Technical Report No. 10-02

Aquatic Biomonitoring at Red Dog Mine, 2009
National Pollution Discharge Elimination System
Permit No. AK-003865-2

by Alvin G. Ott and William A. Morris

Aufeis in Grayling Junior Creek on July 7, 2009
Adult Arctic Grayling Observed Throughout This Reach
Photograph by Bill Morris

May 2010

Alaska Department of Fish and Game
Division of Habitat

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Acknowledgements

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Dr. Phyllis Weber Scannell (Scannell Technical Services) updated our long-term water quality data base with 2009 information. Ms. Nora Foster (NRF Taxonomic Services) was responsible for sorting and identification of aquatic invertebrates collected with drift nets. Mr. Jack Winters and Mr. Robert Napier provided constructive review of our report.

Executive Summary

• Metals concentrations (Cd, Pb, and Zn) in Mainstem Red Dog Creek exceed those found in North Fork Red Dog, Ikalukrok, and Buddy creeks. Metals concentrations in Mainstem Red Dog Creek are lower than those reported pre-mining. There are no apparent trends for increasing metals concentrations in Mainstem Red Dog, North Fork Red Dog, and Buddy creeks. Metal concentrations (Cd, Pb, and Zn) in Bons Pond remain unchanged for the last five years. Ni concentrations are still elevated in Middle Fork Red Dog Creek with the highest concentrations coming from Rachael Creek. Total dissolved solids (TDS), conductivity, and sulfate are higher than baseline data – these higher concentrations are directly related to the higher TDS associated with the waste water treatment effluent.

• Algal biomass, as measured by chlorophyll-a concentration, is sampled each year at a number of sites in the Red Dog Creek and Bons/Buddy Creek drainages. Generally, chlorophyll-a concentrations are highest in North Fork Red Dog, Bons, and Buddy creeks compared to Middle Fork Red Dog, Mainstem Red Dog, and Ikalukrok creeks. Chlorophyll-a concentrations track with changes in metals concentrations in Ikalukrok Creek at Station 9, a site that is not affected by wastewater discharge or drainage from the Red Dog Mine. Fish use is higher in those systems exhibiting higher chlorophyll-a concentrations.

• Aquatic invertebrate densities appear to be a relatively good measure of stream productivity. Higher densities were found in the Bons and Buddy Creek and North Fork Red Dog Creek sites. Lower densities are found in sample sites with the higher metals concentrations (Middle Fork Red Dog Creek). The percentage of Ephemeroptera, Plecoptera, and Tricoptera (EPT) which normally would be higher in cleaner water does not reflect this pattern for the Red Dog sites. No apparent differences are seen in taxa richness for all sites among sample years.

• Juvenile Dolly Varden are collected each year from selected sites (Mainstem Red Dog, Buddy, and Anxiety Ridge creeks) and are analyzed for whole body metal concentrations. Of the metals discussed, there is less difference among the three sample sites for Se than for the other metals (Cd, Pb, and Zn). Both Cd and Pb have been decreasing in juvenile Dolly Varden taken from Mainstem Red Dog Creek since 2007 and Zn concentrations have been decreasing since 2006. Previous results suggest that length was not related to metals loading, but we now suspect that age class of fish may be influential. There is some indication that perhaps age-1, age-2, and age-3 fish may differ slightly in metals loading. Based on these data and the analysis, we plan to be more diligent in retaining only juvenile Dolly Varden from 90 to 140 mm.

• Adult Dolly Varden from the Wulik River have been sampled for Al, Cd, Cu, Pb, and Zn concentrations in gill, kidney, liver, muscle, and reproductive tissue since 1990. Se was added in 1997 and in 2003, Hg was included in the analyte matrix. None of the analytes measured have been found to concentrate in muscle tissue. Various metals do

concentrate in specific tissues: Al in gill, Cd in kidney, Cu in liver, Pb in gill, Se in kidney and ovary, Zn in ovary, and Hg in kidney. However, it is highly unlikely that tissue metals concentrations or changes could be related to events at the Red Dog Mine since large Dolly Varden attain their growth in the marine environment.

• The number of Dolly Varden is estimated each fall in the Wulik River. There is no indication, based on surveys conducted before and after mining, that the estimated number of fish overwintering in the Wulik River has exhibited a trend of increasing or decreasing numbers. Aerial surveys prior to mine development found that 90% of the Dolly Varden in the Wulik River are located below the mouth of Ikalukrok Creek. Surveys post mining continue to find that 90% of the fish counted in the fall are found downstream of the mouth of Ikalukrok Creek.

• Annual aerial surveys are made to assess the distribution of chum salmon in Ikalukrok Creek. Aerial counts of adult chum salmon after mine development in 1990 and 1991 were much lower than those reported in baseline studies. The highest estimated number of chum salmon was 4,185 in 2006. Fairly large returns of chum salmon (890 to 3,820) have been seen in 2001, 2002, 2006, 2007, 2008, and 2009.

• With almost 20 years of sampling for juvenile Dolly Varden in streams near the Red Dog Mine, we have developed the following conclusions: abundance is higher in the upper reaches of each sampled stream; and peak use occurs from late July to late August depending upon fall water temperatures which likely trigger outmigration. Although catches vary annually, juvenile Dolly Varden are most abundant in Anxiety Ridge and Buddy creeks. Juvenile Dolly Varden continue to use Mainstem Red Dog Creek for rearing.

• The Arctic grayling spring migration of fish into North Fork Red Dog Creek was strong in spring 2009. Part of the recruitment seen is from fish leaving Bons Pond and returning to North Fork Red Dog Creek. Breakup was late in 2009 and spawning was judged to be substantially completed by June 12. Most of the Arctic grayling spawning occurred in Mainstem Red Dog Creek in 2009, but very few fry were seen in July and August.

• Pre-mining slimy sculpin abundance is unknown, but baseline data reports indicated that this species was numerous in the Ikalukrok Creek drainage, but uncommon in the Red Dog Creek drainage. We did catch 3 large slimy sculpin (133, 129, and 132 mm) in spring 2008 and 4 large slimy sculpin (132, 134, 136, and 142) in spring 2009 in the North Fork Red Dog Creek fyke net. The overall trend appears to be for an increasing number of slimy sculpin in Mainstem Red Dog Creek. Slimy sculpin are indicators of good water quality and thus these data suggest that conditions in the system have improved over time.

Introduction

The Red Dog zinc (Zn) and lead (Pb) deposit is located in northwestern Alaska, about 130 km north of Kotzebue and 75 km inland from the Chukchi Sea coast (Figure 1). Mine operations, facilities, surrounding vegetation, and wildlife are described in Weber Scannell and Ott (1998). A chronology of development and operations at the Red Dog Mine is presented in Appendix 1. Aquatic resources in the Wulik River drainage are described in Weber Scannell et al. 2000.

In July 1998, the US Environmental Protection Agency (EPA) issued a draft National Pollution Discharge Elimination System Permit No. AK-003865-2 (NPDES Permit) to Teck Cominco Alaska Inc. (now officially referred to as Teck) to allow discharge of up to 2.418 billion gallons of treated effluent per year. The Alaska Department of Environmental Conservation (ADEC) issued a Certificate of Reasonable Assurance and the NPDES permit became effective August 28, 1998.

The NPDES Permit requires biomonitoring of fish, aquatic invertebrates, and periphyton in streams downstream from and adjacent to the Red Dog Mine. Although the NPDES Permit expired August 28, 2003, it was administratively extended until such time as a new permit is issued. Aquatic biomonitoring has continued annually as required by the NPDES Permit. Our report contains results of studies undertaken by the Alaska Department of Fish and Game (ADF&G) in 2009 and comparisons of the 2009 data set with previous years.

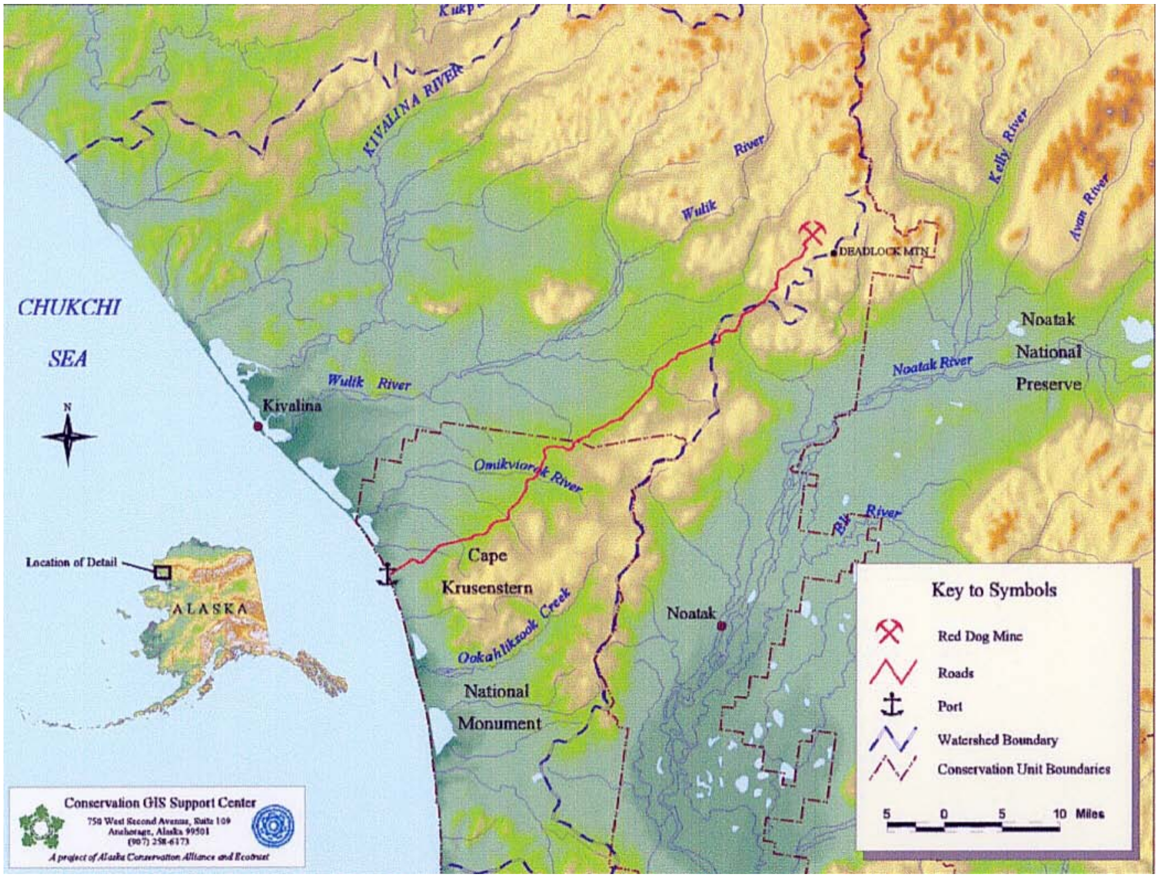

Figure 1. Location of the Red Dog Mine in northwestern Alaska. Map used with permission of Conservation GIS Support Center, Anchorage, Alaska.

Structure of Report

Water quality, periphyton standing crop, and aquatic invertebrate data are presented in the first three sections of our report. Metals concentration data for juvenile Dolly Varden (*Salvelinus malma*) collected from small streams near the mine and for adult Dolly Varden collected from the Wulik River are then presented. Aerial survey estimates of overwintering Dolly Varden in the Wulik River and chum salmon (*Oncorhynchus keta*) spawners in Ikalukrok Creek are covered next. Finally, biological monitoring data for Dolly Varden juveniles, Arctic grayling (*Thymallus arcticus*), and slimy sculpin (*Cottus cognatus*) are discussed.

Location of Sample Sites

Biomonitoring is conducted in streams adjacent to and downstream from the Red Dog Mine as required under the EPA NPDES Permit No. AK-003865-2 (Table 1, Figure 2). A description of the site location and Station Number is presented in Table 1. A site map of the Red Dog Creek drainage with sample locations shown is presented in Figure 3.

Table 1. Sample site locations for NPDES biomonitoring.

Stream of Site Name	Station Number
Ikalukrok Creek downstream of Dudd Creek	Station 7
Ikalukrok Creek upstream of Dudd Creek	no station #
Ikalukrok Creek downstream of Mainstem Red Dog Creek	Station 8
Ikalukrok Creek upstream of Mainstem Red Dog Creek	Station 9
Mainstem Red Dog Creek	Station 10
North Fork Red Dog Creek	Station 12
Middle Fork Red Dog Creek	Station 20

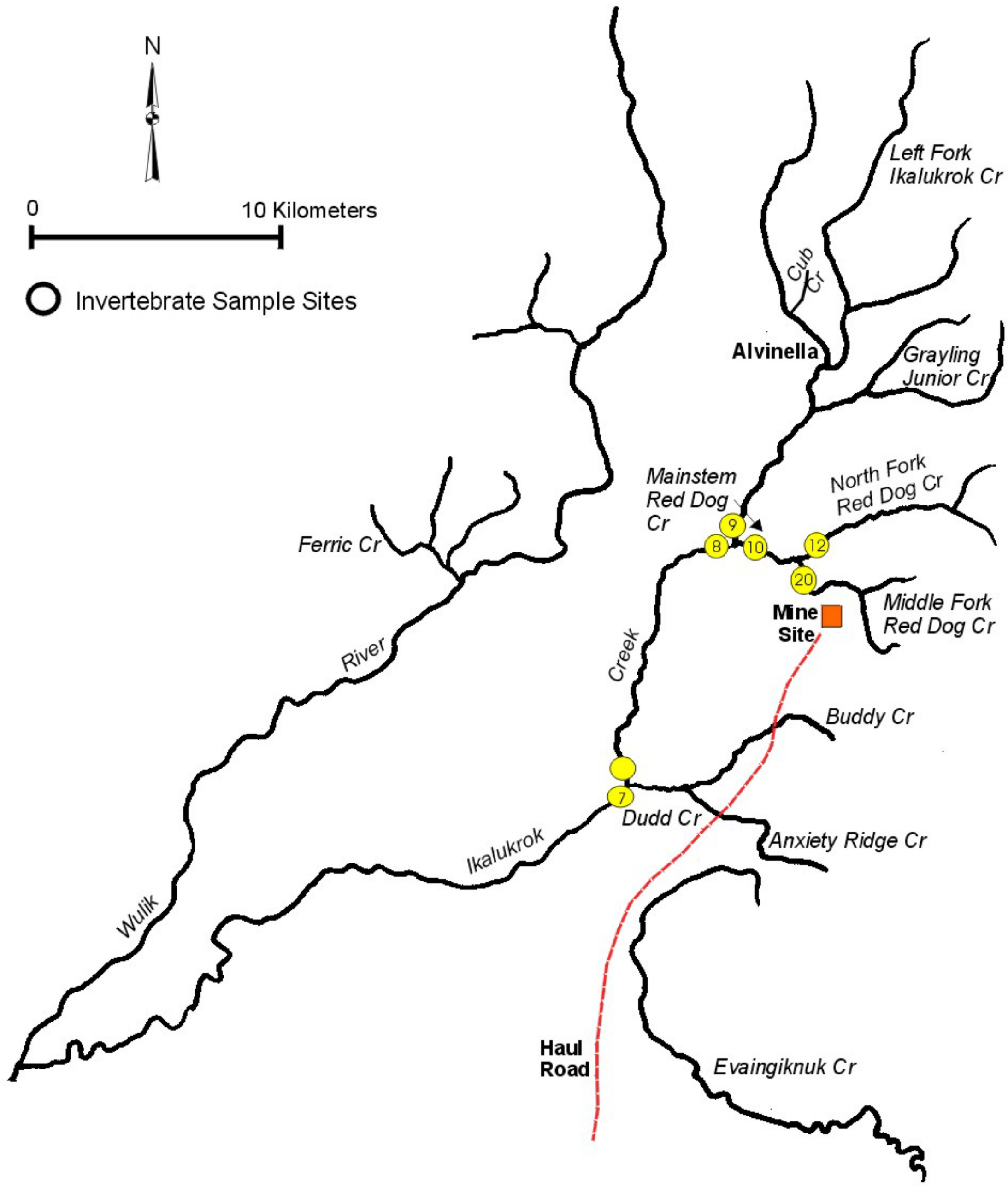

Figure 2. Location of sample sites in the Ikalukrok Creek drainage for aquatic invertebrate and periphyton sampling. The site in Ikalukrok Creek immediately upstream of Dudd Creek does not have a numerical designation.

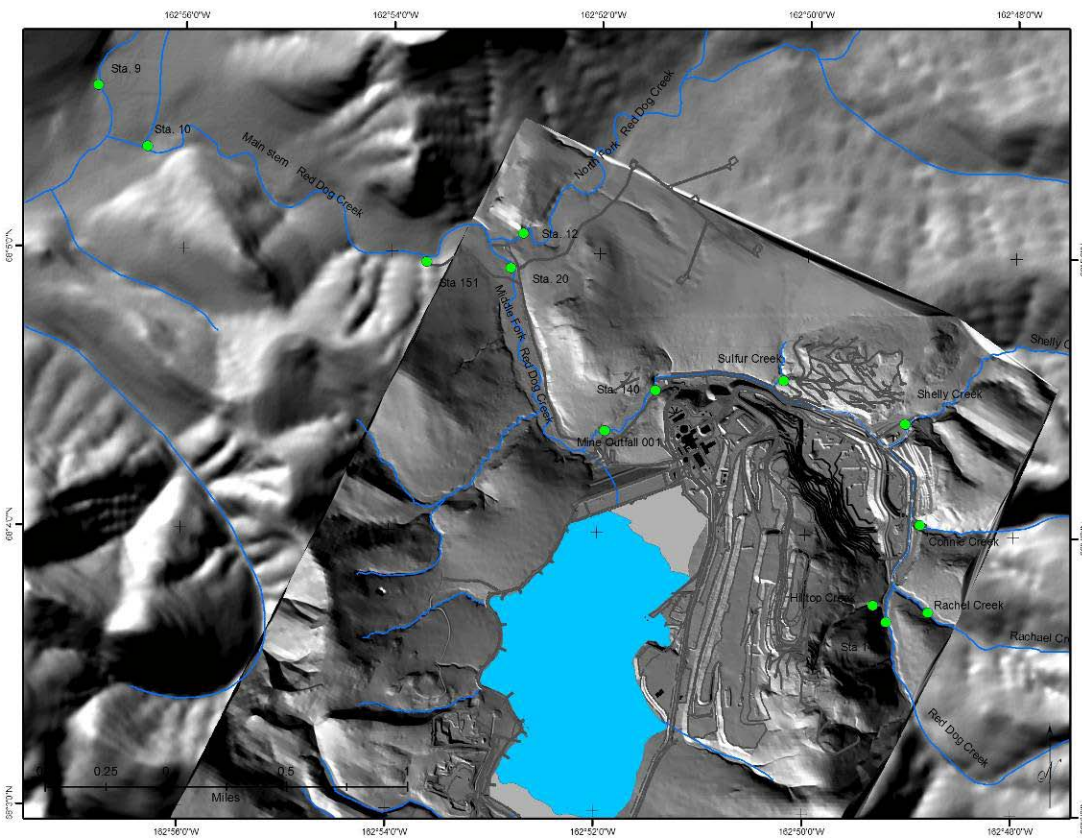

Figure 3. Location of sample sites in the Red Dog Creek drainage (map provided by Teck).

Supplemental biomonitoring in the Bons and Buddy Creek drainages is conducted under a voluntary agreement between Teck and the ADEC. Water quality data are collected at sites in these drainages by Teck. The ADF&G conducts biological sampling at four sites in the Bons and Buddy Creek drainages (Figure 4).

- Bons Creek, about 200 m upstream of Bons Pond;
- Bons Creek, downstream of Bons Pond and about 50 m upstream from its confluence with Buddy Creek (Station 220);
- Buddy Creek, about 50 m upstream of the Haul Road (Station 221); and
- Buddy Creek, below the waterfall that is a barrier to upstream movement of fish.

