Isopoda	Gammaride	*Gammarus*	-	14%	-	-	-

Pollution-sensitive taxa, such as the mayflies *Cinygmula* and *Paraleptophlebia* were well represented (Figure 24). The presence of these orders reflects the stream channel characteristics of a small, valley-bottom stream with attached wetland areas. The diverse benthic macroinvertebrate community at Tributary Creek Site 9 included such non-insects as springtails (Collembola), worms (Oligochaeta), mites (Acarina), and seed shrimp (Ostracoda) (Appendix 3).

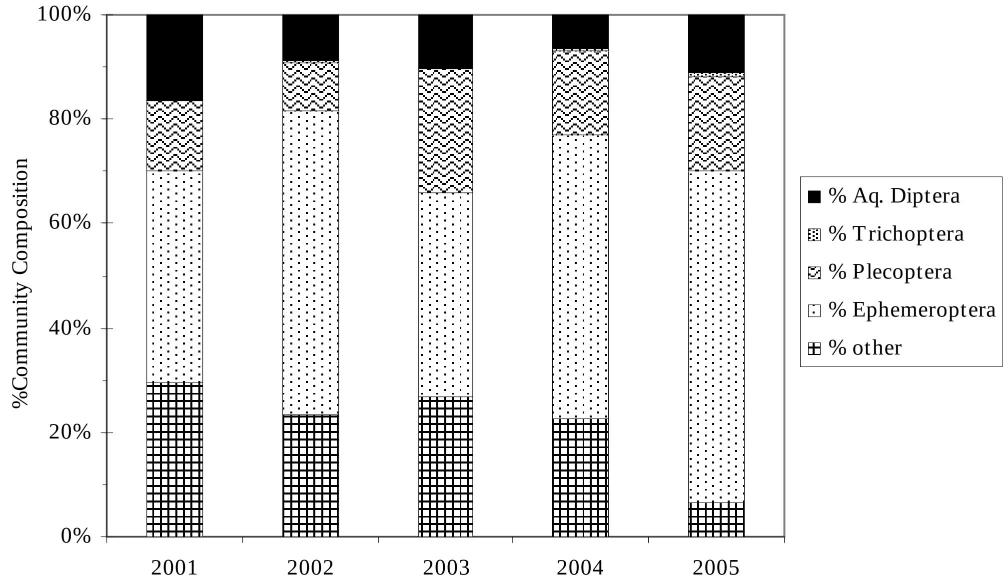

Figure 24. Community composition of benthic macroinvertebrates at Tributary Creek Site 9 in 2001 through 2005.

Juvenile Fish Populations

The 2005 juvenile fish survey in Tributary Creek Site 9 captured 140 coho salmon, 44 Dolly Varden, 2 cutthroat trout, and two sculpin in 22 minnow traps in the same 50-m sample reach as sampled in 2002, 2003, and 2004. Four "block" traps were set immediately downstream of the sample reach and two upstream; they captured an additional 61 coho salmon, 24 Dolly Varden, 1 cutthroat trout, and 2 sculpin that are not included in the reported results. The estimated 2005 population sizes for the reach, based on a 3-pass removal, was 150 coho salmon with an approximate density of 1.15 fish/m², and 55 Dolly Varden with an approximate density of 0.42 fish/m² of wetted stream surface area (Table 10). Estimates of the Dolly Varden population in this sample reach were significantly higher than in 2003 and 2004, significantly lower than in 2001, and similar to those for 2002. Coho salmon population estimates for 2005 were significantly higher than in previous years (Table 10, Appendix 4). The effect of limitations on available habitat due to low or fluctuating water levels is unknown for either species composition or density, but the total density of fish in available habitat areas (nearly 1.6 fish/m²) was also the highest observed at this site in five years of biomonitoring.

The ranges of fork lengths measured in both Dolly Varden and coho salmon captured at Tributary Creek Site 9 in 2005 suggest use by multiple age classes of both species (Figures 25 and 26).

Table 10. Juvenile fish population estimates for Tributary Creek Site 9 based on minnow trapping in 2001 through 2005.

Year Sampled	Fish Species	No. Fish Caught	FLength, mm	Popn Estimate, fish (95% CI)	Sample Reach, m	Density, fish/m^2
2001	DV	81	60-110*	81 (81)	44	0.65
2002	DV	51	38-147	57 (53-76)	50	0.46
2003	DV	19	54-114	20 (17-23)	50	0.3**
2004	DV	32	64-109	33 (31-35)	50	0.56
2005	DV	44	59-131	55 (41-69)	50	0.42
2001	CO	118	40-105*	120 (119-128)	44	0.94
2002	CO	44	27-85	46 (45-57)	50	0.35
2003	CO	52	46-88	53 (51-55)	50	0.8**
2004	CO	27	40-94	27 (27)	50	0.46
2005	CO	139	39-103	150 (139-161)	50	1.15

* Lengths represent upper end of 5-mm summary intervals reported by USFS.
** Based on estimated wetted area value.

Metals Concentrations in Juvenile Fish

Concentrations of metals in juvenile Dolly Varden tissues from Tributary Creek Site 9 were generally similar to those found in previous years' samples (Figure 27, Appendix 5). In 2005 samples, concentrations of selenium were significantly greater than the 2000[4] concentrations, and concentrations of zinc were significantly less than the 2000 concentrations. The mean rank scores for silver, cadmium, copper, and lead concentrations in 2005 were not statistically different from those of previous years.

[4] Note that the fish collected for metals testing in 2000 were two coho salmon and four Dolly Varden, while those collected in 2001 through 2005 were all Dolly Varden.

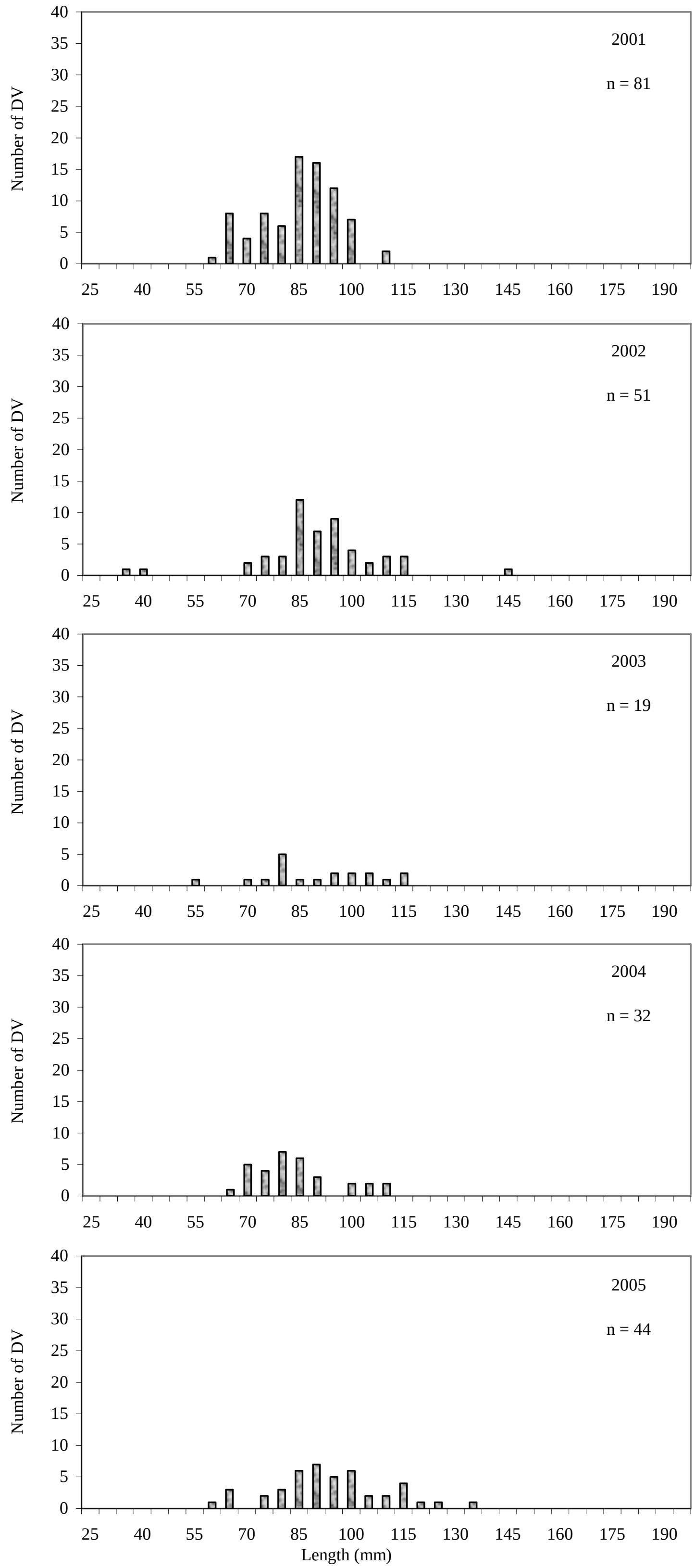

Figure 25. Length frequencies of Dolly Varden captured at Tributary Creek Site 9 in 2001 through 2005.

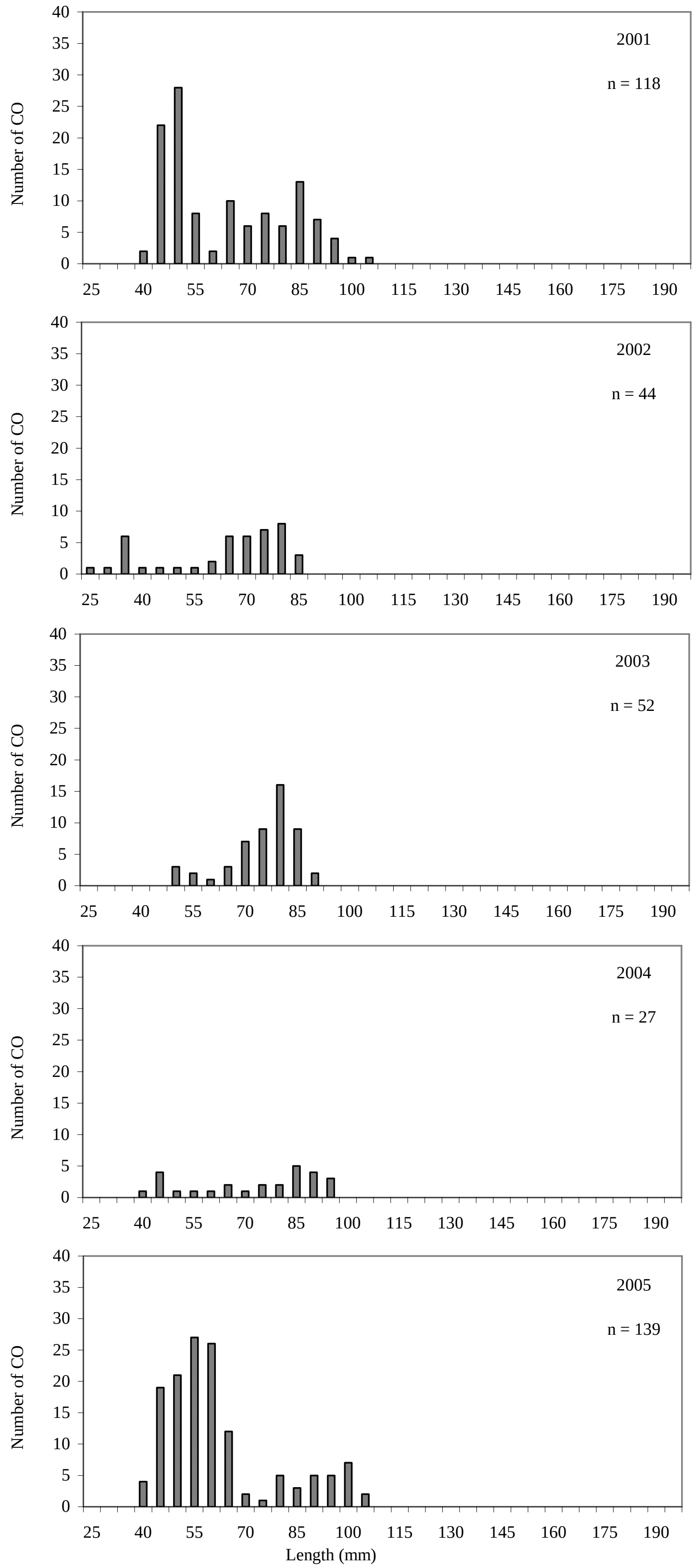

Figure 26. Length frequencies of juvenile coho salmon captured at Tributary Creek Site 9 in 2001 through 2005.

