Technical Report No. 07-02

Aquatic Biomonitoring at Greens Creek Mine, 2006

by James D. Durst
Laura L. Jacobs

May 2007

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

Cover: Benthic macroinvertebrate sampling at Upper Greens Creek Site 48, 2006. ADNR/OHMP photo.

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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 at Greens Creek Mine on Admiralty Island in southeast Alaska 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 through 2006.

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 Tributary Creek 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 these aquatic communities over time that may result from changes in water quality associated with surface- or ground-water inputs to the streams. Elements of the biological monitoring program developed to meet the stated purpose include surveys of periphyton biomass, benthic macroinvertebrate density and community structure, juvenile fish abundance and distribution, and concentrations of selected heavy metals in fish tissues.

The three biomonitoring sites on Greens Creek (Upper Greens Creek Site 48 above all facilities, Middle Greens Creek Site 6 below the mine portal and mill facilities, and Greens Creek Below Pond D Site 54 below all facilities) and one site on Tributary Creek (Tributary Creek Site 9 below the dry-stack tailings facility) continued to sustain functioning, relatively diverse aquatic communities in 2006. The two sample reaches on Greens Creek downstream of mine facilities (Middle Greens Creek Site 6 and Greens Creek Below Pond D Site 54) were generally similar to the reference site (Upper Greens Creek Site 48). The Tributary Creek sample reach continued to have diverse aquatic communities, but generally at a lower abundance than in past years of sampling. The general theme of the 2006 biomonitoring sampling appears to be "perturbation," with Greens Creek sites exposed to high overwinter flows and the Tributary Creek site exposed to at least episodic elevated turbidity levels.

Periphyton biomass and community composition at the three Greens Creek sites continue to appear robust, with a pronounced diatom component and a minimal green algae component.

Chlorophyll *a* concentrations were similar among the three Greens Creek sites in 2006, and those sites each had significantly more periphyton biomass than in 2001. Periphyton biomass at Tributary Creek Site 9 was the lowest recorded in six years of sampling at the site, and was significantly lower than the high chlorophyll *a* concentrations in 2003. The community composition at Tributary Creek continued to be similar to that at the Greens Creek sites.

The benthic macroinvertebrate communities of all four biomonitoring sites showed essentially the opposite trends of those seen in the periphyton communities. Benthic macroinvertebrate samples from the three Greens Creek sites were lower in abundance and taxonomic richness in 2006 relative to past years, although populations of many disturbance-sensitive taxa were well represented. The mean rank scores for benthic macroinvertebrate abundance and taxonomic richness at the three Greens Creek sites in 2006 were the lowest of the years sampled and were not statistically different between sites. Tributary Creek Site 9 benthic macroinvertebrate abundance and taxonomic richness were moderate in 2006, and substantially different only from the high densities of 2003. . In contrast to most of the past five years of sampling, the number of common taxa in Tributary Creek Site 9 samples in 2006 was equal to or less than that found in Greens Creek samples. Distinctive differences in the benthic macroinvertebrate community between the two streams persisted. The percentage of the water quality-sensitive Ephemeroptera, Plecoptera, and Trichoptera taxa in all sites' benthic macroinvertebrate samples remained high in 2006. The continuing community differences between the Greens Creek and Tributary Creek sites are likely influenced by differences in physical characteristics of the two streams, including gradient, stream size, water velocity, and scour patterns.

Dolly Varden (*Salvelinus malma*) populations continue to be relatively abundant at each of the Greens Creek sites. Captures were intermediate to those in previous years, with multiple size classes of fish present. Dolly Varden captures at Tributary Creek Site 9 were significantly lower than in the previous five years of sampling at that site; no size classes typically associated with young-of-the-year Dolly Varden were captured at Site 9. Coho salmon (*Oncorhynchus kisutch*) captures were significantly lower in 2006 than in previous years' sampling at the three biomonitoring sites accessible to coho; no size classes typically associated with young-of-the-year coho salmon were captured. Total fish densities per square meter of wetted stream area among the three Greens Creek sites continued to be higher at Greens Creek Below Pond D Site 54 than at Upper Greens Creek Site 48, with Middle Greens Creek Site 6 having intermediate densities. The total fish densities per square meter of wetted area at Tributary Creek Site 9 were lower in 2006 than those at Upper Greens Creek Site 48 for the first time in six years of sampling.

The range of whole body concentrations of metals in juvenile Dolly Varden tissues were generally similar to those found in previous years' samples at each site. In general, metals concentrations in fish tissues were somewhat elevated in 2006 over previous years, particularly zinc in fish from Greens Creek and silver in fish from Tributary Creek, although a clear pattern of differential tissues metals concentration did not emerge between sites upstream and downstream of mine facilities or at sites over time. Tissues of Dolly Varden from Tributary Creek Site 9 had different characteristics of metals concentrations than did tissues from Dolly Varden at the three Greens Creek sites (48, 6, and 54) in 2006.

Overall, the aquatic communities in Upper Greens Creek Site 48, Middle Greens Creek Site 6, Greens Creek Below Pond D Site 54, and Tributary Creek Site 9 have remained fairly diverse and generally abundant during the six years of biomonitoring sampling. Differences noted between years and between the streams (Greens Creek compared to Tributary Creek) have typically been of larger amplitude than have differences between the control and below-mining sites within Greens Creek or over time at the Tributary Creek site. Although no trends of reduced productivity, community changes, or metals accumulation attributable to operations of the Greens Creek Mine have been noted, the 2006 biomonitoring results raise concerns that will need to be followed in future years of biomonitoring: low abundance of periphyton in Tributary Creek, low density and richness of benthic macroinvertebrates in Greens Creek, low density of Dolly Varden in Tributary Creek, low density of coho salmon in both Greens Creek and Tributary Creek, and somewhat elevated levels of metals in fish tissues at all sites.

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 Admiralty Island National Monument in southeast Alaska.

Based on 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 sixth year (2006) of the Greens Creek Mine Biological Monitoring Program as specified in the FWMP, and was conducted by the ADNR Office of Habitat Management and Permitting as successor to the ADF&G Habitat and Restoration Division. Results from previous years' biomonitoring can be found in Weber Scannell and Paustian (2002), Jacobs et al. (2003), Durst and Townsend (2004), Durst et al. (2005), and Durst and Jacobs (2006).

The intent of the Greens Creek Mine Biological Monitoring Program 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 in the aquatic communities that may result from changes in water chemistry through either surface- or ground-water inputs to the streams.

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 individually 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 document 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 changes that may have occurred in aquatic communities.

The biological monitoring program for the Greens Creek mine was 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.[1]

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 facilities; two exploratory drilling holes have been drilled upstream of this site. Annual biomonitoring at Upper Greens Creek Site 48 serves as a control. Middle Greens Creek Site 6 monitors Greens Creek downstream of the mine portal and mill facilities but upstream of the production rock storage area; Site 6 was sampled in 2001 to provide 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 to detect changes over time as a partial treatment site. Greens Creek Below Pond D Site 54 monitors Greens Creek downstream of mine portal and mill facilities and the production rock storage area and its associated pond system; annual biomonitoring at Site 54 serves as a complete treatment site. Tributary Creek Site 9 monitors Tributary Creek downstream of the dry-stack tailings storage facility, which sits at the head of the drainage. Biomonitoring occurs at Site 9 annually to detect any changes over time as a complete treatment site. KGCMC monitors the ambient water quality at these and other FWMP sites on a regular basis, and reports the results of that monitoring under separate cover. Figure 1 shows the location of the Greens Creek Mine and the biomonitoring sampling locations.

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[1] The toxicity testing component of the Greens Creek Biomonitoring Program was suspended after the 2003 sampling period (McGee and Marthaller 2004).

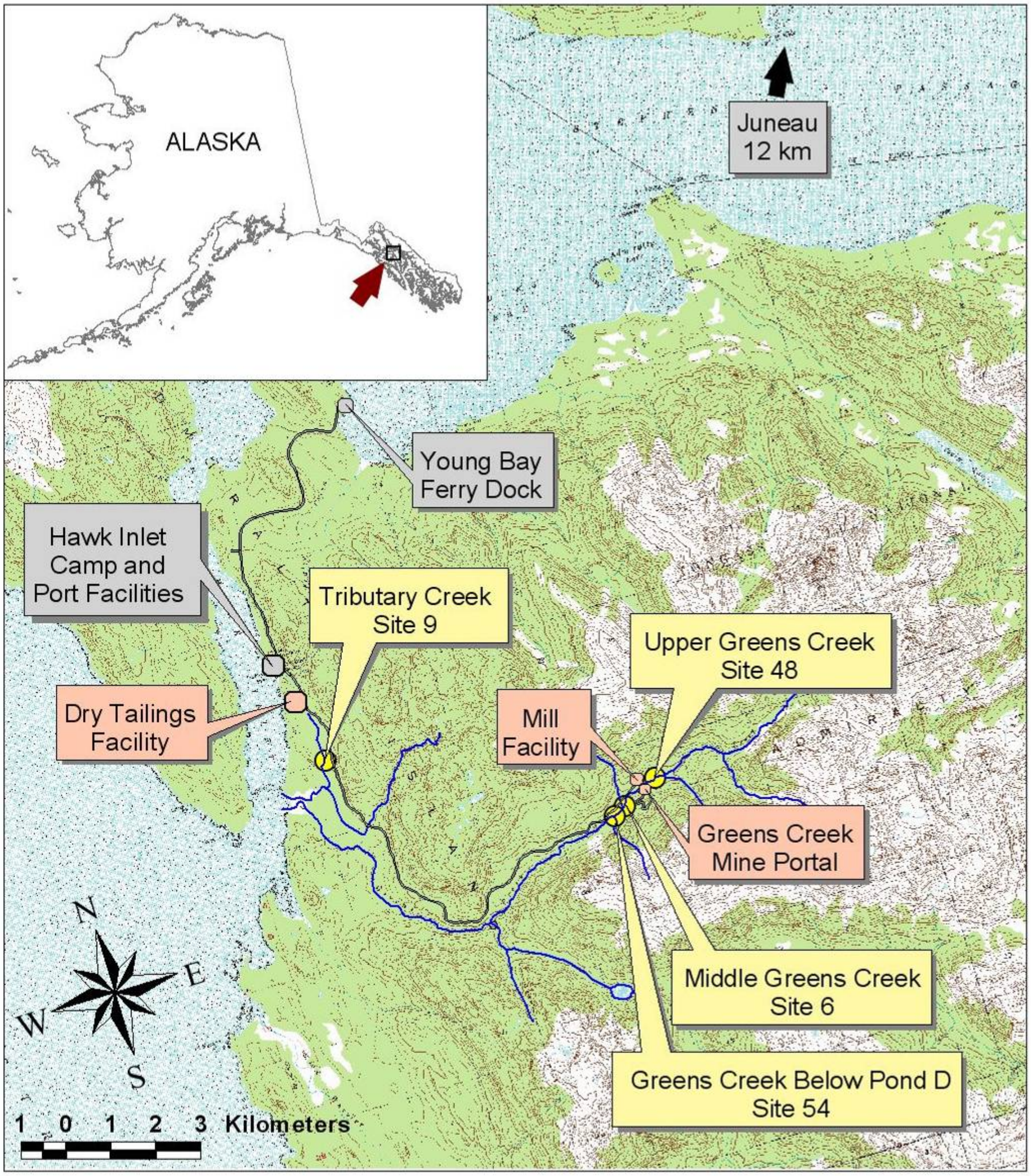

Figure 1. Location of the Greens Creek Mine operation and biomonitoring sampling sites on Admiralty Island in southeast Alaska, southwest of Juneau.

METHODS

Five to six hours are required at each site to gather the suite of raw data needed for biomonitoring sampling. 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, Durst et al. 2005, Durst and Jacobs 2006). In addition to the procedures detailed below, field measurements included air and water temperatures, wetted widths, water velocities at benthic sample locations, and a quick survey for cross sectional area and discharge. Photographs were taken to document site conditions and sampling areas in each survey reach.

Data analyses were performed using hand calculators, Microsoft® Excel 2003, and Statistix® 8 (Analytical Software 2003). Kruskal-Wallis One-Way Analysis of Variance, 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 mine facilities. This site, at approximately 265 m elevation, is upstream of all mining facilities and of all activities except for two exploratory drill holes, one each drilled in 2004 and 2006. 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 portion 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.

The periphyton and benthic macroinvertebrate sample reach is just downstream of the fish sample reach at this site. Both reaches are fairly homogeneous, with split- and single-channel areas, large woody debris, and a mix of pool and riffle habitats.

Middle Greens Creek Site 6

Water quality at the Middle Greens Creek Site 6 (immediately 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 but upstream of the production rock storage site and its associated treatment ponds. 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 is used to detect possible changes in aquatic communities that occur from natural causes or as a result of mine activities. Following the five-year pulsed sampling schedule presented in the FWMP, biomonitoring data were collected at Site 6 in 2001 for reference information (Weber Scannell and Paustian 2002) and again in 2006.

Middle Greens Creek Site 6 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 portion of moderately sized basins in southeast Alaska (Paustian et al. 1992, Weber Scannell and Paustian 2002). Cobble is the dominant streambed material. Large woody debris is less abundant at this site than at the other two Greens Creek sites, but still integral to pool formation and fish habitat cover.

The periphyton and benthic macroinvertebrate sample reach is immediately upstream of the confluence of Bruin Creek with Greens Creek, while the fish sample reach is a short distance upstream above a large woody debris tangle. Both reaches are single-channel areas; the fish reach has both overhanging and pool-forming large woody debris.

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 the production rock storage area and treatment pond in addition to the facilities upstream of Middle Greens Creek Site 6. 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 portion 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.

The periphyton and benthic macroinvertebrate sample reach is a short distance upstream of the fish sample reach at this site, with Gallagher Creek entering at the upstream end of the fish sample reach. Both reaches have a single- or split-channel configuration depending on water level, with instream and overhanging large woody debris.

Tributary Creek Site 9

Tributary Creek is a small lowland stream with a dense canopy. This site, at approximately 25 m elevation, was monitored under the FWMP from 1981 through 1993, with water quality monitoring beginning again in 2006. Site 9 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 are 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).

The periphyton sampling area is within the upstream half of the fish sampling reach at this site, and the benthic macroinvertebrate reach is immediately downstream of the fish sampling reach. This low-energy stream is single channel, with moderately developed pools and riffles and a mixture of overhanging and embedded large woody debris.

PERIPHYTON BIOMASS

Rationale

Periphyton, or attached algae, is sensitive to changes in water quality. An abundance of periphyton confirms that productivity is occurring at that specific location 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 relatively stable flow, and not after scouring flow events. Ten rocks were collected from the nearshore area of the stream 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), and placed in a sealed labeled plastic bag with a desiccant. Filters were frozen on site in a lightproof container with desiccant, and then transported to Fairbanks where they were kept frozen until laboratory analyses were conducted 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 hours to extract the chlorophyll. After extraction, samples were centrifuged for 20 minutes at 1,600 rpm and then read on a Shimadzu Spectrophotometer UV-601 at optical densities (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 predominant in all living plants, 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 interquartile range), the line bisecting the box represents the median, and the vertical "whiskers" are the typical range of data in the sample. Whiskers always end at a data point that is within 1½ times the interquartile range. An asterisk represents possible outliers lying outside the box (interquartile range) by more than 1½ times the interquartile range, and ○ is used to represent probable outliers more than 3 times the interquartile range (Analytical Software 2003). We have no evidence to suggest that potential and probable outlier data values are other than 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.

The sampler ring encompassed approximately 0.1 m^2 of substrate, and was pushed into the stream bottom to define the sample area. 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 debris and identified to the lowest practical taxonomic level by a contracted taxonomist.

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 mine surface 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 roe 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.

Sample reaches were identified by aluminum tree tags and flagging set by the USFS during previous years' sampling, and 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 six 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. When Middle Greens Creek Site 6 was last sampled in 2001, a 135 m reach was used for trap placement. Habitat variations within such a long reach made population estimation difficult (Weber Scannell and Paustian 2002), and the authors recommended reducing the length of the trapped reach to 30 m to 40 m for subsequent sampling efforts. In 2006, USFS and OHMP staff established a 49 m reach for sampling within the upstream portion of the 135 m reach. The need for natural breaks in the channel to provide some closure to the population during depletion sampling necessitated a slightly longer sample reach than recommended in 2002.

Traps were placed throughout each sample reach 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 are used to help define upper and lower sample reach boundaries to minimize fish movement into the sample section during sampling. To better meet the closure assumption of the three-pass removal method, 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 kept supplied with aerated water to reduce stress on captured fish. The traps were re-baited and reset for a second 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 block traps were counted and identified to species, but not included in further analyses.

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 reach 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 biomonitored streams, tissue sampling of juvenile fish living in those streams should reflect such 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, and correction made for the weight of the 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 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. From 2001 through 2006, all fish retained for metals analysis were Dolly Varden. Samples from Middle Greens Creek Site 6, Greens Creek Below Pond D Site 54, and Tributary Creek Site 9 potentially contained a mixture of resident and anadromous forms, although this would not be expected to alter accumulation levels in fish from the size range collected.

Samples were numbered following the convention established by ADF&G in 2001: Date/StreamCode/Site/SpeciesCode/AgeCode/SampleNumber. For example, one fish sample was labeled 072006GC48DVJ01 where 072006 represents July 20, 2006; GC48 represents Upper Greens Creek Site 48; DV represents Dolly Varden; J represents juvenile; and 01 represents sample replicate number 1.

Quality Control / Quality Assurance of Laboratory Analysis

Written chain of custody documentation was maintained on each fish collected for metals testing. The analytical laboratory (Columbia Analytical Services, Inc. in Kelso, Washington) provided Tier III quality assurance/quality control validation information for each analyte including matrix spikes, standard reference materials, laboratory calibration data, sample blanks, and sample duplicates.

RESULTS AND DISCUSSION

Water levels and stream discharges appeared moderate at the Greens Creek and Tributary Creek sites during sampling in 2006 compared to 2001 through 2005 biomonitoring sampling, although rainfall in 2006 caused water levels to rise noticeably on the second day of sampling (sites 6 and 9). No evidence was noted of scouring flows during the weeks prior to sampling. 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 Upper Greens Creek Site 48 and Middle Greens Creek Site 6 (Table 1). The same general pattern was present when comparing flows the three weeks prior to sampling each year.

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
2006	July 20	35	0.99
	July 21	59	1.67

A major high flow event occurred on Greens Creek since the 2005 biomonitoring sampling. On November 22, 2005, the USGS gage recorded an instantaneous peak discharge of 440 cfs, with a mean daily discharge of 272 cfs. This tied for the second highest peak discharge recorded since the gage was installed in 1989 and was the highest since the record event on October 20, 1998. We noted some changes in the channel configuration and large woody debris distribution in the Upper Greens Creek Site 48 and Greens Creek Below Pond D Site 54 sampling reaches during the 2006 biomonitoring sampling. In general, the Greens Creek sample reaches appeared to be somewhat straighter and less braided in 2006 than in previous years of biomonitoring sampling, with fewer pools, backwaters, and large woody debris pieces.

UPPER GREENS CREEK SITE 48

Upper Greens Creek Site 48 (Figure 2) was sampled in the afternoon of 20 July 2006. The weather was partly cloudy with some drizzle and light winds; the water temperature was 10°C and the air temperature 16°C. There was no evidence of recent high flow or other recent disturbance events, although there was evidence of high water since our 2005 sampling. Compared to the previous years of biomonitoring sampling, the channel was somewhat straighter, with fewer pools and backwaters. No major changes in large woody debris distribution were noted. We attributed these changes to the November 2005 high water event.

Figure 2. Upper Greens Creek Site 48, 20 July 2006.

Periphyton Biomass

Concentrations of chlorophyll *a*, an estimate of periphyton biomass, in Upper Greens Creek Site 48 were significantly[2] different between years when 2001 through 2006 were analyzed together. Multiple pairwise comparisons showed that the robust values in 2006 were significantly higher than those found at this site in 2001 and 2002 (Appendix 2). Only 2003 samples had a higher

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

mean rank than the 2006 samples. The Box and Whisker output plot from Statistix is shown in Figure 3.

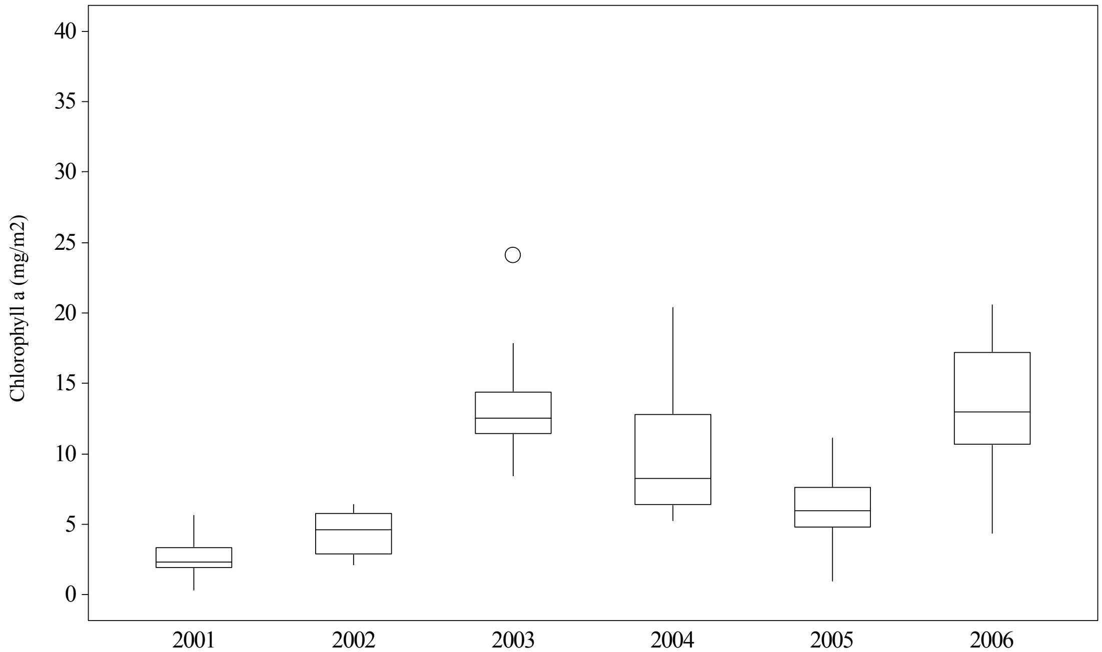

Figure 3. Estimated periphyton biomass densities at Upper Greens Creek Site 48 in 2001 through 2006 (n = 10 samples each year). Box encompasses middle half of data; horizontal line is median value. One probable statistical outlier value (○) was identified in the 2003 data set.

The significantly higher proportions of chlorophyll *c* than chlorophyll *b* in all six years sampled (Figure 4) indicate that diatoms and/or dinoflagellates are a major component of the periphyton community at Upper Greens Creek Site 48, while the low to undetectable concentrations of chlorophyll *b* indicate low populations of green algae.

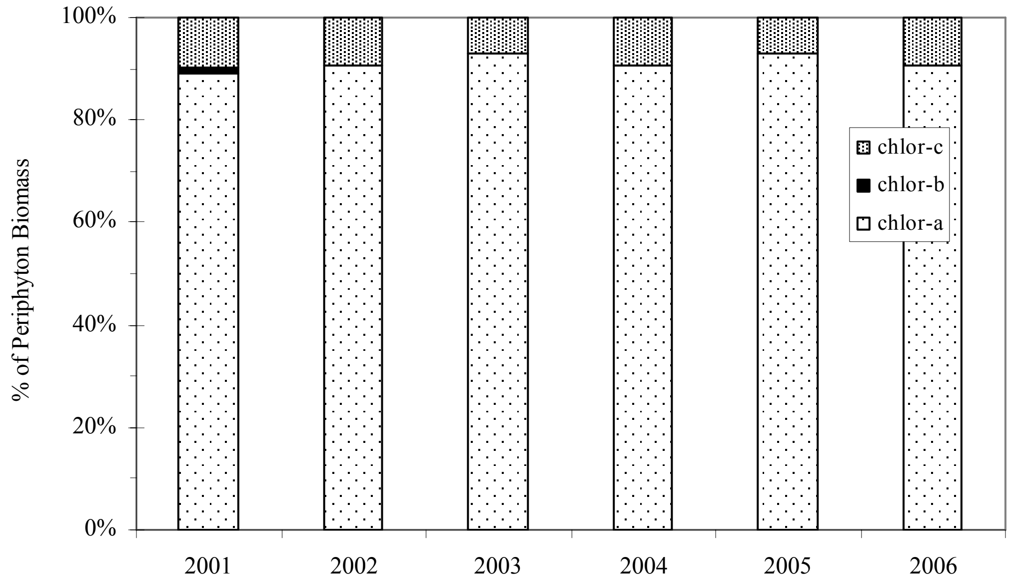

Figure 4. Proportions of mean chlorophyll *a*, *b*, and *c* concentrations in Upper Greens Creek Site 48 samples in 2001 through 2006.

Benthic Macroinvertebrates

The mean density of benthic macroinvertebrates in Upper Greens Creek Site 48 samples in 2006 was the lowest found in six years of sampling at this site, but was significantly different only from the high mean density of 2003 (Table 2, Figure 5). Taxonomic richness per sample was also low (Appendix 3), with the 2006 values significantly lower than the high values of 2004.

Table 2. Summary of benthic macroinvertebrate samples at Upper Greens Creek Site 48 in 2001 through 2006.

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
2006	1386	22	11.8

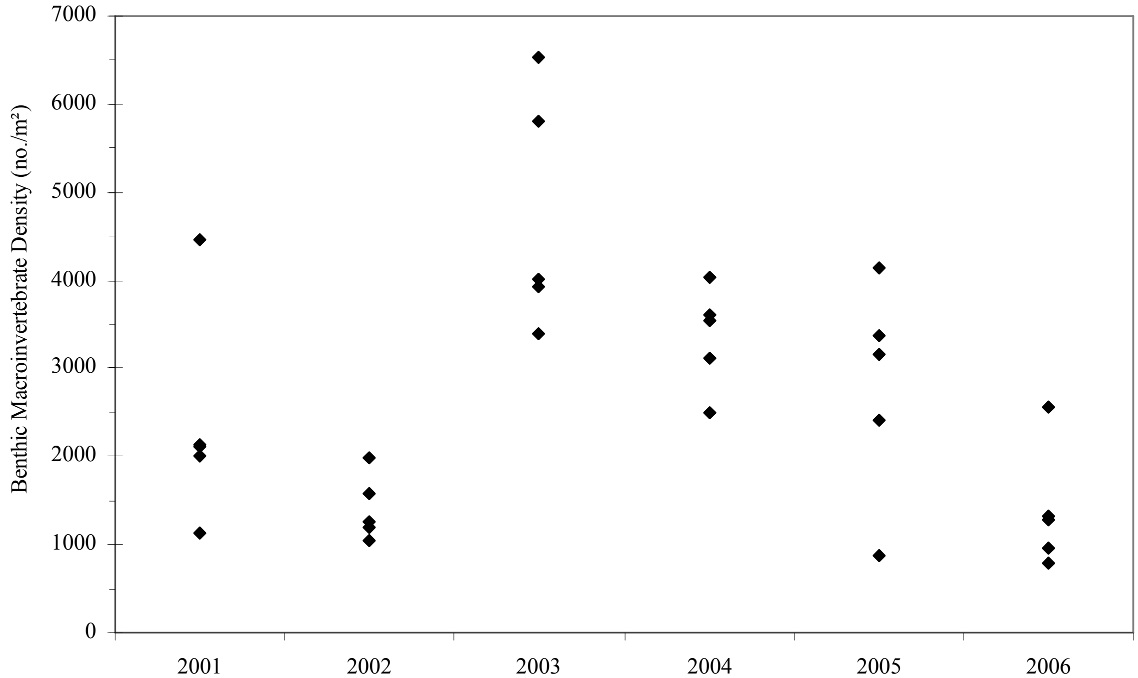

Figure 5. Density of benthic macroinvertebrates (n = 5 samples each year) at Upper Greens Creek Site 48 in 2001 through 2006.