Arctic grayling were transplanted into Bons Pond in 1994 and 1995. In 1994, 107 juvenile and adult Arctic grayling were moved from North Fork Red Dog Creek to Bons Pond. In 1995, about 200 Arctic grayling fry were transported from North Fork Red Dog Creek to Bons Pond. In summer 2003, Ott and Townsend (2003) reported that an Arctic grayling population had been established in Bons Pond. Prior to the fish transplant, fish were absent from the Bons and upper Buddy Creek drainages by an impassable waterfall located about 1.6 km below Bons Pond.

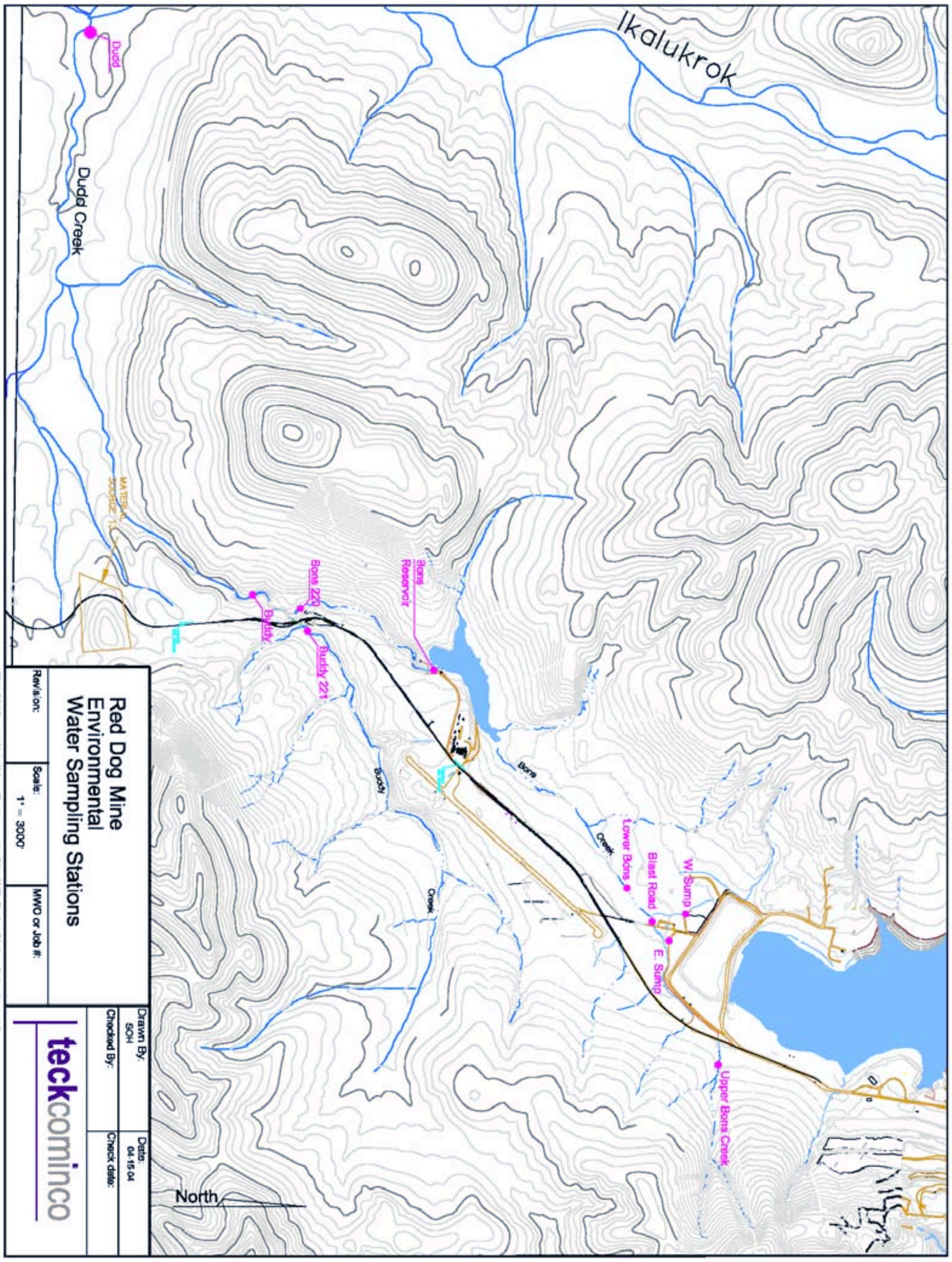

Figure 4. Bons and Buddy creeks and Bons Pond (map provided by Teck).

Description of Streams

All streams in the study area are in the Wulik River drainage, except for Evaingiknuk Creek, which is in the Noatak River drainage. Station numbers correspond either to those used by Dames and Moore (1983) during baseline work or to the current water quality program being conducted by Teck. Water quality and fish data collected during baseline studies (1979 to 1982) represent pre-mining conditions. Each monitoring component and sample site listed in Table 2 is required by either the NPDES Permit No. AK-003865-2 or the ADEC Certificate of Reasonable Assurance. Supplemental sampling not required by permits also is conducted to further our understanding of aquatic communities (Table 3). Ott and Morris (2007) summarized aquatic biomonitoring in Bons Pond and Bons and Buddy Creeks from 2004 through 2006. Aquatic biomonitoring in the Bons and Buddy Creek drainages continued in summer 2009.

Table 2. Study sites and components required by NPDES Permit and ADEC Certificate of Reasonable Assurance.

Ikalukrok Creek Stations 7, 8, 9, and upstream of Dudd Creek Creek	periphyton (as chlorophyll-a, mg/m^2) aquatic invertebrates (taxa richness, density) fish presence and use
Mainstem Red Dog (10), North Fork Red Dog (12) Creeks	periphyton (as chlorophyll-a, mg/m^2) aquatic invertebrates (taxa richness, density) fish presence and use
Middle Fork Red Dog Creek (20)	periphyton (as chlorophyll-a, mg/m^2) aquatic invertebrates (taxa richness, density)
Ikalukrok Creek	chum salmon aerial survey
Wulik River	Dolly Varden fall aerial survey
Anxiety Ridge, Evaingiknuk, and Buddy Creeks	fish presence and use

Table 3. Study sites and components of supplemental biomonitoring in 2009.

Ikalukrok Creek, upstream of Mainstem Red Dog Creek	aerial Arctic grayling surveys
Mainstem Red Dog Creek	juvenile Dolly Varden, whole body metal analyses fish presence and use downstream of North Fork spawning condition of Arctic grayling (spent, ripe) mark-recapture of Arctic grayling
North Fork Red Dog Creek	spawning condition of Arctic grayling (spent, ripe) mark-recapture of Arctic grayling
Buddy Creek, below waterfalls	periphyton (as chlorophyll-a, mg/m^2) aquatic invertebrates (taxa richness, density) juvenile Dolly Varden, whole body metal analyses
Buddy Creek, above Haul Road	periphyton (as chlorophyll-a, mg/m^2) aquatic invertebrates (taxa richness, density) fish presence and use
Bons Creek, below Bons Pond	periphyton (as chlorophyll-a, mg/m^2) aquatic invertebrates (taxa richness, density) fish presence and use
Bons Pond	fish presence and use mark-recapture of Arctic grayling Arctic grayling population estimate
Bons Creek, above Bons Pond	periphyton (as chlorophyll-a, mg/m^2) aquatic invertebrates (taxa richness, density) fish presence and use spawning condition of Arctic grayling (spent, ripe) mark-recapture of Arctic grayling

Methods Used for NPDES Biomonitoring

All methods used for the NPDES biomonitoring study are described by ADF&G (1998) and submitted to EPA for their approval and comment. Only minor modifications, as described by Ott and Weber Scannell (2003), have been made.

The method detection limit (MDL) in 2000 for copper (Cu), Pb, and selenium (Se) was 50, 20, and 50 *u*g/L, respectively, for a portion of the samples early in the ice-free season. MDL's were changed part way through summer 2000 for Cu, Pb, and Se to 1, 2, and 1 *u*g/L respectively. Because of the high MDLs used in early 2000, water quality data for these samples are not presented.

Water quality data presented in our report are for "total recoverable." All water quality data are provided by Teck. The number of water quality samples taken each year varies with the permit condition requirements, but for most analytes samples are collected twice each month with a sample size of 9 to 13 for each ice-free season.

Results and Discussion

Water Quality

Water samples are collected each year by Teck at a number of sites, including those required under the NPDES Permit. Sampling occurs twice each month during the open water season. As we did in last year's report, we focus on several key sites that depict whether water quality conditions are changing. Key sites include Mainstem Red Dog Creek (Stations 151 and 10), North Fork Red Dog Creek (Station 12), Ikalukrok Creek upstream of Red Dog Creek (Station 9), and Buddy Creek (below confluence with Bons Creek) (Appendix 2). North Fork Red Dog Creek, Ikalukrok Creek at Station 9, and Buddy Creek are not directly affected by the mine wastewater discharge. Mainstem Red Dog Creek is directly affected by the mine wastewater effluent and by water from the clean water bypass (Figure 5).

Figure 5. Mainstem Red Dog Creek at Station 10 on July 3, 2009. Adult Arctic grayling were observed in deep water pools in the sample reach.

Teck continued to maintain the mine's clean water bypass system which picks up water from Sulfur, Shelly, Connie, Rachael, and Middle Fork Red Dog creeks and moves the water through the active pit area via a combination of culverts and lined open ditch. Pb and Zn concentrations at Station 10, downstream of the clean water bypass system, indicate that both of these elements are lower now than they were pre-mining, with the exception of several maximum Pb concentrations (Figures 6 and 7, Appendix 2). Median Pb concentrations remain consistently lower than pre-mining (Figure 6).

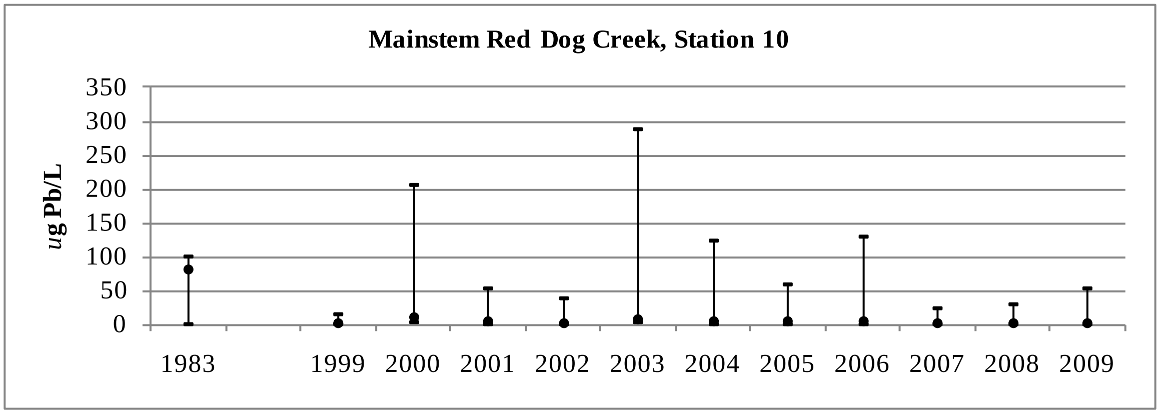

Figure 6. Median, maximum, and minimum Pb concentrations at Station 10.

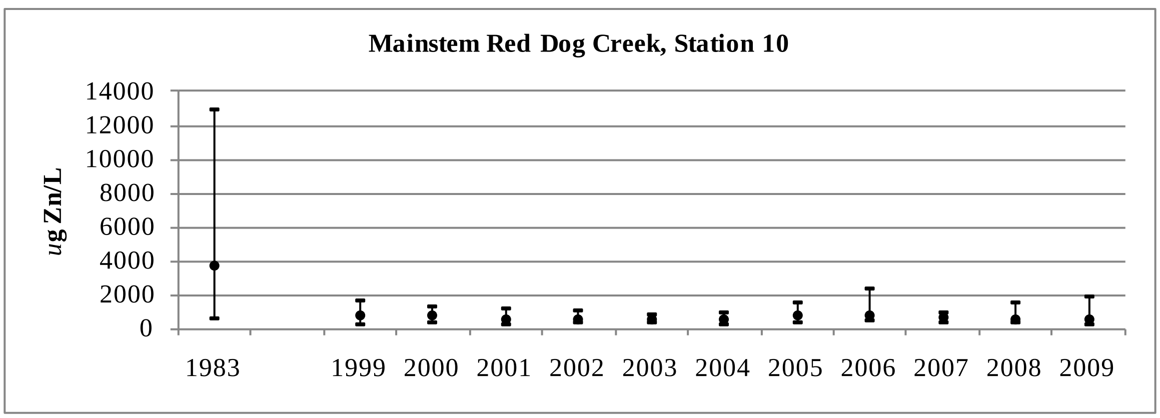

Figure 7. Median, maximum, and minimum Zn concentrations at Station 10.

We continued to evaluate water quality data being collected in Mainstem Red Dog Creek at Station 10 as part of the ongoing biomonitoring program. Median Al concentrations at

Station 10 continue to be lower than pre-mining (Figure 8). Cd concentrations at Station 10 also continue to be lower than pre-mining conditions (Figure 9). Maximum values for both Al (215 *u*g/L) and Cd (16.6 *u*g/L) occurred in May during spring breakup.

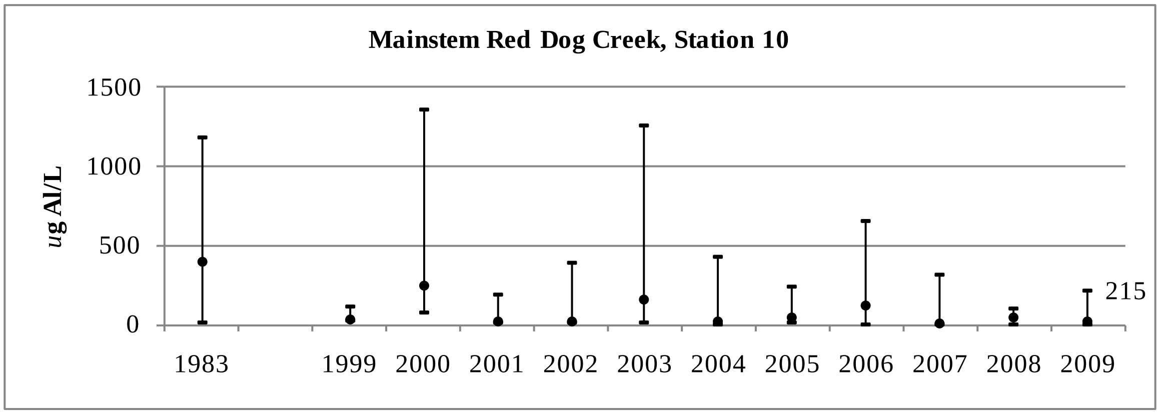

Figure 8. Median, maximum, and minimum Al concentrations at Station 10.

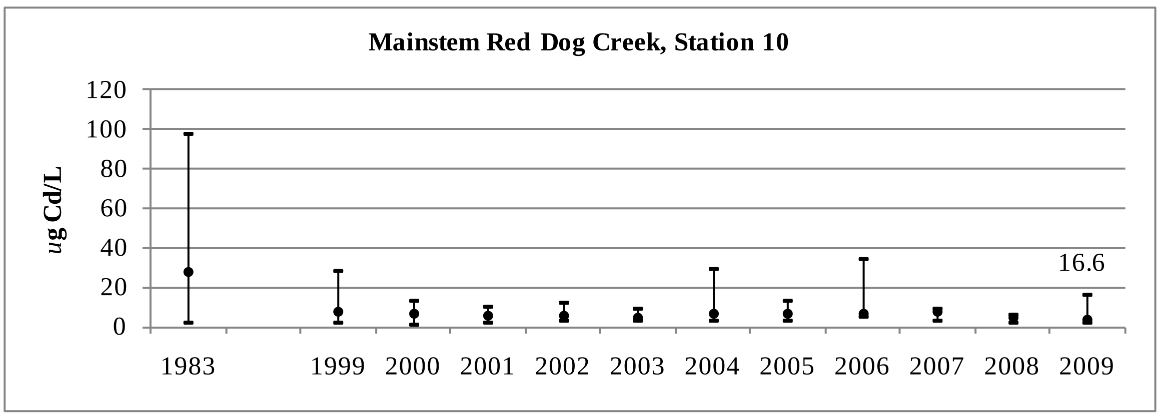

Figure 9. Median, maximum, and minimum Cd concentrations at Station 10.

Specific conductance at Station 10 is higher than pre-mining. Higher specific conductance is directly related to higher TDS associated with the treated wastewater discharge at Station 001 (Figure 10). Specific conductance has remained relatively stable since 1999.

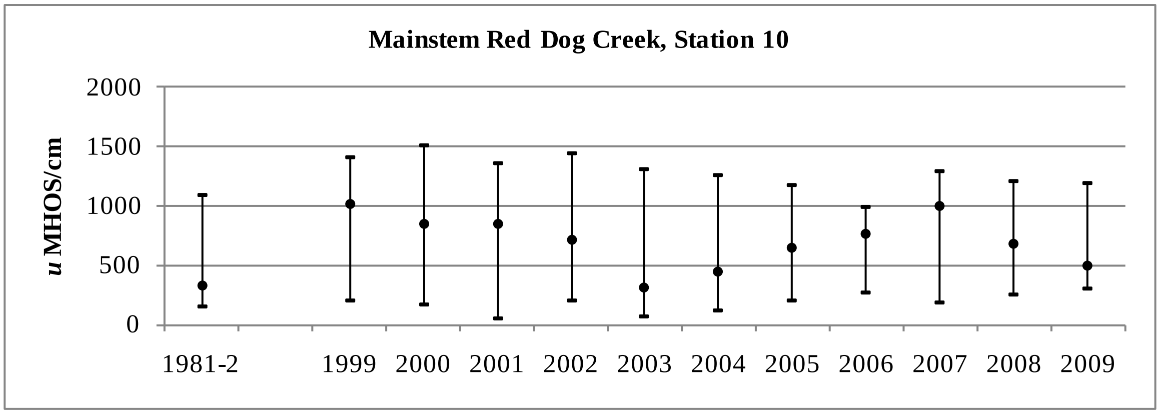

Figure 10. Median, maximum, and minimum specific conductance at Station 10.

Cu concentrations for baseline conditions and from 1999 through 2008 are presented in Figure 11. Data for 2000 are not presented for reasons stated in the methods section of this report. Median Cu concentrations except for 2003 are lower than baseline data. The maximum Cu concentration (5.3 *u*g/L) in 2009 occurred during spring breakup.

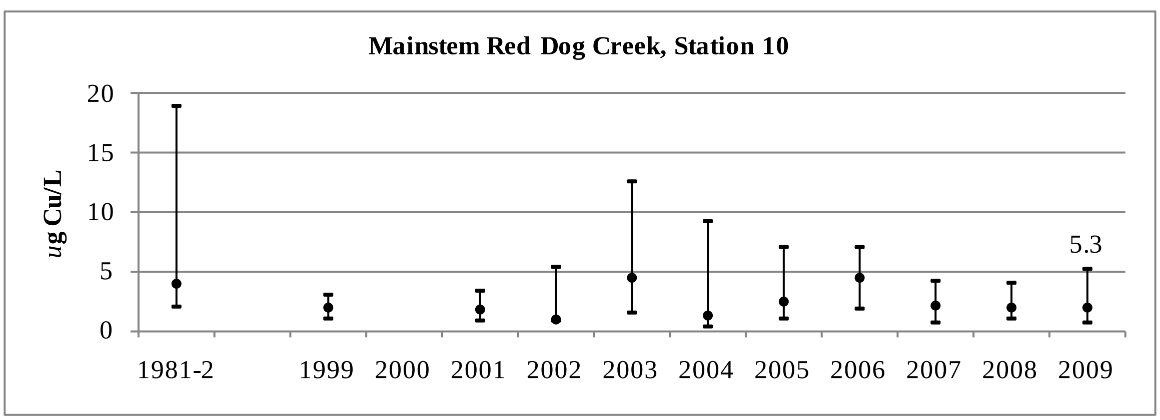

Figure 11. Median, maximum, and minimum Cu concentrations at Station 10.