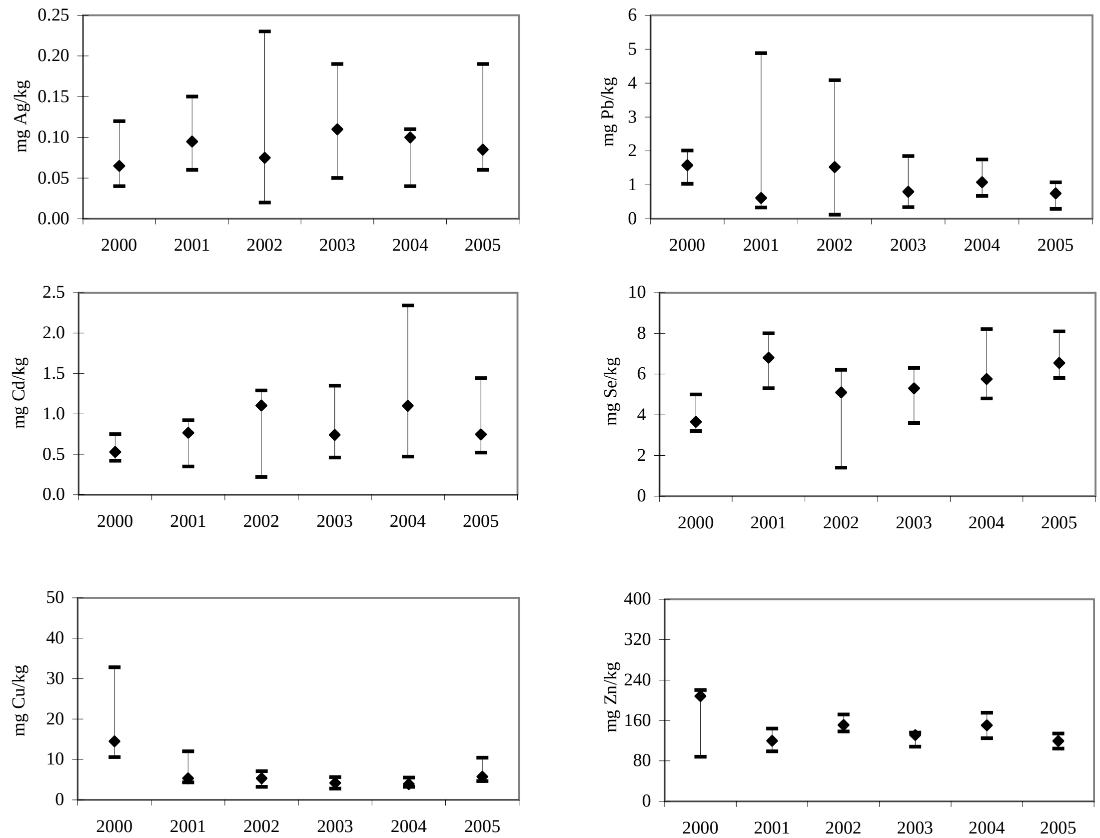

Figure 27. Whole body metals concentrations (medians and ranges) in fish captured at Tributary Creek Site 9 in 2000 through 2005. The six fish sampled each year were Dolly Varden except for two coho salmon in 2000.

Summary

The relatively abundant periphyton and benthic macroinvertebrate communities, abundance of disturbance-sensitive invertebrate species, and relatively stable metals concentrations in Dolly Varden over time in Tributary Creek Site 9 samples signify a functioning and apparently healthy aquatic community. The Dolly Varden and coho salmon population densities and size distributions are within expectations for this type of stream channel reach with access to anadromous fish.

COMPARISONS AMONG SITES

Although not explicitly analyzed, it is evident that appreciable portions of the variability noted between sites and within sites between years can be attributed to differences in physical characteristics of the sampled stream reaches (including gradient, substrate, water velocity, elevation, and location in watershed) and to annual differences in discharge and water level. Also not evaluated was the level of interaction effects between biotic components such as benthic macroinvertebrate consumption of periphyton or juvenile fish predation on benthic macroinvertebrates.

Periphyton Biomass

Periphyton biomass at the two Greens Creek sites has shown a similar pattern over the five years sampled, with lower values in 2001 and 2002 followed by a peak in 2003 and decreases in 2004 and 2005. Values from Greens Creek Below Pond D Site 54 were not statistically different from those found at Upper Greens Creek Site 48.

The pattern at the Tributary Creek site is generally similar to that at the Greens Creek sites but more variable within each year (Figure 28). Chlorophyll *a* concentrations were not statistically different between the Greens Creek sites in 2005, but those from Tributary Creek Site 9 were significantly higher than those from Greens Creek Below Pond D Site 54. Taking the three sites together, the 2005 periphyton biomass values were significantly lower than the 2003 values; 2005 values were within the range of and not statistically different from values for 2001, 2002, or 2004.

There were no major differences in community composition of the periphyton sampled at the Greens Creek and Tributary Creek sites in 2005 (Figure 29). As at the Greens Creek sites (48 and 54), the Tributary Creek Site 9 samples were primarily chlorophyll *a*, and contained significantly higher proportions of chlorophyll *c* than chlorophyll *b*. No statistical differences in chlorophyll *b* or chlorophyll *c* abundances were found between the sites in 2005 although Tributary Creek Site 9 had a significantly higher level of chlorophyll *a* than did Greens Creek Below Pond D Site 54.

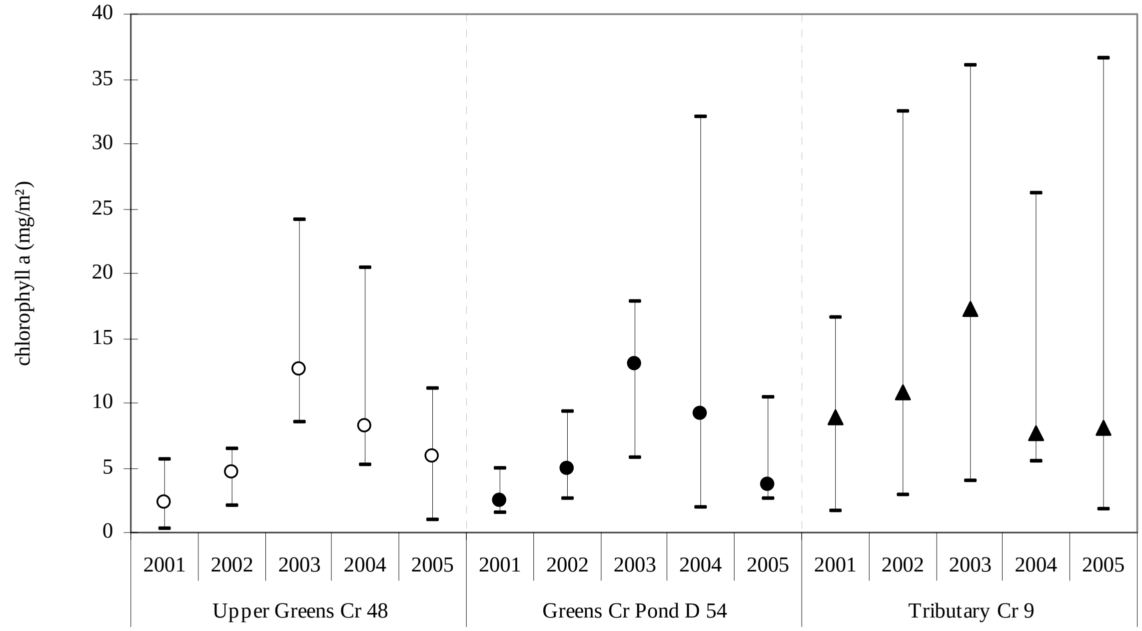

Figure 28. Comparison of estimated periphyton biomass (medians and ranges) among Greens Creek Mine biomonitoring sites sampled in 2001 through 2005 (n = 10 samples per site each year).

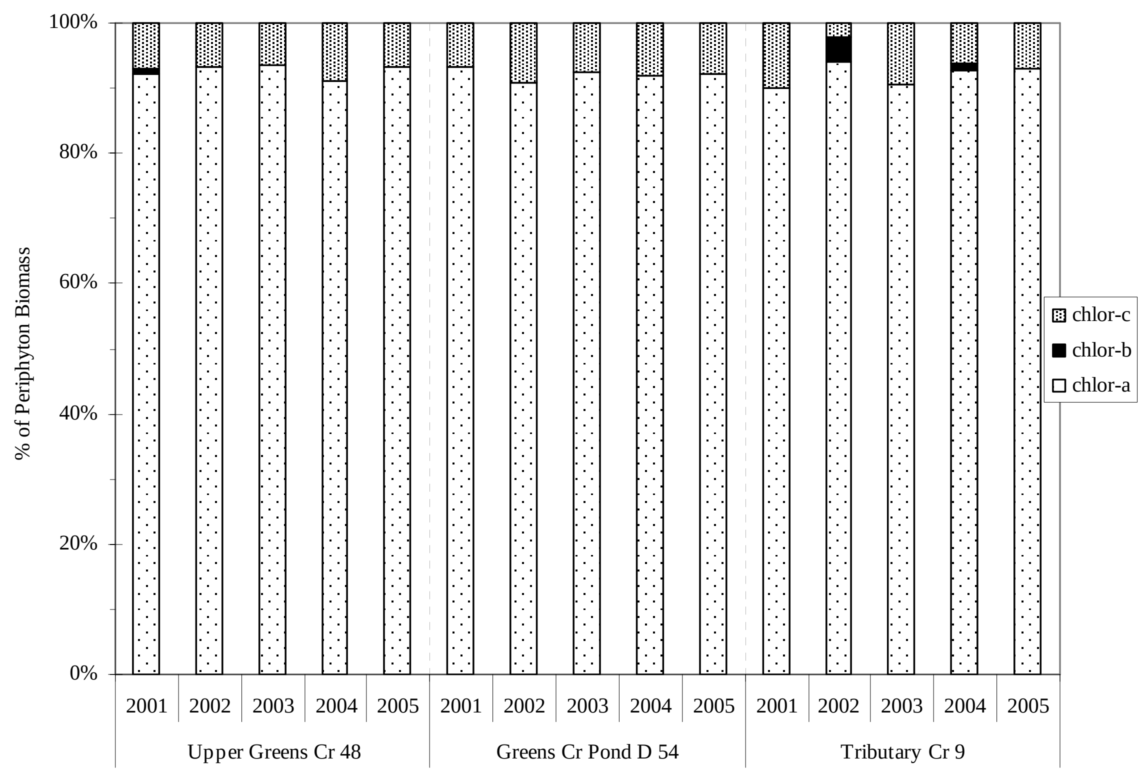

Figure 29. Comparison of proportions of chlorophylls *a*, *b*, *c* among Greens Creek Mine biomonitoring sites in 2001 through 2005.

Chlorophyll *a* is a primary photosynthetic pigment, is present in all algae, and is a useful indicator of a healthy algal community (Wetzel 1983). The low concentrations of chlorophyll *b*, sometimes below detection limits, are not unusual. Chlorophyll *b* is an accessory pigment and is usually found in combination with other photosynthetic pigments. When measured above detection limits, chlorophyll *b* is an indication of the presence of green algae and euglenophytes. Chlorophyll *c* is also an accessory pigment, and is only found in the photosynthetic Chromista (includes diatoms) and dinoflagellates (Waggoner and Speer 1999). Diatoms play an important role in primary production in aquatic systems, and measurable quantities of chlorophyll *c* indicate the importance of diatoms in the community.

In the 2001 Upper Greens Creek Site 48, and 2002 and 2004 Tributary Creek Site 9 samples, chlorophyll *b* was higher than in other samples, suggesting that at the time of sampling there was a larger percentage of green and blue-green bacteria in the periphyton community (Wetzel 1983). Given the differences in channel morphology, flow regimes and streamside vegetation between streams and years, the differences in algal communities are not unexpected. The periphyton communities in all biomonitoring sites are well within ranges of healthy aquatic systems (Wetzel 1983).

Benthic Macroinvertebrates

Similar to what was seen in 2004, benthic macroinvertebrate densities in 2005 at Tributary Creek Site 9 were substantially lower than either of the Greens Creek sites, and the two Greens Creek sites were not statistically different from each other (Figure 30).

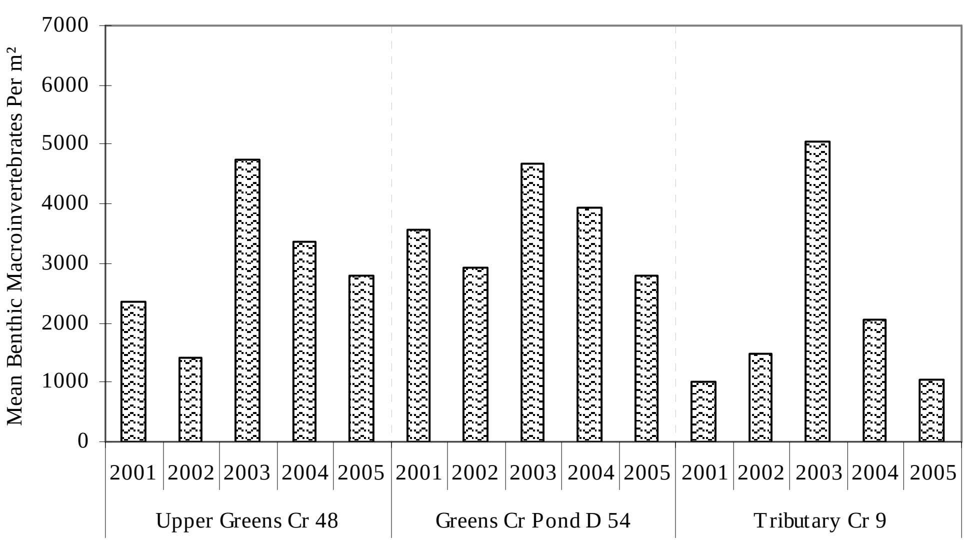

Figure 30. Comparison of benthic macroinvertebrate density among Greens Creek Mine biomonitoring sites in 2001 through 2005.