Invertebrate communities were somewhat different among the six years sampled, with relatively low but somewhat different proportions of Chironomidae occurring each year (Figure 6). The numbers of Chironomidae in 2006 samples were less than those found in all but 2001. The EPT taxa (Ephemeroptera [mayflies], Plecoptera [stoneflies], and Trichoptera [caddisflies]) continued to be most prevalent (Figure 7). 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.

At Upper Greens Creek Site 48, mayflies (Ephemeroptera) dominated the benthic macroinvertebrate samples (Figure 7, Table 3). Common taxa in the six 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 six years, pollution-sensitive taxa dominated the invertebrate community at Upper Greens Creek Site 48, and the 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 2006.

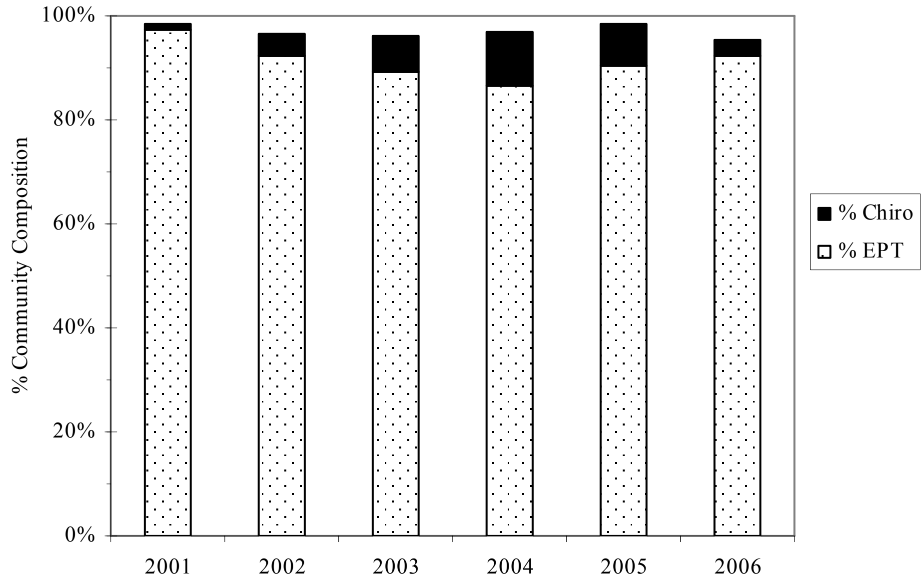

Figure 6. Proportions of EPT taxa and Chironomidae in Upper Greens Creek Site 48 samples in 2001 through 2006.

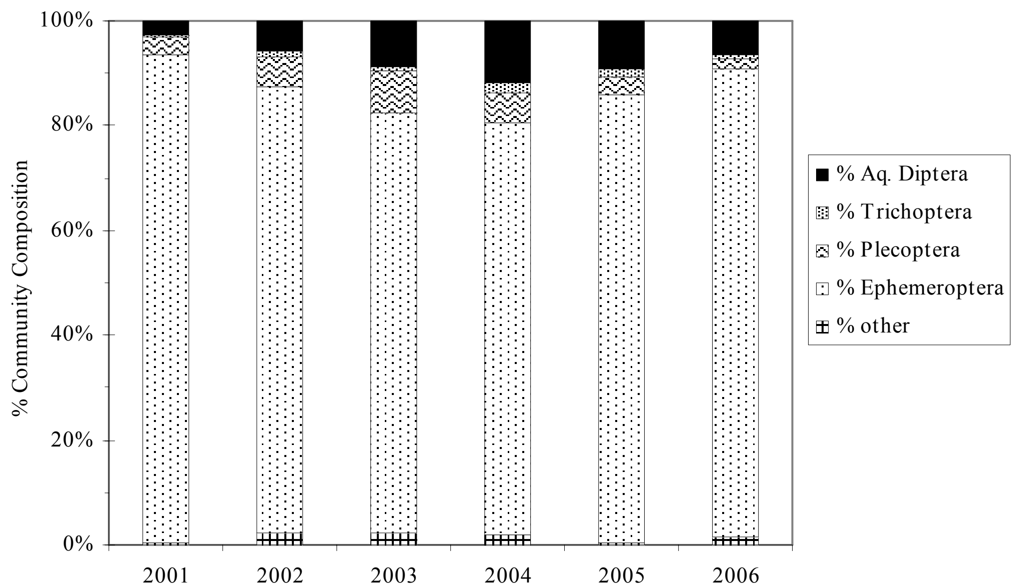

Figure 7. Community composition of benthic macroinvertebrates in Upper Greens Creek Site 48 samples in 2001 through 2006.

Table 3. Common taxa (>5.0% of benthic macroinvertebrates) found in Upper Greens Creek Site 48 samples in 2001 through 2006. The percent dominant taxon each year is bold.

Order	Family	Genus	2001	2002	2003	2004	2005	2006
Ephemeroptera	Baetidae	*Baetis*	26%	22%	19%	23%	20%	19%
	Ephemerellidae	*Drunella*	-	7%	**27%**	**24%**	26%	15%
	Heptageniidae	*Cinygmula*	8%	-	-	6%	6%	7%
		Epeorus	**38%**	**27%**	16%	12%	**27%**	**35%**
		Rhithrogena	16%	**27%**	12%	12%	5%	13%
Diptera	Chironomidae		-	-	7%	11%	8%	-

Juvenile Fish Populations

The 2006 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 through 2005. Three "block" traps were set downstream of this reach, and three upstream; they captured 25 additional Dolly Varden that are not included in the reported results. The estimated 2006 population size for the reach, based on a three-pass removal, was 228 Dolly Varden with an approximate density of 0.59 fish/m² of wetted stream surface area. This was significantly fewer fish than in 2003, not statistically difference from the 2004 and 2005 estimates, and significantly more fish than in 2001 and 2002 (Table 4, Appendix 4). The density estimates follow the same trend, with the 2006 value being intermediate between the higher values for 2003 and 2004 and the considerably lower values for 2001 and 2002.

Table 4. Juvenile fish population estimates for Upper Greens Creek Site 48 based on minnow trapping in 2001 through 2006.

Year Sampled	Fish Species	No. Fish Caught	FLength, mm	Popn Estimate, fish (95% CI)	Sample Reach, m	Density, fish/m^2
2001	DV	68	48-139	96 (68-124)	72	0.20
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
2006	DV	212	49-150	228 (215-241)	50	0.59

* Forklengths recorded in 5mm intervals.
** Based on estimated wetted area value.

Fork lengths of captured Dolly Varden represent a wide range of fish sizes. Although we have no validation data to correlate fish lengths with age such as scale or otolith analyses, the length frequency plots (Figure 8) suggest that multiple age classes of Dolly Varden were captured in all six years of biomonitoring. Young-of-the-year are not well represented in any of the six years' sampling, but the numbers of larger fish the following years indicate that recruitment is occurring.

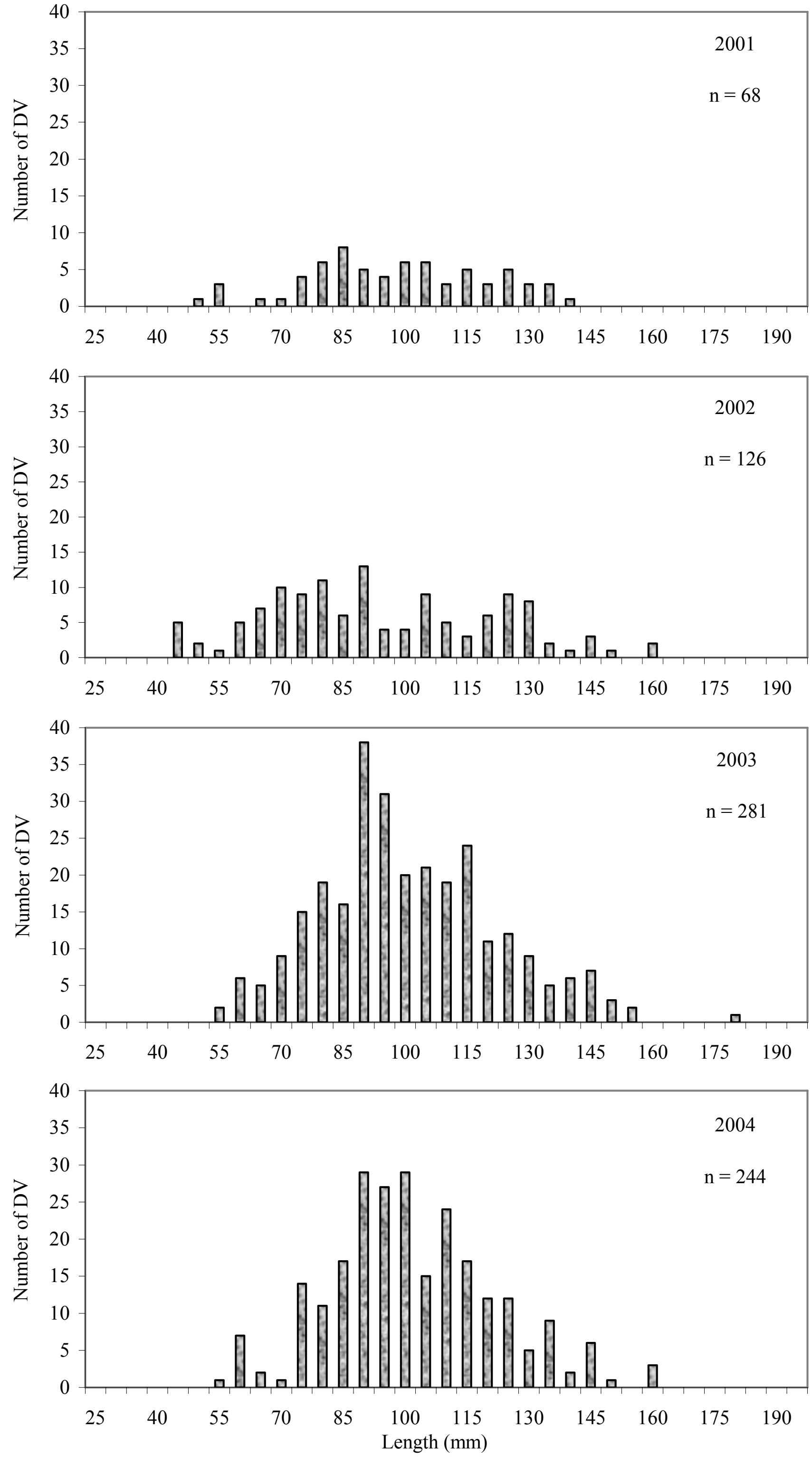

Figure 8. Length frequencies of Dolly Varden captured at Upper Greens Creek Site 48 in 2001 through 2006.

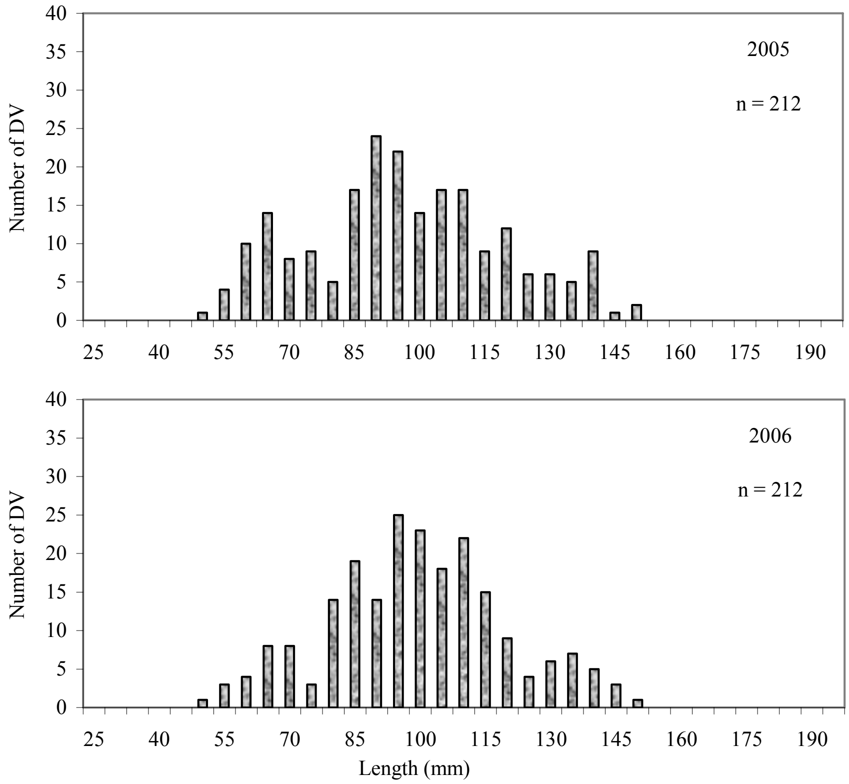

Figure 8. (Continued)

Metals Concentrations in Juvenile Fish

Median concentrations of metals in Upper Greens Creek Site 48 juvenile Dolly Varden tissues in 2006 generally varied from those found in samples from the previous five years of biomonitoring at this site (Figure 9, Appendix 5). Silver concentrations at Site 48 reported as not detected were assumed to be at the detection level of 0.02 mg Ag/kg during statistical analyses. The mean rank scores for concentrations of silver, copper, and zinc were the highest in six years of sampling at this site. Silver concentrations were significantly higher in 2006 than in 2003 and 2004, lead concentrations were significantly higher in 2006 than in 2003, zinc was significantly higher in 2006 than in 2001, and copper was substantially higher in 2006 than in 2003. Cadmium levels were substantially lower in 2006 than in 2001, while selenium concentrations were moderate and not statistically different[3] from previous years.

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[3] Throughout this report, groups reported as *not statistically different* were neither significantly different ($\alpha \leq 0.05$) nor substantially different ($0.05 < \alpha \leq 0.10$).

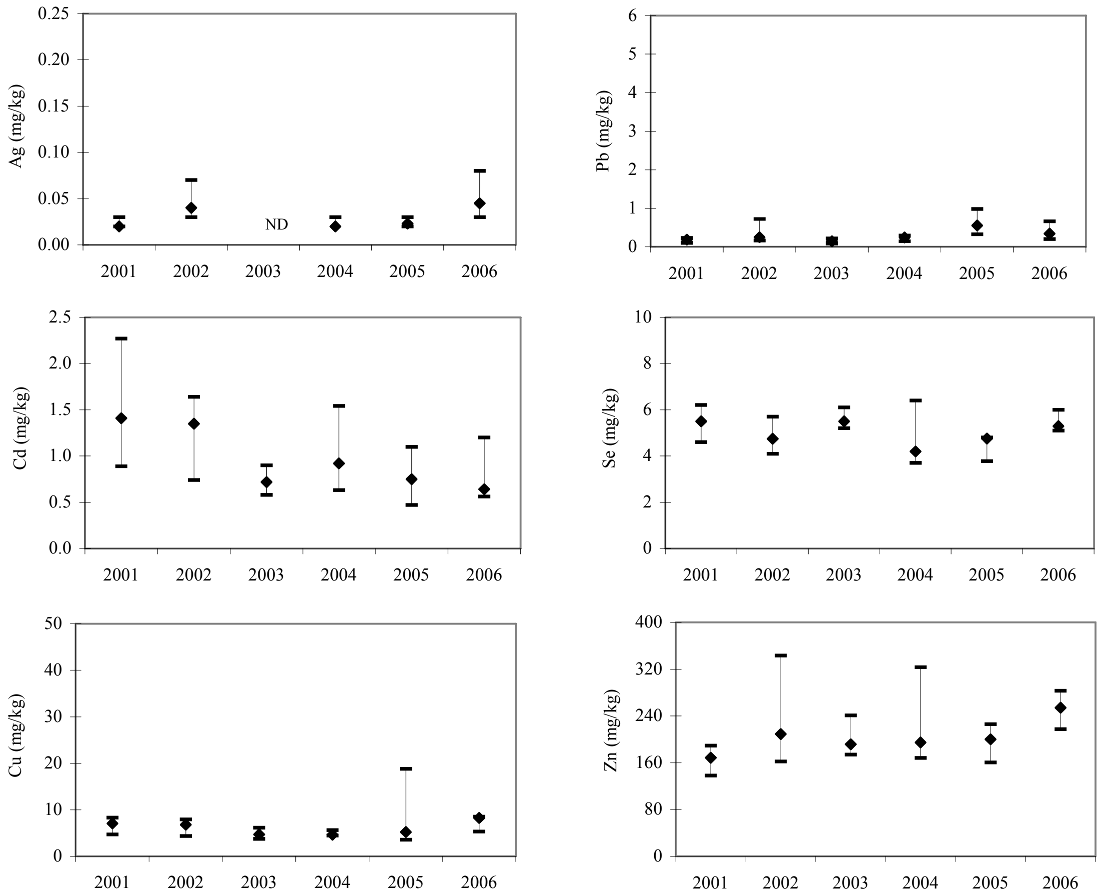


Figure 9. Whole body metals concentrations (medians and ranges) in Dolly Varden captured at Upper Greens Creek Site 48 in 2001 through 2006. ND = Not Detected at reporting limit for Ag of 0.02 mg/kg.

Summary

Upper Greens Creek Site 48 serves as a "control" site for biomonitoring; the sampling reach is just upstream of all KGCMC mine facilities and roads. Any trends over time are anticipated to reflect changes in natural background conditions rather than effects from mine development and operation. In 2006, this site exhibited abundant periphyton levels; relatively low benthic macroinvertebrate density and taxonomic richness; a moderate and stable Dolly Varden population; higher juvenile fish tissue concentrations of silver, copper, and zinc; tissue concentrations of lead and selenium similar to previous years; and lower tissue concentrations of cadmium. We have no evidence to suggest that these results are indicative of anything other than natural variability within this stream reach. The benthic macroinvertebrate community remains dominated by disturbance-sensitive species, and the reductions noted may be at least partially attributed to a November 2005 high water event that moved bedload and shifted large woody debris in this sampling reach. 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. Upper Greens Creek Site 48 samples appear consistent with a functioning and apparently healthy aquatic community that is reestablishing after a perturbation such as the November 2005 high water event.

MIDDLE GREENS CREEK SITE 6

Middle Greens Creek Site 6 (Figure 10) was sampled in the morning of 21 July 2006. The weather was low overcast and raining. Rain had fallen most of the previous 12 hours as well. The water temperature was 8°C and the air temperature 12°C. Greens Creek was slightly turbid when we arrived at the site, and the water level and turbidity rose somewhat during sampling. Since this was the first time in five years that this stream reach had been sampled for biomonitoring, we were not able to evaluate recent channel changes due to high flow or other disturbance events. The channel is relatively simple and straight, with some gravel bars and backwater pools. Large woody debris pieces were relatively few and generally quite large.

Figure 10. Middle Greens Creek Site 6, 21 July 2006.

Periphyton Biomass

Concentrations of chlorophyll *a*, an estimate of periphyton biomass, in Middle Greens Creek Site 6 samples were significantly higher in 2006 than in 2001. The 2006 values were more variable than, and higher than all of, the values from 2001 (Appendix 2). The Box and Whisker output plot from Statistix is shown in Figure 11.

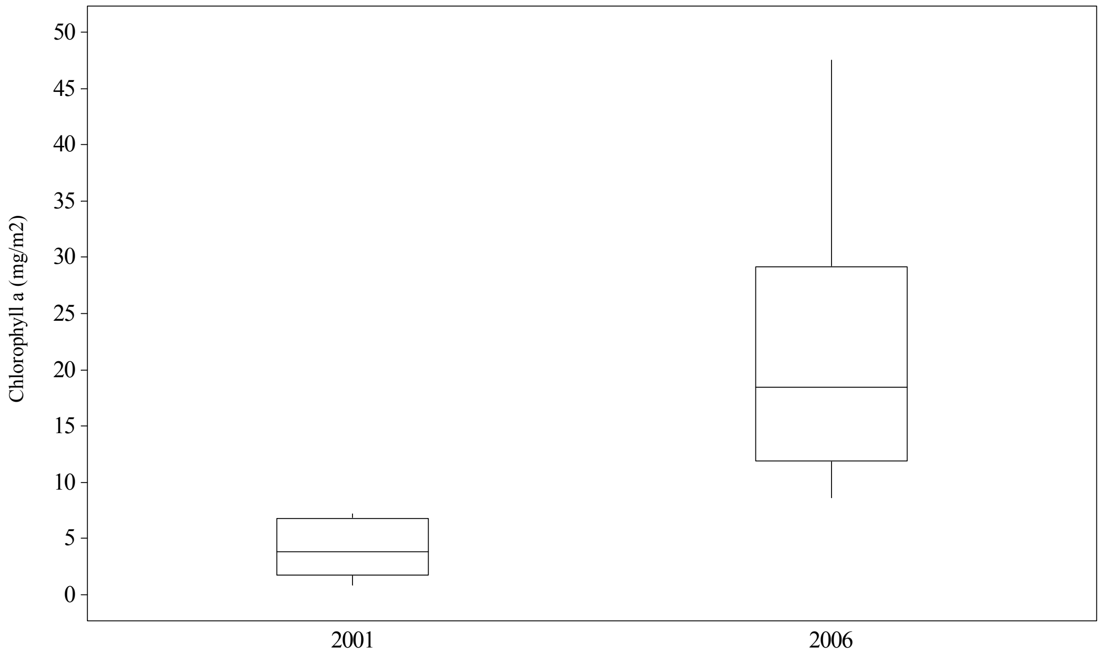


Figure 11. Estimated periphyton biomass densities at Middle Greens Creek Site 6 in 2001 and 2006 (n = 10 samples each year). Box encompasses middle half of data; horizontal line is median value.

The periphyton community at Middle Greens Creek Site 6 had a significantly higher proportion of chlorophyll *c* than chlorophyll *b* in both years sampled (Figure 12), indicating communities dominated by diatoms or dinoflagellates. Low to undetectable concentrations of chlorophyll *b* indicate low populations of green algae.

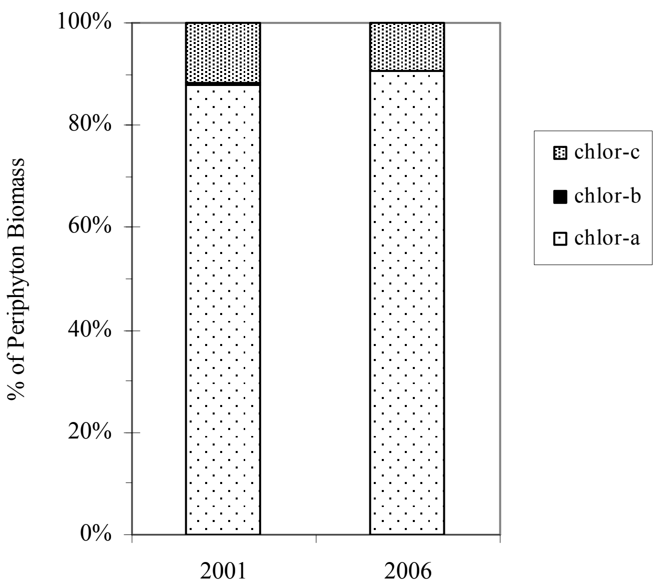


Figure 12. Proportions of mean chlorophyll *a*, *b*, and *c* concentrations in Middle Greens Creek Site 6 samples in 2001 and 2006.

Benthic Macroinvertebrates

The average density of benthic macroinvertebrates (both median and mean) in Middle Greens Creek Site 6 samples was significantly lower in 2006 than in 2001 (Table 5, Figure 13). Taxonomic richness was also less in 2006 than in 2001, but was not statistically different.

Table 5. Summary of benthic macroinvertebrate samples at Middle Greens Creek Site 6 in 2001 and 2006.

Year	Mean Density (aqua. invert./m^2)	Taxonomic Richness	Mean Taxa Per Sample
2001	1996	19	11.2
2006	614	13	7.8

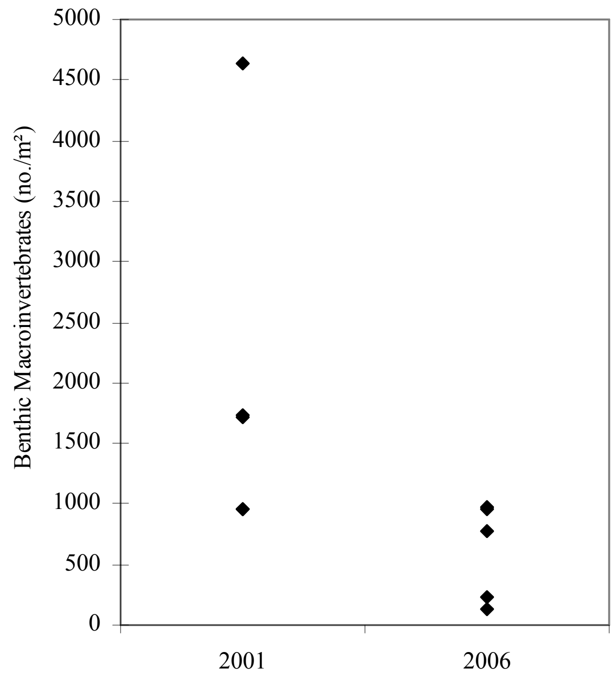


Figure 13. Density of benthic macroinvertebrates (n = 5 samples each year) in Middle Greens Creek Site 6 samples in 2001 and 2006.

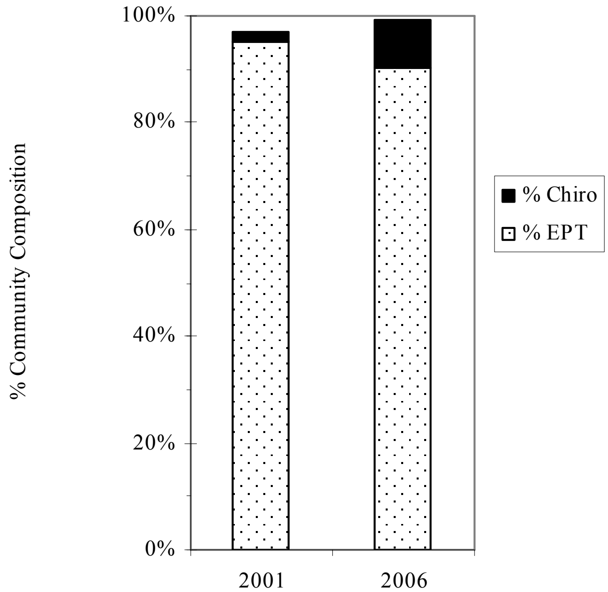


Figure 14. Proportions of EPT taxa and Chironomidae in Middle Greens Creek Site 6 samples in 2001 and 2006.