Baseline data for Fe are not available. There has been no apparent increase or decrease in Fe concentrations at Station 10 from 1999 through 2009 (Figure 12). Median concentrations of Fe were highest in 2000 (827 *u*g/L) and 2006 (326 *u*g/L) and lowest in 2002 and 2007 (40 *u*g/L).

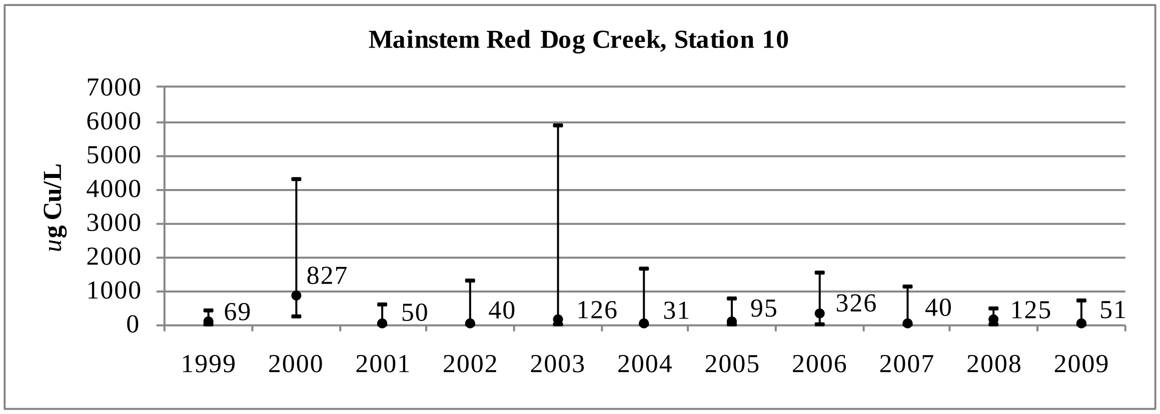

Figure 12. Median, maximum, and minimum Fe concentrations at Station 10. The values shown are the median Fe concentration.

Baseline data for Ni are not available. Ni concentrations at Station 10 have increased in recent years (Figure 13). Higher median Ni concentrations were observed first in 2006 (19.05 *u*g) and have remained high in 2007, 2008, and 2009.

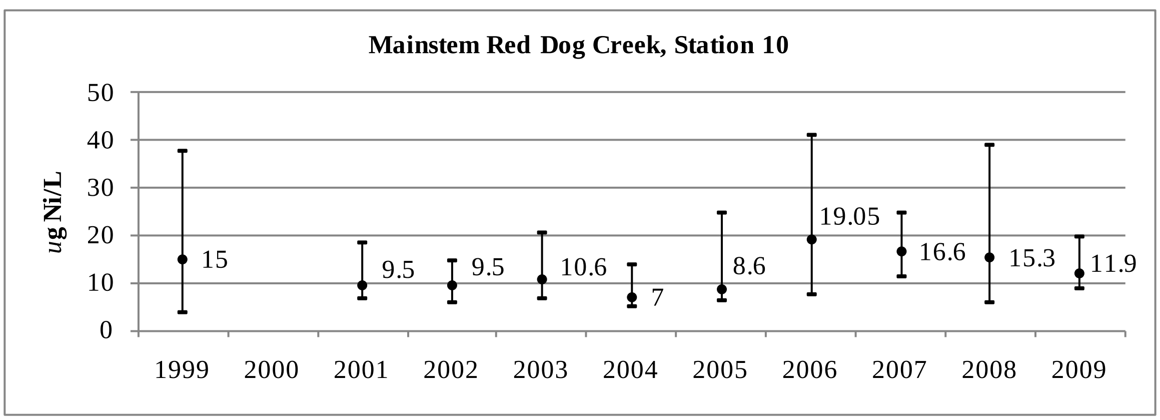

Figure 13. Median, maximum, and minimum Ni concentrations at Station 10. The values shown are the median Ni concentration.

Water quality data are collected by Teck in tributaries to the clean water bypass. In past years, when metals concentrations have increased in the bypass system, they generally have originated from either Connie or Rachael creeks. Ni concentrations at various sites upstream (Station 145, Middle Fork above bypass), in tributaries to the bypass (Rachael, Connie, Shelley), and downstream (Stations 20 and 10) are presented in Figure 14. The major source of Ni continues to be Rachael Creek and it is clear that the outfall input (i.e., wastewater discharge) substantially decreases Ni concentrations immediately downstream at Station 20 (Middle Fork Red Dog Creek) and that input from North Fork Red Dog Creek reduces it further at Station 10. These data show essentially the same pattern as those collected in 2008 (Ott and Morris 2009); however, the median nickel concentration in Rachael Creek decreased from 394 *u*g/L in 2008 to 298 *u*g/L in 2009.

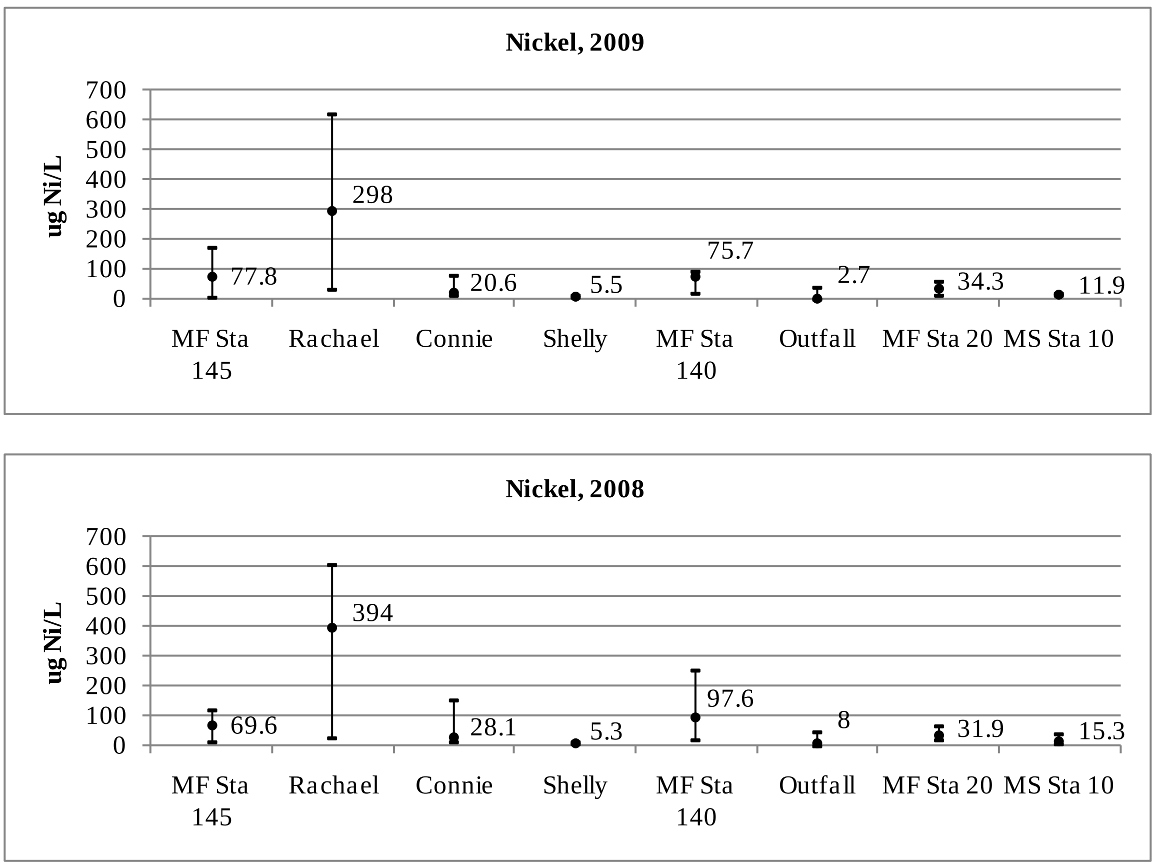

Figure 14. Median, maximum, and minimum Ni concentrations at various sites along and downstream of the clean water bypass (median Ni values shown).

The pH at Station 10 has been fairly consistent since 1999 (Figure 15). Generally, the pH is slightly more basic than pre-mining and has not dropped below 6 as seen in 1990. The 1990 data set is during mining, but prior to construction of the clean water bypass. The bypass system was constructed in late winter prior to spring breakup 1991. Numerous modifications and improvements to the clean water bypass system have been made since the initial construction (key construction and maintenance events are included in Appendix 1).

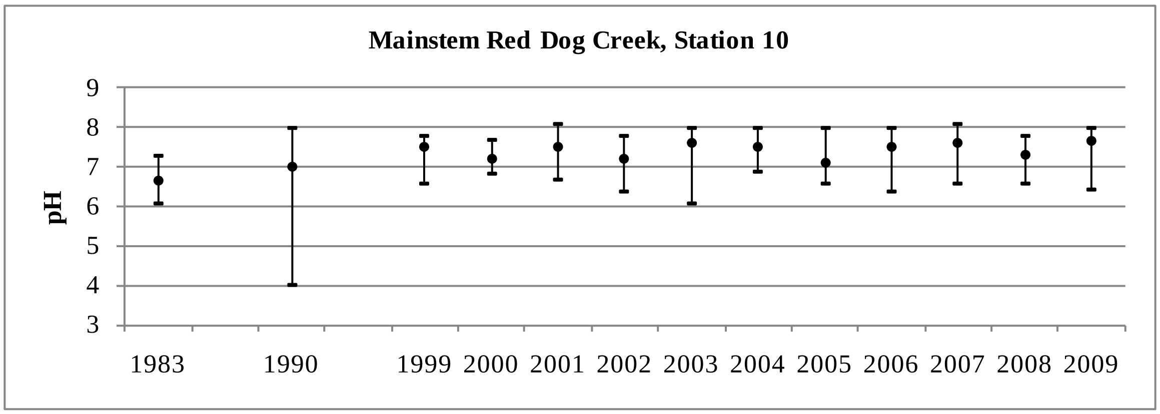

Figure 15. Median, maximum, and minimum pH values at Station 10.

Pre-mining Se data are not available. Median Se concentrations have been similar since 1999 (Figure 16).

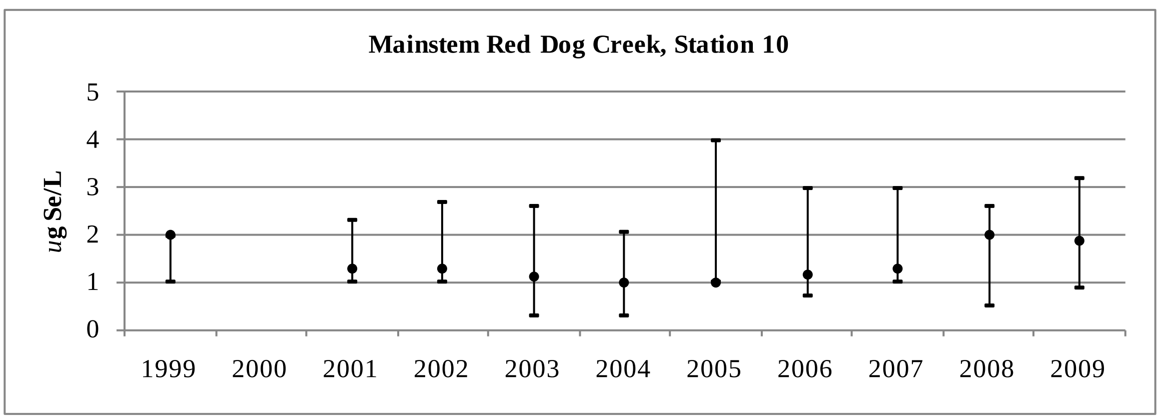

Figure 16. Median, maximum, and minimum Se concentrations at Station 10.

Sulfate concentrations at Station 10 have varied among the sample years and are higher compared to baseline data (Figure 17). The higher sulfate concentrations are directly associated with the higher TDS concentrations in the treated water effluent (Figure 18). The majority of TDS in the water consists of $CaSO_4$ (gypsum).

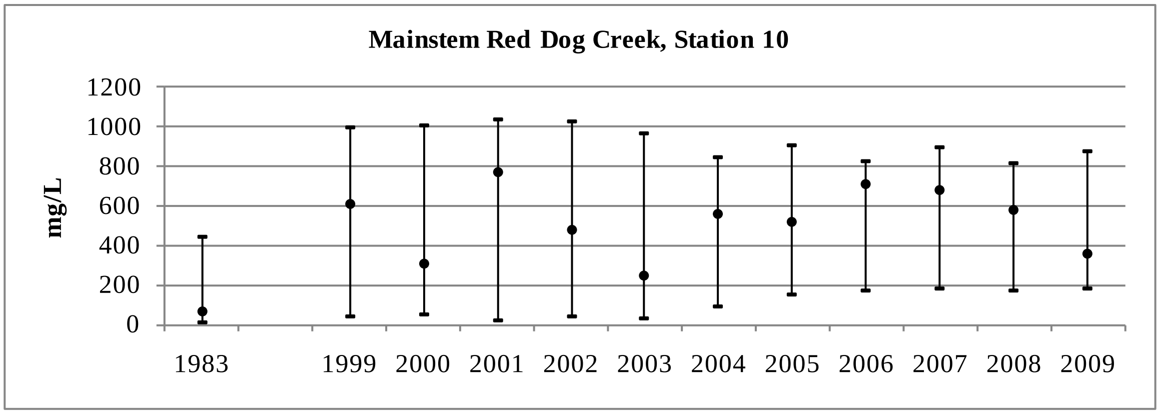

Figure 17. Median, maximum, and minimum sulfate concentrations at Station 10.

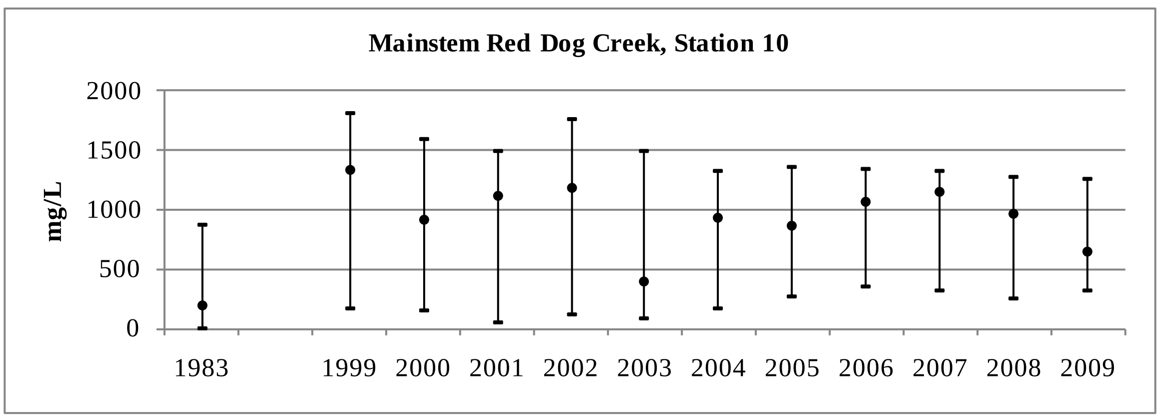

Figure 18. Median, maximum, and minimum TDS concentrations at Station 10.

We next compare Cd, Pb, Se, and Zn concentrations in Mainstem Red Dog Creek (Station 10) with those found in North Fork Red Dog Creek (Station 12), Ikalukrok Creek (Station 9), and Buddy Creek (below the confluence of Bons and Buddy creeks) (Appendix 2). Cd, Pb, and Zn concentrations are highest in Mainstem Red Dog Creek. Selenium concentrations are similar at all four sites. Overall, the metals concentrations are lowest in Buddy and North Fork Red Dog creeks. Ikalukrok Creek at Station 9 has higher concentrations of Cd and Zn than Buddy and North Fork Red Dog creeks. As we will discuss in subsequent sections of our report, biological productivity in the Red Dog Mine area is highest in those creeks where the metals concentrations are lower. Productivity in Buddy and North Fork Red Dog creeks as assessed by periphyton standing crop, aquatic invertebrates, and fish is much higher than in Mainstem Red Dog Creek or in Ikalukrok Creek at Station 9. Ikalukrok at Station 9 is directly impacted by mineral seeps located in the upper portion of the drainage (Figure 19).

Figure 19. Cub Creek seep, July 2009. Seep flows into Ikalukrok Creek and adversely affects water quality downstream. The seep is located about 10 km upstream from Station 9.

We also looked at the seasonality of metals concentrations (Zn, Cd, Pb, and Se) in Bons Pond. Although these metals are present at low concentrations, Cd, Pb, and Zn peak during spring breakup (Figures 20, 21, and 22). In contrast, Se concentrations show a gradual increase with time during the summer (Figure 23).

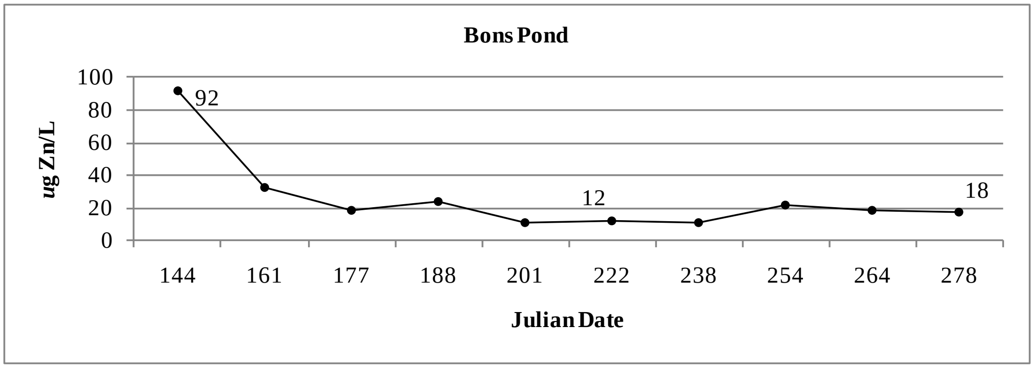

Figure 20. Zn concentrations in Bons Pond (2009).

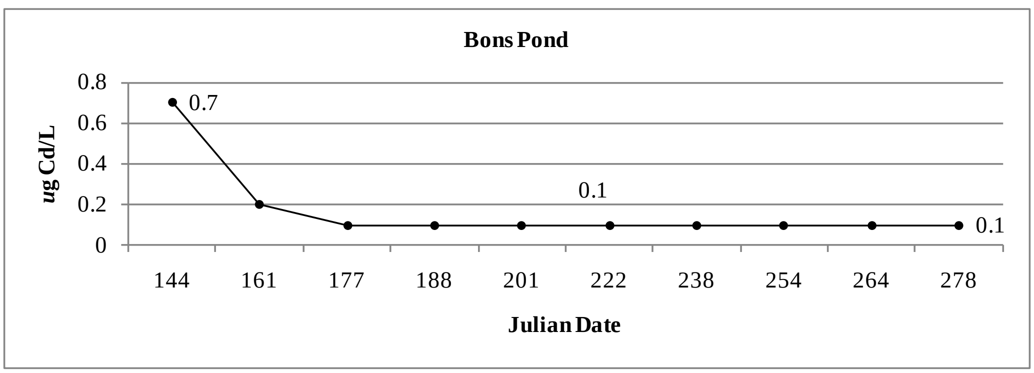

Figure 21. Cd concentrations in Bons Pond (2009).