All three of the biomonitoring sites had complex invertebrate communities with abundant numbers of taxa (taxonomic richness) per sample (Figure 31). More than 50% of the invertebrates in samples from Greens Creek Site 48 and Greens Creek Below Pond D Site 54 were from two dominant taxa, while three dominant taxa accounted for more than 50% of the invertebrates in samples from Upper Tributary Creek Site 9 (Table 11). The number of taxa in all sites taken together in 2005 was substantially lower than in 2003, but was not statistically different from the higher number of taxa in 2004 or the lower numbers in 2001 and 2002. Differences in the structure of these communities likely reflect differences in channel morphology, influences of tributaries, frequency of flood events, streamside vegetation, and flow rates. Aquatic habitats with fairly even stream flows, such as Tributary Creek Site 9, usually do not have communities dominated by as few taxa as do more variable habitats (Hynes 1970). The predominance of fewer taxa in the Greens Creek sites may be a result of perturbations due to variations in stream flows and rapid re-colonization during relatively stable water levels.

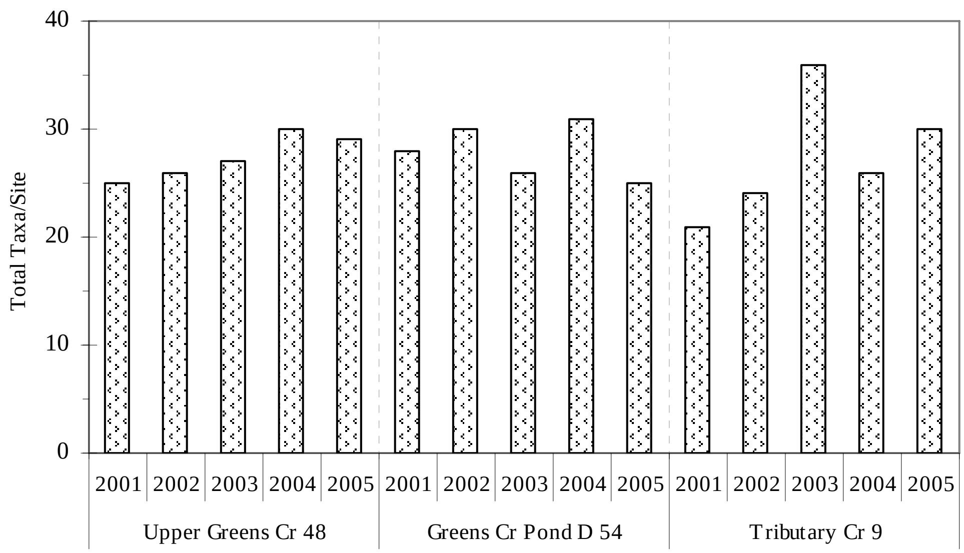

Figure 31. Comparison of benthic macroinvertebrate taxonomic richness among Greens Creek Mine biomonitoring sites in 2001 through 2005.

Table 11. Common taxa (>5.0% of aquatic invertebrates) found in Greens Creek Mine biomonitoring sites in 2005. The dominant taxon percent for each site is bold.

Order	Family	Genus	Upper Greens Creek 48	Greens Creek Pond D 54	Tributary Creek 9
Ephemeroptera	Baetidae	*Baetis*	20%	14%	7%
	Ephemerellidae	*Drunella*	26%	39%	-
	Heptageniidae	*Cinygma*	-	-	8%
		Cinygmula	6%	6%	-
		Epeorus	**27%**	**25%**	-
		Rhithrogena	5%	-	-
	Leptophlebiidae	*Paraleptophlebia*	-	-	**36%**
Plecoptera	Chloroperlidae	*Suwallia*	-	-	7%
	Nemouridae	*Zapada*	-	-	8%
Diptera	Chironomidae		8%	-	8%

The percent EPT metric, based on the concept that most Ephemeroptera, Plecoptera, and Trichoptera taxa are sensitive to pollutants (Merritt and Cummins 1996), was high in all of the biomonitoring sites in each of the four years sampled (Figure 32), and much higher than the percent of Chironomidae, which are ranked as much less sensitive to water quality. The percent of Chironomidae has been relatively constant at the Tributary Creek site but more variable in their presence at both Greens Creek sites.

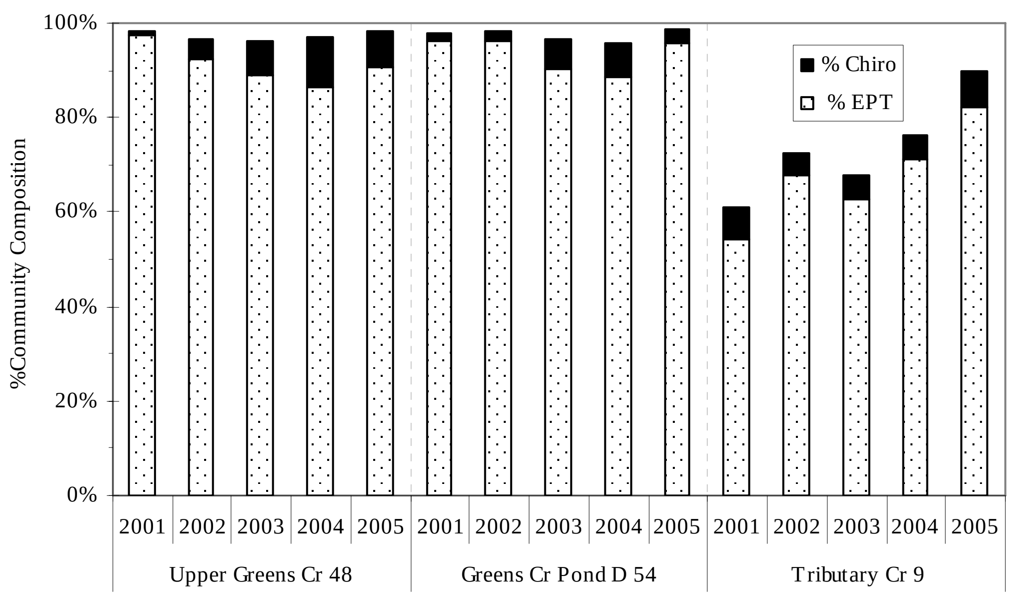

Figure 32. Comparison of proportions of EPT taxa and Chironomidae among Greens Creek Mine biomonitoring sites in 2001 through 2005.

Benthic macroinvertebrate community compositions at the two Greens Creek sites continued to be similar to one another and somewhat different from that at the Tributary Creek site (Figure 33). The communities at both Greens Creek sites were dominated by Ephemeroptera (mayflies), with small contributions by Plecoptera (stoneflies) and aquatic Diptera (primarily midge and blackfly larvae). In contrast, the Tributary Creek site community was less dominated by Ephemeroptera, Plecoptera were a more important component, and more non-insect invertebrates were present. These differences in community composition are most likely due to the different physical characteristics of the streams.

Density and taxonomic richness metrics showed all three sites to have well-developed, complex communities with abundant benthic macroinvertebrate populations. The percent dominant taxa showed the communities to have high proportions of pollution-sensitive invertebrates, and where a community was dominated by one or two groups, those groups were sensitive to pollution. Because all three communities continue to be composed of a prevalence of pollution-sensitive species, we believe that any perturbations by pollution or natural stressors in the future would likely cause a noticeable change in the abundance or diversity of benthic macroinvertebrates.

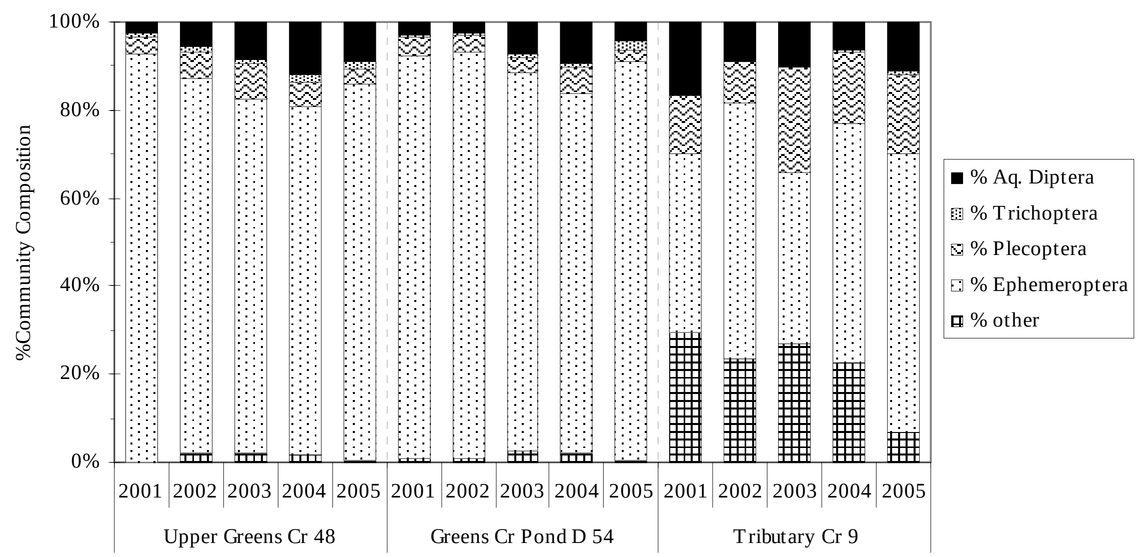

Figure 33. Comparison of community composition of benthic macroinvertebrates among Greens Creek Mine biomonitoring sites in 2001 through 2005.

Juvenile Fish Populations

All three biomonitoring sites continued to support relatively abundant fish populations in 2005 for the stream types and locations (Paustian et al. 1990). All three sites had Dolly Varden population and density estimates mid-range of the values seen during the previous four years of biomonitoring sampling. Coho salmon population and density estimates at the two sites accessible to coho (Greens Creek Below Pond D Site 54 and Tributary Creek Site 9) were significantly higher than in the previous four years of sampling. Estimates of fish abundance at Tributary Creek Site 9 in 2005 reversed a trend toward lower abundance of Dolly Varden and coho salmon that was seen from 2001 to 2004 (Figure 34, Appendix 4).

Although comparisons among all sites must include the differences in size, channel type, and elevation between the Greens Creek and Tributary Creek sites, some generalizations can be made regarding the fish density values (population estimate per m² of wetted area in each sample reach) shown in Table 12. Using this metric, Upper Greens Creek Site 48 (upstream of mine facilities) has been less productive each year (both for total fish captured and for Dolly Varden only) than has Greens Creek Below Pond D Site 54 (downstream of mine facilities). The productivity of Tributary Creek Site 9 has typically been intermediate between the values for Greens Creek Below Pond D Site 54 and for Upper Greens Creek Site 48, with generally lower densities of Dolly Varden and always higher densities of coho salmon.

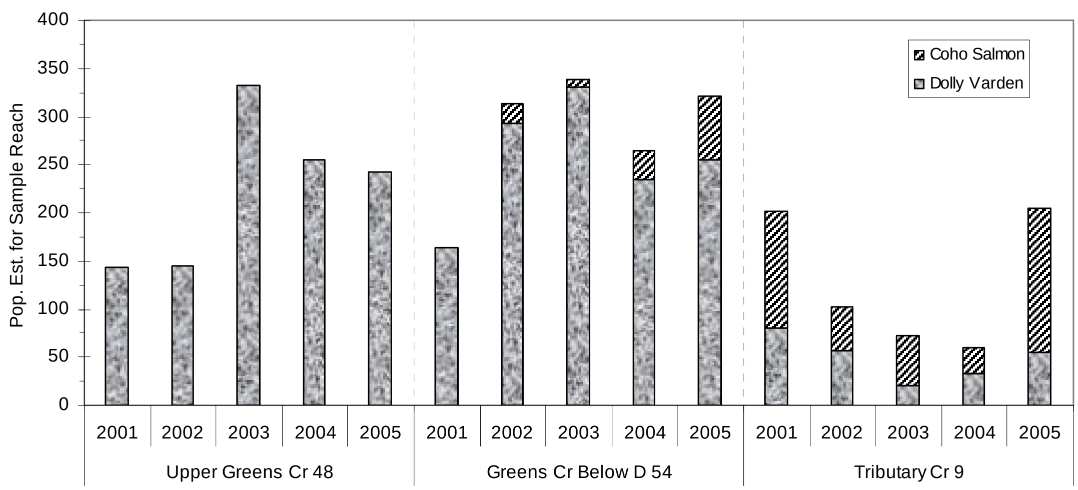

Figure 34. Population estimates for juvenile fish captured at Greens Creek Mine biomonitoring sites in 2001 through 2005.