Benthic macroinvertebrate communities at Middle Greens Creek Site 6 were dominated by EPT taxa (Figure 14). In both of the years sampled, Ephemeroptera were the most commonly collected order (Figure 15). In 2006, the Ephemeroptera were dominated by Baetidae: *Baetis,* Ephemerella: *Drunella*, and Heptageniidae: *Cinygmula, 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). The continued 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 community at this site.

Table 6. Common taxa (>5.0% of benthic macroinvertebrates) found in Middle Greens Creek Site 6 samples in 2001 and 2006. The percent dominant taxon each year is bold.

Order	Family	Genus	2001	2006
Ephemeroptera	Baetidae	*Baetis*	15%	10%
	Ephemerellidae	*Drunella*	-	16%
	Heptageniidae	*Cinygmula*	30%	9%
		Epeorus	**41%**	**35%**
		Rhithrogena	16%	13%
Diptera	Chironomidae		-	9%

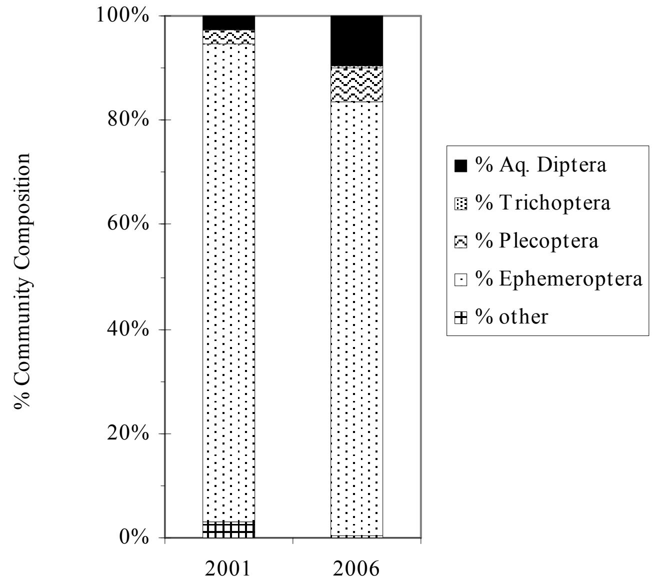


Figure 15. Community composition of benthic macroinvertebrates in Middle Greens Creek Site 6 samples in 2001 and 2006.

Juvenile Fish Populations

During the 2006 juvenile fish survey at Middle Greens Creek Site 6, 97 Dolly Varden and one coho salmon were captured in 22 minnow traps in a 49-m reach that encompassed the upstream portion of the 2001 sample reach (Table 7). Three "block" traps were used immediately downstream of the sample reach and three upstream; they captured an additional 14 Dolly Varden that are not included in the reported results. The estimated 2006 population sizes for the reach, based on a three-pass removal, were 114 Dolly Varden with an approximate density of 0.25 fish/m² and one coho salmon with an approximate density of less than 0.01 fish/m² of stream wetted area (Table 7). Because the reach sampled in 2006 was much shorter than in 2001, the lower absolute number of Dolly Varden captured represents nearly twice the density of fish in the sample reach. The very low capture rates and estimated populations of juvenile coho salmon at this site represent similar, albeit low, fish densities in both 2001 and 2006 (Table 7, Appendix 4).

Table 7. Juvenile fish population estimates for Middle Greens Creek Site 6 based on minnow trapping in 2001 and 2006.

Year Sampled	Fish Species	No. Fish Caught	FLength mm	Popn Estimate, fish (95% CI)	Sample Reach, m	Density, fish/m^2
2001	DV	131	52-168	161 (137-185)	135	0.13
2006	DV	97	53-150	114 (98-130)	49	0.25
2001	CO	3	81-90	3 (3)	135	<0.01
2006	CO	1	89	1 (1)	49	<0.01

Fork lengths of Dolly Varden captured in 2006 at Middle Greens Creek Site 6 represent a wide range of fish sizes, similar in range to that of fish captured in 2001 (Figure 16). Although we have no validation data to correlate fish lengths with age such as scale or otolith analyses, the length frequency plots suggest that multiple age classes of Dolly Varden were captured in both years of biomonitoring. Young-of-the-year are not well represented in sampling, but the distribution pattern is the same as seen at other Greens Creek sites and suggests that recruitment is occurring.

The single juvenile coho salmon caught at this site in 2006 was similar in length to the three captured in 2001 (Figure 17) and appeared to be in good condition.

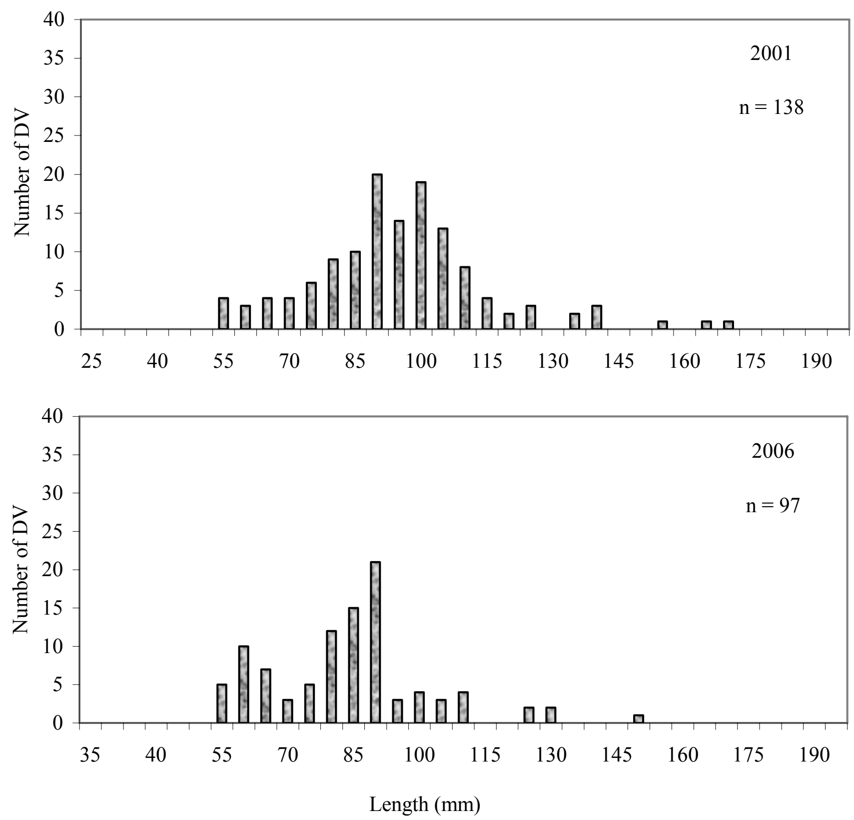


Figure 16. Length frequencies of Dolly Varden captured at Middle Greens Creek 6 in 2001 and 2006.

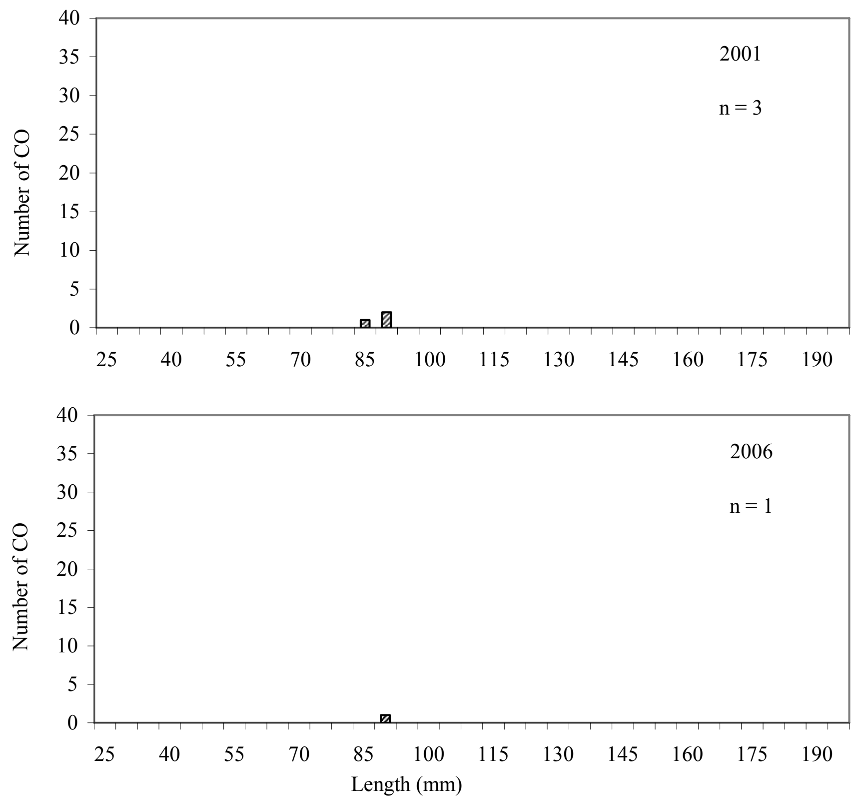


Figure 17. Length frequencies of juvenile coho salmon captured at Middle Greens Creek Site 6 in 2001 and 2006.

Metals Concentrations in Juvenile Fish

Median concentrations of metals in juvenile Dolly Varden tissues at Middle Greens Creek Site 6 in 2006 were generally similar to those found in the 2001 samples (Figure 18, Appendix 5). The mean rank scores for concentrations of cadmium in 2006 were significantly lower than in 2001, while those for zinc were significantly higher than in 2001. The values for silver, copper, lead, and selenium were not statistically different between the two years.

Summary

Middle Greens Creek Site 6 serves as an intermediate "treatment" site for biomonitoring sampling; the sampling area is downstream of the KGCMC mine portal and mill facilities and upstream of the waste rock pile discharge area. Any trends over time that differ from those seen at Upper Greens Creek Site 48 could potentially result from mine operations, and trends that differ from those of the downstream Greens Creek Below Pond D Site 54 site could potentially result from waste rock drainage. The KGCMC Fresh Water Monitoring Program specifies this site be sampled on a five-year schedule instead of the annual schedule for the other three biomonitoring sites. Because of this, trends would need to occur over a longer time period or with greater amplitude of change to be detected. In 2006, this site exhibited abundant periphyton levels; low benthic macroinvertebrate density and taxonomic richness; a low Dolly Varden abundance and a very low coho salmon abundance; higher juvenile fish tissue concentrations of zinc; tissue concentrations of silver, copper, lead, and selenium similar to 2001; and lower tissue concentrations of cadmium. We have no information to suggest that these are other than natural variability within this stream reach. The benthic macroinvertebrate community was dominated by disturbance-sensitive species, and the reductions may be at least partially attributed to a November 2005 high water event that moved channel substrate in the sample reach. The Dolly Varden population number and density are within expectations for this type of stream channel reach; the very low coho salmon population density is consistent between years sampled. Size distributions for both fish species are similar between years. Middle Greens Creek Site 6 samples appear consistent with a functioning and apparently healthy aquatic community that is reestablishing after a perturbation such as the November 2005 high water event.

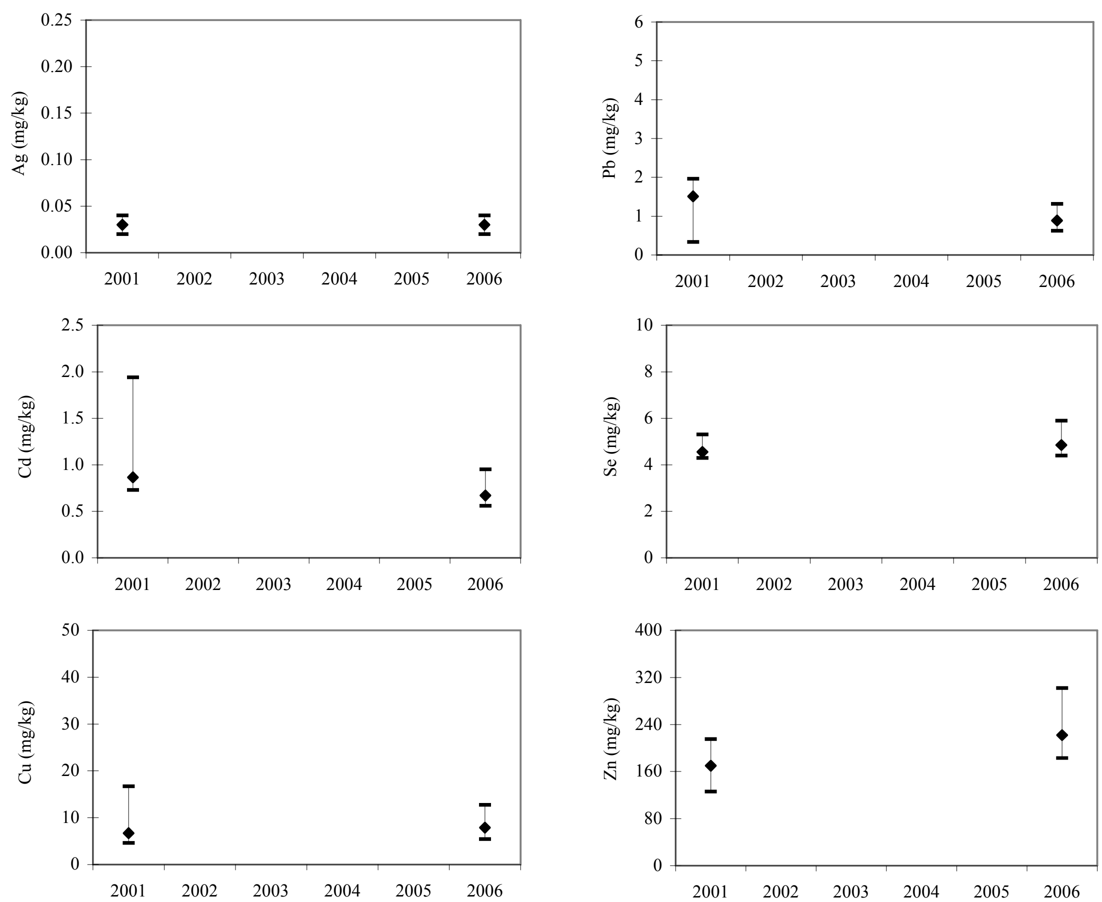


Figure 18. Whole body metals concentrations (medians and ranges) in Dolly Varden captured at Middle Greens Creek Site 6 in 2001 and 2006 (site not sampled 2002-2005).

<u>GREENS CREEK BELOW POND D SITE 54</u>

Greens Creek Below Pond D Site 54 (Figure 19) was sampled in the morning of 20 July 2006. The weather was clearing after a rainy night; the water temperature was 9.0°C and the air temperature was 15.5°C. There was no evidence of recent high flow or other recent disturbance events, although there was evidence of high water since our 2005 sampling. Compared to the previous years of biomonitoring sampling, the channel was somewhat straighter, with fewer pools and backwaters. The thalweg and side channel locations in the upper portion of the reach had swapped, a gravel bar had been deposited, and a large woody debris jam immediately downstream of the mouth of Gallagher Creek had been dislodged and removed from the reach. We attributed these changes to the November 2005 high water event.

Figure 19. Greens Creek Below Pond D Site 54, 20 July 2006.

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 data from 2001 through 2006 were analyzed together. The 2006 values were quite variable, with a higher median for all years but 2003 (Appendix 2). Multiple pairwise comparisons showed that 2006 values were significantly higher than the low values of 2001 and 2005. The Box and Whisker output plot from Statistix is shown in Figure 20.

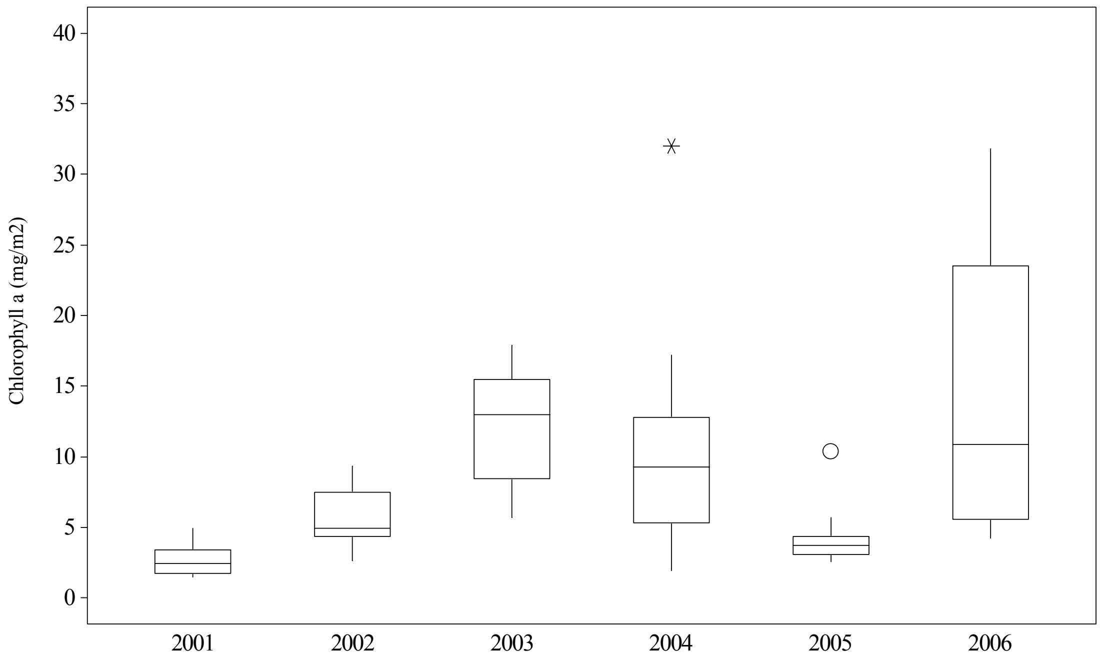


Figure 20. Estimated periphyton biomass densities at Greens Creek Below Pond D Site 54 in 2001 through 2006 (n = 10 samples each year). Box encompasses middle half of data; horizontal line is median value. One possible statistical outlier value (*) was identified in the 2004 data set, and one probable statistical outlier value (○) was identified in the 2005 data set.

The periphyton community at Greens Creek Below Pond D Site 54 had a significantly higher proportion of chlorophyll *c* than chlorophyll *b* in all six years sampled (Figure 21), indicating communities dominated by diatoms and/or dinoflagellates. Low to undetectable concentrations of chlorophyll *b* indicate low populations of green algae in the periphyton communities.

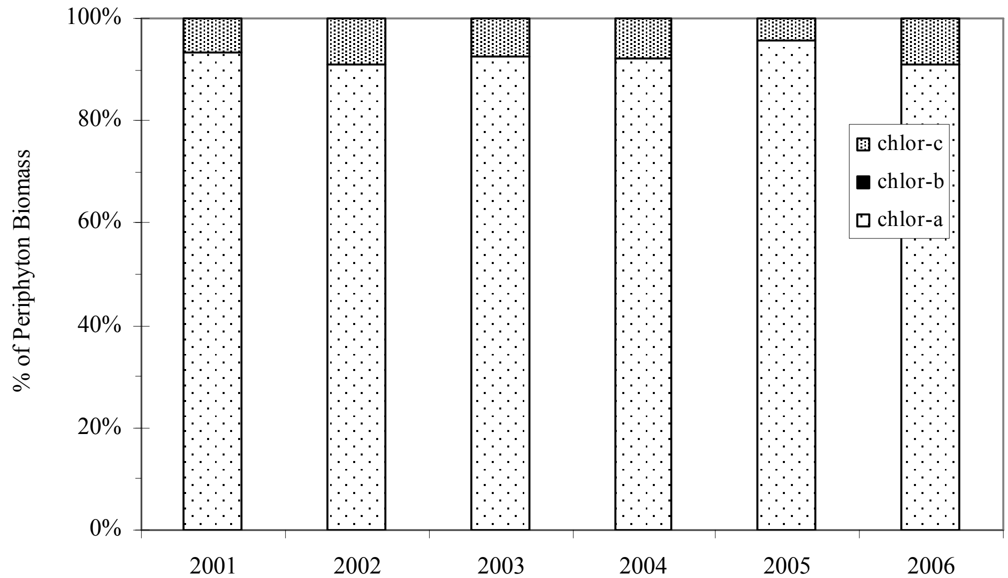


Figure 21. Proportions of mean chlorophyll *a*, *b*, and *c* concentrations in Greens Creek Below Pond D Site 54 samples in 2001 through 2006.

Benthic Macroinvertebrates

The average density of benthic macroinvertebrates (both median and mean) in 2006 Greens Creek Below Pond D Site 54 samples was the lowest of the six years sampled at this site, and significantly lower than the high densities found in the 2003 and 2004 samples (Table 8, Figure 22). Taxonomic richness followed a similar pattern, being substantially lower in 2006 than the samples from 2003 and significantly lower in 2006 than the samples from 2004.

Table 8. Summary of benthic macroinvertebrate samples at Greens Creek Below Pond D Site 54 in 2001 through 2006.

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
2006	1050	15	10.0

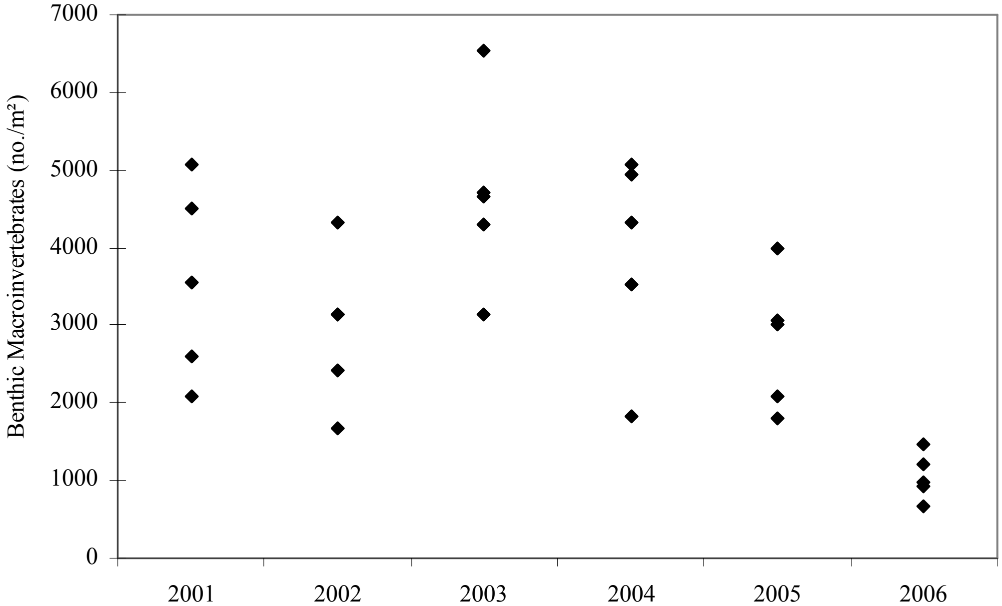


Figure 22. Density of benthic macroinvertebrates (n = 5 samples each year) in Greens Creek Below Pond D Site 54 samples in 2001 through 2006.

Invertebrate communities in Greens Creek Site 54 continued to be dominated by EPT taxa (Figure 23). In each of the six years sampled, Ephemeroptera were the most commonly collected order (Figure 24). In 2006, the Ephemeroptera were dominated by Baetidae: *Baetis,* Ephemerella: *Drunella*, and Heptageniidae: *Cinygmula, 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). The dominance of the benthic macroinvertebrate community by pollution-sensitive taxa (Table 9), combined with the mixture of many species of mayflies, stoneflies, caddisflies, and true flies (Appendix 3) suggests a complex and productive aquatic community at this site.

Table 9. Common taxa (>5.0% of benthic macroinvertebrates) found in Greens Creek Below Pond D Site 54 samples in 2001 through 2006. The percent dominant taxon each year is bold.

Order	Family	Genus	2001	2002	2003	2004	2005	2006
Ephemeroptera	Baetidae	*Baetis*	14%	15%	9%	15%	14%	20%
	Ephemerellidae	*Drunella*	7%	19%	**38%**	**38%**	**39%**	11%
	Heptageniidae	*Cinygmula*	18%	5%	8%	6%	6%	13%
		Epeorus	**53%**	**43%**	17%	12%	25%	**24%**
		Rhithrogena	-	10%	13%	9%	-	22%
Diptera	Chironomidae		-	-	6%	8%	-	-

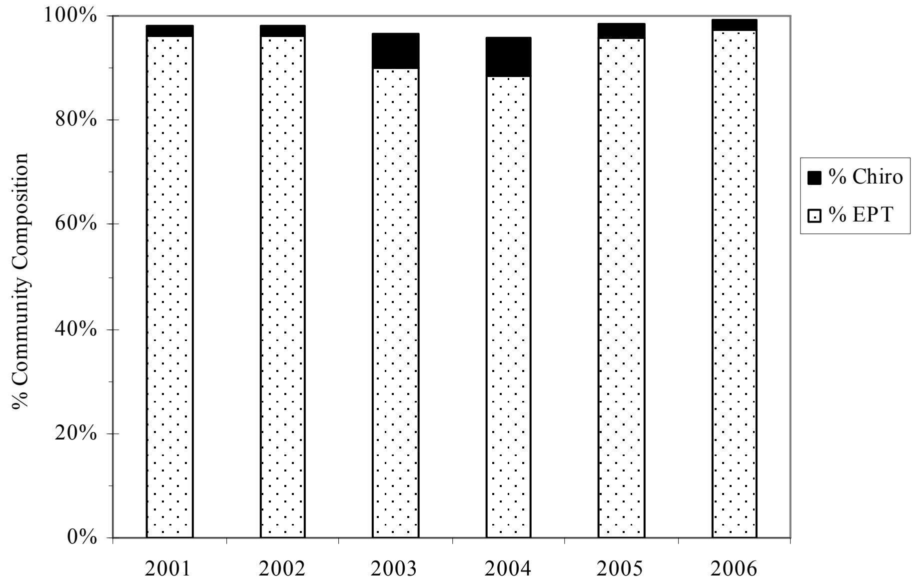


Figure 23. Proportions of EPT taxa and Chironomidae in Greens Creek Below Pond D Site 54 samples in 2001 through 2006.

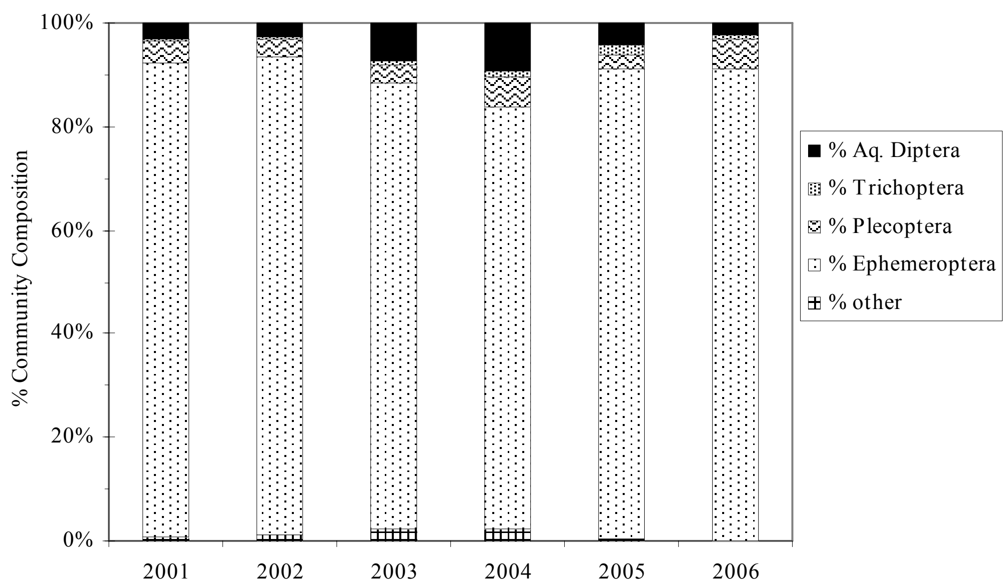


Figure 24. Community composition of benthic macroinvertebrates in Greens Creek Below Pond D Site 54 samples in 2001 through 2006.