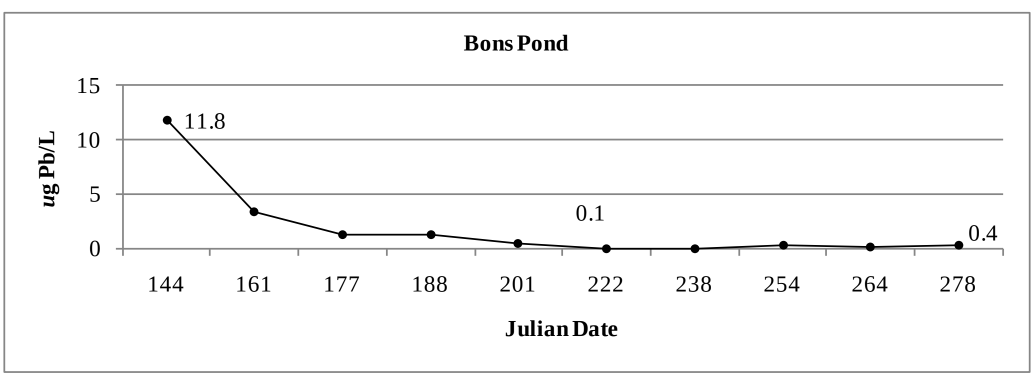

Figure 22. Pb concentrations in Bons Pond (2009).

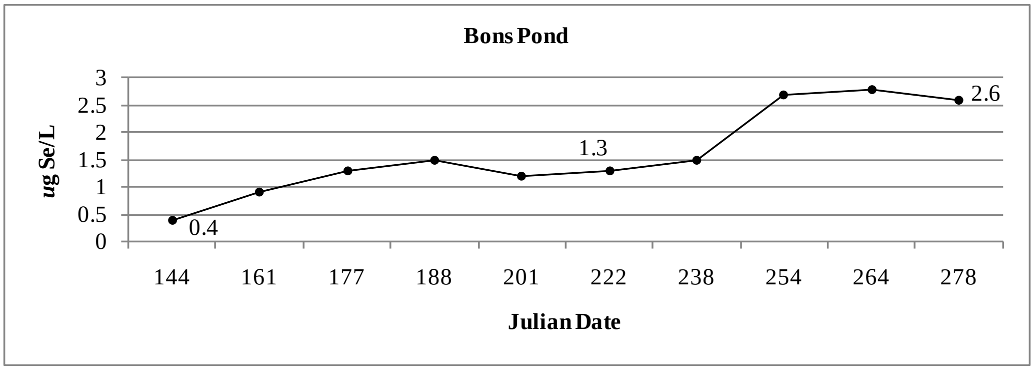

Figure 23. Se concentrations in Bons Pond (2009).

Morris and Ott (2009) reported that there may be several reasons for the peak concentrations of Zn, Cd, and Pb to occur in early spring. These include the flushing of fugitive dust accumulations from the prior winter, sediment input from the creeks from erosion, and the possibility that the interceptor system downstream of the Kivalina Waste Dump does not function effectively until the ground has thawed. Several projects are underway and have been for some time to mitigate fugitive dust. Consideration should be given to evaluating the long-term effectiveness of the interceptor system downstream of the Kivalina Waste Dump. We note the pattern of Zn, Cd, Pb, and Se concentrations in North Fork Red Dog Creek for summer 2009 is very similar to that seen in Bons Pond with the exception of a second peak occurring in the fall that is most likely associated with rainfall events (Figure 24, Appendix 3).

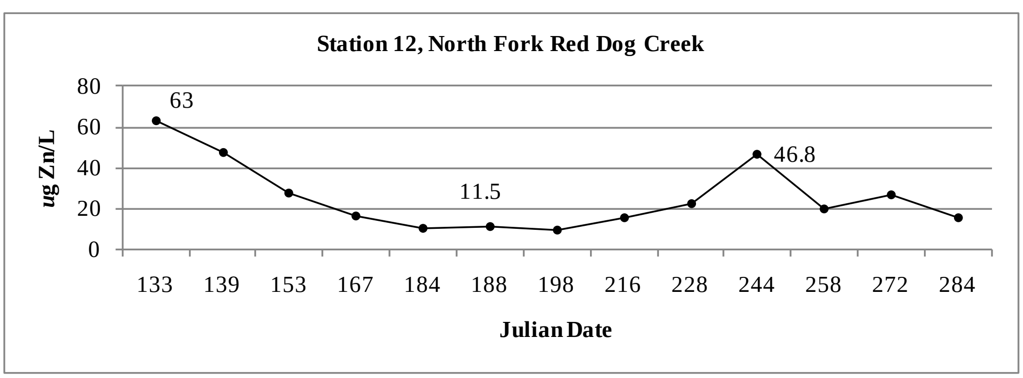

Figure 24. Zn concentrations in North Fork Red Dog Creek (2009).

Finally, we looked at Cd, Pb, Se, and Zn concentrations in Bons Pond outlet channel for the past five years. There are no indications of any trend for an increase or decrease in these metal concentrations (Figure 25, Appendix 4).

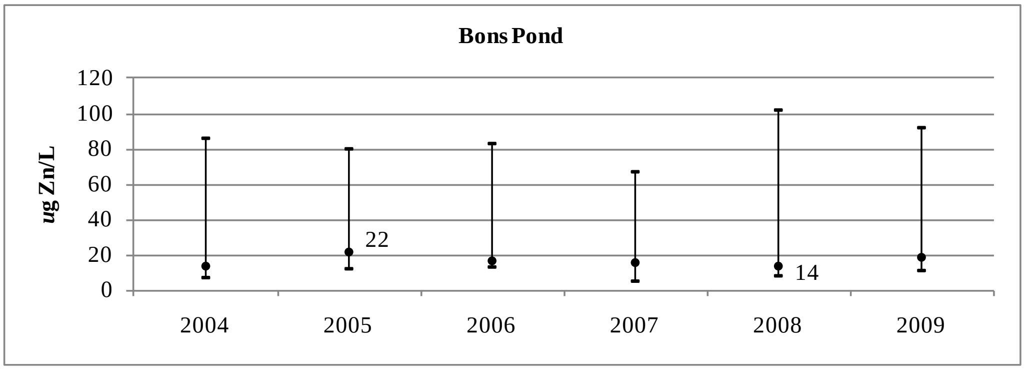

Figure 25. Median Zn concentrations in Bons Pond (2004 to 2009).

Periphyton Standing Crop

Algal biomass samples, as estimated by chlorophyll-a concentrations (mg/m^2), are collected each year at seven NPDES sites. We have now collected these samples for 11 years (1999 to 2009). In 2004, we added four new sites in the Bons and Buddy Creek drainages. In all years except 2006, these samples were collected in early July. The lowest chlorophyll-a concentrations in 2009 were seen in Middle Fork Red Dog Creek (Station 20) with some of the highest occurring in the Bons and Buddy Creek sites (Figure 26 and Appendix 5). Similar patterns were seen in 2007 and 2008 (Figures 27 and 28).

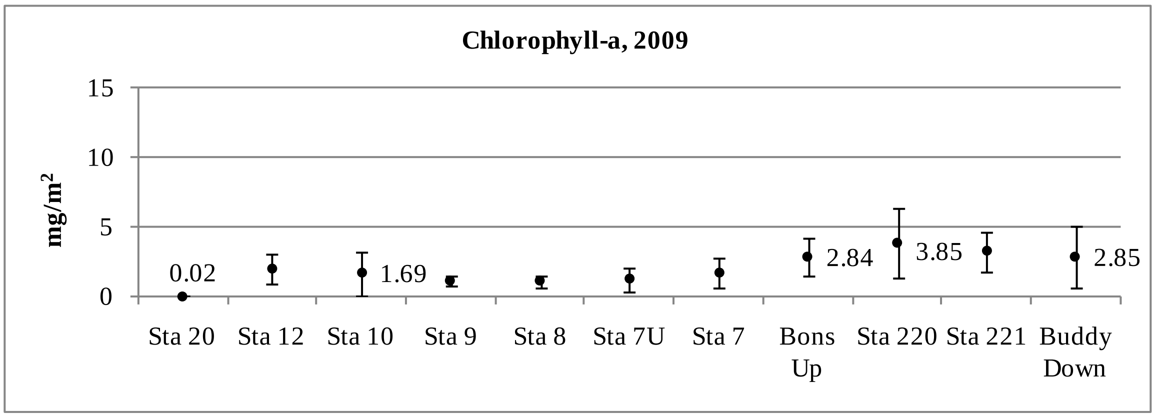

Figure 26. Average concentration of chlorophyll-a, plus and minus one standard deviation, at the NPDES sample sites and in the Bons and Buddy Creek drainages.

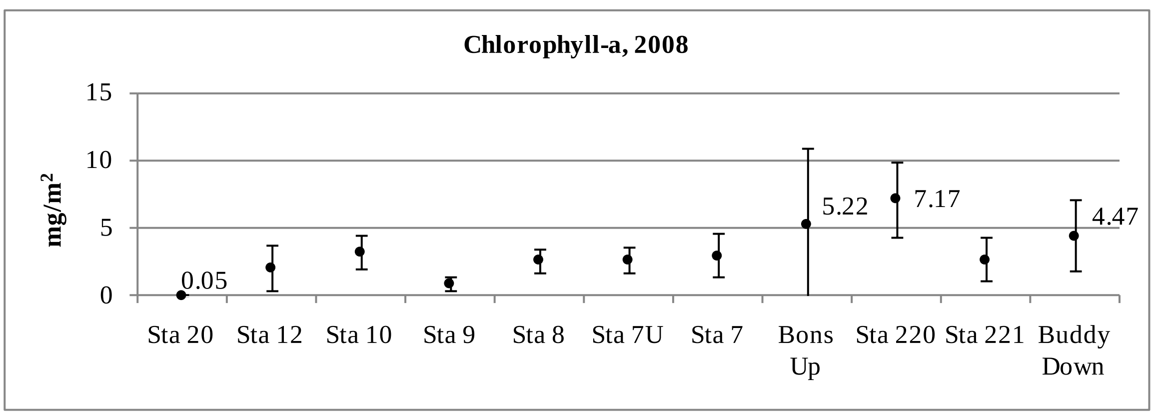

Figure 27. Average concentration of chlorophyll-a, plus and minus one standard deviation, at the NPDES sample sites and in the Bons and Buddy Creek drainages.

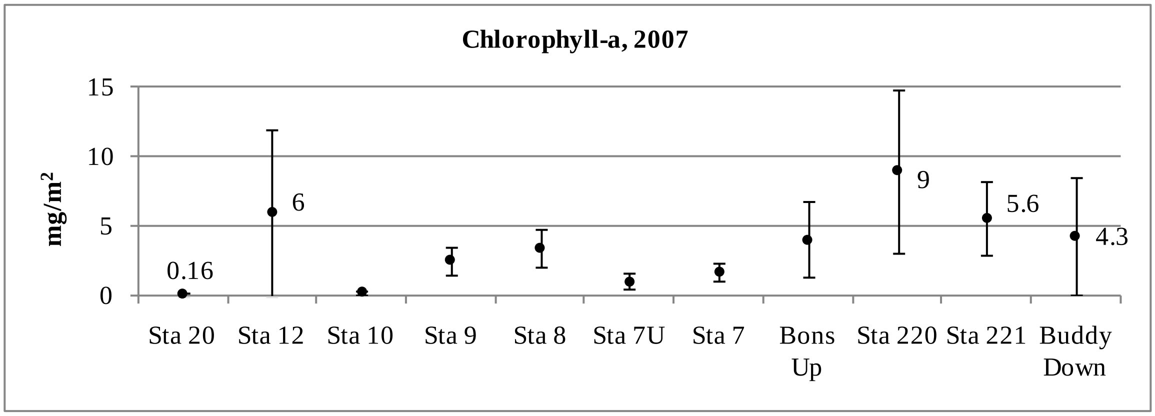

Figure 28. Average concentration of chlorophyll-a, plus and minus one standard deviation, at the NPDES sample sites and in the Bons and Buddy Creek drainages.

Average chlorophyll-a concentrations in North Fork Red Dog Creek from 1999 through 2009 varied from a low of 0.97 to a high of 6.39 mg/m^2 (Figure 29). Generally, chlorophyll-a concentrations in North Fork Red Dog Creek are higher than in Mainstem Red Dog Creek (Figure 30). In 8 out of 11 years, higher concentrations are found in North Fork Red Dog Creek. Except for 2004, chlorophyll-a concentrations were greater than 2 mg/m^2 in North Fork Red Dog Creek. In contrast, the average chlorophyll-a concentrations in Middle Fork Red Dog Creek ranged from the detection limit to a high of 0.28 mg/m^2 (Figure 31). The lower periphyton standing crop in Middle Fork Red Dog Creek is likely related to higher metals concentrations from the clean water bypass.

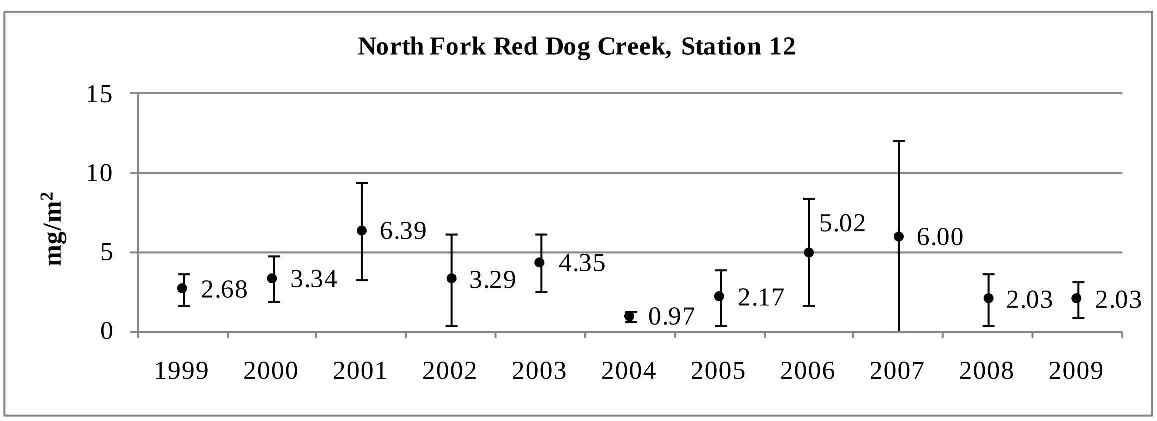

Figure 29. Average concentration of chlorophyll-a, plus and minus one standard deviation, in North Fork Red Dog Creek.

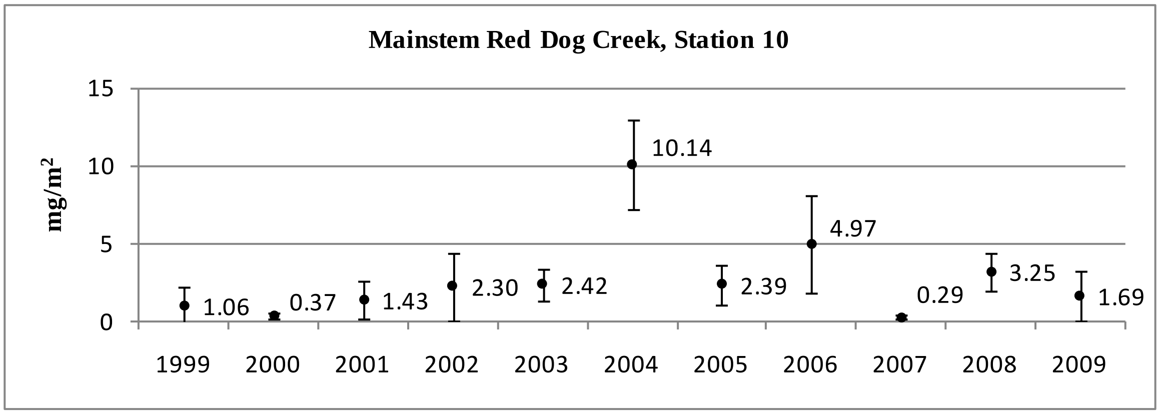

Figure 30. Average concentration of chlorophyll-a, plus and minus one standard deviation, in Mainstem Red Dog Creek.

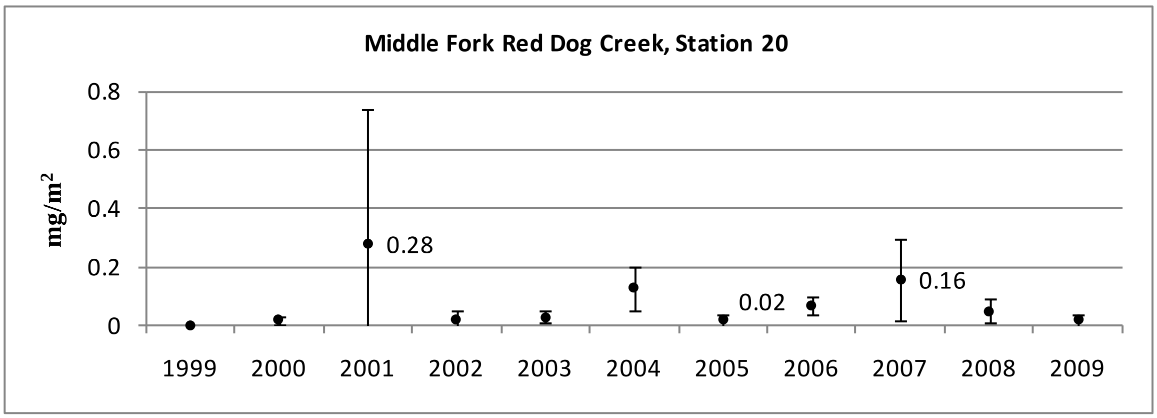

Figure 31. Average concentration of chlorophyll-a, plus and minus one standard deviation, in Middle Fork Red Dog Creek. Nearly all concentrations are at or below the annual detection limit.

Periphyton standing crop tracks very closely with elevated Zn and Cd in Ikalukrok Creek at Station 9. Water quality at Station 9 is not affected by water from the Red Dog Mine facility, but is affected by natural mineral seeps located upstream and along Ikalukrok Creek (Ott and Morris, 2007) (Figure 32). Chlorophyll-a concentrations are higher when the Zn and Cd concentrations are lower (Figures 33, 34, and 35).

Figure 32. Cub Creek seep is located about 10 km upstream of Station 9.

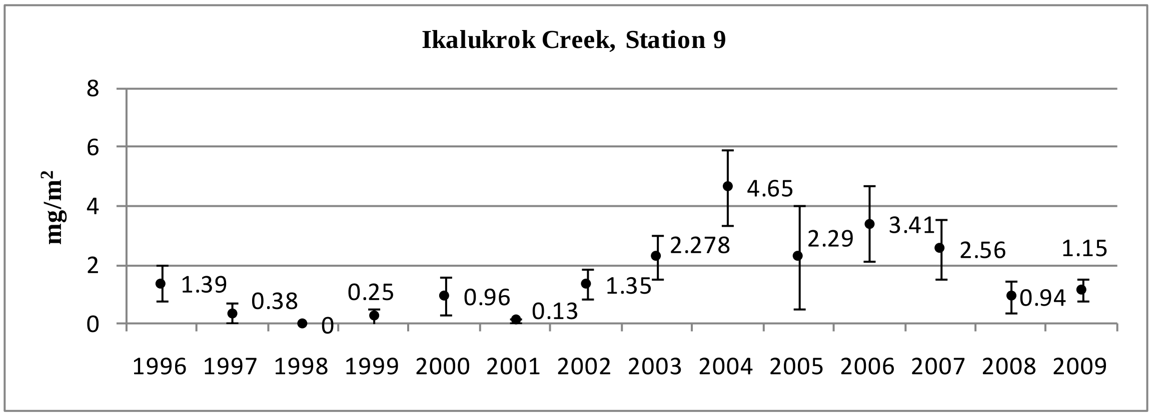

Figure 33. Average concentration of chlorophyll-a, plus and minus one standard deviation, in Ikalukrok Creek.