Table 12. Fish captures, populations estimates, and densities in Greens Creek Mine biomonitoring reaches during 2001 through 2005.

	Upper Greens Creek Site 48		Greens Creek Below Pond D Site 54		Tributary Creek Site 9	
	Coho Salmon[1]	Dolly Varden	Coho Salmon	Dolly Varden	Coho Salmon	Dolly Varden
2001						
Number of Fish Caught	---	68	---[2]	138	118	81
Population Estimate	---	144	---[2]	164	120	81
Sample Reach (m)	---	72	28	28	44	44
Density Est. (fish/m²)	---	0.2	---[2]	0.6	0.94	0.65
2002						
Number of Fish Caught	---	126	21	271	44	51
Population Estimate	---	145	21	293	46	57
Sample Reach (m)	---	50	28	28	50	50
Density Est. (fish/m²)	---	0.23	0.07	1.0	0.35	0.46
2003						
Number of Fish Caught	---	285	8	232	52	19
Population Estimate	---	333	8	331	53	20
Sample Reach (m)	---	50	28	28	50	50
Density Est. (fish/m²)	---	0.9[3]	0.04[3]	1.8[3]	0.8[3]	0.3[3]
2004						
Number of Fish Caught	---	244	24	201	27	32
Population Estimate	---	255	31	234	27	33
Sample Reach (m)	---	50	28	28	50	50
Density Est. (fish/m²)	---	0.88	0.21	1.57	0.46	0.56
2005						
Number of Fish Caught	---	212	61	213	139	44
Population Estimate	---	243	67	255	150	55
Sample Reach (m)	---	50	28	28	50	50
Density Est. (fish/m²)	---	0.65	0.31	1.17	1.15	0.42

[1] Coho salmon not present at Site 54 because upstream of barrier to anadromous fish.

[2] Forest Service reported as too few fish captured to generate estimate.

[3] Based on approximate values for wetted area.

Metals Concentrations in Juvenile Fish

Tissues of Dolly Varden from Tributary Creek Site 9 had different metals concentration characteristics than did tissues from Dolly Varden at the two Greens Creek sites (48 and 54) in 2005, although a clear pattern is not apparent (Figure 35). Fish tissues from Tributary Creek had significantly higher concentrations of silver and selenium, and significantly lower concentrations of zinc, than did tissues from either Greens Creek site. Tributary Creek samples had significantly higher concentrations of lead than did Greens Creek Below Pond D Site 54 samples, while Upper

Greens Creek Site 48 sample lead concentrations were substantially higher than those of Greens Creek Below Pond D Site 54. The mean rank scores for cadmium and copper tissue concentrations were not statistically different among the three sites in 2005.

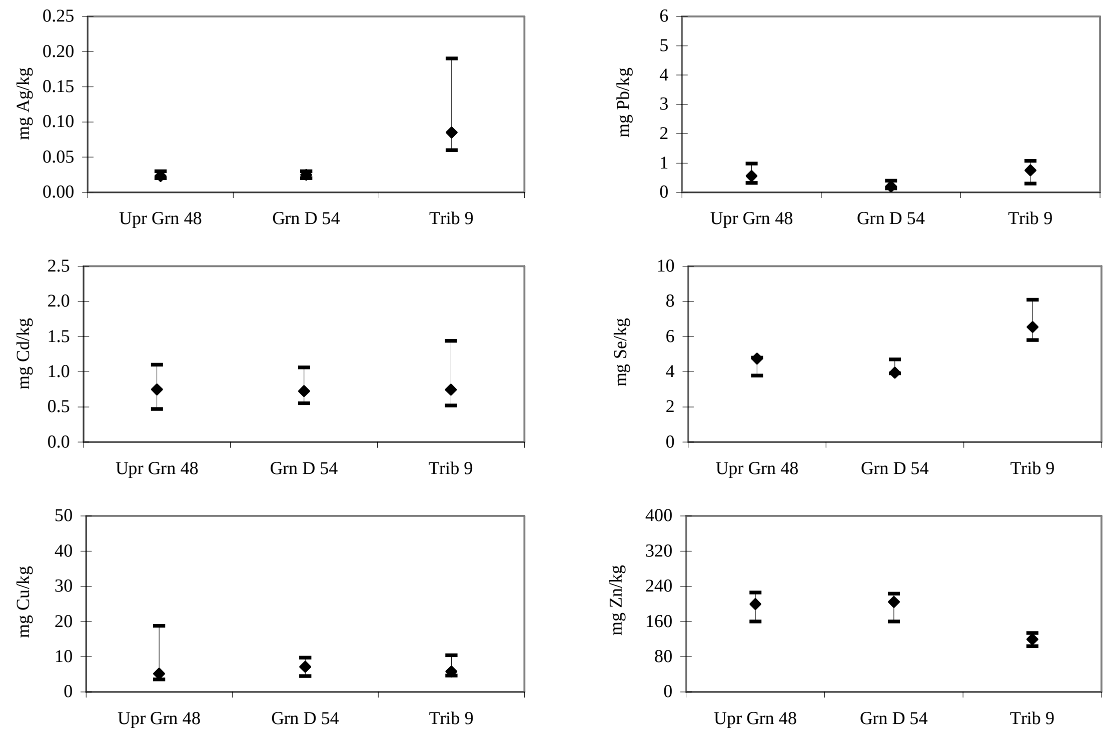

Figure 35. Comparison among sites of whole body metals concentrations (median, maximum, and minimum) in six Dolly Varden captured at each biomonitoring site in 2005. ND = Not Detected at reporting level for Ag of 0.02 mg/kg

CONCLUSIONS

The two biomonitoring sites on Greens Creek (Upper Greens Creek Site 48 above all facilities and Greens Creek Below Pond D Site 54) and one on Tributary Creek (Tributary Creek Site 9 below the dry-stack tailings facility) continued to sustain functioning, relatively abundant, and diverse aquatic communities in 2005.

Periphyton biomass and community composition continue to appear robust, with a pronounced diatom component and minimal amounts of filamentous green algae or blue-green bacteria. Chlorophyll *a* concentrations were similar between the two Greens Creek sites in 2005, and those sites had significantly less periphyton biomass than in 2003. Tributary Creek Site 9 chlorophyll *a* concentrations in 2005 were intermediate to and not statistically different than samples from 2001 through 2004.

The benthic macroinvertebrate communities at all three sites were taxonomically rich and moderately abundant in 2005, and populations of many disturbance-sensitive taxa were well represented. Benthic macroinvertebrate densities tended to be lower in 2005 than in previous years, but were not statistically lower. The two Greens Creek sites had similar benthic macroinvertebrate densities in 2005; that at Tributary Creek Site 9 was moderate for the years sampled and was substantially lower than those at the Greens Creek sites. The percentage of benthic macroinvertebrates in samples from both Greens Creek sites that were Chironomidae decreased in 2005 compared to 2004.

Juvenile fish populations continue to be relatively abundant at each site. Dolly Varden captures were intermediate to those in previous years at each site, with multiple size classes of fish present. Coho salmon captures were significantly higher than all previous years at the two sites accessible to them, with multiple size classes of fish present at the Tributary Creek site. Total fish densities were moderate compared to previous years at the Greens Creek sites and the highest in five years at Tributary Creek Site 9, and were higher than the regional average densities for each channel type. Moderately low water levels in July 2005 affected the wetted area available for fish habitat, particularly in Tributary Creek.

Whole body concentrations of metals in juvenile Dolly Varden tissues were generally similar to those found in previous years' samples. Tissues of Dolly Varden from Tributary Creek Site 9 had different metals concentration characteristics than did tissues from Dolly Varden at the two Greens Creek sites (48 and 54) in 2005, although a clear pattern of differential water quality did not emerge between sites upstream and downstream of mine facilities or at sites over time.

No testing of acute toxicity of water from the biomonitoring sites was done in 2005.

Aquatic communities at the sampled sites have remained abundant and diverse. Differences between the Greens Creek and Tributary Creek sites were typically of larger amplitude than were differences between the Greens Creek control and below-mining sites. We noted no indications of reduced productivity, community changes, or metals accumulation attributable to operations of the Greens Creek Mine.

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APPENDIX 1. USFS CHANNEL TYPE DESCRIPTIONS

Descriptions and definitions of channel types as developed by Paustian et al. (1992).

MM2 – Moderate Width Mixed Control Channel Type

An MM2 channel is defined as "normally found in the middle to lower portion of moderate size drainage basins. MM2 streams are often confined by mountainslope, footslope, and hillslope landforms, but they can develop a narrow flood plain. Bedrock knickpoints with cascades or falls may be present.

MM2 channels are generally accessible to anadromous species, with several species of spawners using the moderate amounts of available spawning area (ASA). These channels have moderate amounts of rearing area which are used by coho, Dolly Varden char, and steelhead juveniles. Pools are relatively deep and are highly dependent on large woody debris. Overwintering habitat is primarily associated with these pools. When located next to accessible lakes, these channels provide good quality spawning for sockeye salmon and steelhead trout.

Large woody debris significantly influences channel morphology and fish habitat quality. Large wood volume is generally high. Large wood accumulations form pool and stream bank rearing habitat, as well as stabilize spawning substrate behind log steps. Maintenance of large woody debris sources is an important management concern.

Banks are composed primarily of unconsolidated cobble and gravel size materials; therefore, stream bank sensitivity is rated high. The volume and energy of flood discharge in MM2 channels are the major factors affecting bank erosion. Disturbance of streamside vegetation root mats may contribute to accelerated channel scour and lateral channel migration.

Flood plains associated with MM2 channel types are generally narrow, however, side channels and flood overflow channels are commonly found along MM2 reaches. Flood plain stability can be a concern in these uncontained channel segments.

FP3 – Narrow Low Gradient Flood Plain Channel Type

FP3 streams are located in the valley bottoms and may also occur within flat lowlands or low elevation drainage divides. Frequently, FP3 streams lie adjacent to the toe of footslopes or hillslopes, adjacent to the main trunk, valley bottom channels. The flood plain of large, low gradient alluvial channels may be dissected by FP3 streams. Where FP3 streams occur parallel to the foot slopes or in the valley bottom locations, they are typically fed by high gradient streams. Less frequently, FP3 streams are situated on mountain slope benches.

The riparian plant associations for FP3 streams are dominated by the Sitka spruce series and the western hemlock series. Salmonberry and alder shrub communities are the principal non-forest riparian plant communities. Willow, shrub, and sedge/sphagnum bog communities are the primary non-forest riparian communities in the FP3 phase. Sitka alder and willow shrub communities are the predominant riparian vegetation associated with the FP3 phase.

FP3 channels are frequently accessible to anadromous species. Coarse and fine gravels compose 49% of the substrate; therefore, available spawning area is high. These channels receive moderate to high spawning use by all anadromous species.

APPENDIX 2. PERIPHYTON BIOMASS DATA

Estimates of periphyton biomass as represented by chlorophyll concentrations (mg/m²) at Greens Creek Mine biomonitoring sampling sites from 2001-2005.