Juvenile Fish Populations

The 2006 juvenile fish survey at Greens Creek Below Pond D Site 54 captured 217 Dolly Varden and 7 coho salmon in 24 minnow traps in the same 28-m reach as sampled in 2002 through 2005

(Table 10). Four "block" traps were used immediately downstream of the sample reach and three upstream; they captured an additional 22 Dolly Varden that are not included in the reported results. The estimated 2006 population sizes for the reach, based on a three-pass removal, was 254 Dolly Varden with an approximate density of 1.22 fish/m² and 7 coho salmon with an approximate density of 0.03 fish/m² of wetted stream area. The estimated populations of Dolly Varden in the Greens Creek Below Pond D Site 54 sample reach continue to be robust, with the 2006 estimate very similar to the 2005 estimate and significantly different only from the low 2001 value. The estimated populations of juvenile coho salmon have been much smaller than those of Dolly Varden each of the six years of biomonitoring sampling at this site. Even so, the 2006 catch of only seven coho was striking because it was significantly less than any of the previous five years, and was nearly an order of magnitude lower than the significantly highest capture rates of the previous (2005) sample (Table 10, Appendix 4).

Table 10. Juvenile fish population estimates for Greens Creek Below Pond D Site 54 based on minnow trapping in 2001 through 2006.

Year Sampled	Fish Species	No. Fish Caught	FLength mm	Popn Estimate, fish (95% CI)	Sample Reach, m	Density, fish/m²
2001	DV	138	27-162	158 (141-175)	28	0.58
2002	DV	271	33-160	290 (276-304)	28	1.00
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
2006	DV	217	49-158	254 (229-279)	28	1.22
2001	CO	12	32-95	17 (8-26)	28	0.06
2002	CO	21	59-85	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
2006	CO	7	62-88	7 (7)	28	0.03

* Based on estimated wetted area value.

Fork lengths of captured Dolly Varden represent a wide range of fish sizes. Although we have no validation data to correlate fish lengths with age such as scale or otolith analyses, the length frequency plots (Figure 25) suggest that multiple age classes of Dolly Varden were captured in all six years of biomonitoring. Young-of-the-year are not well represented in any year's sampling, but the numbers of larger fish the following years indicate that recruitment is occurring. Juvenile coho salmon caught at Greens Creek Below Pond D Site 54 in 2006 were similar in size to those captured in 2002, 2004, and 2005; the data from 2001 and 2003 appear to show a smaller age class (Figure 26).

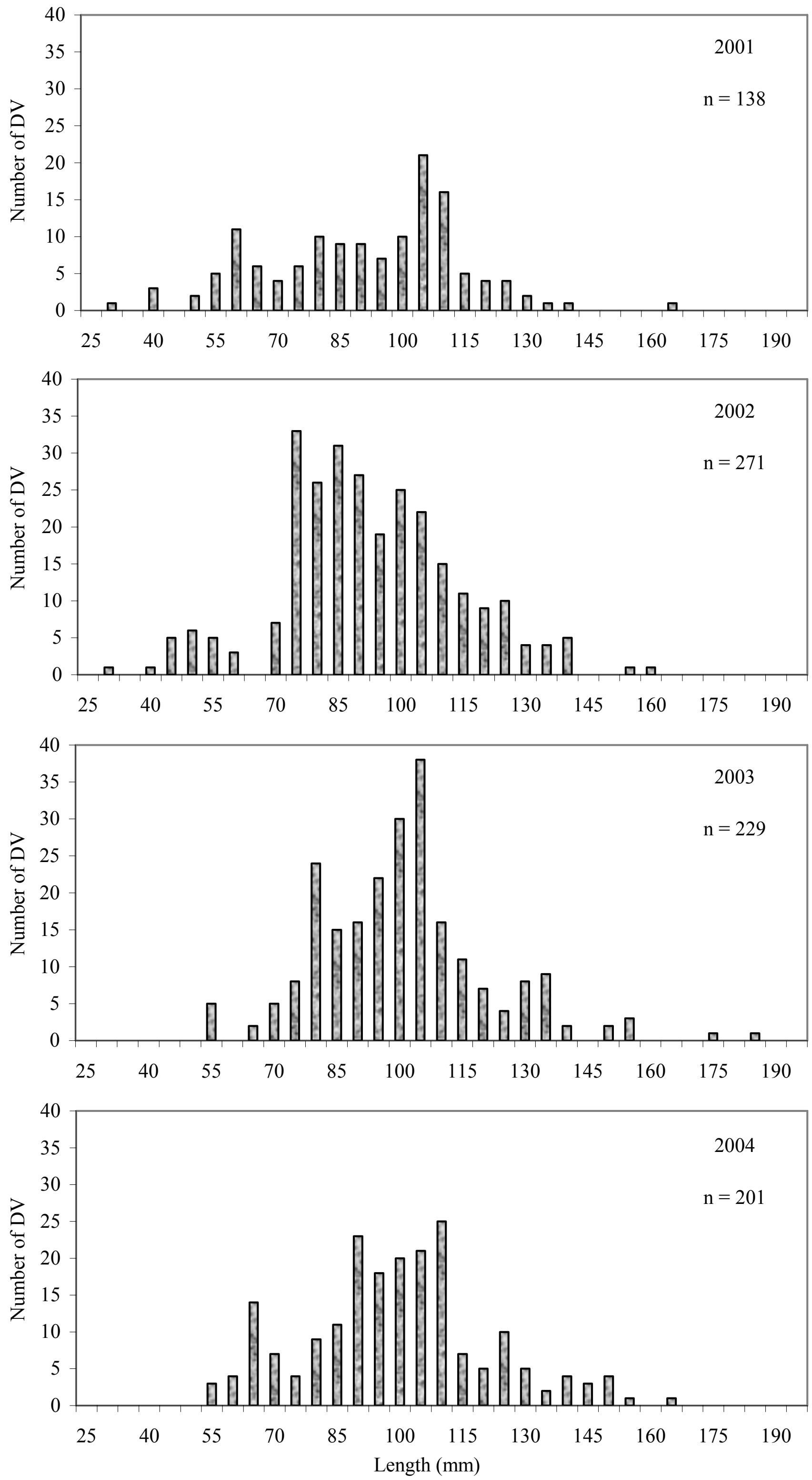
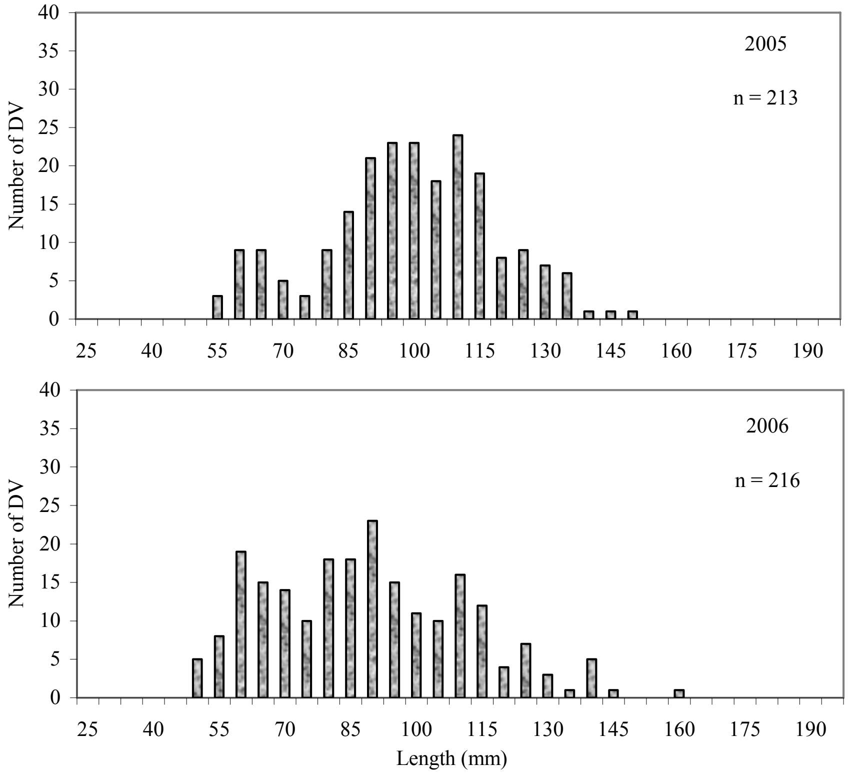


Figure 25. Length frequencies of Dolly Varden captured at Greens Creek Below Pond D Site 54 in 2001 through 2006.



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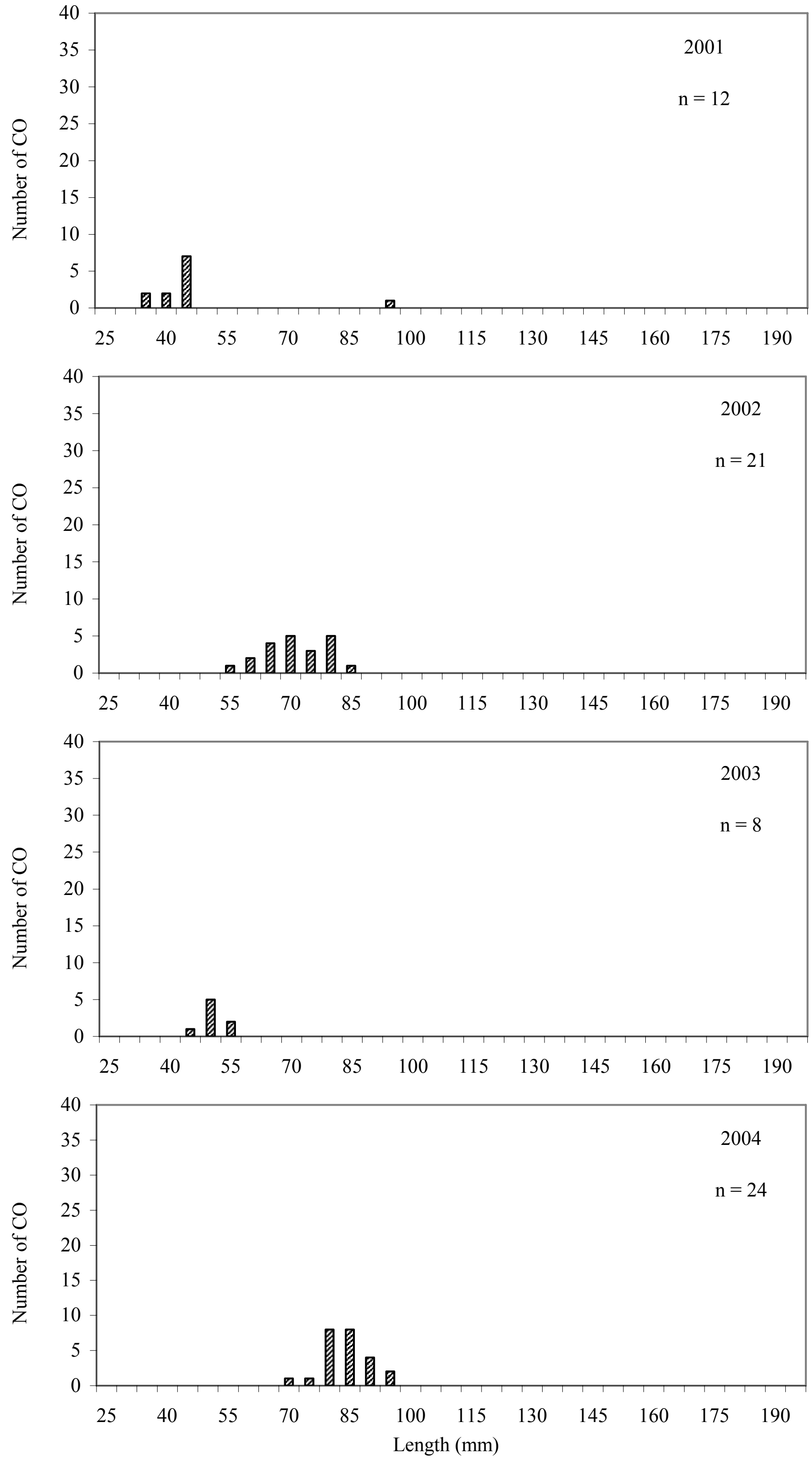


Figure 26. Length frequencies of juvenile coho salmon captured at Greens Creek Below Pond D Site 54 in 2001 through 2006.

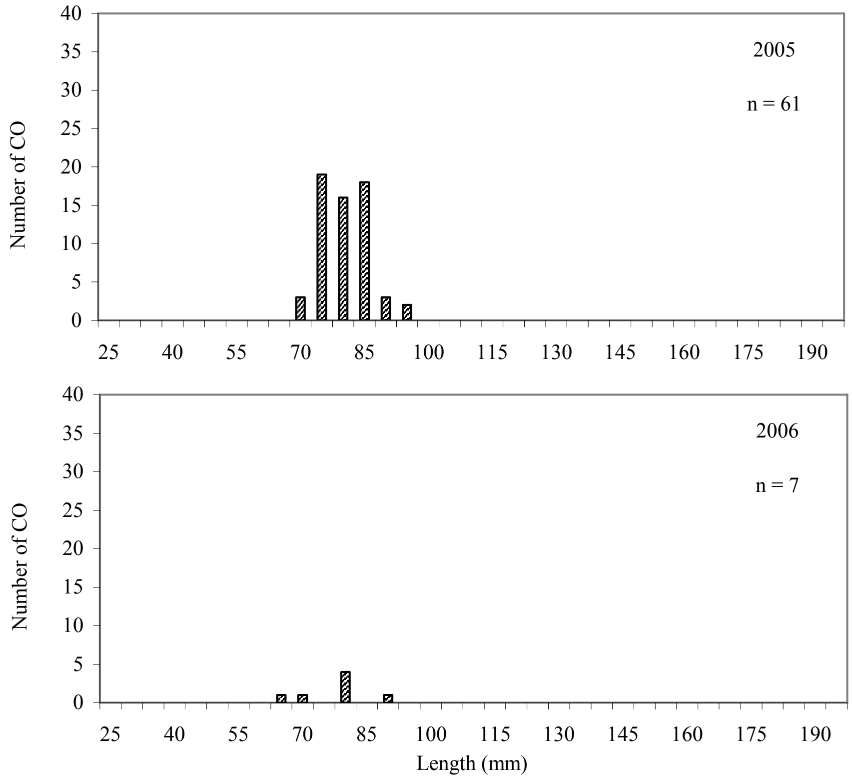


Figure 26. (Continued)

Metals Concentrations in Juvenile Fish

Median concentrations of metals in juvenile Dolly Varden tissues at Greens Creek Below Pond D Site 54 in 2006 were generally somewhat elevated from those found in the previous six years' samples (Figure 27, Appendix 5). Mean rank scores for concentrations of selenium in 2006 samples was significantly higher than in 2002, and those for lead were substantially higher than in 2005. Zinc concentrations in 2006 were the highest found in Greens Creek Dolly Varden tissues during biomonitoring, and significantly higher than in 2001. The mean rank scores for whole body concentrations of silver, cadmium, and copper in 2006 were not statistically different from those of previous years.

Summary

Greens Creek Below Pond D Site 54 serves as a "treatment" site for biomonitoring sampling; the sampling reach is just downstream of all KGCMC mine, mill, and waste rock facilities along Greens Creek. Any trends over time that differ from those in Upper Greens Creek Site 48 could potentially result from mine development and operation. In 2006, Site 54 exhibited abundant periphyton levels; low benthic macroinvertebrate density and taxonomic richness; a moderately high Dolly Varden abundance and density; low coho salmon abundance and density; higher juvenile fish tissue concentrations of lead, selenium, and zinc; and tissue concentrations of silver, cadmium, and copper similar to values in previous years. The benthic macroinvertebrate community is still dominated by disturbance-sensitive species and the noted reductions may be at least partially attributed to a November 2005 high water event that moved much of the Greens Creek bedload and large woody debris in the sample reach. The Dolly Varden population density and size distribution is within expectations for this type of stream channel reach. Greens Creek Below Pond D Site 54 samples appear consistent with a functioning and apparently healthy aquatic community that is reestablishing after a perturbation such as the November 2005 high water event.

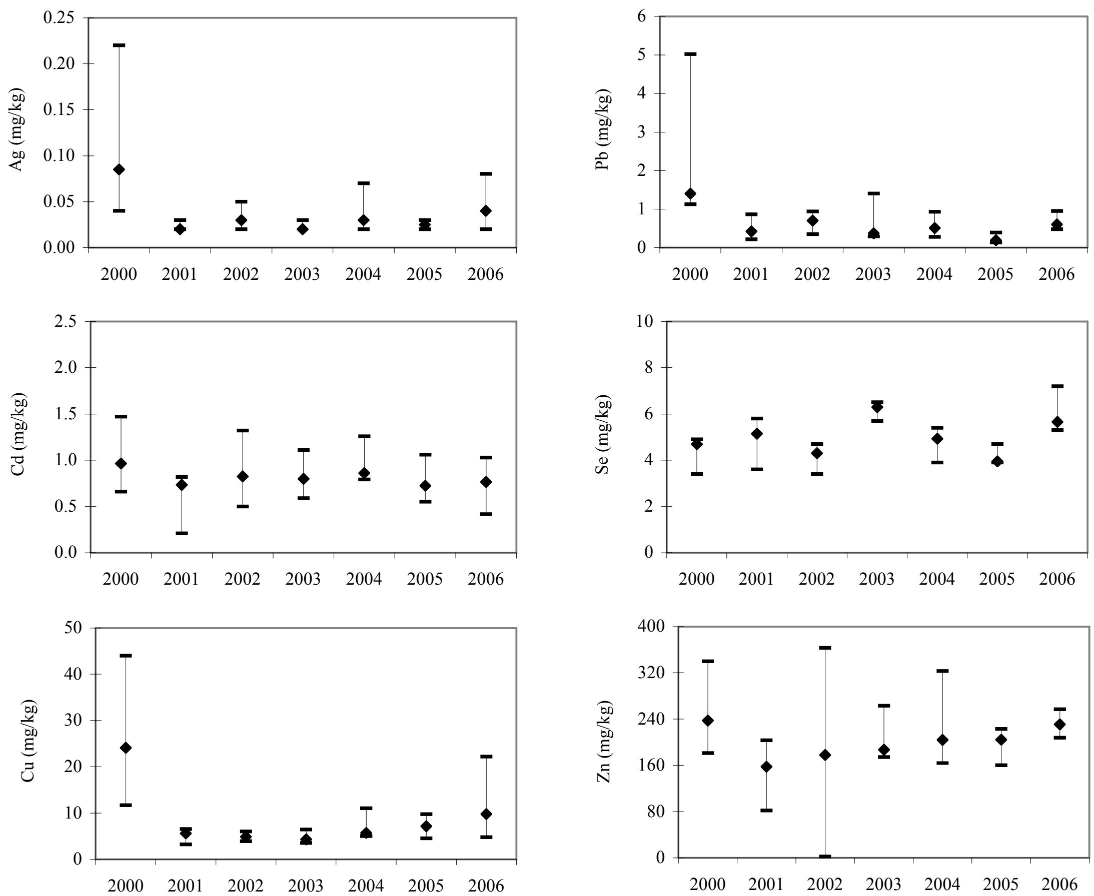


Figure 27. Whole body metals concentrations (medians and ranges) in fish captured at Greens Creek Below Pond D Site 54 in 2000 through 2006. The six fish sampled were coho salmon in 2000, and Dolly Varden in other years.

TRIBUTARY CREEK SITE 9

Tributary Creek Site 9 (Figure 28) was sampled in the afternoon of 21 July 2006. The weather was raining and foggy; the water temperature was 12°C and the air temperature 14°C. Rain had fallen steadily for nearly a day. Water levels were moderate when sampling began but rose approximately 10 cm during the five hour sampling. Also noticeable was a marked increase in the turbidity of Tributary Creek during our sampling period, to a level occularly estimated at more than 100 NTUs. There was no evidence of recent high flow or other disturbance events and, in contrast to the Greens Creek sites, there was no evidence of a high water event since the 2005 biomonitoring sampling. This is likely because Tributary Creek has a much smaller, lower elevation drainage basin than does Greens Creek and a series of beaver ponds upstream of the sample reach also dampen flow fluctuations.

Figure 28. Tributary Creek Site 9, 21 July 2006.

Periphyton Biomass

Concentrations of chlorophyll *a*, an estimate of periphyton biomass, at Tributary Creek Site 9 were not statistically different among the first five years sampled (2001 through 2005); however, the values from 2006 samples were significantly lower than the high values from 2003 samples. Median biomass in 2006 was less than the medians from 2001 through 2005 (Appendix 2). The Box and Whisker output plot from Statistix is shown in Figure 29.

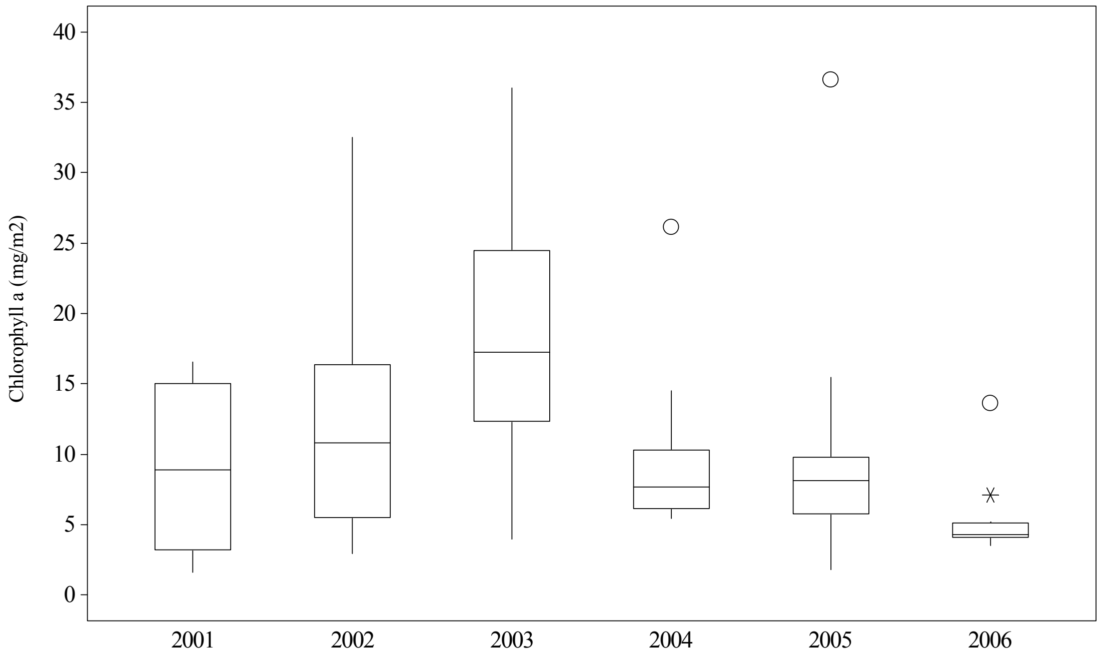


Figure 29. Estimated periphyton biomass densities at Tributary Creek Site 9 in 2001 through 2006 (n = 10 samples each year). Box encompasses middle half of data; horizontal line is median value. One possible statistical outlier value (*) was identified in the 2006 data set, and one probable statistical outlier value (○) was identified in each of the 2004, 2005, and 2006 data sets.

The periphyton community at Tributary Creek Site 9 in 2006 had a higher proportion of chlorophyll *c* than chlorophyll *b*, but the two medians were not statistically different. This compares with four years (2001, 2003, 2004, and 2005) that had a significantly higher proportion of chlorophyll *c* than chlorophyll *b*, and 2002 when the chlorophyll *c* proportions were actually higher than those for chlorophyll b but not statistically different (Figure 30). Higher concentrations of chlorophyll *b* compared to chlorophyll *c* indicate the presence of at least patchy populations of green algae (chlorophyll *b*) in addition the presence of diatoms and/or dinoflagellates (chlorophyll *c*).

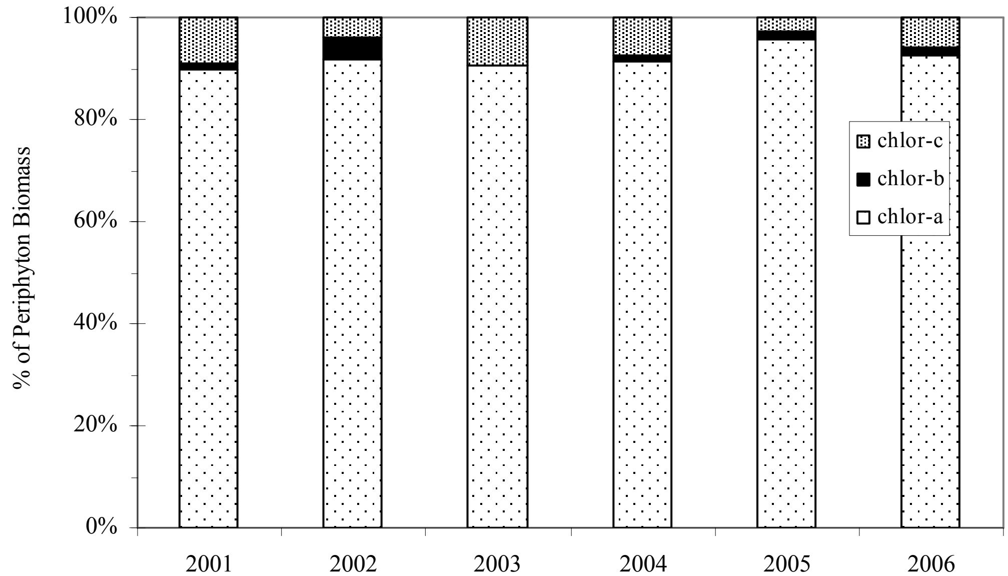


Figure 30. Proportions of mean chlorophyll *a*, *b*, and *c* concentrations in Tributary Creek Site 9 samples in 2001 through 2006.

Benthic Macroinvertebrates

The average density of benthic macroinvertebrates (both median and mean) in 2006 Tributary Creek Site 9 samples was moderate compared to previous years (Table 11, Figure 31), and substantially different from the higher densities of 2003. Taxonomic richness, as expressed by number of taxa in samples, was moderate over the whole site but lower per sample in 2006, and significantly lower than the many taxa in the 2003 samples.

Table 11. Summary of benthic macroinvertebrate samples at Tributary Creek Site 9 in 2001 through 2006.