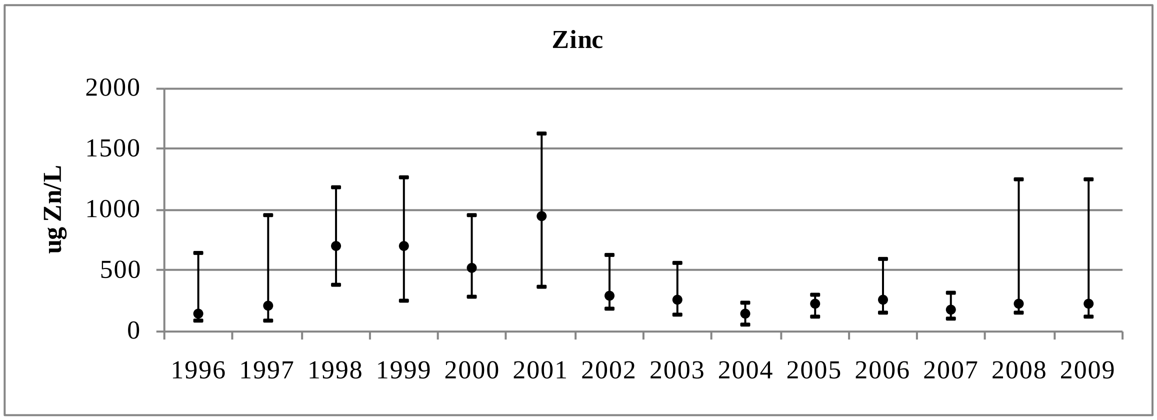

Figure 34. Median, maximum, and minimum Zn concentrations at Station 9.

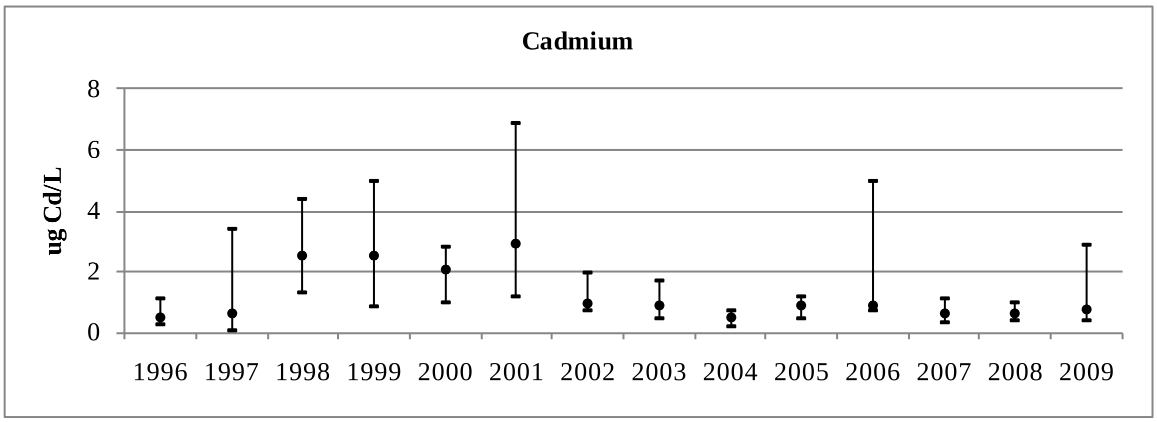

Figure 35. Median, maximum, and minimum Cd concentrations at Station 9.

Aquatic Invertebrates

Aquatic invertebrate samples are collected annually using drift nets at seven NPDES sample sites. The NPDES sites have been sampled since 1999 with all sampling done in late-June/early-July, except in 2006 when, due to rainfall events, samples were collected in August. In 2004, we added four new sites in the Buddy and Bons Creek drainages and employed the same methods/protocols as the NPDES sites. Summary data for these sites are presented in Appendix 6.

In 2009, the density of aquatic invertebrates (79.0/m^3) was highest in Buddy Creek below the confluence of Buddy and Bons creeks (Figure 36). The higher densities reflect large catches of both Chironomidae and Simuliidae. Aquatic invertebrate densities were lowest in Ikalukrok, Middle Fork Red Dog, and Mainstem Red Dog Creeks. The lowest density found was 1.8/m^3 in Middle Fork Red Dog Creek. The Middle Fork Red Dog Creek site (Station 20) also has the lowest periphyton standing crop and the highest metals concentrations. Generally, the higher densities of aquatic invertebrates track closely with the periphyton standing crop data, with higher densities found in the Bons and Buddy Creek and North Fork Red Dog Creek drainages.

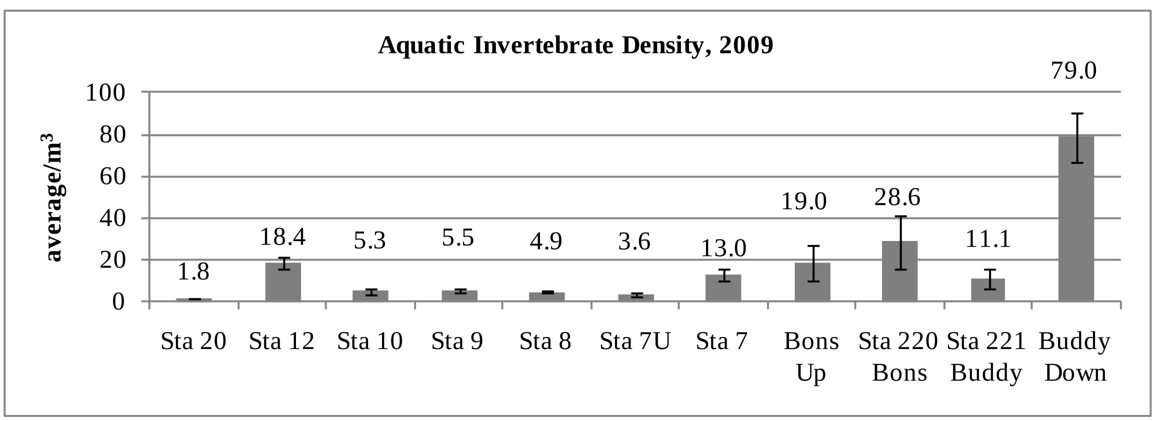

Figure 36. Aquatic invertebrate densities (average plus and minus one SD).

Aquatic invertebrate densities for Middle Fork Red Dog, Mainstem Red Dog, North Fork Red Dog, and Buddy Creek are presented in Figures 37, 38, 39, and 40. The lowest densities of aquatic invertebrates are found each year in Middle Fork Red Dog Creek (Figure 37) and the highest densities, with one exception, are found in North Fork Red Dog Creek (Figure 38) and Buddy Creek (Figure 39). Generally, densities are higher in Mainstem Red Dog Creek than in Middle Fork Red Dog Creek (Figure 38). Although there is a large amount of variability with aquatic invertebrate samples, there also is a certain degree of consistency when looking at the long term data base. The most productive creeks continue to exhibit the higher number of aquatic invertebrates per cubic meter of water.

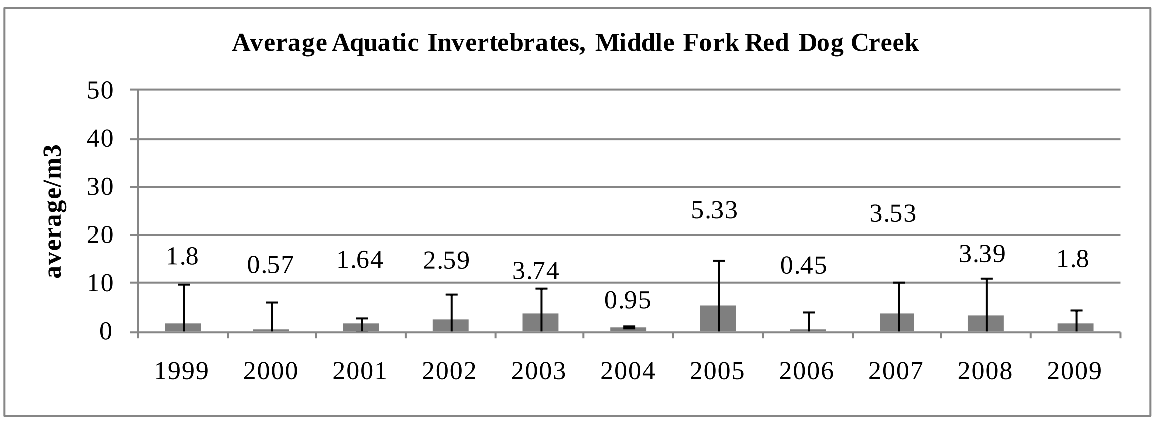

Figure 37. Aquatic invertebrate density (plus and minus one SD) in Middle Fork Red Dog Creek.

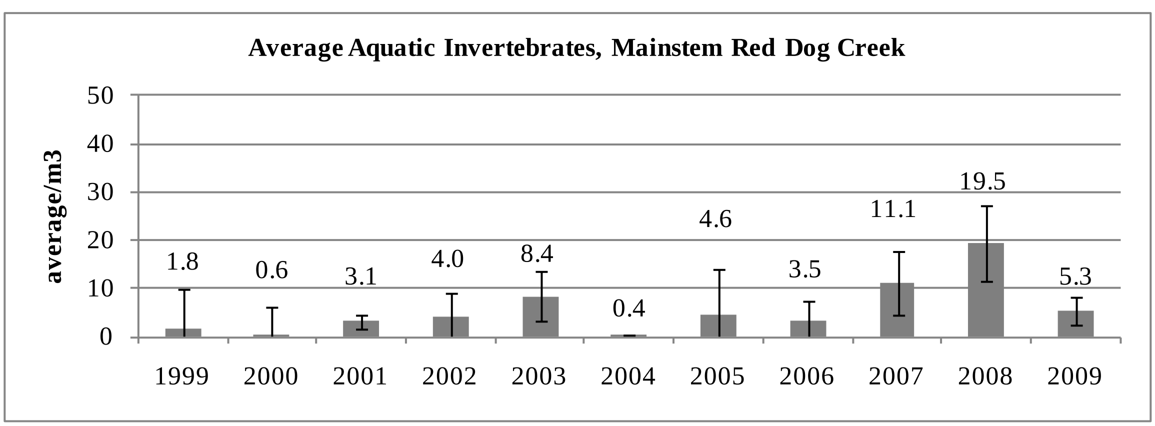

Figure 38. Aquatic invertebrate density (plus and minus one SD) in Mainstem Red Dog Creek.

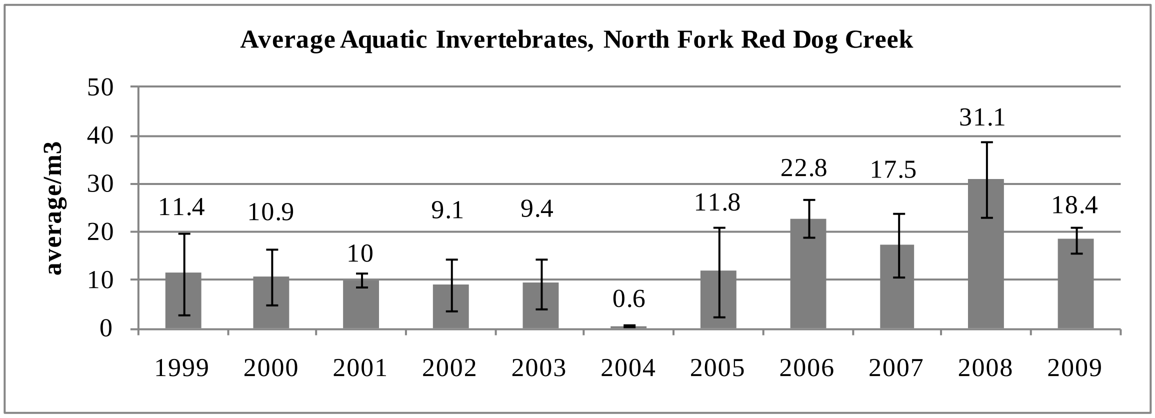

Figure 39. Aquatic invertebrate density (plus and minus one SD) in North Fork Red Dog Creek.

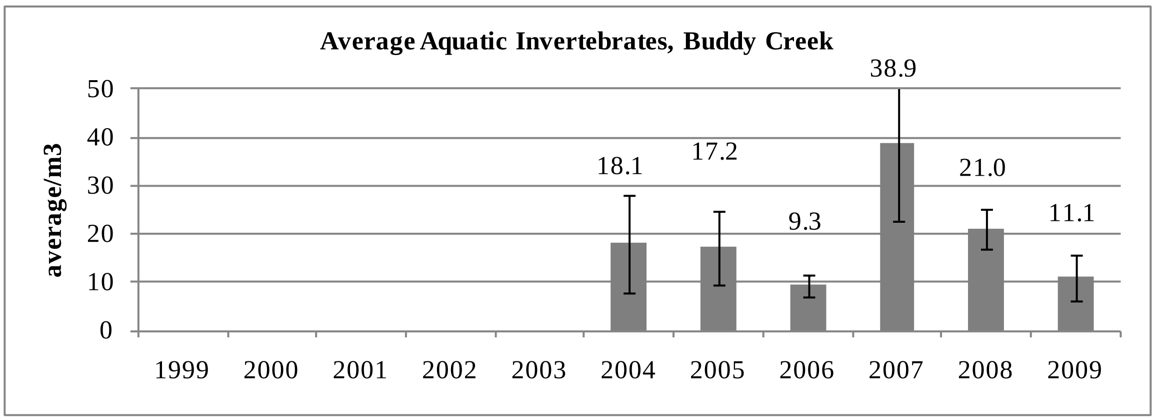

Figure 40. Aquatic invertebrate density (plus and minus one SD) in Buddy Creek at Station 221 (upstream of road). Drift net sampling in Buddy Creek began in 2004.

The percent Ephemeroptera, Plecoptera, and Tricoptera (EPT) and the percent Chironomidae in Middle Fork Red Dog, North Fork Red Dog, Mainstem Red Dog, and Buddy creeks is presented in Figures 41, 42, 43, and 44. Caddisflies are an insignificant contributor to EPT. In North Fork Red Dog Creek, a reference site not directly affected by the mine, Chironomidae were more prevalent in the aquatic drift samples in 8 out of 11 years. In Buddy Creek, a reference site indirectly affected by the road, Chironomidae were more abundant in 4 out of 6 years. The aquatic systems in the Red Dog Mine area are dominated by Chironomidae which is one of the primary food items of the fish species using these creeks.

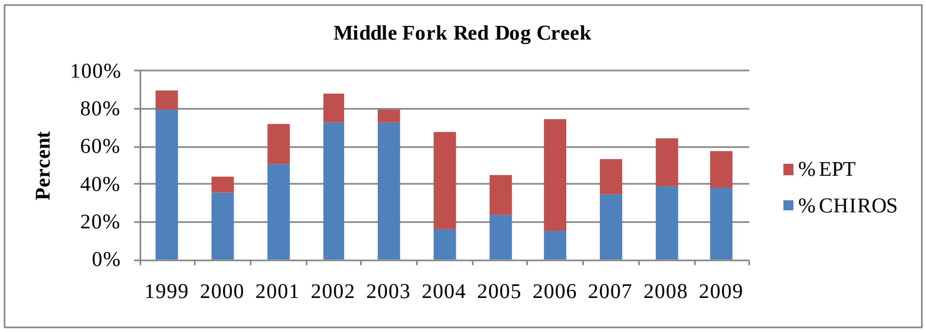

Figure 41. Percent Chironomidae and EPT in Middle Fork Red Dog Creek.

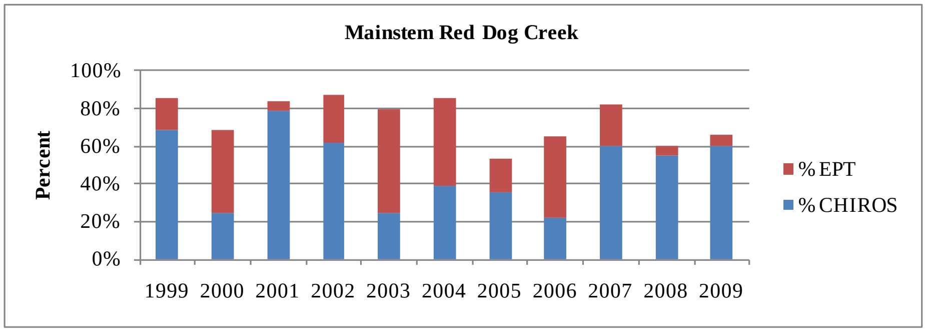

Figure 42. Percent Chironomidae and EPT in Mainstem Red Dog Creek.

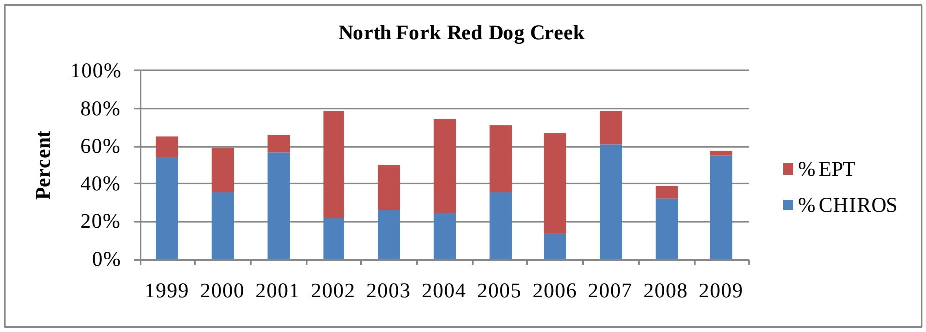

Figure 43. Percent Chironomidae and EPT in North Fork Red Dog Creek.

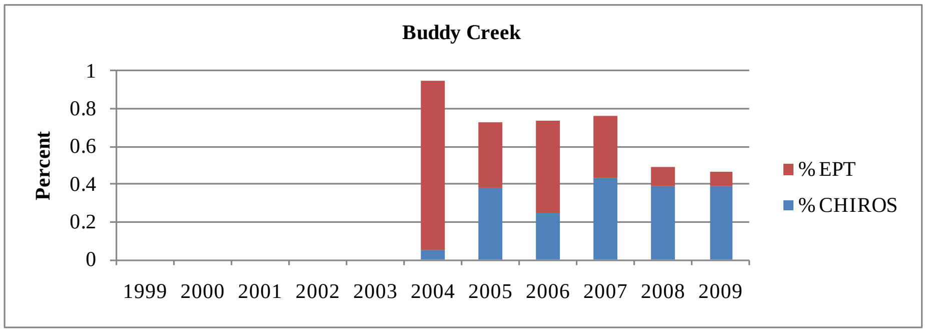

Figure 44. Percent Chironomidae and EPT in Buddy Creek.

We looked at taxa richness for all current sample sites from 2004 to 2009 (Figure 45). During this time period, we have aquatic invertebrate data from all 11 sites (7 NPDES sites and 4 Bons/Buddy Creek sites). Taxa richness is typically consistent year to year relative to other sites. Most variability is between years for any given site and most sites track the same. Years with low richness tend to be consistent among all sites. Perhaps the biggest exception to this is Site 220 (Bons Creek below Bons Pond); it seems relatively consistent regardless of what the other sites do in any given year. Site 220 is probably more consistent because annual variation in water conditions (flow and temperature) are moderated by Bons Pond. Some sites are consistently "less" rich (Station 10, Mainstem Red Dog Creek) or "more" rich (Station 8, Ikalukrok Creek downstream of Mainstem Red Dog Creek).