	2001			2002			2003		
mg/m²	chlor-a	chlor-b	chlor-c	chlor-a	chlor-b	chlor-c	chlor-a	chlor-b	chlor-c
Upper Greens Creek Site 48									
	1.9143	0.0121	0.1393	5.1650	0.0000	0.2948	14.4103	0.0000	1.2645
	1.8257	0.0000	0.1830	4.0309	0.0000	0.2146	17.8250	0.0255	1.5659
	5.6124	0.0000	0.6948	6.2095	0.0000	0.7130	8.4320	0.0890	0.3896
	0.3127	0.0790	0.0582	2.8302	0.0000	0.2460	9.5307	0.0086	0.6354
	2.9595	0.0375	0.3613	5.1572	0.0000	0.7548	11.3567	0.0000	0.7204
	5.4420	0.0000	0.6166	6.3926	0.0000	0.7539	11.7638	0.0156	0.8633
	3.3793	0.0000	0.4670	5.8430	0.0000	0.7291	24.0949	0.0000	2.1368
	1.8669	0.0338	0.1460	2.0910	0.0722	0.2479	13.3054	0.1280	0.9883
	2.6348	0.1374	0.1442	3.2026	0.0000	0.3583	11.5404	0.0000	0.5652
	1.2286	0.0227	0.1649	2.5588	0.0000	0.1507	13.9690	0.0000	0.8948
median	2.2746	0.0174	0.1740	4.5941	0.0000	0.3265	12.5346	0.0043	0.8790
max	5.6124	0.1374	0.6948	6.3926	0.0722	0.7548	24.0949	0.1280	2.1368
min	0.3127	0.0000	0.0582	2.0910	0.0000	0.1507	8.4320	0.0000	0.3896
Middle Greens Creek Site 6									
	5.0689	0.0000	0.7004	-	-	-	-	-	-
	7.1544	0.0349	0.7218	-	-	-	-	-	-
	4.4715	0.0000	0.7804	-	-	-	-	-	-
	1.2695	0.0744	0.2259	-	-	-	-	-	-
	3.1962	0.0000	0.4260	-	-	-	-	-	-
	1.6426	0.0000	0.1421	-	-	-	-	-	-
	0.9033	0.1012	0.1440	-	-	-	-	-	-
	2.5114	0.0000	0.1574	-	-	-	-	-	-
	6.8816	0.0000	1.0188	-	-	-	-	-	-
	7.0238	0.0000	0.9988	-	-	-	-	-	-
median	3.8338	0.0000	0.5632	-	-	-	-	-	-
max	7.1544	0.1012	1.0188	-	-	-	-	-	-
min	0.9033	0.0000	0.1421	-	-	-	-	-	-
Greens Creek Below Pond D Site 54									
	1.5952	0.0065	0.1488	2.6468	0.0000	0.3031	13.2892	0.0000	1.0489
	3.0952	0.0458	0.4090	9.3238	0.0000	1.0170	8.3547	0.0000	0.7884
	3.6108	0.0000	0.2070	7.5189	0.0000	0.2386	14.8960	0.0000	1.4546
	2.9660	0.0000	0.2936	4.2958	0.0000	0.3775	5.9381	0.0000	0.6177
	1.8799	0.0000	0.0106	5.1517	0.0000	0.5282	15.5146	0.0000	1.7368
	1.7783	0.0000	0.1897	2.9762	0.8652	1.2582	10.4992	0.0000	1.0601
	4.9471	0.0000	0.2232	6.2634	0.0000	0.6386	5.7082	0.0000	0.3872
	1.4594	0.0000	0.1011	4.6212	0.0000	0.3984	16.4246	0.0000	1.7150
	1.6900	0.0000	0.1354	4.7095	0.0000	0.4528	12.6034	0.0000	1.0746
	3.4750	0.0000	0.1594	8.0829	0.0000	0.7912	17.8620	0.0000	1.7483
median	2.4229	0.0000	0.1745	4.9306	0.0000	0.4905	12.9463	0.0000	1.0673
max	4.9471	0.0458	0.4090	9.3238	0.8652	1.2582	17.8620	0.0000	1.7483
min	1.4594	0.0000	0.0106	2.6468	0.0000	0.2386	5.7082	0.0000	0.3872
Tributary Creek Site 9									
	6.6232	0.0000	0.7882	8.9053	0.0000	0.5190	12.8934	0.0000	1.2610
	11.1495	0.0000	1.2000	16.4332	0.9503	1.2761	8.5504	0.0000	0.7921
	15.0542	0.0000	1.4721	12.6468	0.1735	0.0000	3.9770	0.0000	0.2889
	16.5773	0.2339	1.5059	5.4410	0.4508	0.0725	12.2904	0.0000	1.1144
	3.1491	0.0000	0.3346	23.7210	1.2053	0.8382	17.0873	0.0000	1.9158
	2.5932	0.0643	0.2794	12.7457	0.4003	0.2162	17.4003	0.0000	1.8759
	1.6081	0.0000	0.0134	32.5316	0.0000	1.8936	33.8710	0.0000	3.9766
	6.6592	0.0000	0.4265	4.4025	1.4958	0.0000	24.5614	0.0000	2.4319
	15.2098	0.8116	1.4358	2.9413	0.3005	0.1720	20.0201	0.0000	1.6884
	11.5499	0.0000	1.5087	8.0068	1.4710	0.2746	36.0168	0.0000	3.8559
median	8.9044	0.0000	0.9941	10.7761	0.4256	0.2454	17.2438	0.0000	1.7821
max	16.5773	0.8116	1.5087	32.5316	1.4958	1.8936	36.0168	0.0000	3.9766
min	1.6081	0.0000	0.0134	2.9413	0.0000	0.0000	3.9770	0.0000	0.2889

Estimates of periphyton biomass as represented by chlorophyll concentrations (mg/m²) at Greens Creek Mine biomonitoring sampling sites from 2001-2005 (continued).

	2004			2005		
mg/m²	chlor-a	chlor-b	chlor-c	chlor-a	chlor-b	chlor-c
Upper Greens Creek Site 48						
	18.0492	0.0000	2.0334	0.9719	0.0000	0.0086
	6.7284	0.0000	0.6901	4.6992	0.0000	0.5099
	8.9712	0.0000	0.8982	6.6216	0.0000	0.2741
	12.8160	0.0000	1.4537	6.1944	0.0000	0.5062
	5.4468	0.0000	0.6233	11.1072	0.0000	0.9152
	20.3988	0.0000	2.1499	5.6604	0.0000	0.5118
	6.3012	0.0000	0.4491	7.6896	0.0000	0.5330
	11.6412	0.0000	1.3841	5.1264	0.0000	0.2909
	7.4760	0.0000	0.6511	2.4564	0.0153	0.2755
	5.2332	0.0000	0.5452	9.0780	0.0000	0.6302
median	8.2236	0.0000	0.7941	5.9274	0.0000	0.5081
max	20.3988	0.0000	2.1499	11.1072	0.0153	0.9152
min	5.2332	0.0000	0.4491	0.9719	0.0000	0.0086
Middle Greens Creek Site 6						
	5.0689	0.0000	0.7004	-	-	-
	7.1544	0.0349	0.7218	-	-	-
	4.4715	0.0000	0.7804	-	-	-
	1.2695	0.0744	0.2259	-	-	-
	3.1962	0.0000	0.4260	-	-	-
	1.6426	0.0000	0.1421	-	-	-
	0.9033	0.1012	0.1440	-	-	-
	2.5114	0.0000	0.1574	-	-	-
	6.8816	0.0000	1.0188	-	-	-
	7.0238	0.0000	0.9988	-	-	-
median	3.8338	0.0000	0.5632	-	-	-
max	7.1544	0.1012	1.0188	-	-	-
min	0.9033	0.0000	0.1421	-	-	-
Greens Creek Below Pond D Site 54						
	17.1948	0.0000	2.0177	10.3596	0.0000	0.5350
	9.7188	0.0000	0.9266	2.5632	0.0000	0.2555
	8.7576	0.0000	0.6740	3.3108	0.0000	0.1688
	32.0400	0.0000	3.6620	2.8836	0.0000	0.1173
	5.2332	0.0000	0.4232	5.6604	0.0000	0.3834
	3.7380	0.0000	0.3051	2.9904	0.0000	0.1346
	12.8160	0.0000	1.3488	4.2720	0.0000	0.1775
	1.9224	0.0310	0.0888	4.3788	0.0000	0.3098
	10.4664	0.0000	1.0866	4.0584	0.0000	0.1604
	5.9808	0.0000	0.5330	3.0972	0.0000	0.1583
median	9.2382	0.0000	0.8003	3.6846	0.0000	0.1732
max	32.0400	0.0310	3.6620	10.3596	0.0000	0.5350
min	1.9224	0.0000	0.0888	2.5632	0.0000	0.1173
Tributary Creek Site 9						
	9.3984	0.2240	0.8033	6.4294	0.0000	0.2502
	5.7672	0.0000	0.4226	8.0100	1.2833	0.1830
	5.4468	0.0000	0.4836	1.8156	0.1313	0.0746
	6.0876	0.0312	0.3827	9.8256	0.0595	0.2907
	14.5248	0.0213	1.3951	5.6818	0.0000	0.1025
	6.5148	0.1726	0.4038	5.3827	0.0000	0.1225
	10.3596	0.1349	0.7986	8.1809	0.0000	0.2028
	6.8352	0.0423	0.3638	15.4326	0.0000	0.4551
	26.1660	0.5112	2.6076	36.6004	0.0989	1.1198
	8.4372	0.2176	0.5308	9.4518	0.0000	0.2629
median	7.6362	0.0886	0.5072	8.0954	0.0000	0.2265
max	26.1660	0.5112	2.6076	36.6004	1.2833	1.1198
min	5.4468	0.0000	0.3638	1.8156	0.0000	0.0746

APPENDIX 3. BENTHIC MACROINVERTEBRATE DATA

Numbers of benthic macroinvertebrates identified in Upper Greens Creek Site 48 biomonitoring samples from 2001-2005.

Order	Family	Genus	2001	2002	2003	2004	2005
Ephemeroptera	Baetidae	*Baetis*	309	152	445	390	279
	Ephemerellidae	*Caudatella*	2	-	-	-	-
		Ephemerella	-	-	10	23	15
		Drunella	47	49	650	406	369
	Heptageniidae	*Cinygmula*	99	20	117	99	89
		Epeorus	444	190	384	209	371
		Rhithrogena	193	187	287	196	71
	Leptophlebiidae	*Paraleptophlebia*	-	1	-	-	-
	Ameletidae	*Ameletus*	-	-	4	-	-
Plecoptera	Capniidae	*Capnia*	-	-	82	-	-
		Eucapnopsis	-	-	-	-	1
	Chloroperlidae	unidentified	-	-	-	-	2
		Alloperla	1	1	-	1	-
		Kathroperla	-	-	2	3	-
		Neaviperla	-	-	70	6	3
		Paraperla	-	-	-	6	-
		Plumiperla	5	-	-	5	-
		Suwallia	8	1	-	-	5
		Sweltsa	1	4	-	-	-
	Leuctridae	*Despaxia*	-	2	-	-	-
		Paraleuctra	4	3	6	65	-
		Perlomyia	-	12	-	-	-
	Nemouridae	*Podmosta*	7	5	-	2	-
		Zapada	23	4	30	7	14
	Perlodidae	unidentified	-	-	-	-	9
		Isoperla	-	-	-	1	9
		Megarcys	-	-	1	-	-
		Skwala	-	9	-	-	4
Trichoptera	Apataniidae	*Apatania*	-	1	-	-	-
	Glossosomatidae	*Glossosoma*	-	-	2	16	14
	Hydropsychidae	*Arctopsyche*	2	-	-	-	-
		Hydropsyche	-	-	1	-	1
	Limnephilidae	*Onocosmoecus*	-	-	1	-	-
	Rhyacophilidae	*Rhyacophila*	5	8	16	15	7
Coleoptera	Elmidae	*Narpus*	-	-	-	1	-
	Staphylinidae		1	-	6	-	-
Diptera	Ceratopogonidae	*Dasyhelea*	-	1	-	-	-
	Chironomidae		14	30	172	177	112
	Deuterophlebiidae	*Deuterophlebia*	2	-	-	1	1
	Empididae	unidentified	-	-	-	-	1
		Chelifera	1	2	5	1	-
		Hemerodromia	-	-	-	-	5
		Oreogeton	3	2	22	11	-
	Psychodidae	*Psychoda*	1	-	-	-	-
	Simuliidae	*Parasimulium*	2	-	-	-	-
		Prosimulium	2	-	-	2	-
		Simulium	6	4	-	1	3

Numbers of benthic macroinvertebrates identified in Upper Greens Creek Site 48 biomonitoring samples from 2001-2005 (continued).

Order	Family	Genus	2001	2002	2003	2004	2005
Diptera (cont.)	Tipulidae	*Antocha*	-	-	2	-	-
		Dicranota	-	-	3	-	2
		Rhabdomastix	-	-	-	-	1
		Tipula	-	-	2	6	1
Collembola	Onychiuridae	*Onychiurus*	-	1	-	-	-
	Sminthuridae	*Dicyrtoma*	2	-	-	-	-
Copepoda	Cyclopoida		-	-	-	1	-
Acarina			-	2	20	10	3
Oligochaeta			-	5	20	8	3
Gastropoda	Pelecypoda		-	-	-	1	-
Ostracoda			-	8	7	9	1

Numbers of benthic macroinvertebrates identified in Greens Creek Below Pond D Site 54 biomonitoring samples from 2001-2005.