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
2006	1250	26	12.4

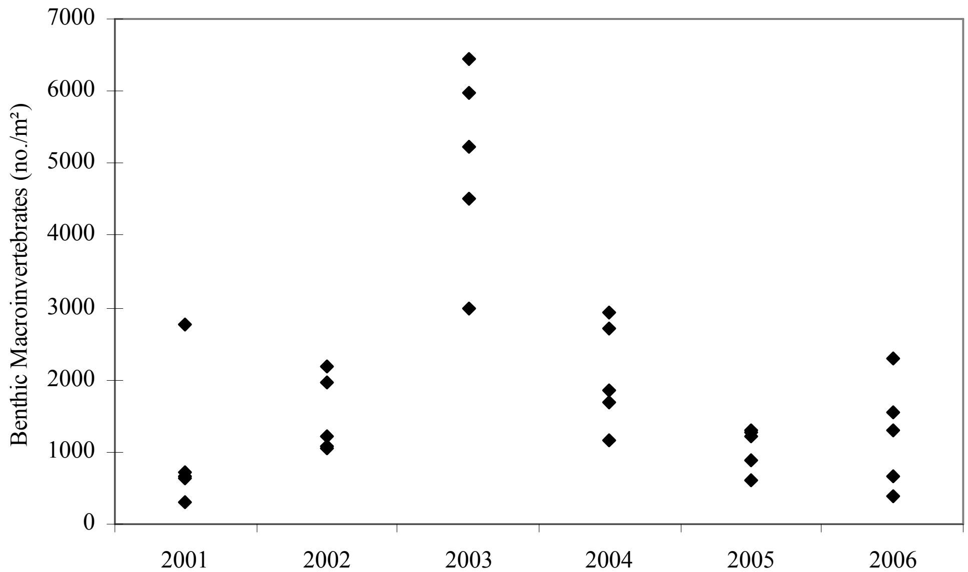


Figure 31. Density of benthic macroinvertebrates (n = 5 samples each year) in Tributary Creek Site 9 samples in 2001 through 2006.

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 32).

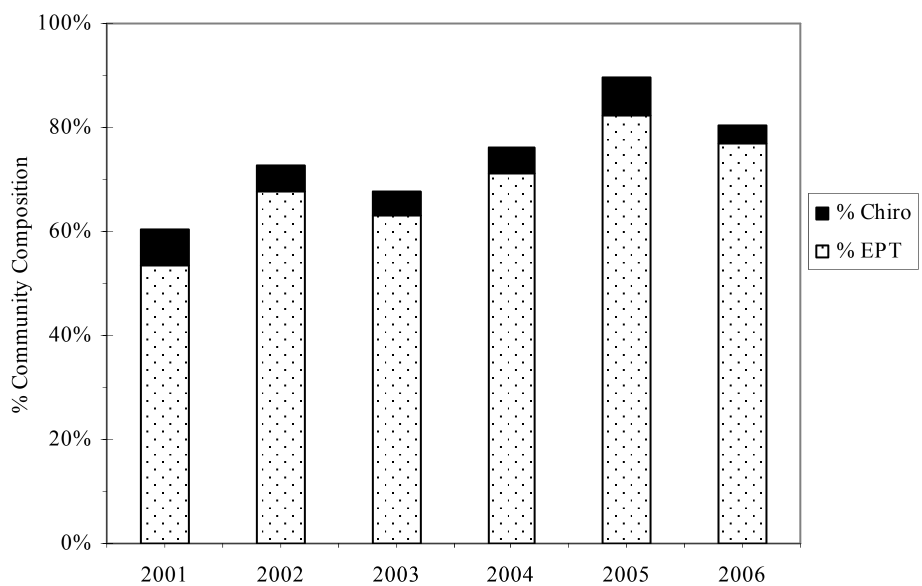


Figure 32. Proportions of EPT taxa and Chironomidae in Tributary Creek Site 9 samples in 2001 through 2006.

In the six years of benthic macroinvertebrate community sampling at Tributary Creek Site 9, the community at this site has tended to be more diverse than at the Greens Creek sites, with more taxa being common in the samples. The 2006 Tributary Creek Site 9 samples were more diverse than those from 2004; less diverse than in 2001, 2002, 2003, and 2005; and about as diverse as the Greens Creek sites (Table 12).

Table 12. Common taxa (>5.0% of benthic macroinvertebrates) found in Tributary Creek Site 9 samples in 2001 through 2006. The dominant taxon percent each year is bold.

Order	Family	Genus	2001	2002	2003	2004	2005	2006
Ephemeroptera	Baetidae	*Baetis*	8%	16%	6%	-	7%	-
	Ephemerellidae	*Ephemerella*	-	-	-	-	-	12%
	Heptageniidae	*Cinygma*	-	-	-	-	8%	-
		Cinygmula	17%	**24%**	**20%**	5%	-	20%
	Leptophlebiidae	*Paraleptophlebia*	13%	13%	10%	**43%**	**36%**	**33%**
	Ameletidae	*Ameletus*	-	-	-	-	-	5%
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%	-	-	11%
Isopoda	Gammaride	*Gammarus*	-	14%	-	-	-	-

Pollution-sensitive taxa, such as the mayflies *Cinygmula* and *Paraleptophlebia* were well represented at this site (Figure 33). 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 includes such non-insects as springtails (Collembola), worms (Oligochaeta), mites (Acarina), and seed shrimp (Ostracoda) (Appendix 3).

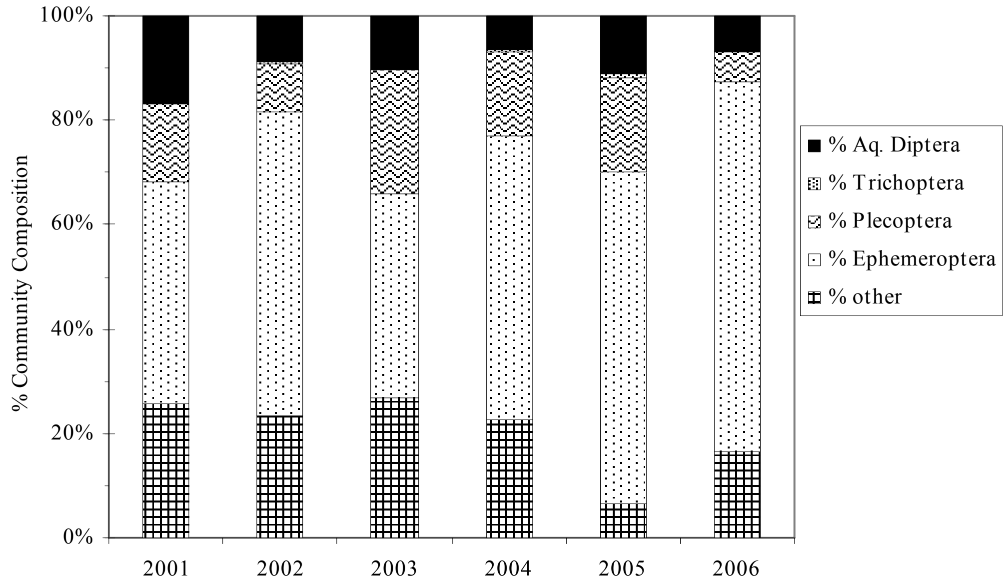


Figure 33. Community composition of benthic macroinvertebrates in Tributary Creek Site 9 samples in 2001 through 2006.

Juvenile Fish Populations

The 2006 juvenile fish survey in Tributary Creek Site 9 captured 11 Dolly Varden and 10 coho salmon in 21 minnow traps in the same 50-m sample reach as sampled in 2002 through 2005 (Table 13). Three "block" traps were set immediately downstream of the sample reach and three upstream; they captured an additional 7 Dolly Varden, 2 coho salmon, and 2 sculpin that are not included in the reported results. The estimated 2006 population sizes for the reach, based on a three-pass removal, was 11 Dolly Varden with an approximate density of 0.09 fish/m² and 10 coho salmon with an approximate density of 0.08 fish/m² of wetted stream surface area. Although capture numbers and fish densities have been quite variable at this site, the population estimates for both Dolly Varden and coho salmon at this site were significantly lower in 2006 than in the previous five years of sampling (Table 13, Appendix 4).

Fork lengths of Dolly Varden and coho salmon captured at Tributary Creek Site 9 in 2001 through 2005 represented a wide range of fish sizes and suggested use by multiple age classes of both species (Figures 34 and 35). Although we have no validation data to correlate fish lengths with age such as scale or otolith analyses, the length frequency plots for 2006 suggest that the few fish present represented only older age classes, with no representation of young-of-the-year Dolly Varden or coho salmon.

Table 13. Juvenile fish population estimates for Tributary Creek Site 9 based on minnow trapping in 2001 through 2006. Captures of incidental species at this sampling site (cutthroat trout, rainbow trout, and sculpin) are not shown, but are reported in Appendix 4.

Year Sampled	Fish Species	No. Fish Caught	FLength, mm	Popn Estimate, fish (95% CI)	Sample Reach, m	Density, fish/m^2
2001	DV	81	58-110	81 (81)	44	0.92
2002	DV	51	38-147	56 (49-63)	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
2006	DV	11	85-117	11 (11)	50	0.09
2001	CO	118	39-101	120 (117-123)	44	0.80
2002	CO	44	27-85	46 (42-50)	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
2006	CO	10	69-108	10 (10)	50	0.08

* Based on estimated wetted area value.

Metals Concentrations in Juvenile Fish

Median concentrations of metals in 2006 juvenile Dolly Varden tissues from Tributary Creek Site 9 were generally similar to but elevated from those found in 2005 samples (Figure 36, Appendix 5). In 2006 samples, the concentration of silver was substantially higher than the values from previous years. The mean ranks of concentrations for cadmium, copper, lead, selenium, and zinc were not statistically different from those of previous years.

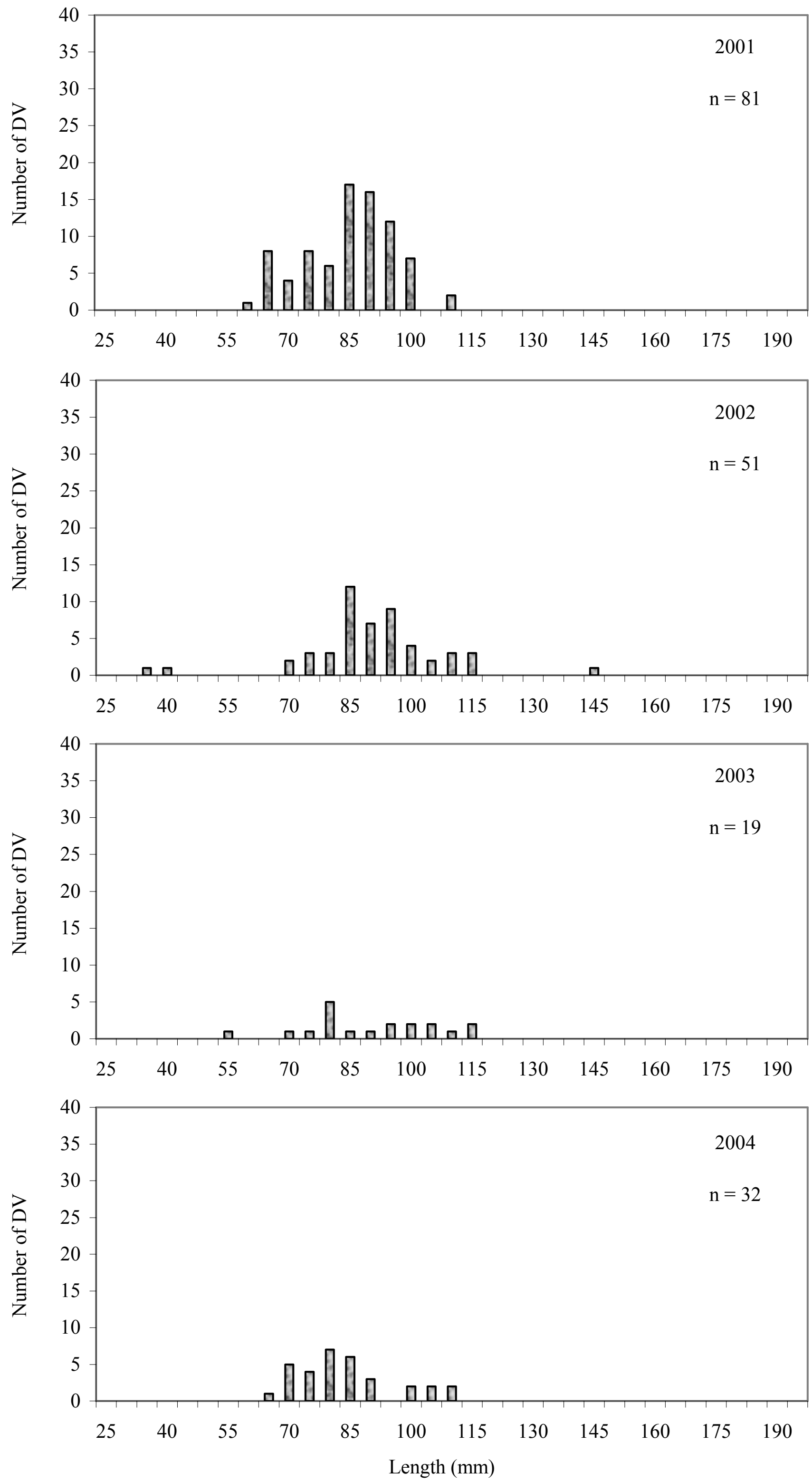
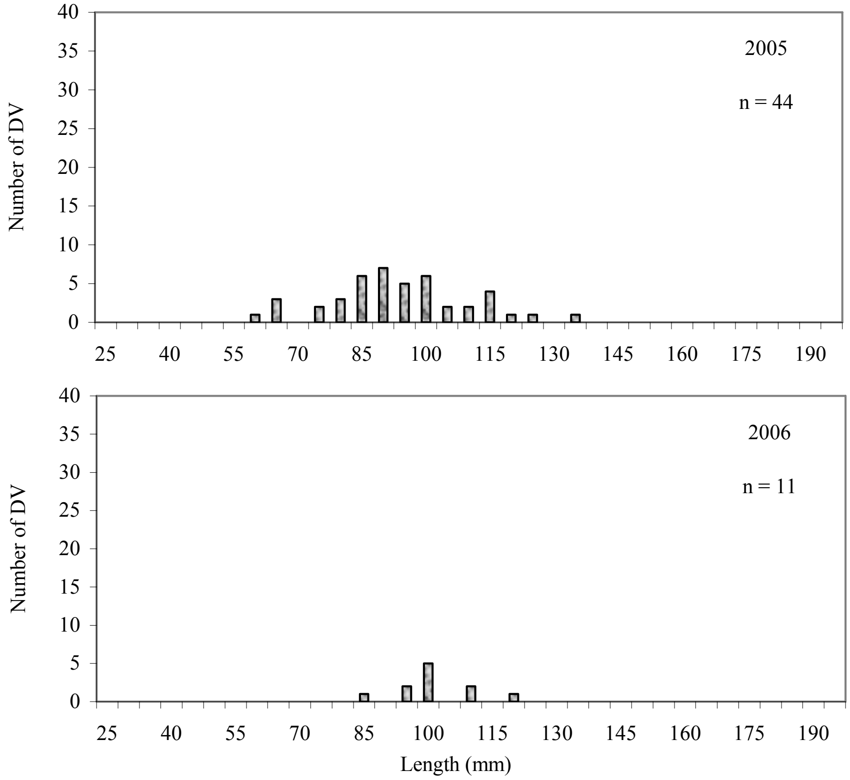


Figure 34. Length frequencies of Dolly Varden captured at Tributary Creek Site 9 in 2001 through 2006.



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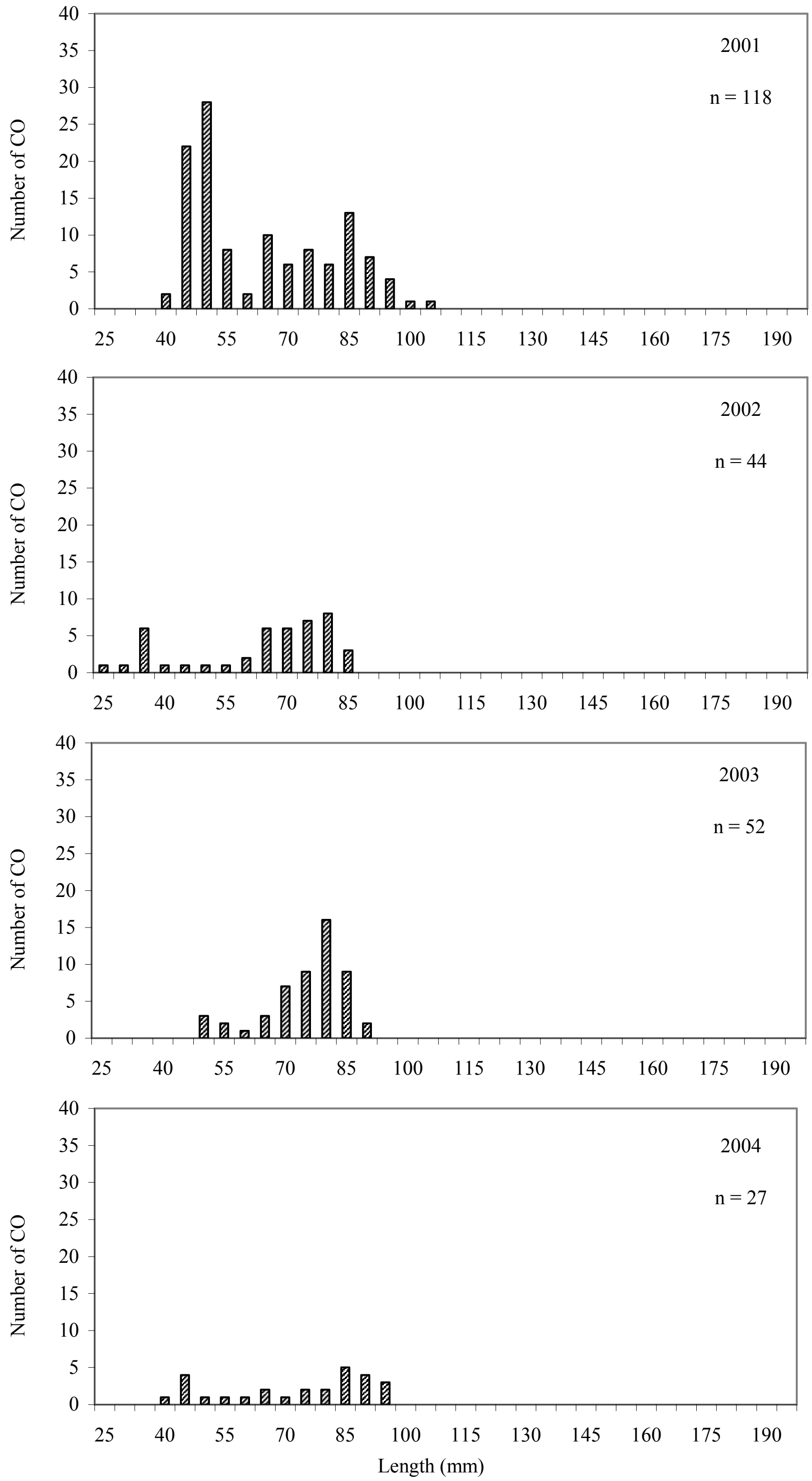

Figure 35. Length frequencies of juvenile coho salmon captured at Tributary Creek Site 9 in 2001 through 2006.

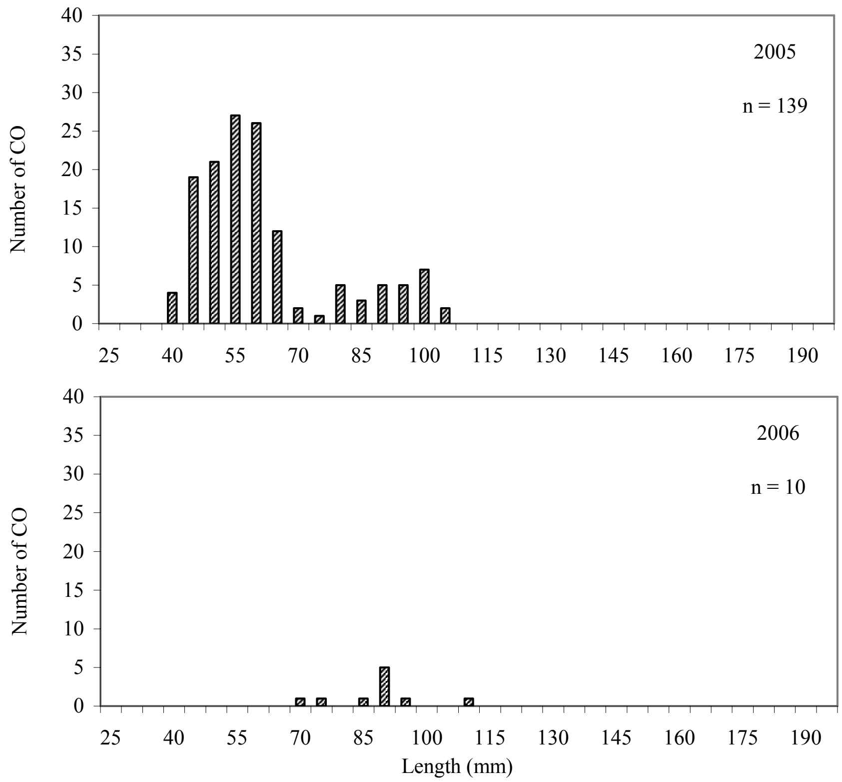

Figure 35. (Continued)

Summary

Tributary Creek Site 9 serves as a "treatment" site for biomonitoring sampling; it is downstream of the dry stack tailings facility. Any trends over time could potentially be attributed to effects on water quality from the tailings facility. In 2006, the Tributary Creek site exhibited low periphyton levels; moderate benthic macroinvertebrate density and taxonomic richness; very low Dolly Varden and coho salmon populations and densities; higher juvenile fish tissue concentrations of silver; elevated but similar to previous years' tissue concentrations of cadmium, copper, lead, and zinc; and lower but similar concentrations of selenium. The moderately abundant benthic macroinvertebrate community was dominated by disturbance-sensitive species although the taxonomic richness was somewhat lower at the scale of individual samples. There was no evidence that the November 2005 high water event on Greens Creek also occurred on Tributary Creek. The Dolly Varden and coho salmon population densities were significantly smaller than in the previous five years of sampling. The size distribution for Dolly Varden and coho salmon is noticeably lacking in smaller size fish. Tributary Creek Site 9 samples appear consistent with a functioning aquatic community that has had a major perturbation. One potential disturbance could be the markedly elevated turbidity levels noted during biomonitoring sampling in 2006.

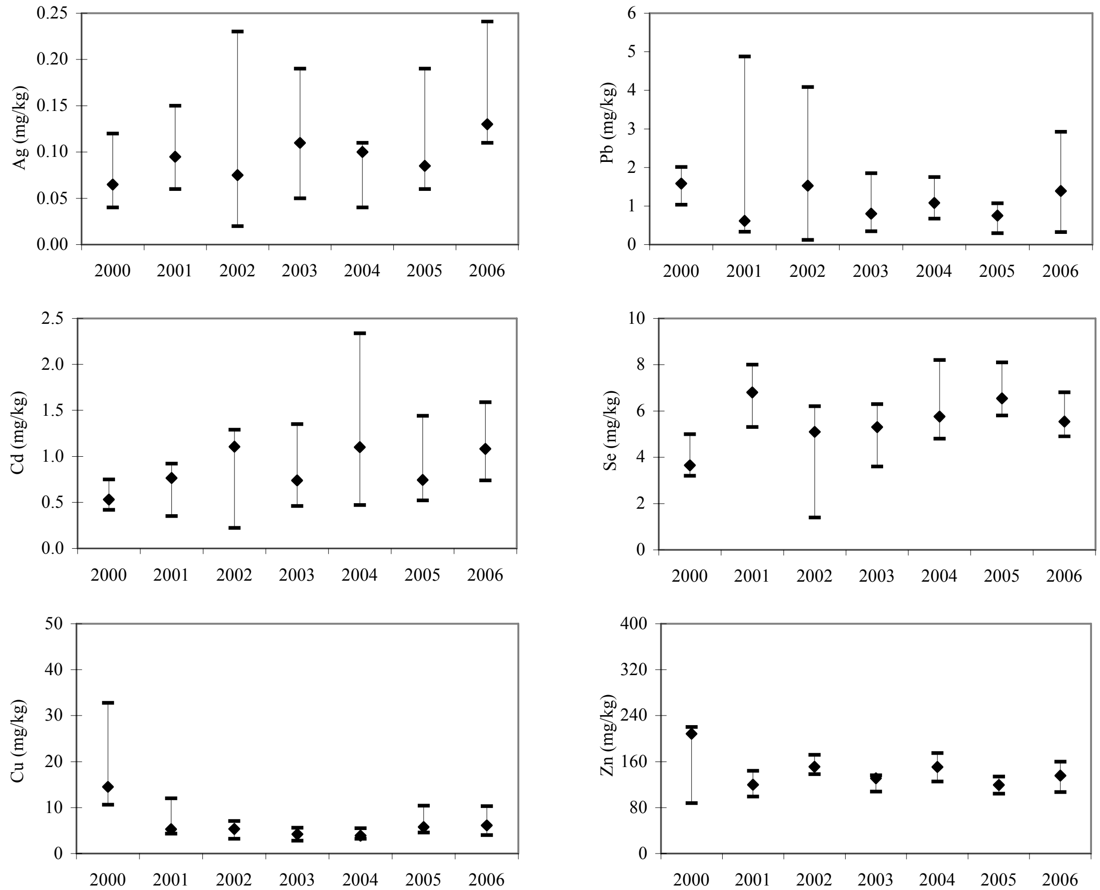

Figure 36. Whole body metals concentrations (medians and ranges) in fish captured at Tributary Creek Site 9 in 2000 through 2006. The six fish sampled each year were Dolly Varden except for two coho salmon in 2000.

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 both 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 weather patterns. 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 Greens Creek sites has shown a similar pattern over the six years sampled, with lower values in 2001 and 2002 followed by a peak in 2003, decreases in 2004 and 2005, and an increase again in 2006 (Figure 37). The pattern of periphyton biomass at the Tributary Creek site was generally similar to that at the Greens Creek sites in 2001 through 2004, but is typically more variable within each year, had less of a decline in 2005, and showed a major decline in 2006.