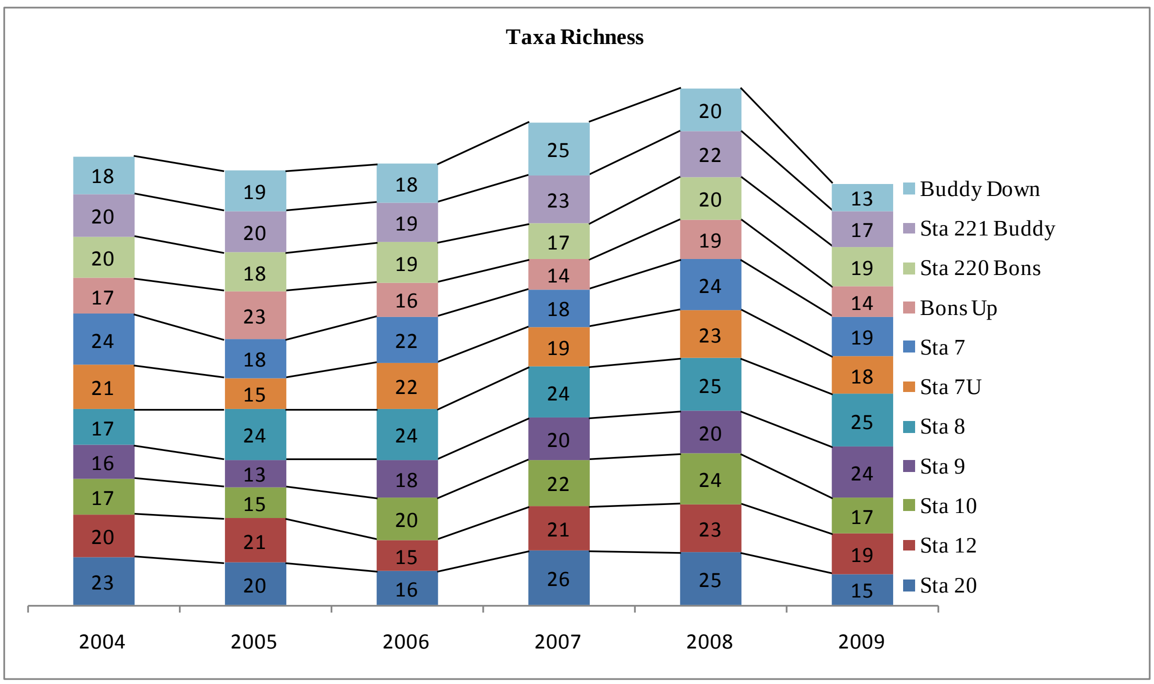

Figure 45. Aquatic invertebrate taxa richness at all sample sites. Note, sites are arranged from the lower to upper part of each creek.

Metals Concentrations in Juvenile Dolly Varden

Although not required by permit condition, we have sampled juvenile Dolly Varden to determine whole body concentrations of selected metals. The purposes of this effort are: (1) to determine if differences exist in metals concentrations in fish among the sample sites that can be linked with background water quality; and (2) to track change over time. Juvenile Dolly Varden were selected as the target species because of their wide distribution in the Red Dog area streams, their presence in Mainstem Red Dog Creek, their residence in freshwater for 2 to 4 years before smolting, and their rearing in the sample sites only during the ice-free season. Juvenile Arctic grayling were added for monitoring after we successfully established a self-sustaining population in Bons Pond. Arctic grayling captured in Bons Pond have been in the pond upstream of the freshwater dam their entire life and therefore serve as a good indicator of year round water quality conditions and change over time. Arctic grayling were not collected in summer 2009, but metals data for Arctic grayling were presented by Ott and Morris (2009).

Ott and Morris (2004) found no relationship between fish length and whole body concentrations of selected metals for pre-smolt sized Dolly Varden. To minimize age-related variability, we targeted juvenile Dolly Varden from 90 to 140 mm (likely 2 and 3 year old fish), and collected all samples in August after fish have likely spent most of the summer in the sample reach. Fish larger than 140 mm are excluded because they could be resident fish and may be much older than the fish from 90 to 140 mm long. In a similar manner, we selected juvenile Arctic grayling that were between 140 and 220 mm long (predominately 2 or 3 year old fish).

We collected our first Dolly Varden juveniles for metals in 1993, and in 1998 began a more systematic program focused on juvenile Dolly Varden in Mainstem Red Dog Creek. Our selected sample size for each stream was initially set at 10 fish, but in 2002 we increased the sample size to 15 fish to better define variability in sample results (Ott and Morris 2004). Even though we have set our sample size at 15 fish, there are years when numbers of fish are low and the desired sample is not achieved. Also, in some years to meet a sample size of 15 fish, we have retained some juvenile Dolly Varden less than 90 mm (age 1 fish).

In 2009 and 2007, numerous fish less than 90 mm long from Mainstem Red Dog Creek were retained in an attempt to meet sample size goals. Analysis over the 2005 through 2009 time period indicates that fish length explains about 14% of the variation observed in Cd tissue concentration, and about 33% of the variation in Se tissue concentration. Se and Cd tissue concentrations show a positive relationship to fish length. When fish less than 90 mm are dropped from the analysis, the relationship between fish length and tissue metals loading drops for all metals with the exception of Zn (significant at all sites but Mainstem Red Dog Creek) and Cd (Cd is only significant for length for Buddy Creek) (Tables 1 and 2 in Appendix 8). However, analysis also indicates that while length may be significantly related to Zn concentrations it also indicates that little of the variation found in Zn data are actually explained by length, suggesting other factors are more influential. We suspect that age class of fish may be most influential. There is some indication that age-1, age-2, and age-3 fish may differ slightly in metals loading. Based on these data and the analysis, we plan to be more diligent in retaining only juvenile Dolly Varden from 90 to 140 mm.

Cd, Pb, Se, and Zn concentrations (mg/Kg dry weight) for fish collected from Anxiety Ridge, Buddy, and Mainstem Red Dog creeks were compared for the period from 2005 to 2009 (Appendix 7). Condition factor (CF = (weight/length^3) X Constant) also was calculated for each fish and compared by stream and year (Figures 1 and 2 in Appendix 8). Dolly Varden condition was similar among the streams in 2009 (KW = 3.18, p = 0.2037); however, fish retained from Mainstem Red Dog Creek were significantly smaller with respect to length than fish retained from Anxiety Ridge and Buddy creeks (KW = 21.84, p <0.0001) (Figures 3 and 4 in Appendix 8). As mentioned above, this is a result of retaining numerous fish smaller than 90 mm. Between 2005 and 2009, fish condition and length have varied and although significant differences do exist between some years for fish condition and length, there are no trends with time for Anxiety Ridge and Buddy creeks. Juvenile Dolly Varden retained from Mainstem Red Dog Creek appear to be trending towards smaller fish with the largest fish retained in 2005 and the smallest in 2009.

Whole body Cd concentrations were consistently higher in fish collected from Mainstem Red Dog Creek and consistently lowest in Anxiety Ridge Creek (Figures 46, 47, and 48 – note y-axis scales differ among graphs). However, in 2009 Cd concentration in juvenile Dolly Varden retained from Mainstem Red Dog Creek had dropped low enough to be statistically similar to fish retained from Buddy Creek (Figures 5 and 6 in Appendix 8). Cd concentrations have remained stable in fish from Buddy and Anxiety Ridge creeks between 2005 and 2009, with the exception of a slight increase in 2006 and 2007. The lowest Cd concentrations in Mainstem Red Dog Creek are in 2009 for the sample period from 2005 to 2009 and for the period of record, 1998 to 2009. Cd has been decreasing in juvenile Dolly Varden retained from Mainstem Red Dog Creek since 2007.

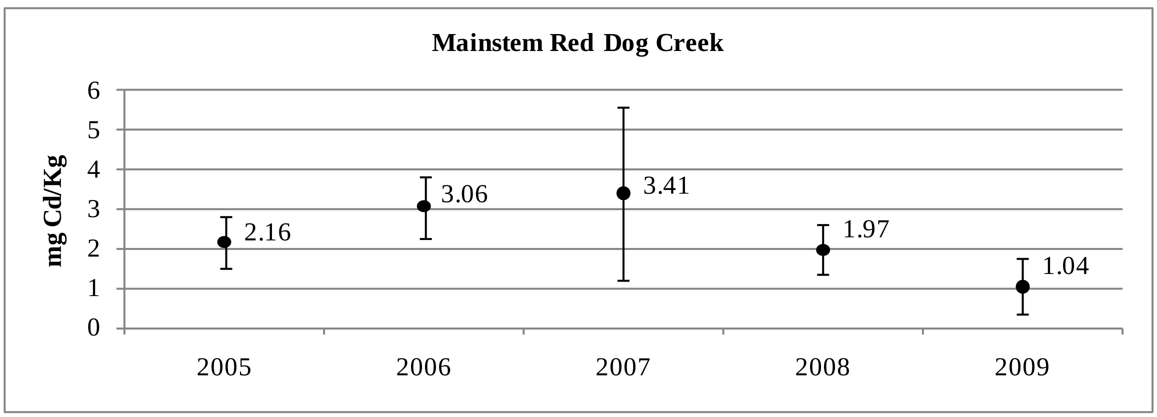

Figure 46. Average Cd (plus and minus 1 SD), juvenile Dolly Varden.

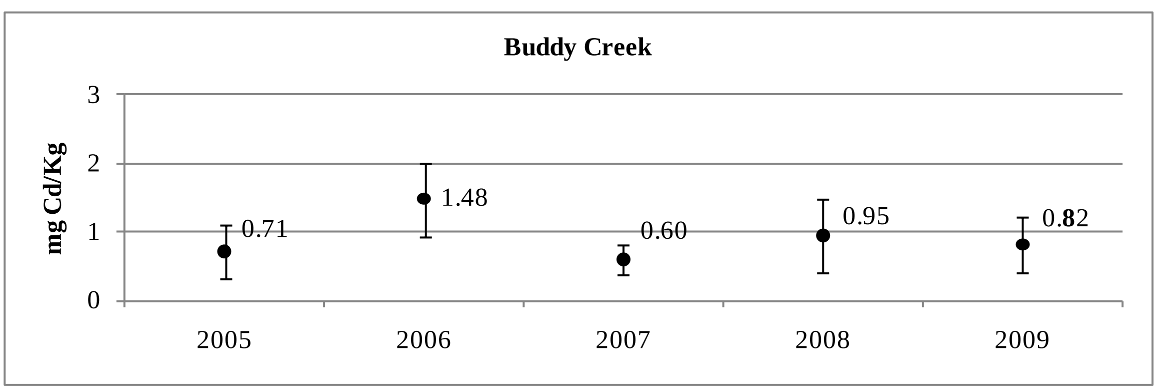

Figure 47. Average Cd (plus and minus 1 SD), juvenile Dolly Varden.

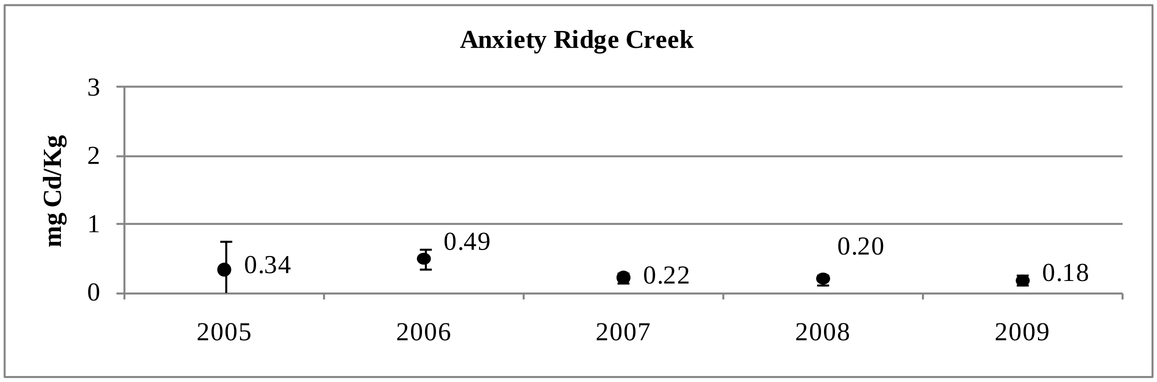

Figure 48. Average Cd (plus and minus 1 SD), juvenile Dolly Varden.

Whole body Pb concentrations also were consistently higher in fish collected from Mainstem Red Dog Creek (Figures 49, 50, and 51 – note y-axis scales differ among graphs). Pb concentrations are similar in fish from Anxiety Ridge and Buddy creeks. The lowest Pb concentration, like Cd, occurred in 2009 in fish from Mainstem Red Dog Creek. Pb concentrations dropped low enough in fish from Mainstem Red Dog Creek to be similar to fish retained from Anxiety Ridge Creek in 2009. Pb concentrations in juvenile Dolly Varden have been decreasing since 2007 in Mainstem Red Dog Creek and have been variable in Anxiety Ridge and Buddy creeks (Figures 7 and 8 and Table 3 in Appendix 8).

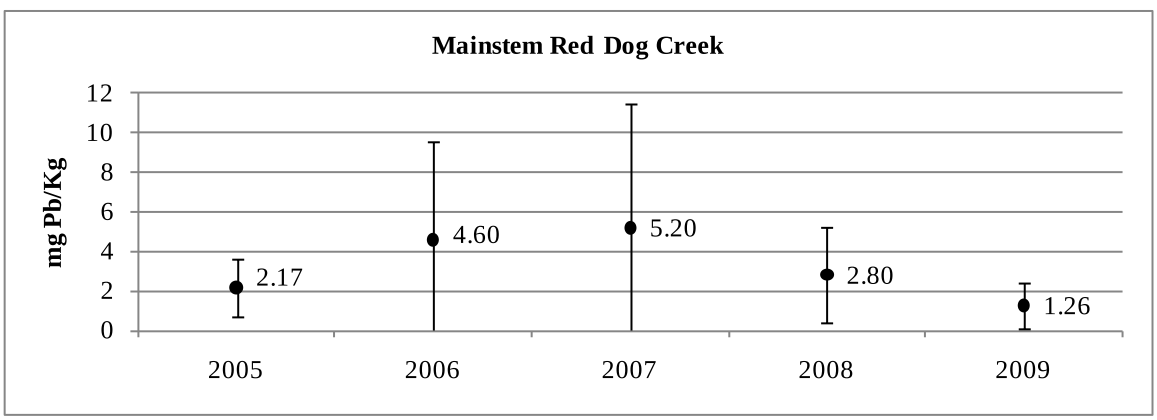

Figure 49. Average Pb (plus and minus 1 SD), juvenile Dolly Varden.

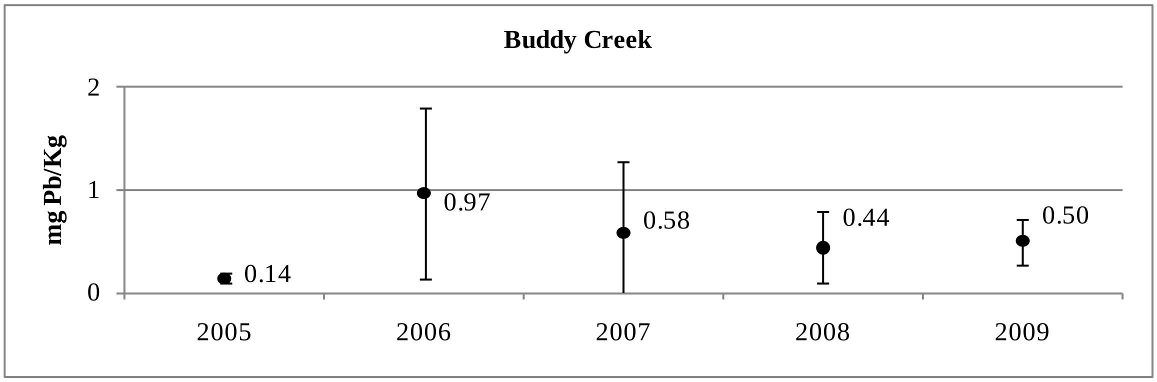

Figure 50. Average Pb (plus and minus 1 SD), juvenile Dolly Varden.

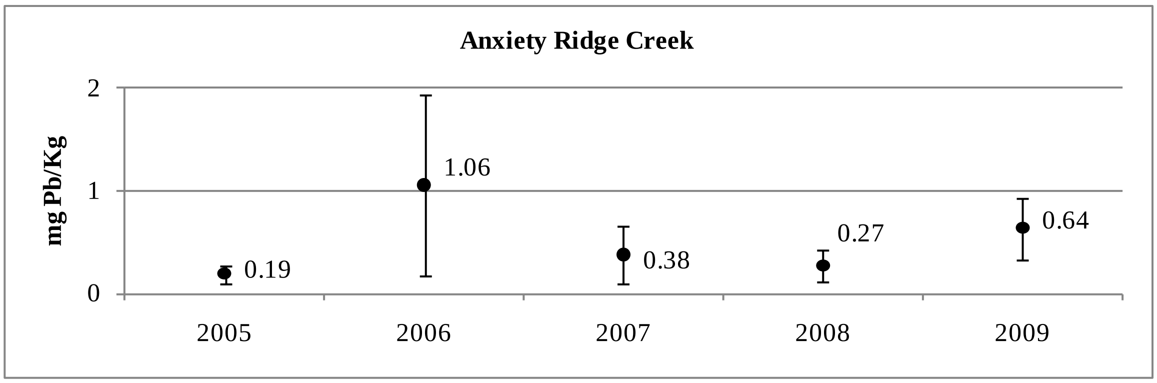

Figure 51. Average Pb (plus and minus 1 SD), juvenile Dolly Varden.

Average whole body Se concentrations were similar for fish retained from Anxiety Ridge and Mainstem Red Dog creeks in 2009, while juvenile Dolly Varden from Buddy Creek exhibited the highest Se concentrations (Figures 52, 53, and 54 – note y-axis scales differ among graphs) (Figures 9 and 10 in Appendix 8). Se concentrations appeared to decrease slightly from 2005 to 2007 and then increase slightly from 2008 to 2009 for all sites. Mainstem Red Dog Creek juvenile Dolly Varden typically exhibit somewhat higher Se concentrations; however, Se concentrations showed one of the higher linear relationships with fish length over the 2005 to 2009 period. This suggests that the trend towards smaller fish retained from Mainstem Red Dog Creek may influence this result (Tables 1, 2, and 3 in Appendix 8). Of the metals discussed, there is less difference among the three sample sites for Se than for the other metals (Cd, Pb, and Zn).

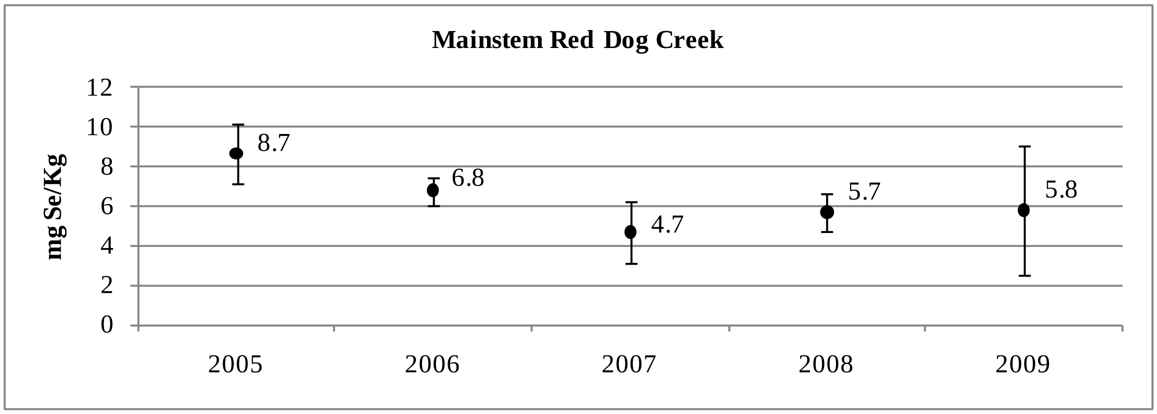

Figure 52. Average Se (plus and minus 1 SD), in juvenile Dolly Varden.