Order	Family	Genus	2001	2002	2003	2004	2005
Ephemeroptera	Baetidae	*Baetis*	248	225	220	299	198
	Ephemerellidae	*Ephemerella*	2	6	6	47	22
		Drunella	118	280	894	742	543
	Heptageniidae	*Cinygmula*	319	75	176	112	90
		Epeorus	935	626	408	228	341
		Rhithrogena	-	140	306	173	66
	Leptophlebiidae	*Paraleptophlebia*	1	-	1	-	4
	Ameletidae	*Ameletus*	4	-	-	-	1
Plecoptera	Capniidae	*Capnia*	-	-	5	-	1
		Eucapnopsis	-	-	-	-	8
	Chloroperlidae	*Alloperla*	3	-	-	1	-
		Kathroperla	-	-	2	2	-
		Neaviperla	-	14	22	26	5
		Paraperla	-	-	5	4	-
		Plumiperla	2	-	-	5	3
		Suwallia	-	-	-	2	-
		Sweltsa	6	-	-	-	-
	Leuctridae	*Despaxia*	-	-	-	15	-
		Paraleuctra	-	4	-	18	-
		Perlomyia	13	3	19	33	-
	Nemouridae	*Podmosta*	-	7	-	-	-
		Zapada	52	22	14	11	15
	Perlodidae	*Diura*	1	-	-	-	-
		Isoperla	3	-	-	-	3
		Skwala	-	3	15	-	2
		Rickera	-	1	-	-	-
Trichoptera	Glossosomatidae	*Glossosoma*	-	-	-	12	1
	Hydropsychidae	*Arctopsyche*	-	1	-	1	-
	Limnephilidae	unidentified	-	-	-	-	2
		Psychoglypha	1	-	-	-	-
	Rhyacophilidae	*Rhyacophila*	6	5	12	6	27
Coleoptera	Elmidae	*Narpus*	-	-	-	3	-
	Staphylinidae		1	1	-	-	-
Diptera	Chironomidae		33	27	149	148	42
	Deuterophlebiidae	*Deuterophlebia*	-	1	1	-	-
	Dolichopodidae		2	-	-	-	-
	Empididae	unidentified	-	-	-	-	2
		Chelifera	2	-	-	1	-
		Hemerodromia	-	-	-	-	8
		Oreogeton	10	4	15	25	-
	Simuliidae	*Prosimulium*	-	1	-	5	-
		Simulium	3	3	-	-	2
	Tipulidae	*Antocha*	1	-	3	2	-
		Dicranota	2	1	-	-	-
		Hesperoconopa	-	1	1	-	-
		Pilaria	-	-	1	-	-
		Rhabdomastix	-	-	3	2	3
		Tipula	-	1	-	1	-

Numbers of benthic macroinvertebrates identified in Greens Creek Below Pond D Site 54 biomonitoring samples from 2001-2005 (continued).

Order	Family	Genus	2001	2002	2003	2004	2005
Collembola	Onychiuridae	*Onychiurus*	-	1	-	-	-
	Sminthuridae	*Dicyrtoma*	-	1	-	-	-
		Sminthurus	-	-	-	2	-
Copepoda	Cyclopoida		-	-	1	1	-
Acarina			9	3	6	11	2
Oligochaeta			3	7	49	18	2
Gastropoda	Valvatidae		1	1	-	-	-
Ostracoda			1	1	1	11	-

Numbers of benthic macroinvertebrates identified in Tributary Creek Site 9 biomonitoring samples from 2001-2005.

Order	Family	Genus	2001	202	2003	2004	2005
Ephemeroptera	Baetidae	*Baetis*	41	123	160	21	38
		Procloeon	5	-	-	-	-
	Ephemerellidae	*Caudatella*	3	-	-	-	-
		Ephemerella	-	14	7	4	1
		Drunella	-	3	10	-	8
	Heptageniidae	*Cinygma*	1	-	-	-	43
		Cinygmula	89	177	507	49	24
		Epeorus	-	8	1	-	2
		Rhithrogena	-	-	1	-	2
	Leptophlebiidae	*Paraleptophlebia*	66	96	249	442	191
	Ameletidae	*Ameletus*	-	15	46	46	25
Plecoptera	Chloroperlidae	unidentified	-	-	-	-	1
		Neaviperla	-	-	174	24	-
		Paraperla	-	11	-	-	-
		Plumiperla	-	-	-	38	-
		Suwallia	34	-	24	20	36
		Sweltsa	-	42	-	-	12
	Leuctridae	*Despaxia*	3	-	6	5	3
		Paraleuctra	7	-	1	-	-
		Perlomyia	-	3	-	-	-
	Nemouridae	*Podmosta*	-	1	-	-	-
		Zapada	23	12	388	41	43
	Perlodidae	*Isoperla*	1	-	-	38	-
Trichoptera	Apataniidae	*Apatania*	-	1	-	-	-
	Brachycentridae	*Brachycentrus*	-	-	1	-	-
	Lepidostomatidae	*Lepidostoma*	-	-	-	1	1
	Limnephilidae	unidentified	-	-	-	-	1
		Ecclisomyia	-	-	1	-	1
		Onocosmoecus	-	-	-	1	-
	Rhycophilidae	*Rhycophila*	-	1	5	3	1
Coleoptera	Elmidae	*Narpus*	2	6	32	14	1
	Dytiscidae	*Megadytes*	-	-	2	-	-
Diptera	Ceratopogonidae	*Bezzia*	-	-	1	-	-
		Dasyhelea	3	-	-	-	-
		Probezzia	-	-	9	-	-
	Chironomidae		35	36	125	52	40
	Empididae	*Chelifera*	-	1	-	-	-
		Hemerodromia	-	-	1	-	1
		Oreogeton	4	2	24	8	1
	Psychodidae	*Psychoda*	-	-	-	-	-
	Simuliidae	*Simulium*	40	22	81	4	14
	Tipulidae	*Antocha*	-	-	10	-	-
		Dicranota	-	-	2	-	2
		Pilaria	-	-	2	-	-
		Rhabdomastix	-	-	1	-	1
		Tipula	4	5	-	2	-
		Limonia	-	-	-	-	1

Numbers of benthic macroinvertebrates identified in Tributary Creek Site 9 biomonitoring samples from 2001-2005 (continued).

Order	Family	Genus	2001	2002	2003	2004	2005
Branchiopoda	Chydoridae		-	-	2	-	-
Collembola	Sminthuridae	*Dicyrtoma*	-	2	-	-	-
		Sminthurus	-	-	3	34	1
Copepoda	Cyclopoida		-	-	6	5	-
	Harpacticoida		-	-	5	-	-
Acarina			15	20	72	39	2
Oligochaeta			40	45	349	111	23
Gastropoda			1	-	1	2	-
Isopoda	Gammaridae	*Gammarus*	-	-	-	1	-
Ostracoda			92	102	207	27	8

APPENDIX 4. JUVENILE FISH CAPTURE DATA

Sampling Site	Fish Species[1]	Number of Fish Captured Set 1	Set 2	Set 3	Total	MLE[2] Pop. Est.	Standard Error	95% Conf. Interval
2001[3]								
Upper Greens Cr 48	DV	---	---	---	118	144	74.76	84 - 448
Middle Greens Cr 6	DV	---	---	---	131	175	21.67	149 – 240
	CO	---	---	---	>0	---	---	---
Greens Cr Below D 54	DV	---	---	---	138	164	12.32	150 - 200
	CO	---	---	---	>0	---	---	---
Tributary Cr 9	DV	---	---	---	81	81	0.78	81 - 81
	CO	---	---	---	118	120	2.14	119 - 128
	CT	---	---	---	>0	---	---	---
	Sc	---	---	---	4	4	0.21	4 - 4
2002[3]								
Upper Greens Cr 48	DV	---	---	---	126	145	9.43	134 - 173
Greens Cr Below D 54	DV	---	---	---	271	293	8.09	282 - 315
	CO	---	---	---	21	21	0.85	21 - 21
Tributary Cr 9	DV	---	---	---	51	57	5.17	53 - 76
	CO	---	---	---	44	46	2.51	45 - 57
	CT	---	---	---	1	---	---	---
	Sc	---	---	---	2	---	---	---
2003								
Upper Greens Cr 48	DV	157	72	56	285	333	14.04	305 - 361
Greens Cr Below D 54	DV	92	81	59	232	331	27.76	275 - 387
	CO	5	3	0	8	8	0.00	8 - 8
Tributary Cr 9	DV	13	4	2	19	20	1.52	17 - 23
	CO	37	11	4	52	53	1.20	51 - 55
	CT	1	0	0	1	1	---	---
	Sc	0	0	1	1	1	---	---
2004								
Upper Greens Cr 48	DV	168	48	28	244	255	4.70	246 - 264
Greens Cr Below D 54	DV	118	36	47	201	234	11.43	211 - 257
	CO	9	9	6	24	31	5.53	20 - 42
Tributary Cr 9	DV	21	6	5	32	33	1.22	31 - 35
	CO	23	2	2	27	27	0.00	27 - 27
	CT	1	0	0	1	1	---	---
	RT	3	1	0	4	4	0	4 - 4
	Sc	1	1	0	2	2	0	2 - 2
2005								
Upper Greens Cr 48	DV	118	56	38	212	243	10.70	222 - 264
Greens Cr Below D 54	DV	111	59	43	213	255	14.13	227 - 283
	CO	33	20	8	61	67	3.97	59 - 75
Tributary Cr 9	DV	21	12	11	44	55	7.16	41 - 69
	CO	82	42	15	139	150	5.31	139 - 161
	CT	1	1	0	2	2	0	2 - 2
	Sc	2	0	0	2	2	---	---

[1] Species: DV = Dolly Varden, CO = coho salmon, CT = cutthroat trout, RT = rainbow trout / steelhead, Sc = sculpin species.

[2] Maximum Likelihood Estimate of fish population in the sample reach.

[3] Data for 2001 and 2002 from USDA Forest Service.

APPENDIX 5. METALS IN JUVENILE FISH DATA

Information on for fish collected in 2000-2005 for analysis of metals in tissues. Sample Number contains codes for date collected, location/site, fish species, age, and replicate number.

Collector	Date Collected	Location	Site	Fish Sp	FLength (mm)	Mass (g)	Solids (%)	Sample Number
ADF&G / FS	23-Jul-2001	Upper Greens Creek	Site 48	DV	131	26.02	21.6	072301GC48DVJ01
ADF&G / FS	23-Jul-2001	Upper Greens Creek	Site 48	DV	137	28.81	23.7	072301GC48DVJ02
ADF&G / FS	23-Jul-2001	Upper Greens Creek	Site 48	DV	119	18.84	20.7	072301GC48DVJ03
ADF&G / FS	23-Jul-2001	Upper Greens Creek	Site 48	DV	121	21.13	22.8	072301GC48DVJ04
ADF&G / FS	23-Jul-2001	Upper Greens Creek	Site 48	DV	111	13.71	21.8	072301GC48DVJ05
ADF&G / FS	23-Jul-2001	Upper Greens Creek	Site 48	DV	121	21.08	20.3	072301GC48DVJ06
ADF&G	24-Jul-2002	Upper Greens Creek	Site 48	DV	133	23.23	24.3	072402GC48DVJ01
ADF&G	24-Jul-2002	Upper Greens Creek	Site 48	DV	120	15.04	19.2	072402GC48DVJ02
ADF&G	24-Jul-2002	Upper Greens Creek	Site 48	DV	122	17.52	22.1	072402GC48DVJ03
ADF&G	24-Jul-2002	Upper Greens Creek	Site 48	DV	127	20.75	21.2	072402GC48DVJ04
ADF&G	24-Jul-2002	Upper Greens Creek	Site 48	DV	134	24.77	21.5	072402GC48DVJ05
ADF&G	24-Jul-2002	Upper Greens Creek	Site 48	DV	128	21.66	20.9	072402GC48DVJ06
ADNR	22-Jul-2003	Upper Greens Creek	Site 48	DV	90	8.9	23.8	072203GC48DVJ01
ADNR	22-Jul-2003	Upper Greens Creek	Site 48	DV	98	9.9	23.6	072203GC48DVJ02
ADNR	22-Jul-2003	Upper Greens Creek	Site 48	DV	103	12.1	23.7	072203GC48DVJ03
ADNR	22-Jul-2003	Upper Greens Creek	Site 48	DV	112	12.5	23.5	072203GC48DVJ04
ADNR	22-Jul-2003	Upper Greens Creek	Site 48	DV	108	11.9	23.8	072203GC48DVJ05
ADNR	22-Jul-2003	Upper Greens Creek	Site 48	DV	100	10.5	24.2	072203GC48DVJ06
ADNR	22-Jul-2004	Upper Greens Creek	Site 48	DV	96	8.6	23.7	072204GC48DVJ01
ADNR	22-Jul-2004	Upper Greens Creek	Site 48	DV	88	6.8	23.4	072204GC48DVJ02
ADNR	22-Jul-2004	Upper Greens Creek	Site 48	DV	101	11.5	23.5	072204GC48DVJ03
ADNR	22-Jul-2004	Upper Greens Creek	Site 48	DV	98	9.3	23.8	072204GC48DVJ04
ADNR	22-Jul-2004	Upper Greens Creek	Site 48	DV	93	7.6	21.4	072204GC48DVJ05
ADNR	22-Jul-2004	Upper Greens Creek	Site 48	DV	91	7.5	23.9	072204GC48DVJ06
ADNR	22-Jul-2005	Upper Greens Creek	Site 48	DV	103	19.7	24.8	072205GC48DVJ01
ADNR	22-Jul-2005	Upper Greens Creek	Site 48	DV	96	13.1	23.6	072205GC48DVJ02
ADNR	22-Jul-2005	Upper Greens Creek	Site 48	DV	119	15.6	23.2	072205GC48DVJ03
ADNR	22-Jul-2005	Upper Greens Creek	Site 48	DV	114	17.1	23.5	072205GC48DVJ04
ADNR	22-Jul-2005	Upper Greens Creek	Site 48	DV	111	15.3	24.9	072205GC48DVJ05
ADNR	22-Jul-2005	Upper Greens Creek	Site 48	DV	125	16.9	23.7	072205GC48DVJ06
ADF&G / FS	23-Jul-2001	Middle Greens Creek	Site 6	DV	139	28.4	20.8	072301GC06DVJ01
ADF&G / FS	23-Jul-2001	Middle Greens Creek	Site 6	DV	140	30.49	22.8	072301GC06DVJ02
ADF&G / FS	23-Jul-2001	Middle Greens Creek	Site 6	DV	167	43.9	21.7	072301GC06DVJ03
ADF&G / FS	23-Jul-2001	Middle Greens Creek	Site 6	DV	155	34.8	21.6	072301GC06DVJ04
ADF&G / FS	23-Jul-2001	Middle Greens Creek	Site 6	DV	109	15.69	22.2	072301GC06DVJ05
ADF&G / FS	23-Jul-2001	Middle Greens Creek	Site 6	DV	168	49.1	21.9	072301GC06DVJ06
ADF&G / FS	21-Jun-2000	Greens Cr Below Pond D	Site 54	CO	72	4.4	20.5	062100GCCOJ01
ADF&G / FS	21-Jun-2000	Greens Cr Below Pond D	Site 54	CO	82	6.1	20.2	062100GCCOJ02
ADF&G / FS	21-Jun-2000	Greens Cr Below Pond D	Site 54	CO	73	4.9	20.4	062100GCCOJ03
ADF&G / FS	21-Jun-2000	Greens Cr Below Pond D	Site 54	CO	68	3.4	21.4	062100GCCOJ04
ADF&G / FS	21-Jun-2000	Greens Cr Below Pond D	Site 54	CO	73	5.9	20.7	062100GCCOJ05
ADF&G / FS	21-Jun-2000	Greens Cr Below Pond D	Site 54	CO	75	6	20.2	062100GCCOJ06
ADF&G / FS	23-Jul-2001	Greens Cr Below Pond D	Site 54	DV	121	21.5	22.6	072301GC54DVJ01
ADF&G / FS	23-Jul-2001	Greens Cr Below Pond D	Site 54	DV	119	19.32	26.1	072301GC54DVJ02
ADF&G / FS	23-Jul-2001	Greens Cr Below Pond D	Site 54	DV	107	15.73	23.5	072301GC54DVJ03
ADF&G / FS	23-Jul-2001	Greens Cr Below Pond D	Site 54	DV	109	13.64	21.1	072301GC54DVJ04
ADF&G / FS	23-Jul-2001	Greens Cr Below Pond D	Site 54	DV	105	13.52	22.8	072301GC54DVJ05
ADF&G / FS	23-Jul-2001	Greens Cr Below Pond D	Site 54	DV	138	27.54	22.1	072301GC54DVJ06