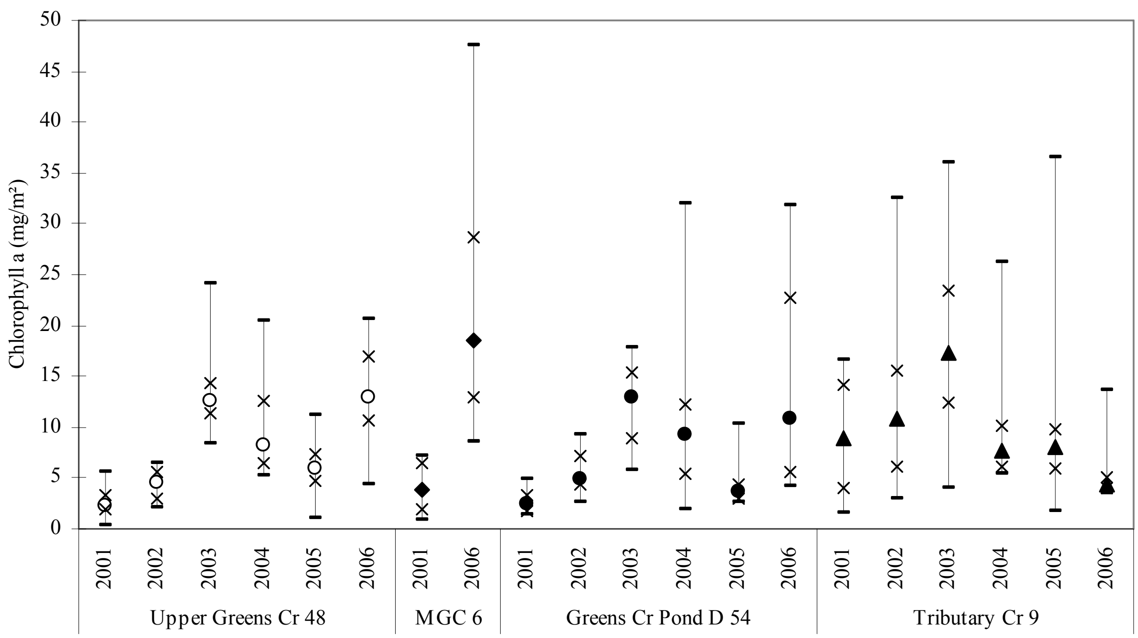

Figure 37. Comparison of estimated periphyton biomass (medians and ranges) among Greens Creek Mine biomonitoring sites sampled in 2001 through 2006 (n = 10 samples per site each year). First and third quartiles are indicated by "x" marks on vertical range line.

The median community composition of the periphyton sampled in 2006 at the three Greens Creek sites was very similar (Figure 38). At each site, samples were primarily chlorophyll *a*, with approximately 10% chlorophyll *c* and no detectable chlorophyll *b*. No statistical differences in chlorophyll *a*, *b*, or *c* abundances were found among the Greens Creek sites in 2006. Chlorophyll *a* and *c* concentrations in the 2006 Tributary Creek Site 9 samples were significantly lower than those from the Greens Creek sites, and significantly lower than those from the high Tributary Creek Site 9 concentrations in 2003. The Tributary Creek Site 9 periphyton community had significantly lower median concentrations of chlorophyll *a* and *c* than did the Greens Creek sites. Half of the Tributary Creek samples had a detectable chlorophyll *b* component, with three of the 10 samples having higher concentrations of chlorophyll *b* than of chlorophyll *c*.

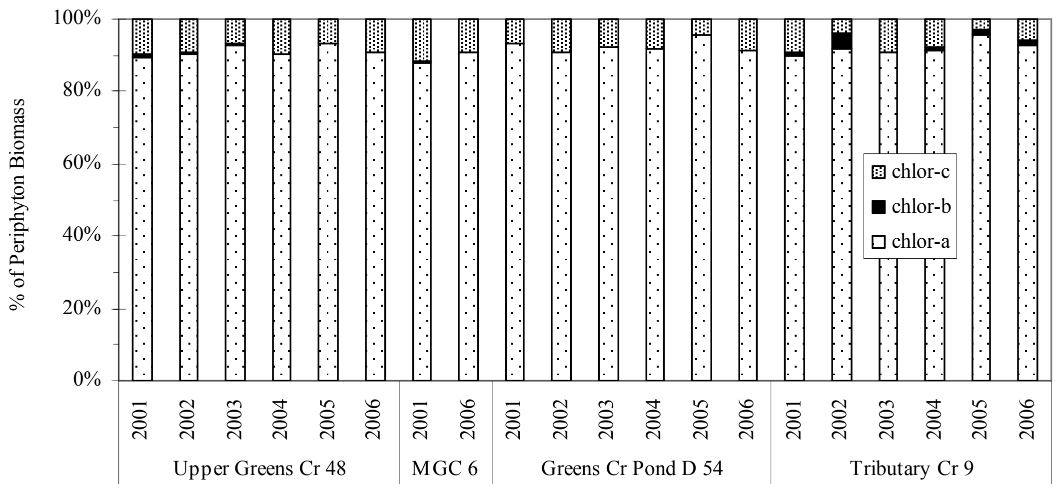

Figure 38. Comparison of proportions of mean chlorophyll *a*, *b*, *c* concentrations among Greens Creek Mine biomonitoring sites in 2001 through 2006. MGC 6 = Middle Greens Creek Site 6.

Chlorophyll *a* is a primary photosynthetic pigment, is present in all algae, and is a useful indicator of periphyton biomass and a healthy algal community (Wetzel 1983). Chlorophyll *b* is an accessory pigment found in combination with other photosynthetic pigments. When measured above detection limits in periphyton communities, 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 (Speer 1997). Diatoms play an important role in primary production in aquatic communities, and measurable quantities of chlorophyll *c* indicate the importance of diatoms in the community.

Some Upper Greens Creek Site 48 and Tributary Creek Site 9 biomonitoring samples over the years have had higher chlorophyll *b* concentrations than have other samples, suggesting that at the time of sampling there was a larger percentage of green algae or euglenophytes in the periphyton community (Wetzel 1983). Given the differences in channel morphology, flow regimes and streamside vegetation between streams and years, some differences in algal communities are not unexpected.

Benthic Macroinvertebrates

Benthic macroinvertebrate densities at all four biomonitoring sites in 2006 were among the lowest values seen in the Greens Creek Biomonitoring program, and were not statistically different from one another (Figure 39). Middle Greens Creek Site 6 samples had substantially fewer taxa in 2006 samples than those from Upper Greens Creek Site 48, but not significantly less. The benthic macroinvertebrate densities and taxa numbers from Tributary Creek Site 9 samples in 2006 were not statistically different than the 2006 samples from the sites on Greens Creek (Figure 40).

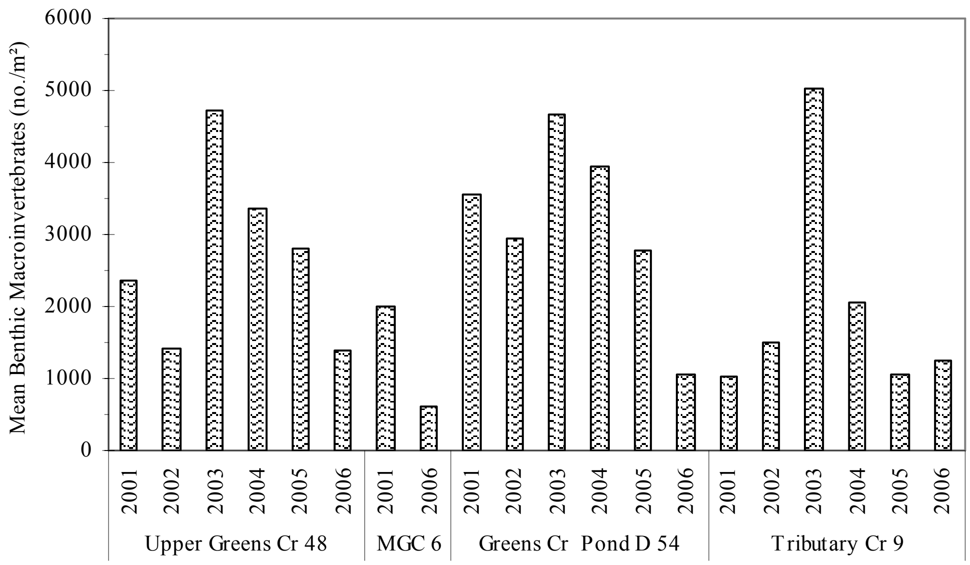

Figure 39. Comparison of benthic macroinvertebrate density among Greens Creek Mine biomonitoring sites in 2001 through 2006.

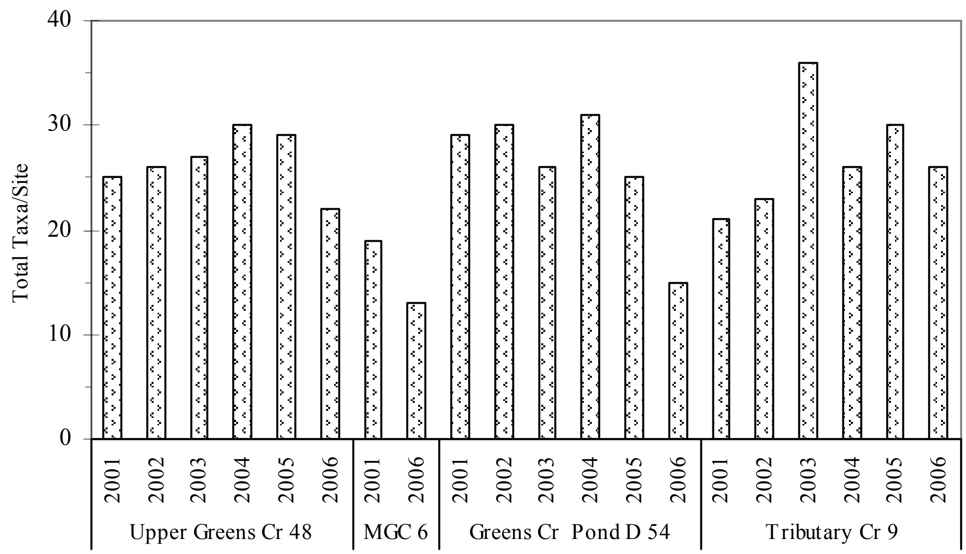

Figure 40. Comparison of benthic macroinvertebrate taxonomic richness among Greens Creek Mine biomonitoring sites in 2001 through 2006.

All four of the biomonitoring sites had complex invertebrate communities with abundant numbers of taxa (taxonomic richness) per sample. More than 50% of the invertebrates in samples from Upper Greens Creek Site 48, Middle Greens Creek Site 6, and Tributary Creek Site 9 were from two dominant taxa, while three dominant taxa accounted for more than 50% of the invertebrates in samples from Greens Creek Below Pond D Site 54 (Table 14). The number of taxa per site (richness) was the lowest encountered in this biomonitoring project at the three Greens Creek sites, and only slightly greater than lowest at Tributary Creek Site 9. Richness was not statistically different between sites in 2006.

For all sites taken together, benthic macroinvertebrate densities in 2006 were significantly lower than in 2003 and 2004 and substantially lower than in 2001, and taxonomic richness per site was significantly lower in 2006 than in 2003, 2004, and 2005. The reasons for these marked declines are unclear. Noted 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. Greens Creek sites could still be affected by the noted substrate movements and channel changes that occurred during the November 2005 high water event, but Tributary Creek showed no signs of such flows. Aquatic habitats with fairly even stream flows, such as Tributary Creek Site 9, usually have communities that are more complex with many taxa present compared to more variable habitats such as the Greens Creek sites where fewer taxa typically dominate the communities (Hynes 1970).

Table 14. Common taxa (>5.0% of benthic macroinvertebrates) found in Greens Creek Mine biomonitoring samples in 2006. The percent dominant taxon percent for each site is bold.

Order	Family	Genus	Upper Grns Cr 48	Middle Grns Cr 6	Grns Cr Pond D 54	Trib Cr 9
Ephemeroptera	Baetidae	*Baetis*	19%	10%	20%	-
	Ephemerellidae	*Drunella*	15%	16%	11%	-
		Ephemerella	-	-	-	12%
	Heptageniidae	*Cinygmula*	7%	9%	13%	20%
		Epeorus	**35%**	**35%**	**24%**	-
		Rhithrogena	13%	13%	22%	-
	Leptophlebiidae	*Paraleptophlebia*	-	-	-	**33%**
	Ameletidae	*Ameletus*	-	-	-	5%
Diptera	Chironomidae		-	9%	-	-
Ostracoda			-	-	-	11%

The percent EPT metric, based on the concept that many taxa within 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 years sampled (Figure 41). The percent of Chironomidae has been relatively constant at the Tributary Creek site but variable in the three Greens Creek sites.

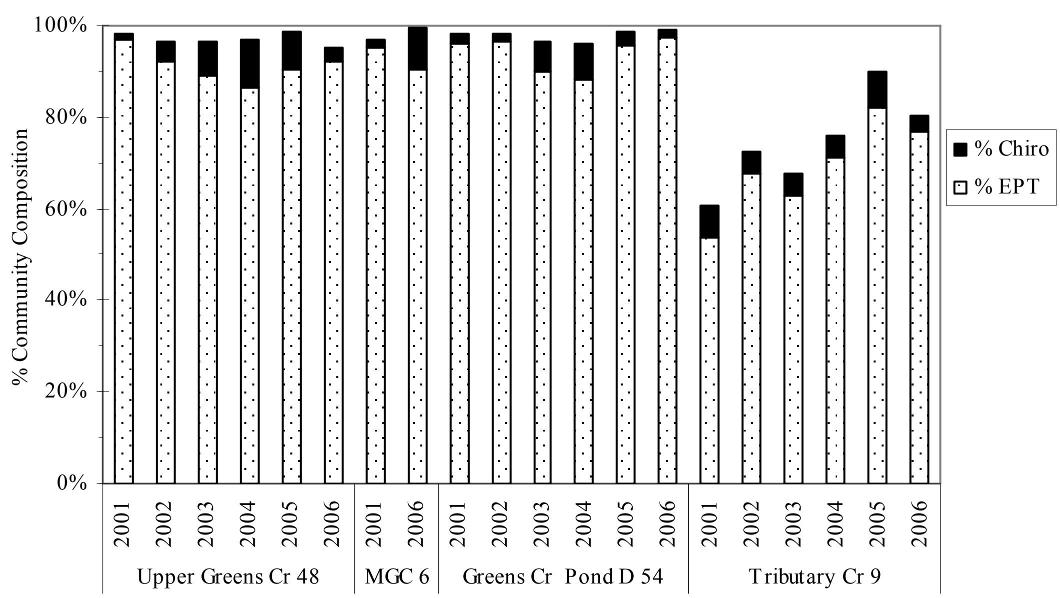

Figure 41. Comparison of proportions of EPT taxa and Chironomidae among Greens Creek Mine biomonitoring sites in 2001 through 2006.

Benthic macroinvertebrate community compositions at the three Greens Creek sites continued to be similar to one another and somewhat different from that at the Tributary Creek site (Figure 42). The communities at the three Greens Creek sites were dominated by Ephemeroptera (mayflies), with small contributions by Plecoptera (stoneflies) and aquatic Diptera (primarily midge and blackfly larvae), while the Tributary Creek site community was somewhat less dominated by Ephemeroptera and more non-insect invertebrates were present. These differences in community composition are most likely due to the different physical characteristics of the streams.

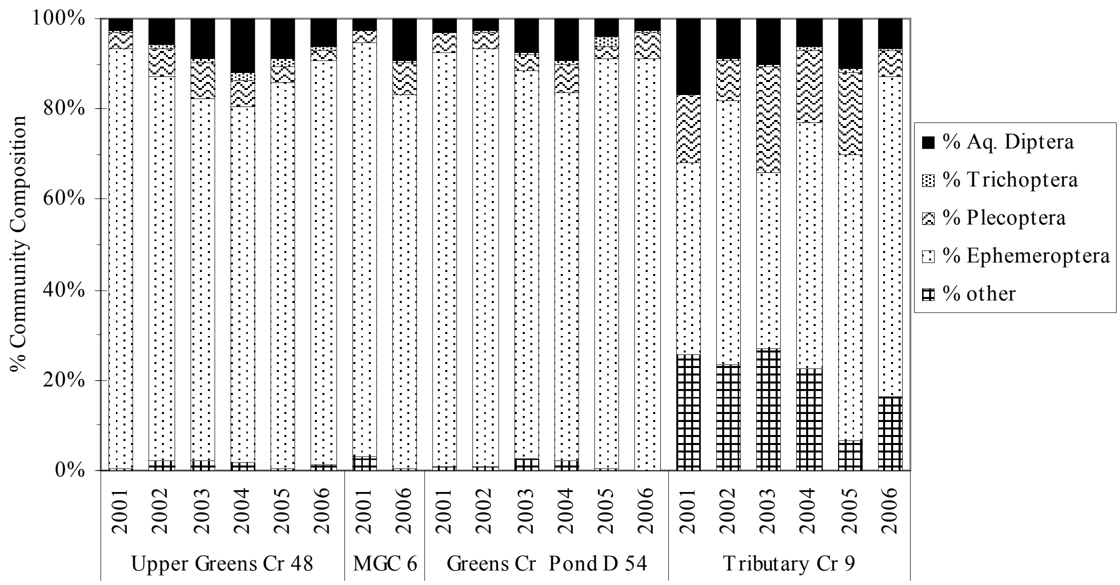

Figure 42. Comparison of community composition of benthic macroinvertebrates among Greens Creek Mine biomonitoring sites in 2001 through 2006.

Density and taxonomic richness metrics showed all four sites to have well-developed, complex communities similar in structure to previous years at the same sites. Abundance was fairly low at all three Greens Creek sites in 2006, while Tributary Creek Site 9 had moderate abundance. 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 considered sensitive to pollution. Because all four communities continue to be dominated by pollution-sensitive species, we believe that any future perturbations by natural stressors or human-facilitated sources would likely cause detectable changes in abundance or richness.

Juvenile Fish Populations

Juvenile fish populations at the four biomonitoring sites displayed a variety of trends in 2006. Dolly Varden at the three Greens Creek sites were captured at similar absolute (population estimate) and relative (fish per square meter of wetted stream area) levels to the previous sampling effort at each site (2005 for sites 48 and 54, 2001 for site 6) (Figure 43, Table 15). Murphy et al. (1986) and Bryant et al. (1991) provide average fish density values for various channel types on the Tongass National Forest. In 2006, Dolly Varden densities were higher than the regional average at Upper Greens Creek Site 48 and Middle Greens Creek Site 6, and much higher than the regional average at Greens Creek Below Pond D Site 54. This trend has remained fairly constant over the six years of this biomonitoring program. The density of Dolly Varden at Tributary Creek Site 9 was much lower in 2006 than in the previous five years of sampling, and was lower than the regional averages for the first time in six years of this biomonitoring program.

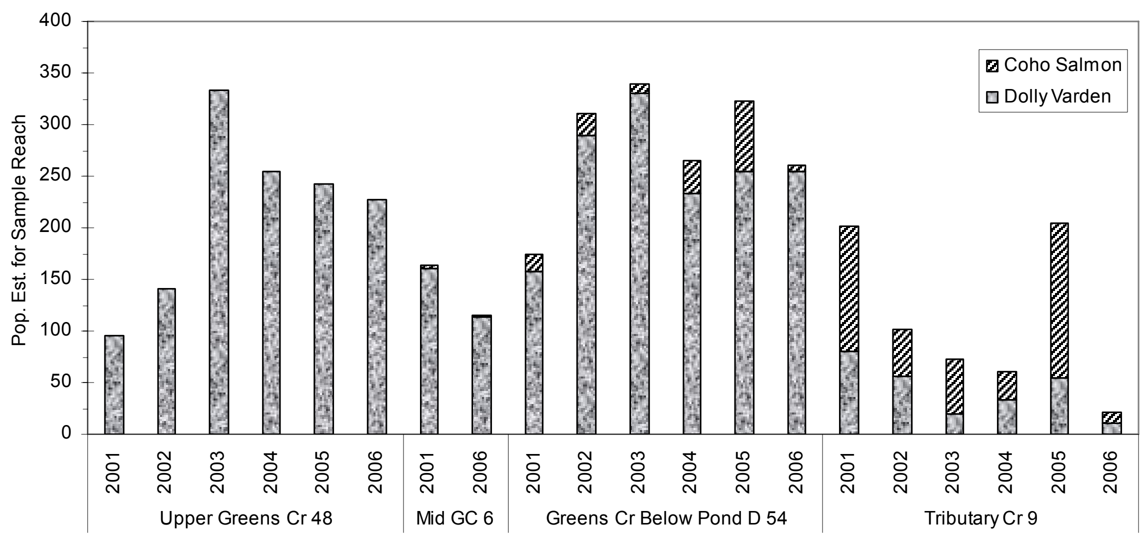

Figure 43. Comparison of population estimates for juvenile fish captured at Greens Creek Mine biomonitoring sites in 2001 through 2006.

Coho salmon population and density estimates at the three sites accessible to coho (Middle Greens Creek Site 6, Greens Creek Below Pond D Site 54, and Tributary Creek Site 9) were lower in 2006 than in the previous years of biomonitoring sampling. Estimates of coho salmon abundance and density in 2006 at Greens Creek Below Pond D Site 54 and Tributary Creek Site 9 were approximately an order of magnitude less than in 2005 at the same sites, much lower than the regional average densities for those channel types (Figure 43, Table 15, Appendix 4).

Although comparisons among all sites must take into consideration 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 15. 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 total fish density at Tributary Creek Site 9 has typically been intermediate between the values for Upper Greens Creek Site 48 and for Greens Creek Below Pond D Site 54, with generally lower densities of Dolly Varden and higher densities of coho salmon. In 2006, Tributary Creek Site 9 Dolly Varden productivity was lower than each of the three Greens Creek sites.

A potential reason for at least some of these differences is the high water event on Greens Creek in November 2005. Ihlenfeldt (2005) found that the preferred spawning areas for resident Dolly Varden are the edges of pools in low velocity water with a gravel substrate size of 1-4 cm. Coho salmon, on the other hand, prefer to spawn in riffle areas (McPhail and Lindsey 1970). Based on comparisons of photos taken July 2005 and July 2006, such areas in Greens Creek were substantially reworked during the November 2005 high water event. This movement of gravels around eggs in the redd may well have killed most or all of the incubating coho salmon eggs through physical jarring, sediment deposition, or physical flushing of the eggs out of the substrate. Sampling in future years will likely shed light on whether or not there is a missing year class in the Greens Creek coho salmon population. High water events can also reduce periphyton, benthic macroinvertebrates, and woody debris in streams. Murphy et al.. (1986) found that coho salmon young-of-the-year densities were directly related to periphyton biomass and benthic macroinvertebrate density, and that coho and Dolly Varden parr were directly related to pool and woody debris features.

Since there was evidence of stream reach effects associated with November 2005 high flow at the three Greens Creek sites but not at the Tributary Creek site, and both coho salmon and Dolly Varden populations are low, a separate mechanism is likely affecting Tributary Creek fish. One candidate to be ruled out in future biomonitoring is the high turbidity noted in Tributary Creek Site 9 during biomonitoring sampling, which could both reduce light levels available for primary production by periphyton and reduce feeding opportunities for fish such as Dolly Varden and coho salmon that are sight feeders.

Table 15. Fish captures, population estimates, and densities in Greens Creek Mine biomonitoring sampling reaches during 2001 through 2006.

	Upper Greens Creek Site 48		Middle Greens Creek Site 6[1]		Greens Creek Below Pond D Site 54		Tributary Creek Site 9	
	Coho Salmon[2]	Dolly Varden	Coho Salmon	Dolly Varden	Coho Salmon	Dolly Varden	Coho Salmon	Dolly Varden
2001								
Number of Fish Caught	---	68	3	131	12	138	118	81
Population Estimate	---	96	3	161	17	158	120	81
Sample Reach (m)	---	72	135	135	28	28	44	44
Density Est. (fish/m²)	---	0.20	<0.01	0.13	0.06	0.58	0.80	0.92
2002								
Number of Fish Caught	---	126	---	---	21	271	44	51
Population Estimate	---	141	---	---	21	290	46	56
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
2006								
Number of Fish Caught	---	212	1	97	7	217	10	11
Population Estimate	---	228	1	114	7	254	10	11
Sample Reach (m)	---	50	49	49	28	28	50	50
Density Est. (fish/m²)	---	0.59	<0.01	0.25	0.03	1.22	0.08	0.09

[1] Middle Greens Creek Site 6 was not sampled in 2002-2005.
[2] Coho salmon are not present at Upper Greens Creek Site 48 because of downstream barrier to anadromous fish.
[3] Based on approximate values for wetted area.

Metals Concentrations in Juvenile Fish

Tissue concentrations of metals in Dolly Varden from the three Greens Creek sites (48, 6, and 54) were generally similar in 2006. The highest median and mean concentrations of zinc in Dolly Varden tissues from each of the Greens Creek sites occurred in 2006. Fish from Middle Greens Creek Site 6 had significantly more lead and substantially less silver in their tissues than did fish from Upper Greens Creek Site 48. Otherwise, metals concentrations in fish tissues from the Greens Creek sites were not statistically different among sites (Figure 44). Compared to tissues from Greens Creek fish, tissues from Tributary Creek Site 9 fish contained significantly more silver than did Middle Greens Creek Site 6 fish, and significantly more lead and less zinc than did Upper Greens Creek Site 48 fish. The mean rank scores for cadmium, copper, and selenium tissue concentrations were not statistically different among the four sites in 2006.

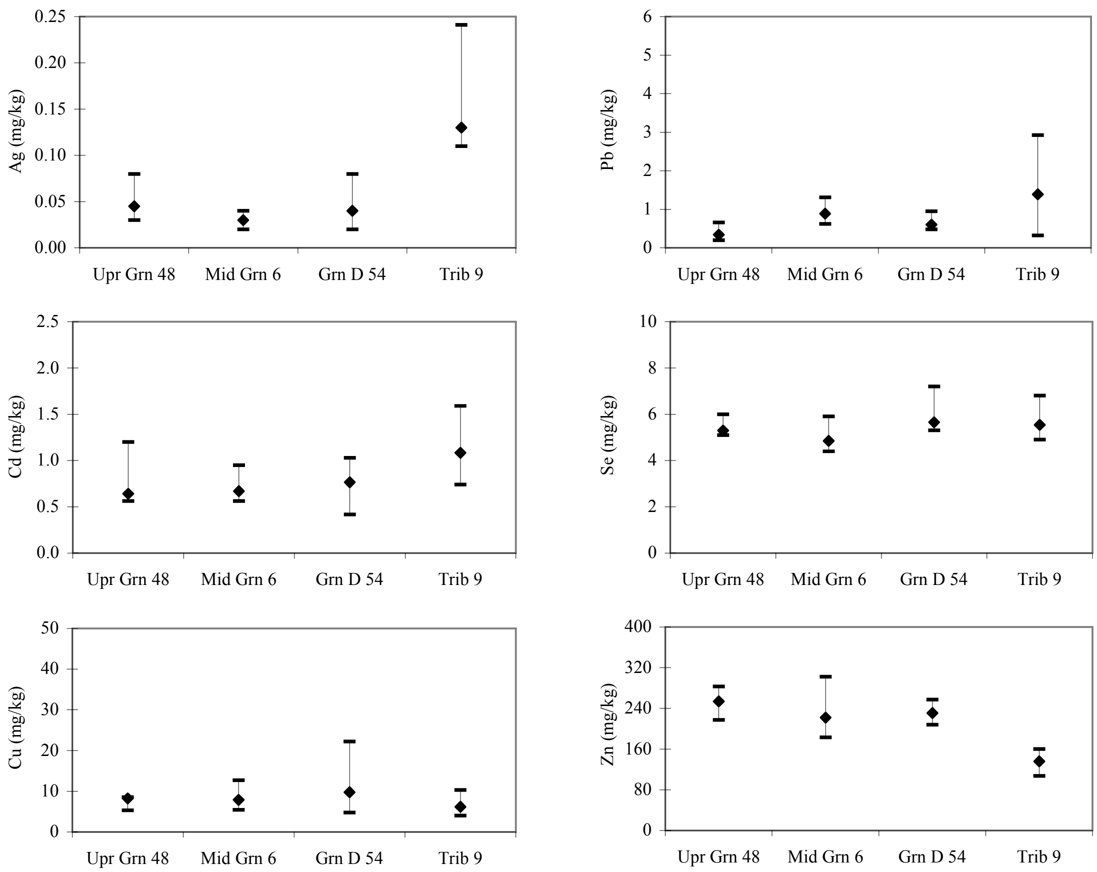

Figure 44. Comparison among sites of whole body metals concentrations (median, maximum, and minimum) in six Dolly Varden captured at each biomonitoring site in 2006.