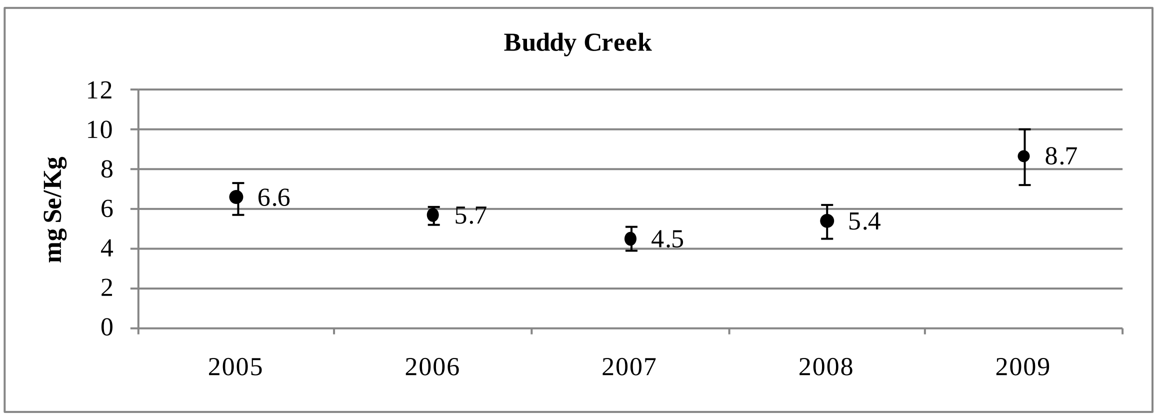

Figure 53. Average Se (plus and minus 1 SD), in juvenile Dolly Varden.

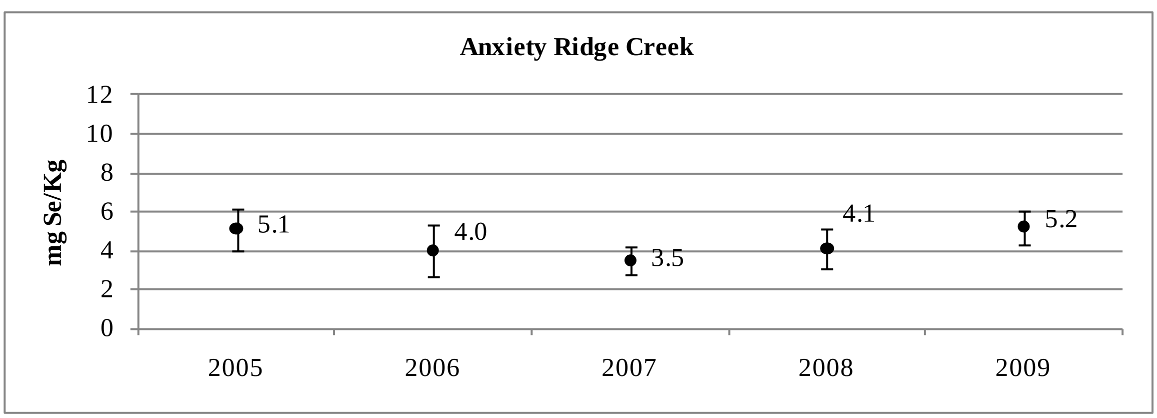

Figure 54. Average Se (plus and minus 1 SD), in juvenile Dolly Varden..

Zn whole body concentrations were higher in Mainstem Red Dog Creek fish than in Buddy Creek fish while Anxiety Ridge Creek fish were similar to fish from both Mainstem Red Dog and Buddy creeks (Figures 55, 56, and 57 – note y-axis scales differ among graphs) (Figures 11 and 12 in Appendix 8). Again, as with Cd and Pb, the whole body Zn concentrations were lowest in 2009 for Mainstem Red Dog Creek and have been decreasing with time since 2006 when an increase occurred (Table 3 in Appendix 8). Mainstem Red Dog Creek Zn concentrations from fish captured in 2009 were similar to those in fish from 2005, the previous lowest Zn concentrations observed.

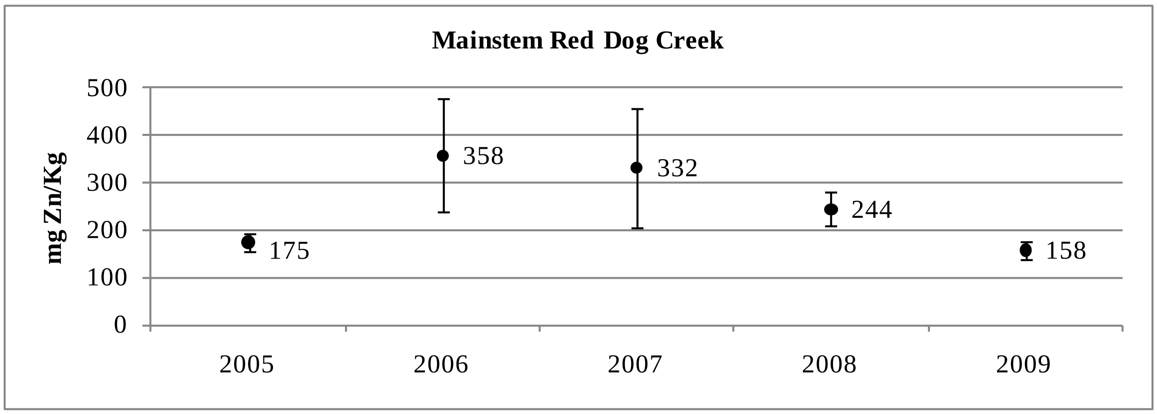

Figure 55. Average Zn (plus and minus 1 SD), in juvenile Dolly Varden.

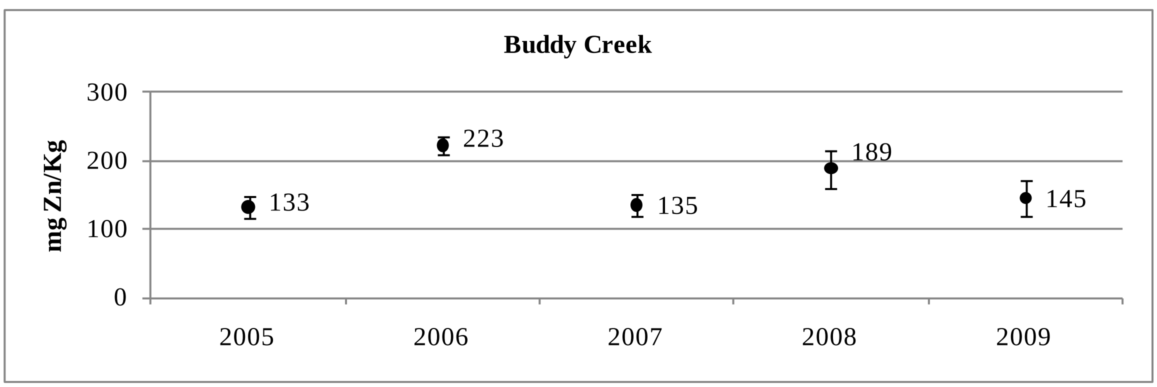

Figure 56. Average Zn (plus and minus 1 SD), in juvenile Dolly Varden.

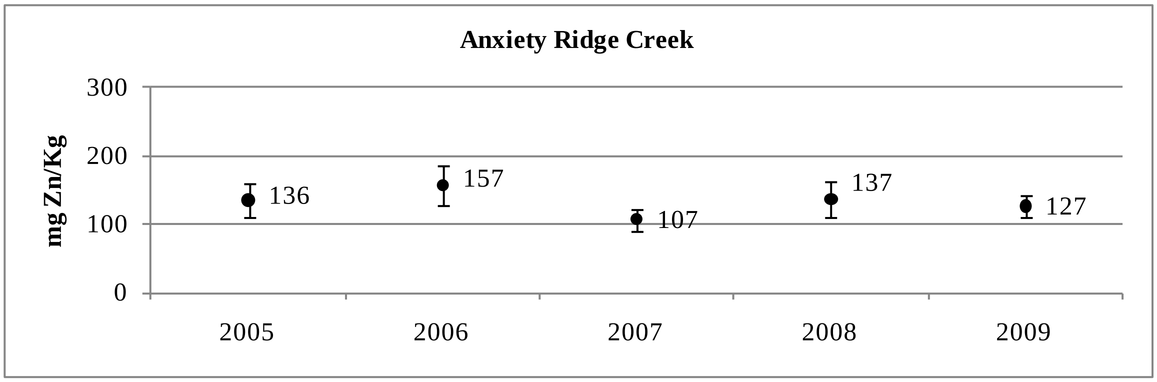

Figure 57. Average Zn (plus and minus 1 SD), in juvenile Dolly Varden.

Juvenile Dolly Varden condition has remained fairly constant over time; however, there is limited evidence that the condition factor has increased slightly over time in Mainstem Red Dog Creek juveniles. Juvenile Dolly Varden length has decreased over time for fish retained from Mainstem Red Dog Creek (Figure 13 and Table 3 in Appendix 8). As described earlier, we attempt to keep fish between 90 and 140 mm for our sample, but this is not always possible. Our sample usually correlates well with fish availability so it appears that smaller age classes of juvenile Dolly Varden are now using Mainstem Red Dog Creek and are thus more available for sampling. Presence and use by small Dolly Varden in Mainstem Red Dog Creek is yet another indication of improved water quality and aquatic habitat, as this was one of the small size classes and species with documented mortalities during pre-mining environmental field studies.

Our second objective was to determine if changes in tissue metals concentrations or fish condition were occurring over time. In Mainstem Red Dog Creek, we have seen no obvious long term pattern of change in Cd concentrations from 1998 through 2009 (Figure 58). From 1998 through 2009, there is a general trend for decreasing Cd concentrations in juvenile Dolly Varden (Figure 13 and Table 3 in Appendix 8). Cd concentrations appear to be event driven (changes in metals concentrations from natural mineral seeps) and tend to increase slowly for a period of time followed by a corresponding period of decrease. From 1998 to 2003, Cd concentrations increased with time, dropped in 2004 and then climbed over time until 2006. Since 2006, Cd concentrations in juvenile Dolly Varden have decreased substantially each year and reached their lowest measured concentration in 2009 (Figure 13 and Table 3 in Appendix 8).

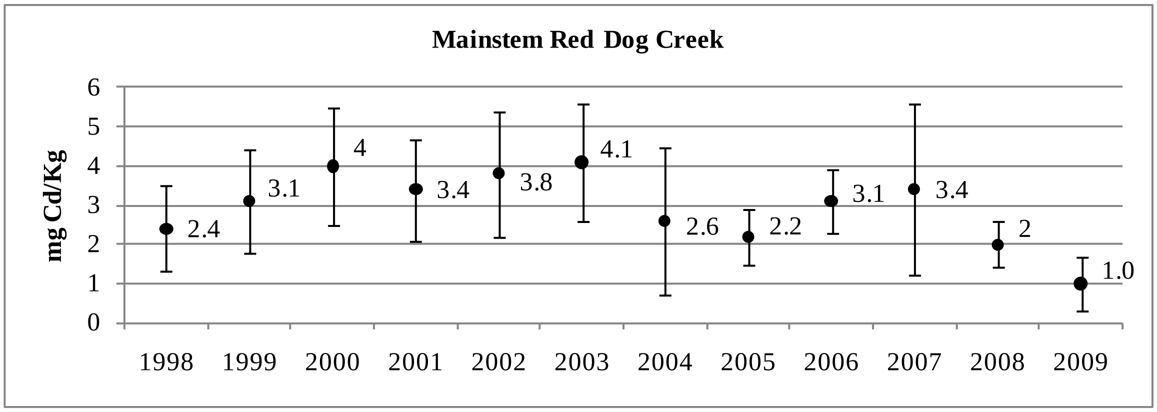

Figure 58. Average Cd (plus and minus 1 SD), in juvenile Dolly Varden.

Average Pb concentrations in juvenile Dolly Varden from Mainstem Red Dog Creek have trended downward over time (Figure 59) (Figure 14 and Table 3 in Appendix 8). Generally, Pb concentrations have shown similar patterns of change with time to other metals in that fluctuations appear to be event driven with periods of increase and periods of decrease. However, Pb concentrations have decreased with time over the entire sampling period from 1998 to 2009.

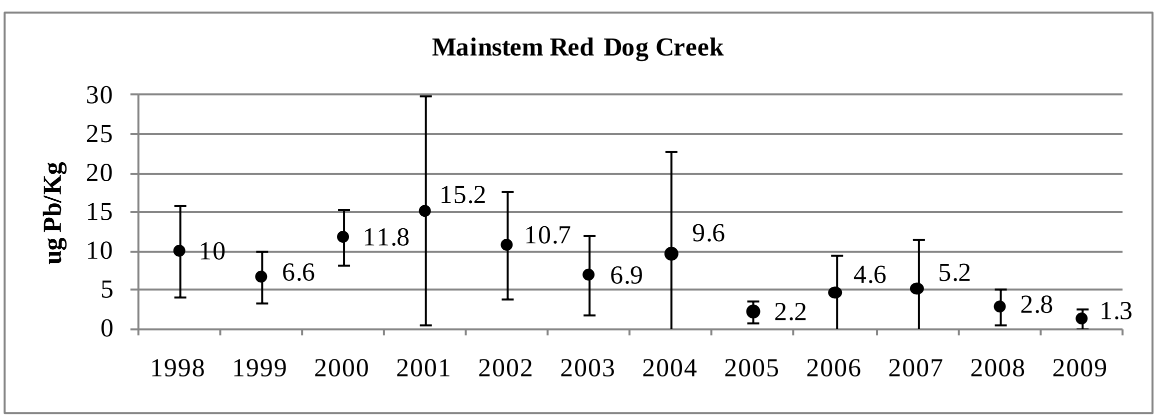

Figure 59. Average Pb (plus and minus 1 SD), in juvenile Dolly Varden.

Juvenile Dolly Varden were analyzed for Zn from 2001 through 2009 (Figure 60). There was an increase in Zn whole body concentrations in 2006 and 2007, but no apparent trend. There is no significant trend with Zn over the entire time period of record (2001 to 2009). However, data from 2006 through 2009 show a significant decreasing trend with time, with sample year explaining about 46% of the variation seen in Zn concentrations in juvenile Dolly Varden (Figure 14 and Table 3 in Appendix 8).

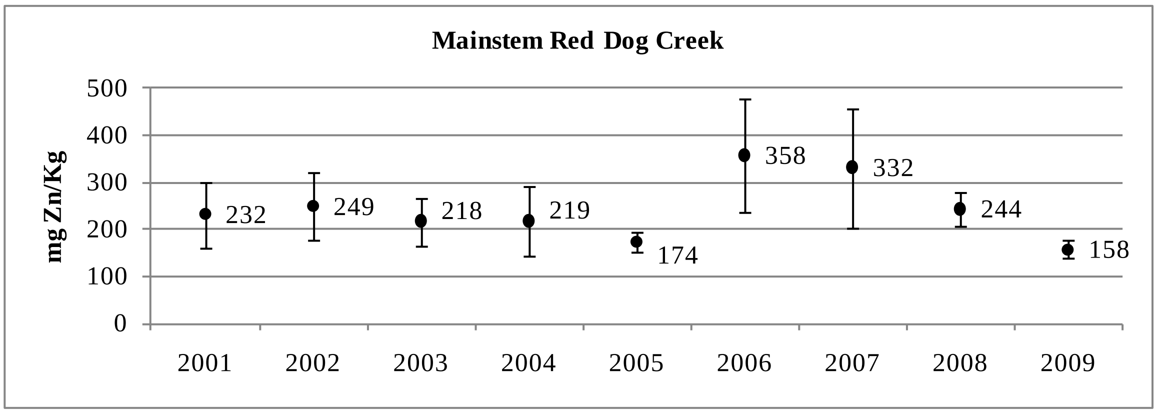

Figure 60. Average Zn (plus and minus 1 SD), in juvenile Dolly Varden.

Metals Concentrations in Adult Dolly Varden

Since 1990, we have sampled adult Dolly Varden from the Wulik River (Station 2) near Tutak Creek for metals concentrations (Al, Cd, Cu, Pb, and Zn) in gill, kidney, liver, and muscle tissue (Weber Scannell et al. 2000). In 1997, we added Se and in 1998 we started sampling reproductive tissue, when available. In 2003, we added Hg and Ca to the analytes being tested. From 2004 through 2009, Dolly Varden tissues were analyzed for Al, Cd, Cu, Pb, Se, Zn, and Hg. The sample size for each spring and fall sample period has been 6 fish, except for the fall 2002 sample, when only 5 fish were collected.

The purpose of sampling adult Dolly Varden for metals concentrations is to monitor the long-term condition of fish over the life of the mine, to identify changes in tissue metals concentrations that may be related to mine activities and to provide a data base for use by other professionals. The most likely benefits of this sampling program are long-term monitoring and use of these data by other professionals. It is highly unlikely that tissue metals concentrations or changes in adult fish could be related to events at the Red Dog Mine since large Dolly Varden attain their growth in the marine environment. All laboratory work has been done with Level III Quality Assurance.

Metals are known to concentrate preferentially in certain organs; however, the relationship of organ concentration to ambient environmental concentrations is unknown. Concentrations of metals vary with season, age, size, weight, and feeding habits of fish (Jenkins 1980) and in the case of anadromous Dolly Varden, the metals concentrations vary with exposure to freshwater and marine environments. None of the analytes we measure concentrate in muscle tissue during either season of collection, but they do in other tissues, as listed below (Figures 1 through 8 and Table 2 in Appendix 9):

- Al concentrates in gill tissue (Figure 61);
- Cd concentrates in kidney tissue (Figure 62);
- Cu concentrates in liver tissue and eggs (Figure 63);
- Pb concentrates in gill tissue (Figure 64);
- Se concentrates in kidney and eggs (Figure 65);
- Zn concentrates in eggs (Figure 66); and
- Hg concentrates in kidney tissue (Figure 67).

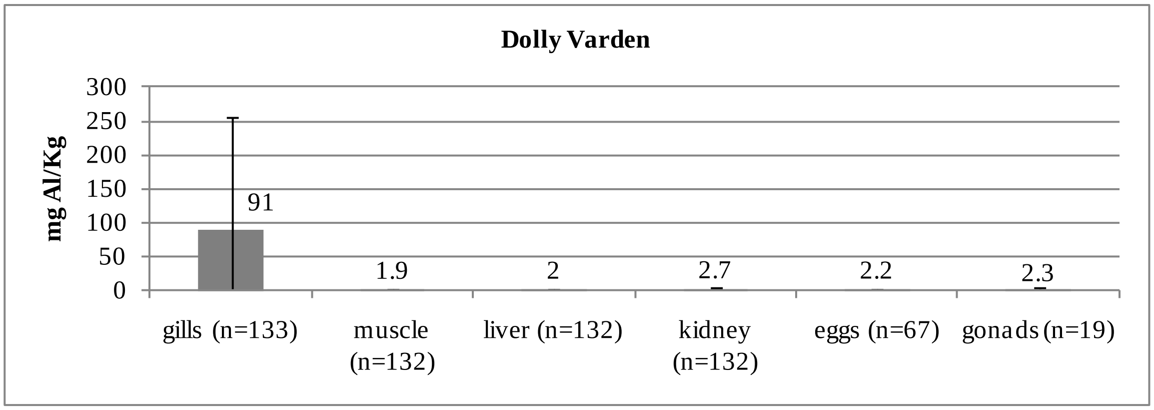

Figure 61. Average Al (plus and minus 1 SD), in adult Dolly Varden (1999 to 2009).