Information on for fish collected in 2000-2005 for analysis of metals in tissues. Sample Number contains codes for date collected, location/site, fish species, age, and replicate number (continued)

Collector	Date Collected	Location	Site	Fish Sp	FLength (mm)	Mass (g)	Solids (%)	Sample Number
ADF&G	24-Jul-2002	Greens Cr Below Pond D	Site 54	DV	118	17.96	21.2	072402GC54DVJ01
ADF&G	24-Jul-2002	Greens Cr Below Pond D	Site 54	DV	128	22.26	23.2	072402GC54DVJ02
ADF&G	24-Jul-2002	Greens Cr Below Pond D	Site 54	DV	115	17.7	21.9	072402GC54DVJ03
ADF&G	24-Jul-2002	Greens Cr Below Pond D	Site 54	DV	115	18.94	21.3	072402GC54DVJ04
ADF&G	24-Jul-2002	Greens Cr Below Pond D	Site 54	DV	124	21.09	21.4	072402GC54DVJ05
ADF&G	24-Jul-2002	Greens Cr Below Pond D	Site 54	DV	123	20.88	20.9	072402GC54DVJ06
ADNR	22-Jul-2003	Greens Cr Below Pond D	Site 54	DV	123	21.1	25.1	072203GC54DVJ01
ADNR	22-Jul-2003	Greens Cr Below Pond D	Site 54	DV	101	10.6	22.9	072203GC54DVJ02
ADNR	22-Jul-2003	Greens Cr Below Pond D	Site 54	DV	88	9.2	22.8	072203GC54DVJ03
ADNR	22-Jul-2003	Greens Cr Below Pond D	Site 54	DV	109	14.8	24.0	072203GC54DVJ04
ADNR	22-Jul-2003	Greens Cr Below Pond D	Site 54	DV	95	10.6	23.9	072203GC54DVJ05
ADNR	22-Jul-2003	Greens Cr Below Pond D	Site 54	DV	92	9.7	23.8	072203GC54DVJ06
ADNR	21-Jul-2004	Greens Cr Below Pond D	Site 54	DV	103	9.9	23.8	072104GC54DVJ01
ADNR	21-Jul-2004	Greens Cr Below Pond D	Site 54	DV	104	10.0	22.6	072104GC54DVJ02
ADNR	21-Jul-2004	Greens Cr Below Pond D	Site 54	DV	86	6.6	23.7	072104GC54DVJ03
ADNR	21-Jul-2004	Greens Cr Below Pond D	Site 54	DV	96	9.3	22.9	072104GC54DVJ04
ADNR	21-Jul-2004	Greens Cr Below Pond D	Site 54	DV	93	9.9	22.1	072104GC54DVJ05
ADNR	21-Jul-2004	Greens Cr Below Pond D	Site 54	DV	104	12.9	21.4	072104GC54DVJ06
ADNR	22-Jul-2005	Greens Cr Below Pond D	Site 54	DV	120	12.3	23.1	072205GC54DVJ01
ADNR	22-Jul-2005	Greens Cr Below Pond D	Site 54	DV	106	12.1	22.6	072205GC54DVJ02
ADNR	22-Jul-2005	Greens Cr Below Pond D	Site 54	DV	113	20.8	23.1	072205GC54DVJ03
ADNR	22-Jul-2005	Greens Cr Below Pond D	Site 54	DV	114	17.9	22.3	072205GC54DVJ04
ADNR	22-Jul-2005	Greens Cr Below Pond D	Site 54	DV	112	16.1	23.0	072205GC54DVJ05
ADNR	22-Jul-2005	Greens Cr Below Pond D	Site 54	DV	118	22.3	22.4	072205GC54DVJ06
ADF&G / FS	21-Jun-2000	Tributary Creek	Site 9	CO	102	9.7	22.9	062100TRCOJ01
ADF&G / FS	21-Jun-2000	Tributary Creek	Site 9	CO	75	5.3	22.5	062100TRCOJ02
ADF&G / FS	21-Jun-2000	Tributary Creek	Site 9	DV	112	12.8	23.1	062100TRCOJ03
ADF&G / FS	21-Jun-2000	Tributary Creek	Site 9	DV	105	13.8	22.2	062100TRDVJ04
ADF&G / FS	21-Jun-2000	Tributary Creek	Site 9	DV	105	13.4	22.1	062100TRDVJ05
ADF&G / FS	21-Jun-2000	Tributary Creek	Site 9	DV	100	11.3	23.0	062100TRDVJ06
ADF&G / FS	23-Jul-2001	Tributary Creek	Site 9	DV	97	9.05	22.1	072301TR09DVJ01
ADF&G / FS	23-Jul-2001	Tributary Creek	Site 9	DV	97	9.66	21.3	072301TR09DVJ02
ADF&G / FS	23-Jul-2001	Tributary Creek	Site 9	DV	97	9.5	22.2	072301TR09DVJ03
ADF&G / FS	23-Jul-2001	Tributary Creek	Site 9	DV	98	10.37	22.6	072301TR09DVJ04
ADF&G / FS	23-Jul-2001	Tributary Creek	Site 9	DV	86	6.42	22.2	072301TR09DVJ05
ADF&G / FS	23-Jul-2001	Tributary Creek	Site 9	DV	93	7.83	20.6	072301TR09DVJ06
ADF&G	24-Jul-2002	Tributary Creek	Site 9	DV	103	10.8	20.9	072402TR09DVJ01
ADF&G	24-Jul-2002	Tributary Creek	Site 9	DV	97	10.43	22.8	072402TR09DVJ02
ADF&G	24-Jul-2002	Tributary Creek	Site 9	DV	100	11.16	23.2	072402TR09DVJ03
ADF&G	24-Jul-2002	Tributary Creek	Site 9	DV	90	7.93	23.1	072402TR09DVJ04
ADF&G	24-Jul-2002	Tributary Creek	Site 9	DV	90	9.19	23.0	072402TR09DVJ05
ADF&G	24-Jul-2002	Tributary Creek	Site 9	DV	100	9.33	17.8	072402TR09DVJ06
ADNR	23-Jul-2003	Tributary Creek	Site 9	DV	106	10.7	21.9	072304TR09DVJ01
ADNR	23-Jul-2003	Tributary Creek	Site 9	DV	89	6.8	22.8	072304TR09DVJ02
ADNR	23-Jul-2003	Tributary Creek	Site 9	DV	112	17.4	24.3	072304TR09DVJ03
ADNR	23-Jul-2003	Tributary Creek	Site 9	DV	95	11.6	22.5	072304TR09DVJ04
ADNR	23-Jul-2003	Tributary Creek	Site 9	DV	91	9.5	22.2	072304TR09DVJ05
ADNR	23-Jul-2003	Tributary Creek	Site 9	DV	84	8.4	23.2	072304TR09DVJ06
ADNR	21-Jul-2004	Tributary Creek	Site 9	DV	84	5.5	23.0	072104TR09DVJ01
ADNR	21-Jul-2004	Tributary Creek	Site 9	DV	96	8.5	23.0	072104TR09DVJ02
ADNR	21-Jul-2004	Tributary Creek	Site 9	DV	105	14.1	23.3	072104TR09DVJ03
ADNR	21-Jul-2004	Tributary Creek	Site 9	DV	85	5.8	22.6	072104TR09DVJ04
ADNR	21-Jul-2004	Tributary Creek	Site 9	DV	81	6.4	24.0	072104TR09DVJ05
ADNR	21-Jul-2004	Tributary Creek	Site 9	DV	86	10.4	17.6	072104TR09DVJ06
ADNR	23-Jul-2005	Tributary Creek	Site 9	DV	97	11.1	25.8	072305TR09DVJ01
ADNR	23-Jul-2005	Tributary Creek	Site 9	DV	113	16.8	26.7	072305TR09DVJ02
ADNR	23-Jul-2005	Tributary Creek	Site 9	DV	115	18.8	26.2	072305TR09DVJ03
ADNR	23-Jul-2005	Tributary Creek	Site 9	DV	117	20.5	26.1	072305TR09DVJ04
ADNR	23-Jul-2005	Tributary Creek	Site 9	DV	101	11.7	27.4	072305TR09DVJ05
ADNR	23-Jul-2005	Tributary Creek	Site 9	DV	107	13.7	25.9	072305TR09DVJ06

Whole body concentration of select metals in juvenile fish collected in 2000-2005.