CONCLUSIONS

The three biomonitoring sites on Greens Creek (Upper Greens Creek Site 48 above all facilities, Middle Greens Creek Site 6 below the mine and mill facilities, and Greens Creek Below Pond D Site 54 below all facilities) and one on Tributary Creek (Tributary Creek Site 9 below the dry-stack tailings facility) continued to sustain functioning, diverse aquatic communities in 2006.

Periphyton biomass and community composition at the three Greens Creek sites continue to appear robust, with a pronounced diatom component and a minimal green algae component. Chlorophyll *a* concentrations were similar among the three Greens Creek sites in 2006, and those sites each had significantly more periphyton biomass than in 2001. Periphyton biomass at Tributary Creek Site 9 was the lowest recorded in six years of sampling at the site, and was significantly lower than the high chlorophyll *a* concentrations in 2003. The community composition at Tributary Creek continued to be similar to that at the Greens Creek sites.

The benthic macroinvertebrate communities at the four biomonitoring sites showed essentially the opposite trends of the periphyton communities. The mean rank scores for benthic macroinvertebrate abundance and taxonomic richness at the three Greens Creek sites in 2006 were the lowest of the years sampled and were not statistically different between sites. Tributary Creek Site 9 benthic macroinvertebrate abundance and taxonomic richness were moderate in 2006, and substantially different only from the high densities of 2003. In contrast to most of the past five years of sampling, the number of common taxa in Tributary Creek Site 9 samples in 2006 was equal to or less than that found in Greens Creek samples. Distinctive differences in the benthic macroinvertebrate community between the two streams persisted. The percentage of the water quality-sensitive Ephemeroptera, Plecoptera, and Trichoptera taxa in all sites' benthic macroinvertebrate samples remained high in 2006.

Dolly Varden populations continue to be relatively abundant at each of the Greens Creek sites. Captures were intermediate to those in previous years the three sites, with multiple size classes of fish present. Dolly Varden captures at Tributary Creek Site 9 were significantly lower than in the previous five years of sampling at that site; no size classes typically associated with young-of-the-year Dolly Varden were captured at Site 9. Coho salmon captures were significantly lower in 2006 than in previous years' sampling at the three biomonitoring sites accessible to coho; no size classes typically associated with young-of-the-year coho salmon were captured. Total fish densities per square meter of wetted stream area among the three Greens Creek sites continued to be higher at Greens Creek Below Pond D Site than at Upper Greens Creek Site 48, with Middle Greens Creek Site 6 having intermediate densities. The total fish densities per square meter of wetted area at Tributary Creek Site 9 were lower in 2006 than those at Upper Greens Creek Site 48 for the first time in six years of sampling.

The range of whole body concentrations of metals in juvenile Dolly Varden tissues were generally similar to those found in previous years' samples at each site. In general, metals concentrations in fish tissues were somewhat elevated in 2006 over previous years, particularly zinc in fish from Greens Creek and silver in fish from Tributary Creek, although a clear pattern of differential tissues metals concentration did not emerge between sites upstream and downstream of mine facilities or at sites over time. Tissues of Dolly Varden from Tributary Creek Site 9 had different characteristics of metals concentrations than did tissues from Dolly Varden at the three Greens Creek sites (48, 6, and 54) in 2006.

Overall, the aquatic communities in Upper Greens Creek Site 48, Middle Greens Creek Site 6, Greens Creek Below Pond D Site 54, and Tributary Creek Site 9 have remained fairly diverse and generally abundant during the six years of biomonitoring sampling. Differences noted between years and between the streams (Greens Creek compared to Tributary Creek) have typically been of larger amplitude than have differences between the control and below-mining sites within Greens Creek or over time at the Tributary Creek site. Although no trends of reduced productivity, community changes, or metals accumulation attributable to operations of the Greens Creek Mine have been noted, the 2006 biomonitoring results raise concerns that will need to be followed in future years of biomonitoring: low abundance of periphyton in Tributary Creek, low density and richness of benthic macroinvertebrates in Greens Creek, low density of Dolly Varden in Tributary Creek, low density of coho salmon in both Greens Creek and Tributary Creek, and somewhat elevated levels of metals in fish tissues at all sites.

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APPENDIX 1. USFS CHANNEL TYPE DESCRIPTIONS

From: A Channel Type User Guide for the Tongass National Forest (Paustian et al. 1992)

MM2 – Moderate Width Mixed Control Channel Type (Greens Creek sites 6, 48, and 54): MM2 channels are 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. The riparian plant communities for the MM2 channel type are dominated by the Sitka spruce series and the western hemlock series.

MM2 channels function as sediment transport systems. These channels have moderate stream energy. Fine sediment is rapidly moved through the MM2 channels, Large woody debris accumulations are extensive and help retain coarse gravels, portion of which will be mobilized during high flow events. Significant stream bank erosion and lateral channel migration can occur during high flow events.

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.

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.

FP3 – Narrow Low Gradient Flood Plain Channel Type (Tributary Creek Site 9): 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.

FP3 channels function as sediment deposition systems. Sediment routed from high and moderate gradient sediment transport channels is temporarily stored in this channel type and on the adjacent flood plain. Sand and fine gravel deposits in point bars and pools are dominant stream bed features. Large woody debris accumulations are frequent and retain significant volumes of fine sediment. Stream power is low, allowing for massive mobilization of sediment only during peak flow events.

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, with the exception of chinook salmon. FP3 channels have a large amount of available rearing area and are used extensively by coho, Dolly Varden, and steelhead. Thirty-seven percent of the active water in pools has an average depth of 0.31 m, which provides good overwintering habitat. Woody debris and beaver dams enhance these pools as overwintering areas.

Stream banks are composed of coarse to fine textured alluvium, which, due to low stream flow volume and relatively low stream power, are only moderately sensitive to disturbance.

APPENDIX 2. PERIPHYTON BIOMASS DATA

Estimates of periphyton biomass as represented by chlorophyll concentrations (mg/m²) at Greens Creek Mine biomonitoring sampling sites from 2001-2006.

	2001			2002			2003			2004		
mg/m²	chlor-a	chlor-b	chlor-c	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	18.0492	0.0000	2.0334
	1.8257	0.0000	0.1830	4.0309	0.0000	0.2146	17.8250	0.0255	1.5659	6.7284	0.0000	0.6901
	5.6124	0.0000	0.6948	6.2095	0.0000	0.7130	8.4320	0.0890	0.3896	8.9712	0.0000	0.8982
	0.3127	0.0790	0.0582	2.8302	0.0000	0.2460	9.5307	0.0086	0.6354	12.8160	0.0000	1.4537
	2.9595	0.0375	0.3613	5.1572	0.0000	0.7548	11.3567	0.0000	0.7204	5.4468	0.0000	0.6233
	5.4420	0.0000	0.6166	6.3926	0.0000	0.7539	11.7638	0.0156	0.8633	20.3988	0.0000	2.1499
	3.3793	0.0000	0.4670	5.8430	0.0000	0.7291	24.0949	0.0000	2.1368	6.3012	0.0000	0.4491
	1.8669	0.0338	0.1460	2.0910	0.0722	0.2479	13.3054	0.1280	0.9883	11.6412	0.0000	1.3841
	2.6348	0.1374	0.1442	3.2026	0.0000	0.3583	11.5404	0.0000	0.5652	7.4760	0.0000	0.6511
	1.2286	0.0227	0.1649	2.5588	0.0000	0.1507	13.9690	0.0000	0.8948	5.2332	0.0000	0.5452
median	2.2746	0.0174	0.1740	4.5941	0.0000	0.3265	12.5346	0.0043	0.8790	8.2236	0.0000	0.7941
max	5.6124	0.1374	0.6948	6.3926	0.0722	0.7548	24.0949	0.1280	2.1368	20.3988	0.0000	2.1499
min	0.3127	0.0000	0.0582	2.0910	0.0000	0.1507	8.4320	0.0000	0.3896	5.2332	0.0000	0.4491
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	17.1948	0.0000	2.0177
	3.0952	0.0458	0.4090	9.3238	0.0000	1.0170	8.3547	0.0000	0.7884	9.7188	0.0000	0.9266
	3.6108	0.0000	0.2070	7.5189	0.0000	0.2386	14.8960	0.0000	1.4546	8.7576	0.0000	0.6740
	2.9660	0.0000	0.2936	4.2958	0.0000	0.3775	5.9381	0.0000	0.6177	32.0400	0.0000	3.6620
	1.8799	0.0000	0.0106	5.1517	0.0000	0.5282	15.5146	0.0000	1.7368	5.2332	0.0000	0.4232
	1.7783	0.0000	0.1897	2.9762	0.8652	1.2582	10.4992	0.0000	1.0601	3.7380	0.0000	0.3051
	4.9471	0.0000	0.2232	6.2634	0.0000	0.6386	5.7082	0.0000	0.3872	12.8160	0.0000	1.3488
	1.4594	0.0000	0.1011	4.6212	0.0000	0.3984	16.4246	0.0000	1.7150	1.9224	0.0310	0.0888
	1.6900	0.0000	0.1354	4.7095	0.0000	0.4528	12.6034	0.0000	1.0746	10.4664	0.0000	1.0866
	3.4750	0.0000	0.1594	8.0829	0.0000	0.7912	17.8620	0.0000	1.7483	5.9808	0.0000	0.5330
median	2.4229	0.0000	0.1745	4.9306	0.0000	0.4905	12.9463	0.0000	1.0673	9.2382	0.0000	0.8003
max	4.9471	0.0458	0.4090	9.3238	0.8652	1.2582	17.8620	0.0000	1.7483	32.0400	0.0310	3.6620
min	1.4594	0.0000	0.0106	2.6468	0.0000	0.2386	5.7082	0.0000	0.3872	1.9224	0.0000	0.0888
Tributary Creek Site 9												
	6.6232	0.0000	0.7882	8.9053	0.0000	0.5190	12.8934	0.0000	1.2610	9.3984	0.2240	0.8033
	11.1495	0.0000	1.2000	16.4332	0.9503	1.2761	8.5504	0.0000	0.7921	5.7672	0.0000	0.4226
	15.0542	0.0000	1.4721	12.6468	0.1735	0.0000	3.9770	0.0000	0.2889	5.4468	0.0000	0.4836
	16.5773	0.2339	1.5059	5.4410	0.4508	0.0725	12.2904	0.0000	1.1144	6.0876	0.0312	0.3827
	3.1491	0.0000	0.3346	23.7210	1.2053	0.8382	17.0873	0.0000	1.9158	14.5248	0.0213	1.3951
	2.5932	0.0643	0.2794	12.7457	0.4003	0.2162	17.4003	0.0000	1.8759	6.5148	0.1726	0.4038
	1.6081	0.0000	0.0134	32.5316	0.0000	1.8936	33.8710	0.0000	3.9766	10.3596	0.1349	0.7986
	6.6592	0.0000	0.4265	4.4025	1.4958	0.0000	24.5614	0.0000	2.4319	6.8352	0.0423	0.3638
	15.2098	0.8116	1.4358	2.9413	0.3005	0.1720	20.0201	0.0000	1.6884	26.1660	0.5112	2.6076
	11.5499	0.0000	1.5087	8.0068	1.4710	0.2746	36.0168	0.0000	3.8559	8.4372	0.2176	0.5308
median	8.9044	0.0000	0.9941	10.7761	0.4256	0.2454	17.2438	0.0000	1.7821	7.6362	0.0886	0.5072
max	16.5773	0.8116	1.5087	32.5316	1.4958	1.8936	36.0168	0.0000	3.9766	26.1660	0.5112	2.6076
min	1.6081	0.0000	0.0134	2.9413	0.0000	0.0000	3.9770	0.0000	0.2889	5.4468	0.0000	0.3638

Appendix 2. (Continued)

	2005			2006		
mg/m²	chlor-a	chlor-b	chlor-c	chlor-a	chlor-b	chlor-c
Upper Greens Creek Site 48						
	0.9719	0.0000	0.0086	8.5030	0.0000	0.7988
	4.6992	0.0000	0.5099	11.5900	0.0000	0.7103
	6.6216	0.0000	0.2741	10.7417	0.0000	1.2532
	6.1944	0.0000	0.5062	20.6036	0.0000	2.0380
	11.1072	0.0000	0.9152	10.6005	0.0000	0.9790
	5.6604	0.0000	0.5118	14.3454	0.0000	1.7241
	7.6896	0.0000	0.5330	17.2710	0.0000	1.7606
	5.1264	0.0000	0.2909	15.8082	0.0000	1.7423
	2.4564	0.0153	0.2755	17.2649	0.0000	1.7302
	9.0780	0.0000	0.6302	4.3364	0.0000	0.5366
median	5.9274	0.0000	0.5081	12.9677	0.0000	1.4887
max	11.1072	0.0153	0.9152	20.6036	0.0000	2.0380
min	0.9719	0.0000	0.0086	4.3364	0.0000	0.5366
Middle Greens Creek Site 6						
	-	-	-	27.3154	0.0000	2.7825
	-	-	-	19.3208	0.0000	2.0456
	-	-	-	17.5776	0.0000	1.7884
	-	-	-	33.9456	0.0000	3.3068
	-	-	-	47.5520	0.0000	4.9348
	-	-	-	16.1184	0.0000	1.5892
	-	-	-	8.9573	0.0000	1.0331
	-	-	-	11.8417	0.0000	1.1067
	-	-	-	8.6446	0.0000	0.9749
	-	-	-	29.1943	0.0000	3.0873
median	-	-	-	18.4492	0.0000	1.9170
max	-	-	-	47.5520	0.0000	4.9348
min	-	-	-	8.6446	0.0000	0.9749
Greens Creek Below Pond D Site 54						
	10.3596	0.0000	0.5350	19.8594	0.0000	1.6172
	2.5632	0.0000	0.2555	5.6248	0.0000	0.7556
	3.3108	0.0000	0.1688	12.7421	0.0000	1.1864
	2.8836	0.0000	0.1173	23.5686	0.0000	2.6259
	5.6604	0.0000	0.3834	4.6147	0.0000	0.4661
	2.9904	0.0000	0.1346	27.6712	0.0000	2.2151
	4.2720	0.0000	0.1775	4.2484	0.0000	0.3842
	4.3788	0.0000	0.3098	8.9576	0.0000	0.9350
	4.0584	0.0000	0.1604	31.8454	0.0000	3.1710
	3.0972	0.0000	0.1583	5.4829	0.0000	0.6776
median	3.6846	0.0000	0.1732	10.8498	0.0000	1.0607
max	10.3596	0.0000	0.5350	31.8454	0.0000	3.1710
min	2.5632	0.0000	0.1173	4.2484	0.0000	0.3842
Tributary Creek Site 9						
	6.4294	0.0000	0.2502	3.5384	0.2492	0.1902
	8.0100	1.2833	0.1830	4.2115	0.3962	0.2018
	1.8156	0.1313	0.0746	7.0732	0.0000	0.4036
	9.8256	0.0595	0.2907	4.0118	0.0108	0.3195
	5.6818	0.0000	0.1025	4.2010	0.0000	0.3909
	5.3827	0.0000	0.1225	4.7449	0.0000	0.2872
	8.1809	0.0000	0.2028	13.6349	0.0000	0.5726
	15.4326	0.0000	0.4551	4.3786	0.0052	0.2053
	36.6004	0.0989	1.1198	5.1579	0.0000	0.5586
	9.4518	0.0000	0.2629	3.7563	0.3717	0.2617
median	8.0954	0.0000	0.2265	4.2951	0.0026	0.3034
max	36.6004	1.2833	1.1198	13.6349	0.3962	0.5726
min	1.8156	0.0000	0.0746	3.5384	0.0000	0.1902

APPENDIX 3. BENTHIC MACROINVERTEBRATE DATA

Appendix 3.1. Numbers of benthic macroinvertebrates identified in Upper Greens Creek Site 48 biomonitoring samples from 2001 through 2006.

Order	Family	Genus	2001	2002	2003	2004	2005	2006
Ephemeroptera	unidentified		-	-	-	-	-	3
	Baetidae	*Baetis*	309	152	445	390	279	130
	Ephemerellidae	*Caudatella*	2	-	-	-	-	-
		Ephemerella	-	-	10	23	15	1
		Drunella	47	49	650	406	369	102
	Heptageniidae	*Cinygmula*	99	20	117	99	89	48
		Epeorus	444	190	384	209	371	240
		Rhithrogena	193	187	287	196	71	88
	Leptophlebiidae	*Paraleptophlebia*	-	1	-	-	-	-
	Ameletidae	*Ameletus*	-	-	4	-	-	-
Plecoptera	unidentified		-	-	-	-	9	7
	Capniidae	*Capnia*	-	-	82	-	-	-
		Eucapnopsis	-	-	-	-	1	-
	Chloroperlidae	unidentified	-	-	-	-	2	-
		Alloperla	1	1	-	1	-	-
		Kathroperla	-	-	2	3	-	2
		Neaviperla	-	-	70	6	3	-
		Paraperla	-	-	-	6	-	-
		Plumiperla	5	-	-	5	-	-
		Suwallia	8	1	-	-	5	-
		Sweltsa	1	4	-	-	-	-
	Leuctridae	*Despaxia*	-	2	-	-	-	-
		Paraleuctra	4	3	6	65	-	3
		Perlomyia	-	12	-	-	-	-
	Nemouridae	*Podmosta*	7	5	-	2	-	-
		Zapada	23	4	30	7	14	5
	Perlodidae	*Isoperla*	-	-	-	1	9	-
		Megarcys	-	-	1	-	-	1
		Skwala	-	9	-	-	4	-
Trichoptera	unidentified		-	-	-	-	-	3
	Apataniidae	*Apatania*	-	1	-	-	-	-
	Glossosomatidae	*Glossosoma*	-	-	2	16	14	-
	Hydropsychidae	*Arctopsyche*	2	-	-	-	-	-
		Hydropsyche	-	-	1	-	1	-
	Limnephilidae	*Onocosmoecus*	-	-	1	-	-	-
	Rhyacophilidae	*Rhyacophila*	5	8	16	15	7	6
Coleoptera	Elmidae	*Narpus*	-	-	-	1	-	-
	Staphylinidae		1	-	6	-	-	-
Diptera	Ceratopogonidae	*Dasyhelea*	-	1	-	-	-	-
		Probezzia	-	-	-	-	-	16
	Chironomidae		14	30	172	177	112	22
	Deuterophlebiidae	*Deuterophlebia*	2	-	-	1	1	1
	Empididae	unidentified	-	-	-	-	1	-
		Chelifera	1	2	5	1	-	-
		Hemerodromia	-	-	-	-	5	-
		Oreogeton	3	2	22	11	-	-
	Psychodidae	*Psychoda*	1	-	-	-	-	-

Appendix 3.1. (Continued)

Order	Family	Genus	2001	2002	2003	2004	2005	2006
Diptera (cont.)	Simuliidae	*Parasimulium*	2	-	-	-	-	-
		Prosimulium	2	-	-	2	-	-
		Simulium	6	4	-	1	3	1
	Tipulidae	*Antocha*	-	-	2	-	-	-
		Dicranota	-	-	3	-	2	-
		Rhabdomastix	-	-	-	-	1	-
		Tipula	-	-	2	6	1	4
Collembola	unidentified		-	-	-	-	-	1
	Onychiuridae	*Onychiurus*	-	1	-	-	-	-
	Sminthuridae	*Dicyrtoma*	2	-	-	-	-	-
Copepoda	Cyclopoida		-	-	-	1	-	-
Acarina			-	2	20	10	3	6
Oligochaeta			-	5	20	8	3	1
Gastropoda	Pelecypoda		-	-	-	1	-	-
Ostracoda			-	8	7	9	1	2

Appendix 3.2. Numbers of benthic macroinvertebrates identified in Middle Greens Creek Site 6 biomonitoring samples in 2001 and 2006.

Order	Family	Genus	2001	2006
Ephemeroptera	Baetidae	*Baetis*	153	30
	Ephemerellidae	*Ephemerella*	-	2
		Drunella	52	48
	Heptageniidae	*Cinygmula*	303	28
		Epeorus	408	107
		Rhithrogena	-	40
Plecoptera	unidentified		-	12
	Chloroperlidae	unidentified	-	6
		Suwallia	2	-
	Leuctridae	*Paraleuctra*	7	-
	Nemouridae	*Zapada*	16	3
	Perlodidae	*Isoperla*	7	-
Trichoptera	Rhyacophilidae	*Rhyacophila*	1	1
Coleoptera	Staphylinidae		1	-
Diptera	Chironomidae		19	28
	Deuterophlebiidae	*Deuterophlebia*	1	-
	Dolichopodidae		1	-
	Empididae	*Chelifera*	1	-
		Oreogeton	3	-
	Tipulidae	*Dicranota*	-	1
Arachnida			1	-
Acarina			4	-
Oligochaeta			15	1
Ostracoda			3	-

Appendix 3.3. Numbers of benthic macroinvertebrates identified in Greens Creek Below Pond D Site 54 biomonitoring samples from 2001 through 2006.

Order	Family	Genus	2001	2002	2003	2004	2005	2006
Ephemeroptera	unidentified		-	-	-	-	-	6
	Baetidae	*Baetis*	248	225	220	299	198	107
	Ephemerellidae	*Ephemerella*	2	6	6	47	22	-
		Drunella	118	280	894	742	543	56
	Heptageniidae	*Cinygmula*	319	75	176	112	90	68
		Epeorus	935	626	408	228	341	124
		Rhithrogena	-	140	306	173	66	116
	Leptophlebiidae	*Paraleptophlebia*	1	-	1	-	4	-
	Ameletidae	*Ameletus*	4	-	-	-	1	-
Plecoptera	unidentified		-	-	-	-	-	7
	Capniidae	*Capnia*	-	-	5	-	1	-
		Eucapnopsis	-	-	-	-	8	-
	Chloroperlidae	*Alloperla*	3	-	-	1	-	-
		Kathroperla	-	-	2	2	-	-
		Neaviperla	-	14	22	26	5	13
		Paraperla	-	-	5	4	-	-
		Plumiperla	2	-	-	5	3	-
		Suwallia	-	-	-	2	-	-
		Sweltsa	6	-	-	-	-	-
	Leuctridae	*Despaxia*	-	-	-	15	-	-
		Paraleuctra	-	4	-	18	-	1
		Perlomyia	13	3	19	33	-	-
	Nemouridae	*Podmosta*	-	7	-	-	-	-
		Zapada	52	22	14	11	15	9
	Perlodidae	*Diura*	1	-	-	-	-	-
		Isoperla	3	-	-	-	3	-
		Skwala	-	3	15	-	2	-
		Rickera	-	1	-	-	-	-
Trichoptera	Glossosomatidae	*Glossosoma*	-	-	-	12	1	-
	Hydropsychidae	*Arctopsyche*	-	1	-	1	-	-
		Hydropsyche	-	-	-	-	-	1
	Limnephilidae	unidentified	-	-	-	-	2	-
		Psychoglypha	1	-	-	-	-	-
	Rhyacophilidae	*Rhyacophila*	6	5	12	6	27	3
Coleoptera	Elmidae	*Narpus*	-	-	-	3	-	-
	Staphylinidae		1	1	-	-	-	-
Diptera	Chironomidae		33	27	149	148	42	9
	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	-

Appendix 3.3. (Continued)

Order	Family	Genus	2001	2002	2003	2004	2005	2006
Diptera (cont.)	Tipulidae	*Antocha*	1	-	3	2	-	-
		Dicranota	2	1	-	-	-	-
		Hesperoconopa	-	1	1	-	-	-
		Pilaria	-	-	1	-	-	-
		Rhabdomastix	-	-	3	2	3	-
		Tipula	-	1	-	1	-	4
Collembola	unidentified		-	-	-	-	-	1
	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	-	-

Appendix 3.4. Numbers of benthic macroinvertebrates identified in Tributary Creek Site 9 biomonitoring samples from 2001 through 2006.

Order	Family	Genus	2001	2002	2003	2004	2005	2006
Ephemeroptera	unidentified		-	-	-	-	-	1
	Baetidae	*Baetis*	41	123	160	21	38	1
		Procloeon	5	-	-	-	-	-
	Ephemerellidae	*Caudatella*	3	-	-	-	-	-
		Ephemerella	-	14	7	4	1	74
		Drunella	-	3	10	-	8	3
	Heptageniidae	*Cinygma*	1	-	-	-	43	-
		Cinygmula	89	177	507	49	24	127
		Epeorus	-	8	1	-	2	-
		Rhithrogena	-	-	1	-	2	1
	Leptophlebiidae	*Paraleptophlebia*	66	96	249	442	191	204
	Ameletidae	*Ameletus*	-	15	46	46	25	33
Plecoptera	unidentified		-	-	-	-	-	21
	Chloroperlidae	unidentified	-	-	-	-	1	-
		Neaviperla	-	-	174	24	-	-
		Paraperla	-	11	-	-	-	-
		Plumiperla	-	-	-	38	-	-
		Suwallia	34	-	24	20	36	-
		Sweltsa	-	42	-	-	12	-
	Leuctridae	*Despaxia*	3	-	6	5	3	1
		Paraleuctra	7	-	1	-	-	-
		Perlomyia	-	3	-	-	-	-
	Nemouridae	*Podmosta*	-	1	-	-	-	-
		Zapada	23	12	388	41	43	13
	Perlodidae	*Isoperla*	1	-	-	38	-	-
Trichoptera	unidentified		-	-	-	-	-	1
	Apataniidae	*Apatania*	-	1	-	-	-	-
	Brachycentridae	*Brachycentrus*	-	-	1	-	-	-
	Lepidostomatidae	*Lepidostoma*	-	-	-	1	1	1
	Limnephilidae	unidentified	-	-	-	-	1	-
		Ecclisomyia	-	-	1	-	1	-
		Onocosmoecus	-	-	-	1	-	-
	Rhycophilidae	*Rhycophila*	-	1	5	3	1	-
Coleoptera	Elmidae	*Narpus*	2	6	32	14	1	8
	Dytiscidae	*Megadytes*	-	-	2	-	-	-
Diptera	unidentified		-	-	-	-	-	1
	Ceratopogonidae	*Bezzia*	-	-	1	-	-	-
		Dasyhelea	3	-	-	-	-	-
		Probezzia	-	-	9	-	-	1
	Chironomidae		35	36	125	52	40	22
	Empididae	*Chelifera*	-	1	-	-	-	-
		Hemerodromia	-	-	1	-	1	-
		Oreogeton	4	2	24	8	1	-
	Simuliidae	*Simulium*	40	22	81	4	14	8
	Tipulidae	*Antocha*	-	-	10	-	-	-
		Dicranota	-	-	2	-	2	6
		Pilaria	-	-	2	-	-	-
		Rhabdomastix	-	-	1	-	1	-
		Tipula	4	5	-	2	-	4
		Limonia	-	-	-	-	1	-

Appendix 3.4. (Continued)

Order	Family	Genus	2001	2002	2003	2004	2005	2006
Branchiopoda	Chydoridae		-	-	2	-	-	-
Collembola	unidentified		-	-	-	-	-	1
	Sminthuridae	*Dicyrtoma*	-	2	-	-	-	-
		Sminthurus	-	-	3	34	1	2
Copepoda	unidentified		-	-	-	-	-	1
	Cyclopoida		-	-	6	5	-	-
	Harpacticoida		-	-	5	-	-	-
Acarina			15	20	72	39	2	-
Oligochaeta			40	45	349	111	23	21
Gastropoda			1	-	1	2	-	1
Isopoda	Gammaridae	*Gammarus*	-	-	-	1	-	-
Ostracoda			92	102	207	27	8	68

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	30	16	22	68	96	13.80	68 - 124
Middle Greens Cr 6	DV	80	8	43	131	161	12.14	137 - 185
	CO	1	0	2	3	3	0.00	3 - 3
Greens Cr Below D 54	DV	70	49	19	138	158	8.44	141 - 175
	CO	2	6	4	12	17	4.46	8 - 26
Tributary Cr 9	DV	70	4	7	81	81	0.00	81 - 81
	CO	89	18	11	118	120	1.69	117 - 123
	CT	1	0	0	1	1	---	---
	Sc	3	1	0	4	4	0.00	4 - 4
2002[3]								
Upper Greens Cr 48	DV	74	29	23	126	141	6.87	127 - 155
Greens Cr Below D 54	DV	168	72	31	271	290	6.81	276 - 304
	CO	14	6	1	21	21	0.00	21 - 21
Tributary Cr 9	DV	29	14	8	51	56	3.63	49 - 63
	CO	29	9	6	44	46	1.92	42 - 50
	CT	0	0	1	1	1	0.00	1 - 1
	Sc	0	1	1	2	2	0.00	2 - 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	0.00	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	0.00	4 - 4
	Sc	1	1	0	2	2	0.00	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	0.00	2 - 2
	Sc	2	0	0	2	2	---	---
2006								
Upper Greens Cr 48	DV	138	40	34	212	228	6.34	215 - 241
Middle Greens Cr 6	DV	44	41	12	97	114	8.24	98 - 130
	CO	1	0	0	1	1	---	---
Greens Cr Below D 54	DV	116	61	40	217	254	12.34	229 - 279
	CO	6	0	1	7	7	0.00	7 - 7
Tributary Cr 9	DV	7	3	1	11	11	0.00	11 - 11
	CO	5	4	1	10	10	0.00	10 - 10
	CT	0	0	0	0	---	---	---
	Sc	0	0	0	0	---	---	---

[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 (Lockwood and Schneider 2000).
[3] Capture data for 2001 and 2002 from USDA Forest Service.