Location	Site	Fish Sp	Analyte Basis	Ag mg/kg	Cd mg/kg	Cu mg/kg	Pb mg/kg	Se mg/kg	Zn mg/kg	Sample Number
Upper Greens Creek	Site 48	DV	dry wt	0.02	1.76	8.30	0.20	6.1	180	072301GC48DVJ01
Upper Greens Creek	Site 48	DV	dry wt	0.03	0.89	7.20	0.17	4.6	146	072301GC48DVJ02
Upper Greens Creek	Site 48	DV	dry wt	0.02	2.27	5.70	0.20	6.2	189	072301GC48DVJ03
Upper Greens Creek	Site 48	DV	dry wt	0.02	1.56	6.90	0.17	5.2	182	072301GC48DVJ04
Upper Greens Creek	Site 48	DV	dry wt	0.03	0.89	4.70	0.23	5.4	138	072301GC48DVJ05
Upper Greens Creek	Site 48	DV	dry wt	0.02	1.26	7.40	0.10	5.6	157	072301GC48DVJ06
Upper Greens Creek	Site 48	DV	dry wt	0.03	1.64	6.80	0.72	4.8	239	072402GC48DVJ01
Upper Greens Creek	Site 48	DV	dry wt	0.07	0.85	7.00	0.28	4.1	210	072402GC48DVJ02
Upper Greens Creek	Site 48	DV	dry wt	0.03	0.74	4.30	0.17	4.9	162	072402GC48DVJ03
Upper Greens Creek	Site 48	DV	dry wt	0.04	1.40	6.10	0.16	4.7	185	072402GC48DVJ04
Upper Greens Creek	Site 48	DV	dry wt	0.05	1.30	7.90	0.46	4.3	208	072402GC48DVJ05
Upper Greens Creek	Site 48	DV	dry wt	0.04	1.56	6.80	0.22	5.7	343	072402GC48DVJ06
Upper Greens Creek	Site 48	DV	dry wt	ND	0.65	4.2	0.14	5.6	191	072203GC48DVJ01
Upper Greens Creek	Site 48	DV	dry wt	ND	0.90	5.1	0.22	5.5	180	072203GC48DVJ02
Upper Greens Creek	Site 48	DV	dry wt	ND	0.82	5.6	0.16	5.4	241	072203GC48DVJ03
Upper Greens Creek	Site 48	DV	dry wt	ND	0.78	6.1	0.11	6.1	192	072203GC48DVJ04
Upper Greens Creek	Site 48	DV	dry wt	ND	0.63	3.9	0.14	5.2	174	072203GC48DVJ05
Upper Greens Creek	Site 48	DV	dry wt	ND	0.58	3.7	0.08	5.5	218	072203GC48DVJ06
Upper Greens Creek	Site 48	DV	dry wt	ND	0.63	4.7	0.15	4.3	206	072204GC48DVJ01
Upper Greens Creek	Site 48	DV	dry wt	ND	0.83	5.6	0.26	4.0	175	072204GC48DVJ02
Upper Greens Creek	Site 48	DV	dry wt	ND	1.54	4.6	0.21	4.1	183	072204GC48DVJ03
Upper Greens Creek	Site 48	DV	dry wt	ND	0.80	5.2	0.28	3.7	168	072204GC48DVJ04
Upper Greens Creek	Site 48	DV	dry wt	ND	1.25	4.4	0.14	6.4	220	072204GC48DVJ05
Upper Greens Creek	Site 48	DV	dry wt	0.03	1.01	4.5	0.29	5.6	323	072204GC48DVJ06
Upper Greens Creek	Site 48	DV	dry wt	0.02	0.66	4.4	0.44	4.2	183	072205GC48DVJ01
Upper Greens Creek	Site 48	DV	dry wt	ND	0.84	14.5	0.98	4.8	220	072205GC48DVJ02
Upper Greens Creek	Site 48	DV	dry wt	ND	0.89	4.3	0.66	4.8	226	072205GC48DVJ03
Upper Greens Creek	Site 48	DV	dry wt	0.02	0.59	6.0	0.32	4.8	178	072205GC48DVJ04
Upper Greens Creek	Site 48	DV	dry wt	0.03	1.10	18.8	0.79	4.6	217	072205GC48DVJ05
Upper Greens Creek	Site 48	DV	dry wt	0.03	0.47	3.6	0.36	3.8	160	072205GC48DVJ06
Middle Greens Creek	Site 6	DV	dry wt	0.04	1.94	16.70	1.24	5.0	173	072301GC06DVJ01
Middle Greens Creek	Site 6	DV	dry wt	0.03	0.84	4.60	1.00	4.5	167	072301GC06DVJ02
Middle Greens Creek	Site 6	DV	dry wt	0.03	0.82	5.30	1.94	4.3	171	072301GC06DVJ03
Middle Greens Creek	Site 6	DV	dry wt	0.03	1.52	5.40	1.78	4.5	215	072301GC06DVJ04
Middle Greens Creek	Site 6	DV	dry wt	0.02	0.89	11.10	0.33	5.3	126	072301GC06DVJ05
Middle Greens Creek	Site 6	DV	dry wt	0.04	0.73	8.00	1.96	4.6	169	072301GC06DVJ06
Greens Cr Below Pond D	Site 54	CO	dry wt	0.04	0.95	15.30	1.40	4.9	251	062100GCCOJ01
Greens Cr Below Pond D	Site 54	CO	dry wt	0.09	0.66	11.70	1.21	4.7	224	062100GCCOJ02
Greens Cr Below Pond D	Site 54	CO	dry wt	0.22	1.07	24.20	1.40	3.4	206	062100GCCOJ03
Greens Cr Below Pond D	Site 54	CO	dry wt	0.10	0.97	24.00	1.12	3.5	181	062100GCCOJ04
Greens Cr Below Pond D	Site 54	CO	dry wt	0.05	0.96	44.00	1.53	4.9	304	062100GCCOJ05
Greens Cr Below Pond D	Site 54	CO	dry wt	0.08	1.47	36.10	5.02	4.7	340	062100GCCOJ06
Greens Cr Below Pond D	Site 54	DV	dry wt	0.03	0.46	4.30	0.33	5.7	126	072301GC54DVJ01
Greens Cr Below Pond D	Site 54	DV	dry wt	0.02	0.21	3.20	0.22	3.6	82	072301GC54DVJ02
Greens Cr Below Pond D	Site 54	DV	dry wt	0.03	0.73	6.30	0.59	4.7	144	072301GC54DVJ03
Greens Cr Below Pond D	Site 54	DV	dry wt	0.02	0.82	5.40	0.86	4.9	172	072301GC54DVJ04
Greens Cr Below Pond D	Site 54	DV	dry wt	0.02	0.79	6.50	0.45	5.8	203	072301GC54DVJ05
Greens Cr Below Pond D	Site 54	DV	dry wt	0.02	0.74	5.80	0.40	5.4	171	072301GC54DVJ06

Whole body concentration of select metals in juvenile fish collected in 2000-2005 (continued).

Location	Site	Fish Sp	Analyte Basis	Ag mg/kg	Cd mg/kg	Cu mg/kg	Pb mg/kg	Se mg/kg	Zn mg/kg	Sample Number
Greens Cr Below Pond D	Site 54	DV	dry wt	0.03	0.50	4.40	0.94	3.4	363	072402GC54DVJ01
Greens Cr Below Pond D	Site 54	DV	dry wt	0.03	0.52	4.50	0.35	4.7	150	072402GC54DVJ02
Greens Cr Below Pond D	Site 54	DV	dry wt	0.05	0.95	6.00	0.66	4.4	161	072402GC54DVJ03
Greens Cr Below Pond D	Site 54	DV	dry wt	0.03	1.03	5.20	0.66	4.2	216	072402GC54DVJ04
Greens Cr Below Pond D	Site 54	DV	dry wt	0.05	1.32	5.20	0.74	3.9	1.94	072402GC54DVJ05
Greens Cr Below Pond D	Site 54	DV	dry wt	0.02	0.70	3.90	0.78	4.4	195	072402GC54DVJ06
Greens Cr Below Pond D	Site 54	DV	dry wt	0.03	0.85	6.4	1.40	6.1	188	072203GC54DVJ01
Greens Cr Below Pond D	Site 54	DV	dry wt	ND	0.67	4.2	0.32	6.4	174	072203GC54DVJ02
Greens Cr Below Pond D	Site 54	DV	dry wt	ND	0.75	4.3	0.35	6.5	186	072203GC54DVJ03
Greens Cr Below Pond D	Site 54	DV	dry wt	ND	1.11	5.8	0.38	5.7	188	072203GC54DVJ04
Greens Cr Below Pond D	Site 54	DV	dry wt	ND	0.59	3.5	0.29	5.7	174	072203GC54DVJ05
Greens Cr Below Pond D	Site 54	DV	dry wt	ND	0.91	4.1	0.43	6.5	263	072203GC54DVJ06
Greens Cr Below Pond D	Site 54	DV	dry wt	0.02	0.79	11.0	0.57	4.6	232	072104GC54DVJ01
Greens Cr Below Pond D	Site 54	DV	dry wt	ND	0.88	5.5	0.54	5.0	206	072104GC54DVJ02
Greens Cr Below Pond D	Site 54	DV	dry wt	ND	1.26	5.1	0.36	5.3	164	072104GC54DVJ03
Greens Cr Below Pond D	Site 54	DV	dry wt	0.03	0.79	5.9	0.28	5.4	191	072104GC54DVJ04
Greens Cr Below Pond D	Site 54	DV	dry wt	ND	0.83	5.0	0.48	3.9	202	072104GC54DVJ05
Greens Cr Below Pond D	Site 54	DV	dry wt	0.07	1.12	7.0	0.93	4.9	216	072104GC54DVJ06
Greens Cr Below Pond D	Site 54	DV	dry wt	0.03	0.72	5.0	0.27	4.0	160	072205GC54DVJ01
Greens Cr Below Pond D	Site 54	DV	dry wt	0.02	0.63	4.5	0.13	3.9	200	072205GC54DVJ02
Greens Cr Below Pond D	Site 54	DV	dry wt	ND	0.73	8.8	0.17	4.7	223	072205GC54DVJ03
Greens Cr Below Pond D	Site 54	DV	dry wt	ND	0.82	9.7	0.17	3.9	222	072205GC54DVJ04
Greens Cr Below Pond D	Site 54	DV	dry wt	0.03	1.06	8.8	0.22	4.4	209	072205GC54DVJ05
Greens Cr Below Pond D	Site 54	DV	dry wt	0.02	0.55	5.5	0.39	3.9	185	072205GC54DVJ06
Tributary Creek	Site 9	CO	dry wt	0.04	0.42	16.20	1.03	3.2	213	062100TRCOJ01
Tributary Creek	Site 9	CO	dry wt	0.07	0.50	16.50	2.01	3.7	220	062100TRCOJ02
Tributary Creek	Site 9	DV	dry wt	0.12	0.75	11.20	1.63	3.8	194	062100TRCOJ03
Tributary Creek	Site 9	DV	dry wt	0.07	0.56	10.60	1.53	3.6	87.9	062100TRDVJ04
Tributary Creek	Site 9	DV	dry wt	0.06	0.58	12.80	1.59	3.5	204	062100TRDVJ05
Tributary Creek	Site 9	DV	dry wt	0.05	0.45	32.80	1.57	5.0	213	062100TRDVJ06
Tributary Creek	Site 9	DV	dry wt	0.09	0.35	4.30	0.56	6.8	127	072301TR09DVJ01
Tributary Creek	Site 9	DV	dry wt	0.10	0.77	5.20	0.67	8.0	118	072301TR09DVJ02
Tributary Creek	Site 9	DV	dry wt	0.15	0.92	5.40	4.88	5.3	144	072301TR09DVJ03
Tributary Creek	Site 9	DV	dry wt	0.15	0.86	6.70	2.19	---	99.1	072301TR09DVJ04
Tributary Creek	Site 9	DV	dry wt	0.08	0.76	4.90	0.33	6.2	106	072301TR09DVJ05
Tributary Creek	Site 9	DV	dry wt	0.06	0.37	12.00	0.38	6.8	122	072301TR09DVJ06
Tributary Creek	Site 9	DV	dry wt	0.02	0.22	3.70	0.12	1.4	144	072402TR09DVJ01
Tributary Creek	Site 9	DV	dry wt	0.07	1.20	5.50	1.66	3.3	172	072402TR09DVJ02
Tributary Creek	Site 9	DV	dry wt	0.13	1.06	6.10	3.40	5.0	138	072402TR09DVJ03
Tributary Creek	Site 9	DV	dry wt	0.23	1.29	7.10	4.08	5.2	168	072402TR09DVJ04
Tributary Creek	Site 9	DV	dry wt	0.08	1.15	5.20	1.39	6.2	150	072402TR09DVJ05
Tributary Creek	Site 9	DV	dry wt	0.04	0.84	3.20	0.33	5.4	152	072402TR09DVJ06
Tributary Creek	Site 9	DV	dry wt	0.06	0.46	2.8	0.34	6.3	134	072304TR09DVJ01
Tributary Creek	Site 9	DV	dry wt	0.10	1.01	4.0	0.82	6.0	131	072304TR09DVJ02
Tributary Creek	Site 9	DV	dry wt	0.16	1.35	4.4	1.85	5.7	108	072304TR09DVJ03
Tributary Creek	Site 9	DV	dry wt	0.19	0.69	5.6	1.30	3.6	136	072304TR09DVJ04
Tributary Creek	Site 9	DV	dry wt	0.05	0.72	4.4	0.56	4.9	131	072304TR09DVJ05
Tributary Creek	Site 9	DV	dry wt	0.12	0.76	3.9	0.78	4.7	125	072304TR09DVJ06
Tributary Creek	Site 9	DV	dry wt	0.10	0.96	3.2	1.19	5.4	169	072104TR09DVJ01
Tributary Creek	Site 9	DV	dry wt	0.10	1.24	3.8	0.67	5.9	138	072104TR09DVJ02
Tributary Creek	Site 9	DV	dry wt	0.10	2.02	4.0	1.75	5.7	125	072104TR09DVJ03
Tributary Creek	Site 9	DV	dry wt	0.04	0.47	3.7	0.93	4.8	175	072104TR09DVJ04
Tributary Creek	Site 9	DV	dry wt	0.09	2.34	4.3	1.44	8.2	140	072104TR09DVJ05
Tributary Creek	Site 9	DV	dry wt	0.11	0.83	5.5	0.97	5.8	161	072104TR09DVJ06
Tributary Creek	Site 9	DV	dry wt	0.06	0.70	10.4	0.29	6.4	104	072305TR09DVJ01
Tributary Creek	Site 9	DV	dry wt	0.10	0.63	4.7	0.97	6.1	122	072305TR09DVJ02
Tributary Creek	Site 9	DV	dry wt	0.07	0.52	6.3	0.53	5.8	109	072305TR09DVJ03
Tributary Creek	Site 9	DV	dry wt	0.19	0.79	9.9	1.07	6.7	117	072305TR09DVJ04
Tributary Creek	Site 9	DV	dry wt	0.07	1.44	5.2	1.00	8.1	130	072305TR09DVJ05
Tributary Creek	Site 9	DV	dry wt	0.10	1.29	4.6	0.46	8.0	134	072305TR09DVJ06