APPENDIX 5. METALS IN JUVENILE FISH DATA

Appendix 5.1. Information on fish collected in 2000 through 2006 for whole body analysis of metals. Sample Number contains codes for date, water body, site, fish species, age, and replicate.

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	26.0	21.6	072301GC48DVJ01
ADF&G / FS	23-Jul-2001	Upper Greens Creek	Site 48	DV	137	28.8	23.7	072301GC48DVJ02
ADF&G / FS	23-Jul-2001	Upper Greens Creek	Site 48	DV	119	18.8	20.7	072301GC48DVJ03
ADF&G / FS	23-Jul-2001	Upper Greens Creek	Site 48	DV	121	21.1	22.8	072301GC48DVJ04
ADF&G / FS	23-Jul-2001	Upper Greens Creek	Site 48	DV	111	13.7	21.8	072301GC48DVJ05
ADF&G / FS	23-Jul-2001	Upper Greens Creek	Site 48	DV	121	21.1	20.3	072301GC48DVJ06
ADF&G	24-Jul-2002	Upper Greens Creek	Site 48	DV	133	23.2	24.3	072402GC48DVJ01
ADF&G	24-Jul-2002	Upper Greens Creek	Site 48	DV	120	15.0	19.2	072402GC48DVJ02
ADF&G	24-Jul-2002	Upper Greens Creek	Site 48	DV	122	17.5	22.1	072402GC48DVJ03
ADF&G	24-Jul-2002	Upper Greens Creek	Site 48	DV	127	20.8	21.2	072402GC48DVJ04
ADF&G	24-Jul-2002	Upper Greens Creek	Site 48	DV	134	24.8	21.5	072402GC48DVJ05
ADF&G	24-Jul-2002	Upper Greens Creek	Site 48	DV	128	21.7	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
ADNR	20-Jul-2006	Upper Greens Creek	Site 48	DV	110	15.8	21.2	072006GC48DVJ01
ADNR	20-Jul-2006	Upper Greens Creek	Site 48	DV	110	15.4	21.4	072006GC48DVJ02
ADNR	20-Jul-2006	Upper Greens Creek	Site 48	DV	113	16.1	23.3	072006GC48DVJ03
ADNR	20-Jul-2006	Upper Greens Creek	Site 48	DV	132	25.0	22.9	072006GC48DVJ04
ADNR	20-Jul-2006	Upper Greens Creek	Site 48	DV	104	12.8	21.0	072006GC48DVJ05
ADNR	20-Jul-2006	Upper Greens Creek	Site 48	DV	114	16.7	20.9	072006GC48DVJ06
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	30.5	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	15.7	22.2	072301GC06DVJ05
ADF&G / FS	23-Jul-2001	Middle Greens Creek	Site 6	DV	168	49.1	21.9	072301GC06DVJ06
ADNR	21-Jul-2006	Middle Greens Creek	Site 6	DV	103	12.6	21.7	072106GC06DVJ01
ADNR	21-Jul-2006	Middle Greens Creek	Site 6	DV	106	13.5	21.3	072106GC06DVJ02
ADNR	21-Jul-2006	Middle Greens Creek	Site 6	DV	96	11.8	21.0	072106GC06DVJ03
ADNR	21-Jul-2006	Middle Greens Creek	Site 6	DV	110	12.0	20.6	072106GC06DVJ04
ADNR	21-Jul-2006	Middle Greens Creek	Site 6	DV	128	23.2	22.0	072106GC06DVJ05
ADNR	21-Jul-2006	Middle Greens Creek	Site 6	DV	102	11.5	20.1	072106GC06DVJ06

Appendix 5.1. (Continued)

Collector	Date Collected	Location	Site	Fish Sp	FLength (mm)	Mass (g)	Solids (%)	Sample Number
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	6.0	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	19.3	26.1	072301GC54DVJ02
ADF&G / FS	23-Jul-2001	Greens Cr Below Pond D	Site 54	DV	107	15.7	23.5	072301GC54DVJ03
ADF&G / FS	23-Jul-2001	Greens Cr Below Pond D	Site 54	DV	109	13.6	21.1	072301GC54DVJ04
ADF&G / FS	23-Jul-2001	Greens Cr Below Pond D	Site 54	DV	105	13.5	22.8	072301GC54DVJ05
ADF&G / FS	23-Jul-2001	Greens Cr Below Pond D	Site 54	DV	138	27.5	22.1	072301GC54DVJ06
ADF&G	24-Jul-2002	Greens Cr Below Pond D	Site 54	DV	118	18.0	21.2	072402GC54DVJ01
ADF&G	24-Jul-2002	Greens Cr Below Pond D	Site 54	DV	128	22.3	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	18.9	21.3	072402GC54DVJ04
ADF&G	24-Jul-2002	Greens Cr Below Pond D	Site 54	DV	124	21.1	21.4	072402GC54DVJ05
ADF&G	24-Jul-2002	Greens Cr Below Pond D	Site 54	DV	123	20.9	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
ADNR	20-Jul-2006	Greens Cr Below Pond D	Site 54	DV	137	27.3	24.6	072006GC54DVJ01
ADNR	20-Jul-2006	Greens Cr Below Pond D	Site 54	DV	112	14.9	21.7	072006GC54DVJ02
ADNR	20-Jul-2006	Greens Cr Below Pond D	Site 54	DV	102	12.0	19.2	072006GC54DVJ03
ADNR	20-Jul-2006	Greens Cr Below Pond D	Site 54	DV	114	19.6	21.8	072006GC54DVJ04
ADNR	20-Jul-2006	Greens Cr Below Pond D	Site 54	DV	98	12.3	20.8	072006GC54DVJ05
ADNR	20-Jul-2006	Greens Cr Below Pond D	Site 54	DV	115	16.9	21.7	072006GC54DVJ06

Appendix 5.1. (Continued)

Collector	Date Collected	Location	Site	Fish Sp	FLength (mm)	Mass (g)	Solids (%)	Sample Number
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	9.1	22.1	072301TR09DVJ01
ADF&G / FS	23-Jul-2001	Tributary Creek	Site 9	DV	97	9.7	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	10.4	22.6	072301TR09DVJ04
ADF&G / FS	23-Jul-2001	Tributary Creek	Site 9	DV	86	6.4	22.2	072301TR09DVJ05
ADF&G / FS	23-Jul-2001	Tributary Creek	Site 9	DV	93	7.8	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	10.4	22.8	072402TR09DVJ02
ADF&G	24-Jul-2002	Tributary Creek	Site 9	DV	100	11.2	23.2	072402TR09DVJ03
ADF&G	24-Jul-2002	Tributary Creek	Site 9	DV	90	7.9	23.1	072402TR09DVJ04
ADF&G	24-Jul-2002	Tributary Creek	Site 9	DV	90	9.2	23.0	072402TR09DVJ05
ADF&G	24-Jul-2002	Tributary Creek	Site 9	DV	100	9.3	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
ADNR	21-Jul-2006	Tributary Creek	Site 9	DV	99	12.9	22.6	072106TR09DVJ01
ADNR	21-Jul-2006	Tributary Creek	Site 9	DV	96	11.6	24.0	072106TR09DVJ02
ADNR	21-Jul-2006	Tributary Creek	Site 9	DV	94	10.9	24.5	072106TR09DVJ03
ADNR	21-Jul-2006	Tributary Creek	Site 9	DV	100	10.9	21.8	072106TR09DVJ04
ADNR	21-Jul-2006	Tributary Creek	Site 9	DV	97	11.7	23.3	072106TR09DVJ05
ADNR	21-Jul-2006	Tributary Creek	Site 9	DV	117	20.8	23.7	072106TR09DVJ06

Appendix 5.2. Whole body concentrations of selected metals in fish collected in 2000-2006

Date Collected	Site	Analyte Basis	Ag mg/kg	Cd mg/kg	Cu mg/kg	Pb mg/kg	Se mg/kg	Zn mg/kg	Sample Number
23-Jul-2001	Site 48	dry wt	0.02	1.76	8.30	0.20	6.1	180	072301GC48DVJ01
23-Jul-2001	Site 48	dry wt	0.03	0.89	7.20	0.17	4.6	146	072301GC48DVJ02
23-Jul-2001	Site 48	dry wt	0.02	2.27	5.70	0.20	6.2	189	072301GC48DVJ03
23-Jul-2001	Site 48	dry wt	0.02	1.56	6.90	0.17	5.2	182	072301GC48DVJ04
23-Jul-2001	Site 48	dry wt	0.03	0.89	4.70	0.23	5.4	138	072301GC48DVJ05
23-Jul-2001	Site 48	dry wt	0.02	1.26	7.40	0.10	5.6	157	072301GC48DVJ06
24-Jul-2002	Site 48	dry wt	0.03	1.64	6.80	0.72	4.8	239	072402GC48DVJ01
24-Jul-2002	Site 48	dry wt	0.07	0.85	7.00	0.28	4.1	210	072402GC48DVJ02
24-Jul-2002	Site 48	dry wt	0.03	0.74	4.30	0.17	4.9	162	072402GC48DVJ03
24-Jul-2002	Site 48	dry wt	0.04	1.40	6.10	0.16	4.7	185	072402GC48DVJ04
24-Jul-2002	Site 48	dry wt	0.05	1.30	7.90	0.46	4.3	208	072402GC48DVJ05
24-Jul-2002	Site 48	dry wt	0.04	1.56	6.80	0.22	5.7	343	072402GC48DVJ06
22-Jul-2003	Site 48	dry wt	ND	0.65	4.2	0.14	5.6	191	072203GC48DVJ01
22-Jul-2003	Site 48	dry wt	ND	0.90	5.1	0.22	5.5	180	072203GC48DVJ02
22-Jul-2003	Site 48	dry wt	ND	0.82	5.6	0.16	5.4	241	072203GC48DVJ03
22-Jul-2003	Site 48	dry wt	ND	0.78	6.1	0.11	6.1	192	072203GC48DVJ04
22-Jul-2003	Site 48	dry wt	ND	0.63	3.9	0.14	5.2	174	072203GC48DVJ05
22-Jul-2003	Site 48	dry wt	ND	0.58	3.7	0.08	5.5	218	072203GC48DVJ06
22-Jul-2004	Site 48	dry wt	ND	0.63	4.7	0.15	4.3	206	072204GC48DVJ01
22-Jul-2004	Site 48	dry wt	ND	0.83	5.6	0.26	4.0	175	072204GC48DVJ02
22-Jul-2004	Site 48	dry wt	ND	1.54	4.6	0.21	4.1	183	072204GC48DVJ03
22-Jul-2004	Site 48	dry wt	ND	0.80	5.2	0.28	3.7	168	072204GC48DVJ04
22-Jul-2004	Site 48	dry wt	ND	1.25	4.4	0.14	6.4	220	072204GC48DVJ05
22-Jul-2004	Site 48	dry wt	0.03	1.01	4.5	0.29	5.6	323	072204GC48DVJ06
22-Jul-2005	Site 48	dry wt	0.02	0.66	4.4	0.44	4.2	183	072205GC48DVJ01
22-Jul-2005	Site 48	dry wt	ND	0.84	14.5	0.98	4.8	220	072205GC48DVJ02
22-Jul-2005	Site 48	dry wt	ND	0.89	4.3	0.66	4.8	226	072205GC48DVJ03
22-Jul-2005	Site 48	dry wt	0.02	0.59	6.0	0.32	4.8	178	072205GC48DVJ04
22-Jul-2005	Site 48	dry wt	0.03	1.10	18.8	0.79	4.6	217	072205GC48DVJ05
22-Jul-2005	Site 48	dry wt	0.03	0.47	3.6	0.36	3.8	160	072205GC48DVJ06
20-Jul-2006	Site 48	dry wt	0.04	0.56	8.50	0.37	5.40	244.00	072006GC48DVJ01
20-Jul-2006	Site 48	dry wt	0.05	1.20	8.30	0.31	6.00	217.00	072006GC48DVJ02
20-Jul-2006	Site 48	dry wt	0.04	0.65	6.30	0.24	5.40	264.00	072006GC48DVJ03
20-Jul-2006	Site 48	dry wt	0.06	0.63	8.14	0.66	5.19	231.70	072006GC48DVJ04
20-Jul-2006	Site 48	dry wt	0.08	0.96	8.50	0.37	5.10	283.00	072006GC48DVJ05
20-Jul-2006	Site 48	dry wt	0.03	0.63	5.30	0.20	5.10	270.00	072006GC48DVJ06
23-Jul-2001	Site 6	dry wt	0.04	1.94	16.70	1.24	5.0	173	072301GC06DVJ01
23-Jul-2001	Site 6	dry wt	0.03	0.84	4.60	1.00	4.5	167	072301GC06DVJ02
23-Jul-2001	Site 6	dry wt	0.03	0.82	5.30	1.94	4.3	171	072301GC06DVJ03
23-Jul-2001	Site 6	dry wt	0.03	1.52	5.40	1.78	4.5	215	072301GC06DVJ04
23-Jul-2001	Site 6	dry wt	0.02	0.89	11.10	0.33	5.3	126	072301GC06DVJ05
23-Jul-2001	Site 6	dry wt	0.04	0.73	8.00	1.96	4.6	169	072301GC06DVJ06
21-Jul-2006	Site 6	dry wt	0.03	0.71	8.00	0.70	5.20	183.00	072106GC06DVJ01
21-Jul-2006	Site 6	dry wt	0.04	0.81	12.00	0.62	5.60	271.00	072106GC06DVJ02
21-Jul-2006	Site 6	dry wt	0.03	0.56	12.70	0.97	4.50	215.00	072106GC06DVJ03
21-Jul-2006	Site 6	dry wt	0.03	0.56	7.70	0.92	5.90	223.00	072106GC06DVJ04
21-Jul-2006	Site 6	dry wt	0.03	0.95	5.40	1.31	4.40	221.00	072106GC06DVJ05
21-Jul-2006	Site 6	dry wt	0.02	0.63	6.50	0.86	4.50	302.00	072106GC06DVJ06

Appendix 5.2. (Continued)

Date Collected	Site	Analyte Basis	Ag mg/kg	Cd mg/kg	Cu mg/kg	Pb mg/kg	Se mg/kg	Zn mg/kg	Sample Number
21-Jun-2000	Site 54	dry wt	0.04	0.95	15.30	1.40	4.9	251	062100GCCOJ01
21-Jun-2000	Site 54	dry wt	0.09	0.66	11.70	1.21	4.7	224	062100GCCOJ02
21-Jun-2000	Site 54	dry wt	0.22	1.07	24.20	1.40	3.4	206	062100GCCOJ03
21-Jun-2000	Site 54	dry wt	0.10	0.97	24.00	1.12	3.5	181	062100GCCOJ04
21-Jun-2000	Site 54	dry wt	0.05	0.96	44.00	1.53	4.9	304	062100GCCOJ05
21-Jun-2000	Site 54	dry wt	0.08	1.47	36.10	5.02	4.7	340	062100GCCOJ06
23-Jul-2001	Site 54	dry wt	0.03	0.46	4.30	0.33	5.7	126	072301GC54DVJ01
23-Jul-2001	Site 54	dry wt	0.02	0.21	3.20	0.22	3.6	82	072301GC54DVJ02
23-Jul-2001	Site 54	dry wt	0.03	0.73	6.30	0.59	4.7	144	072301GC54DVJ03
23-Jul-2001	Site 54	dry wt	0.02	0.82	5.40	0.86	4.9	172	072301GC54DVJ04
23-Jul-2001	Site 54	dry wt	0.02	0.79	6.50	0.45	5.8	203	072301GC54DVJ05
23-Jul-2001	Site 54	dry wt	0.02	0.74	5.80	0.40	5.4	171	072301GC54DVJ06
24-Jul-2002	Site 54	dry wt	0.03	0.50	4.40	0.94	3.4	363	072402GC54DVJ01
24-Jul-2002	Site 54	dry wt	0.03	0.52	4.50	0.35	4.7	150	072402GC54DVJ02
24-Jul-2002	Site 54	dry wt	0.05	0.95	6.00	0.66	4.4	161	072402GC54DVJ03
24-Jul-2002	Site 54	dry wt	0.03	1.03	5.20	0.66	4.2	216	072402GC54DVJ04
24-Jul-2002	Site 54	dry wt	0.05	1.32	5.20	0.74	3.9	1.94	072402GC54DVJ05
24-Jul-2002	Site 54	dry wt	0.02	0.70	3.90	0.78	4.4	195	072402GC54DVJ06
22-Jul-2003	Site 54	dry wt	0.03	0.85	6.4	1.40	6.1	188	072203GC54DVJ01
22-Jul-2003	Site 54	dry wt	ND	0.67	4.2	0.32	6.4	174	072203GC54DVJ02
22-Jul-2003	Site 54	dry wt	ND	0.75	4.3	0.35	6.5	186	072203GC54DVJ03
22-Jul-2003	Site 54	dry wt	ND	1.11	5.8	0.38	5.7	188	072203GC54DVJ04
22-Jul-2003	Site 54	dry wt	ND	0.59	3.5	0.29	5.7	174	072203GC54DVJ05
22-Jul-2003	Site 54	dry wt	ND	0.91	4.1	0.43	6.5	263	072203GC54DVJ06
21-Jul-2004	Site 54	dry wt	0.02	0.79	11.0	0.57	4.6	232	072104GC54DVJ01
21-Jul-2004	Site 54	dry wt	ND	0.88	5.5	0.54	5.0	206	072104GC54DVJ02
21-Jul-2004	Site 54	dry wt	ND	1.26	5.1	0.36	5.3	164	072104GC54DVJ03
21-Jul-2004	Site 54	dry wt	0.03	0.79	5.9	0.28	5.4	191	072104GC54DVJ04
21-Jul-2004	Site 54	dry wt	ND	0.83	5.0	0.48	3.9	202	072104GC54DVJ05
21-Jul-2004	Site 54	dry wt	0.07	1.12	7.0	0.93	4.9	216	072104GC54DVJ06
22-Jul-2005	Site 54	dry wt	0.03	0.72	5.0	0.27	4.0	160	072205GC54DVJ01
22-Jul-2005	Site 54	dry wt	0.02	0.63	4.5	0.13	3.9	200	072205GC54DVJ02
22-Jul-2005	Site 54	dry wt	ND	0.73	8.8	0.17	4.7	223	072205GC54DVJ03
22-Jul-2005	Site 54	dry wt	ND	0.82	9.7	0.17	3.9	222	072205GC54DVJ04
22-Jul-2005	Site 54	dry wt	0.03	1.06	8.8	0.22	4.4	209	072205GC54DVJ05
22-Jul-2005	Site 54	dry wt	0.02	0.55	5.5	0.39	3.9	185	072205GC54DVJ06
20-Jul-2006	Site 54	dry wt	0.06	0.42	4.78	0.50	5.72	207.69	072006GC54DVJ01
20-Jul-2006	Site 54	dry wt	0.04	0.75	16.00	0.95	7.20	223.00	072006GC54DVJ02
20-Jul-2006	Site 54	dry wt	0.02	0.93	22.20	0.52	6.30	239.00	072006GC54DVJ03
20-Jul-2006	Site 54	dry wt	0.04	1.03	7.60	0.85	5.30	252.00	072006GC54DVJ04
20-Jul-2006	Site 54	dry wt	0.08	0.54	10.90	0.48	5.40	223.00	072006GC54DVJ05
20-Jul-2006	Site 54	dry wt	0.04	0.78	8.60	0.68	5.60	257.00	072006GC54DVJ06

Appendix 5.2. (Continued)

Date Collected	Site	Analyte Basis	Ag mg/kg	Cd mg/kg	Cu mg/kg	Pb mg/kg	Se mg/kg	Zn mg/kg	Sample Number
21-Jun-2000	Site 9	dry wt	0.04	0.42	16.20	1.03	3.2	213	062100TRCOJ01
21-Jun-2000	Site 9	dry wt	0.07	0.50	16.50	2.01	3.7	220	062100TRCOJ02
21-Jun-2000	Site 9	dry wt	0.12	0.75	11.20	1.63	3.8	194	062100TRCOJ03
21-Jun-2000	Site 9	dry wt	0.07	0.56	10.60	1.53	3.6	87.9	062100TRDVJ04
21-Jun-2000	Site 9	dry wt	0.06	0.58	12.80	1.59	3.5	204	062100TRDVJ05
21-Jun-2000	Site 9	dry wt	0.05	0.45	32.80	1.57	5.0	213	062100TRDVJ06
23-Jul-2001	Site 9	dry wt	0.09	0.35	4.30	0.56	6.8	127	072301TR09DVJ01
23-Jul-2001	Site 9	dry wt	0.10	0.77	5.20	0.67	8.0	118	072301TR09DVJ02
23-Jul-2001	Site 9	dry wt	0.15	0.92	5.40	4.88	5.3	144	072301TR09DVJ03
23-Jul-2001	Site 9	dry wt	0.15	0.86	6.70	2.19	---	99.1	072301TR09DVJ04
23-Jul-2001	Site 9	dry wt	0.08	0.76	4.90	0.33	6.2	106	072301TR09DVJ05
23-Jul-2001	Site 9	dry wt	0.06	0.37	12.00	0.38	6.8	122	072301TR09DVJ06
24-Jul-2002	Site 9	dry wt	0.02	0.22	3.70	0.12	1.4	144	072402TR09DVJ01
24-Jul-2002	Site 9	dry wt	0.07	1.20	5.50	1.66	3.3	172	072402TR09DVJ02
24-Jul-2002	Site 9	dry wt	0.13	1.06	6.10	3.40	5.0	138	072402TR09DVJ03
24-Jul-2002	Site 9	dry wt	0.23	1.29	7.10	4.08	5.2	168	072402TR09DVJ04
24-Jul-2002	Site 9	dry wt	0.08	1.15	5.20	1.39	6.2	150	072402TR09DVJ05
24-Jul-2002	Site 9	dry wt	0.04	0.84	3.20	0.33	5.4	152	072402TR09DVJ06
23-Jul-2003	Site 9	dry wt	0.06	0.46	2.8	0.34	6.3	134	072304TR09DVJ01
23-Jul-2003	Site 9	dry wt	0.10	1.01	4.0	0.82	6.0	131	072304TR09DVJ02
23-Jul-2003	Site 9	dry wt	0.16	1.35	4.4	1.85	5.7	108	072304TR09DVJ03
23-Jul-2003	Site 9	dry wt	0.19	0.69	5.6	1.30	3.6	136	072304TR09DVJ04
23-Jul-2003	Site 9	dry wt	0.05	0.72	4.4	0.56	4.9	131	072304TR09DVJ05
23-Jul-2003	Site 9	dry wt	0.12	0.76	3.9	0.78	4.7	125	072304TR09DVJ06
21-Jul-2004	Site 9	dry wt	0.10	0.96	3.2	1.19	5.4	169	072104TR09DVJ01
21-Jul-2004	Site 9	dry wt	0.10	1.24	3.8	0.67	5.9	138	072104TR09DVJ02
21-Jul-2004	Site 9	dry wt	0.10	2.02	4.0	1.75	5.7	125	072104TR09DVJ03
21-Jul-2004	Site 9	dry wt	0.04	0.47	3.7	0.93	4.8	175	072104TR09DVJ04
21-Jul-2004	Site 9	dry wt	0.09	2.34	4.3	1.44	8.2	140	072104TR09DVJ05
21-Jul-2004	Site 9	dry wt	0.11	0.83	5.5	0.97	5.8	161	072104TR09DVJ06
23-Jul-2005	Site 9	dry wt	0.06	0.70	10.4	0.29	6.4	104	072305TR09DVJ01
23-Jul-2005	Site 9	dry wt	0.10	0.63	4.7	0.97	6.1	122	072305TR09DVJ02
23-Jul-2005	Site 9	dry wt	0.07	0.52	6.3	0.53	5.8	109	072305TR09DVJ03
23-Jul-2005	Site 9	dry wt	0.19	0.79	9.9	1.07	6.7	117	072305TR09DVJ04
23-Jul-2005	Site 9	dry wt	0.07	1.44	5.2	1.00	8.1	130	072305TR09DVJ05
23-Jul-2005	Site 9	dry wt	0.10	1.29	4.6	0.46	8.0	134	072305TR09DVJ06
21-Jul-2006	Site 9	dry wt	0.12	0.74	4.00	0.32	6.30	120.00	072106TR09DVJ01
21-Jul-2006	Site 9	dry wt	0.12	0.76	7.70	1.32	6.80	157.00	072106TR09DVJ02
21-Jul-2006	Site 9	dry wt	0.18	1.59	10.30	2.48	4.90	160.00	072106TR09DVJ03
21-Jul-2006	Site 9	dry wt	0.11	1.34	8.50	1.46	5.20	142.00	072106TR09DVJ04
21-Jul-2006	Site 9	dry wt	0.14	0.88	4.60	0.96	5.20	107.00	072106TR09DVJ05
21-Jul-2006	Site 9	dry wt	0.24	1.29	4.30	2.92	5.88	129.30	072106TR09DVJ06