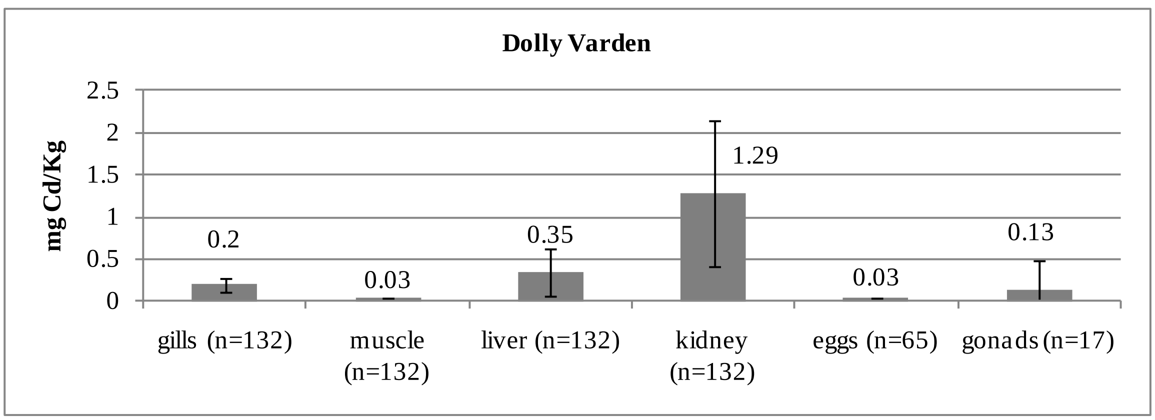

Figure 62. Average Cd (plus and minus 1 SD), in adult Dolly Varden (1999 to 2009).

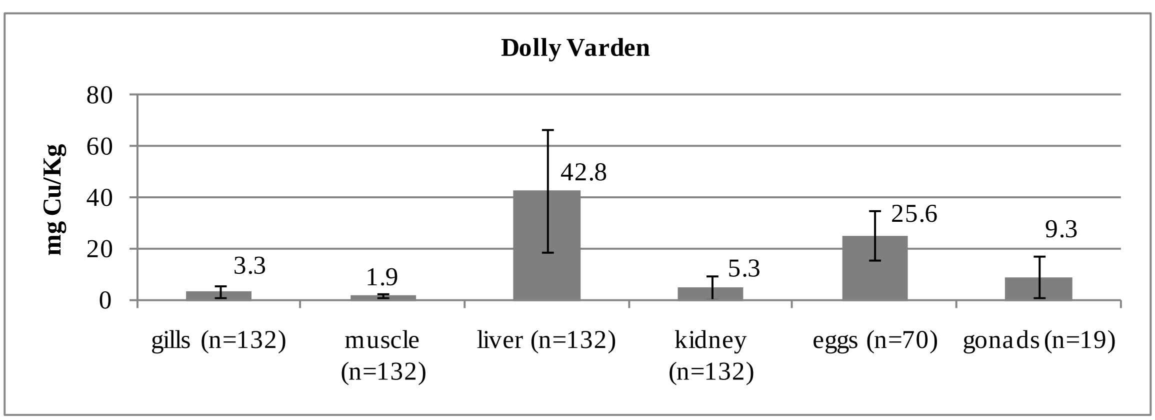

Figure 63. Average Cu (plus and minus 1 SD), in adult Dolly Varden (1999 to 2009).

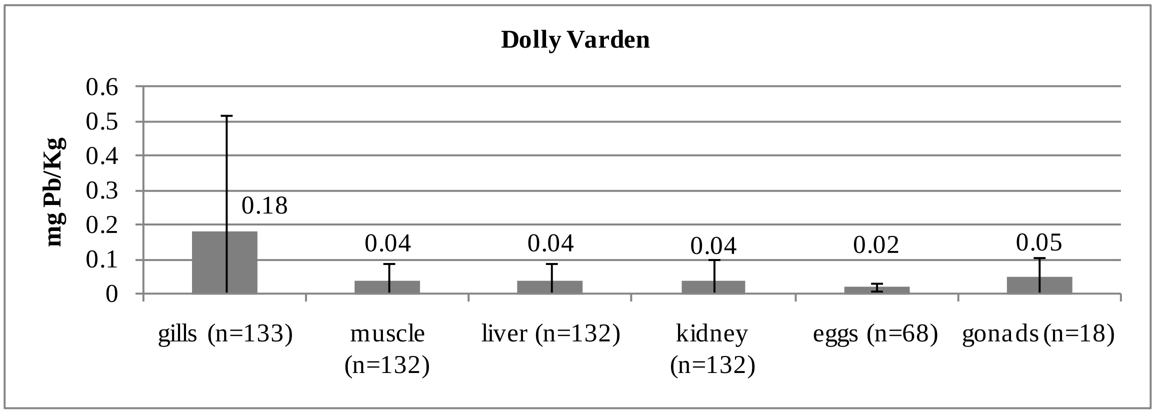

Figure 64. Average Pb (plus and minus 1 SD), in adult Dolly Varden (1999 to 2009).

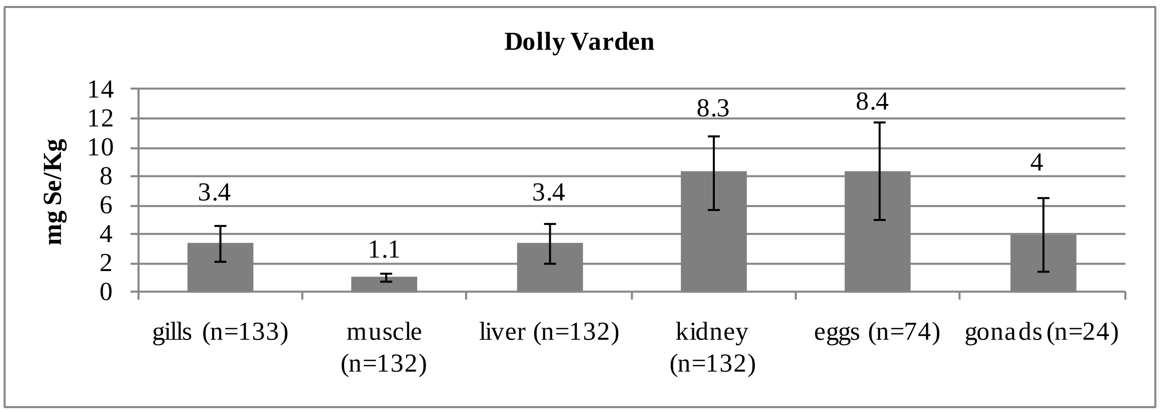

Figure 65. Average Se (plus and minus 1 SD), in adult Dolly Varden (1999 to 2009).

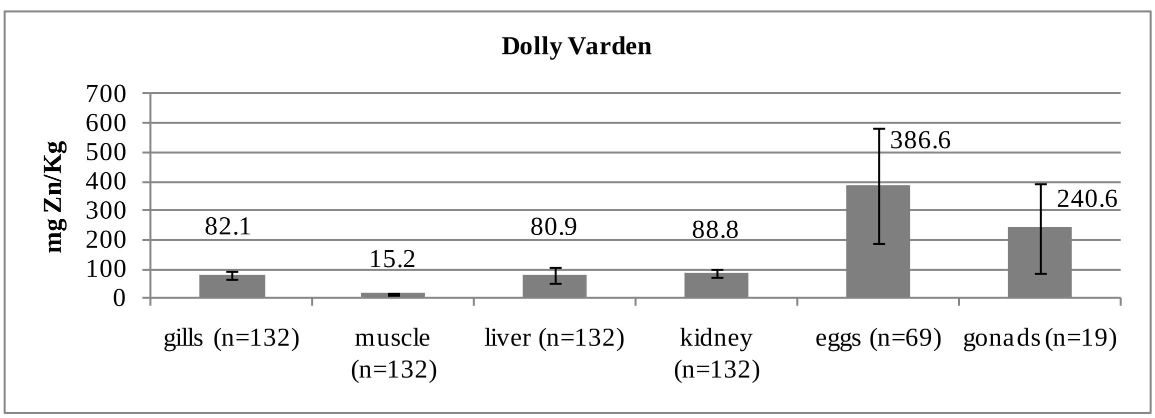

Figure 66. Average Zn (plus and minus 1 SD), in adult Dolly Varden (1999 to 2009).

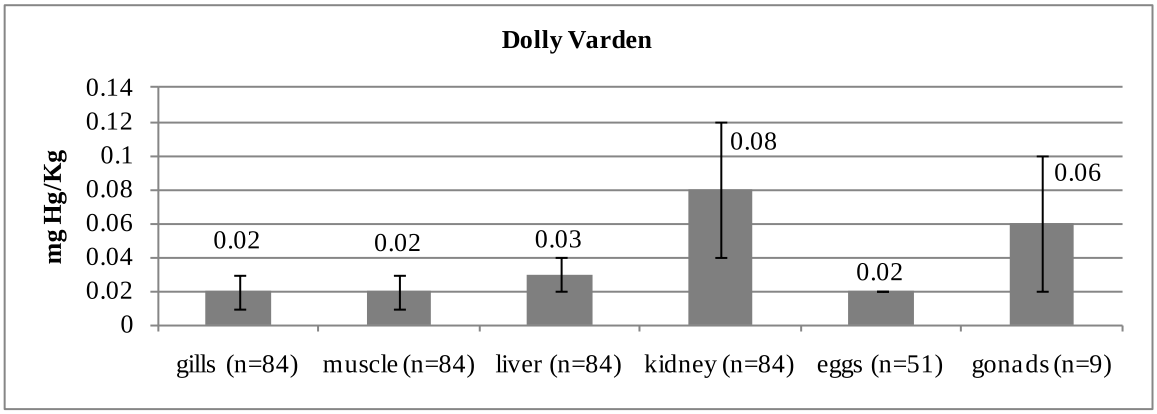

Figure 67. Average Hg (plus and minus 1 SD), in adult Dolly Varden (1999 to 2009).

Included in Appendix 9 are figures showing the median, maximum, and minimum concentrations of Al in gill, Cd in kidney, Cu in liver, Pb in gill, Se in ovary, Zn in ovary, and Hg in kidney tissues. Linear regression analysis was used to investigate trends with time for each tissue-metal pair listed above, by season of fish capture. All linear regressions that indicated time was significant in explaining any of the variation observed in the metal concentration are presented in Appendix 9. All linear regressions were computed for the uncompressed dataset for each analyte-metal pair, meaning these regressions are based on raw data and not on median or mean annual concentrations.

Raw Al concentrations are highly variable within samples and among sample events, but a trend up or down is not apparent. Median Cd concentrations in kidney tissue, both spring and fall, are lower than baseline data. Over the last five years except for fall 2009, Cd concentrations have been stable and lower than those previously reported. Analysis of the uncompressed dataset for kidney Cd concentrations suggests that spring caught Dolly Varden kidney Cd concentrations may be declining somewhat over time (Figures 8 and 10 in Appendix 9).

Median Cu concentrations in liver tissue are higher than baseline data, and generally, Cu concentrations in spring-caught fish are higher than in fall-caught fish. Median concentrations of Pb in gill tissue are slightly higher than those reported in baseline reports. Se concentrations in reproductive tissues show a significant increasing trend with time from 1999 to 2009; however, the linear fit is poor suggesting a linear increase is not particularly likely (Figures 12 and 13 in Appendix 9). When the uncompressed data are viewed on the linear regression (Figure 13 in Appendix 9), it is apparent that Se concentrations in the reproductive tissues of spring-caught adult Dolly Varden underwent a period of increase from 1999 through 2004 and generally have been decreasing since. Regardless, fish recently returning to freshwater from the ocean, fall-caught Dolly Varden, have higher Se concentrations in their ovaries than spring-caught fish. Median Se concentrations in ovarian tissue consistently are higher in fall-caught fish. Median Zn concentrations in ovarian tissue have remained fairly consistent, but are generally higher in fall-caught fish. Generally, the concentrations of Hg in all tissues, except kidney, are at or below the detection limit. There is indication that Hg concentrations may be increasing slightly with time in adult Dolly Varden captured in both spring and fall (Figures 9 and 11 in Appendix 9). Table 1 in Appendix 9 provides nonparametric analysis of variance results between spring- and fall-caught Dolly Varden for all tissues and metals.

Dolly Varden, Overwintering

An aerial survey to estimate the number of overwintering Dolly Varden in the Wulik River was flown on September 25, 2009, with a R-44 helicopter provided by Teck (DeCicco 2009). Discharge in the Wulik River was about 800 cfs, slightly below the mean of 860 cfs. The survey was flown in late afternoon to take advantage of the highest sun angle. The weather was clear and the east wind was light; overall, conditions were nearly ideal. Counts began about 1.6 km upstream of Kivalina Lagoon. Fish were distributed nearly to the lagoon and were likely still entering from the sea. Two counts were made (60,998 and 63,977 fish). Overall the count was lower than in the recent past. Like the past few years, very few small fish were present. The smaller Dolly Varden often enter freshwater late in the migration and they may have not yet entered from the sea or the low numbers of first year migrants (250 to 325 mm long) may indicate reduced production.

The number of Dolly Varden estimated in the fall in the Wulik River varies annually (Figure 68 and Appendices 10 and 11). Survey results in 2009 found that over 99% of the fish seen were downstream of the mouth of Ikalukrok Creek. Only in 2004 has the percentage of fish below Ikalukrok Creek been less than 90%. Continued use of this section of the Wulik River by the majority of overwintering Dolly Varden suggests that conditions have not changed to alter the distribution of these fish.

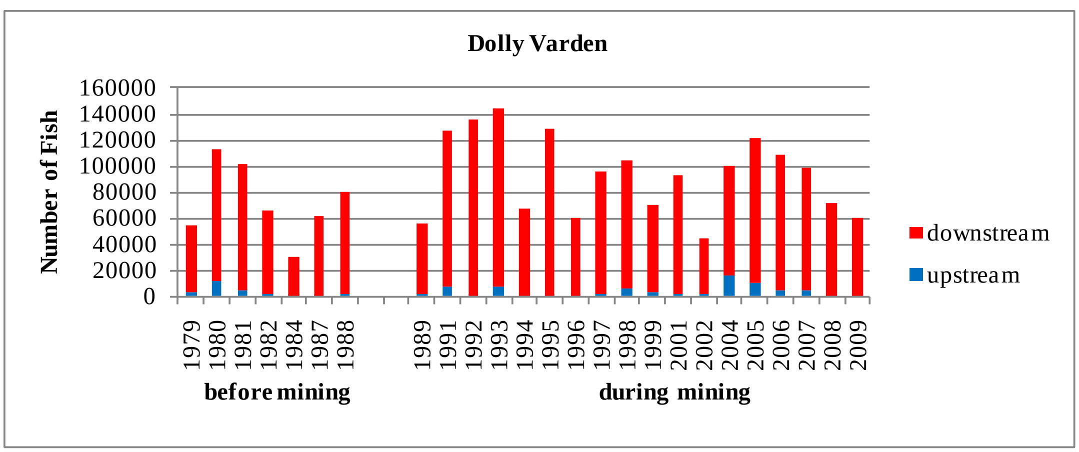

Figure 68. Estimated Dolly Varden in the Wulik River just prior to freezeup.

Chum Salmon, Spawning

ADF&G conducts annual aerial surveys to assess the distribution of adult chum salmon in Ikalukrok Creek from its confluence with the Wulik River upstream to Dudd Creek (Table 4 and Appendix 11). In fall 2009, we flew two surveys using a R-44 helicopter. Survey conditions were poor on July 31, 2009, and we flew only a partial survey focusing on the lower portion of Ikalukrok Creek where most of the spawning occurs. We saw about 100 chum salmon in the lower portion of Ikalukrok Creek and none at its mouth. DeCicco and Scanlon flew Ikalukrok Creek late in the day on the September 25 - a low sun angle was not the best for observing fish. They counted 2,051 chum salmon in Ikalukrok Creek and believed their estimate was low. DeCicco (2009) stated that this was a very large number of chum salmon still spawning this late.

Our estimated chum salmon return to Ikalukrok Creek in 2009 was at least 2,051 fish. We have seen good returns of chum salmon for the last four years. Our highest count since mining began at Red Dog Mine was in 2006 when we counted 4,185 fish.

All chum salmon observed were below Station 160 on Ikalukrok Creek, - the downstream limit of the effluent discharge mixing zone. Counts of chum salmon in Ikalukrok Creek in 1990 and 1991 (mine discharge began in 1989) were lower than reported in baseline studies. Surveys began again in 1995, with the highest count made in fall 2006. Large returns of chum salmon in recent years are good indications that the population has recovered from the early 1990s.

Table 4. Number of chum salmon adults in Ikalukrok Creek.

Survey Date	Number of Chum Salmon	Reference
September 1981	3,520 to 6,960	Houghton and Hilgert 1983
August September 1982	353 to 1,400	Houghton and Hilgert 1983
August 1984	994	DeCicco 1990c
August 1986	1,985	DeCicco 1990c
August 1990	<70	Ott et al. 1992
August 1991	<70	Ott et al. 1992
August 16, 1995	49	Townsend and Lunderstadt 1995
August 1995	300 to 400	DeCicco 1995
August 11, 1996	180	Townsend and Hemming 1996
August 12, 1997	730 to 780	Ott and Simpers 1997
1998	no survey	
August 9, 1999	75	Ott and Morris 1999
2000	no survey	
August 7, 2001	850	Morris and Ott 2001
August 28, 2001	2,250	DeCicco 2001b
August 29, 2001	1,836	DeCicco 2001b
September 23, 2001	500	DeCicco 2001c
October 8, 2001	232	DeCicco 2001a
August 5, 2002	890	Ott and Townsend 2002
August 11, 2003	218	Townsend and Ingalls 2003
August 26, 2004	405	Townsend and Conley 2004
August 29, 2005	350	Thompson 2005
August 14, 2006	4,185	Ott and Timothy 2006
August 11, 2007	1,408 and 1,998	Ott and Townsend 2007
August 6, 2008	3,820	Ott and Jacobs 2008
July 31, 2009	100	Ott and Benkert 2009
September 25, 2009	2,051	DeCicco 2009

Dolly Varden, Juveniles

Limited pre-mining juvenile Dolly Varden distribution and use data are available for streams in the Red Dog Mine area. Houghton and Hilgert (1983) identified Anxiety Ridge Creek as the most productive system in the project area. They also reported finding only one Dolly Varden in the North Fork Red Dog Creek drainage and presumed that it was a resident fish. Surveys along Mainstem Red Dog Creek reported either few fish or no fish, and in some cases mortalities for small juvenile Dolly Varden and Arctic grayling fry (EVS Consultants Ltd and Ott Water Engineers 1983, Ward and Olson 1980).

We have targeted juvenile Dolly Varden in streams in the Red Dog Mine area since 1990. We added new sample sites and increased the number of minnow traps per sample reach in 1992. Currently, we sample 10 sites, as listed in Table 5 (Appendix 13), with 10 minnow traps per sample reach, a fishing effort of about 24 hr, and two sample events each summer (one in late June/early July and one in early to mid-August). The upper North Fork Red Dog Creek site is not part of our standard sample program.

Table 5. Location of juvenile Dolly Varden sample sites.

Site Name	Station No.	Year Sampling Started
Evaingiknuk Creek		1990
Anxiety Ridge Creek		1990
Buddy Creek		1996
North Fork Red Dog Creek	12	1993
Mainstem Red Dog Creek	11	1995
Mainstem Red Dog Creek	10	1996
Ikalukrok Creek above Mainstem	9	1996
Ikalukrok Creek below Mainstem	8	1996
Ikalukrok Creek above Dudd		1990
Ikalukrok Creek below Dudd	7	1990

Minnow traps are the preferred sampling gear for juvenile Dolly Varden in the Wulik River drainage because they are very effective for this species and age classes present, the gear is suitable for all sample areas (i.e., large to small streams), the effort is uniform across sample sites, variability due to sampler-induced bias is reduced, and there is virtually no mortality. Juvenile Dolly Varden generally are the most numerous fish species present and are distributed most widely in the sample area. Our objectives are to assess seasonal patterns of use, to assess numbers of fish using streams over time, and to sample juvenile Dolly Varden for whole body metal analyses from selected streams. Data relevant to whole body metal analyses were presented in a previous section of this report.

The relative abundance of juvenile Dolly Varden varies considerably among sample years (Figure 69 and Appendix 13); however, the relative catches among the sample sites follow similar patterns. Natural environmental conditions such as the duration of breakup, patterns and magnitude of rainfall, ambient air temperatures, and the strength of the age 1 cohort affect distribution of juveniles and relative abundance. We believe that the most important factor is the strength of the age 1 cohort which is directly related to numbers of spawners, spawning success, and survival the previous winter.

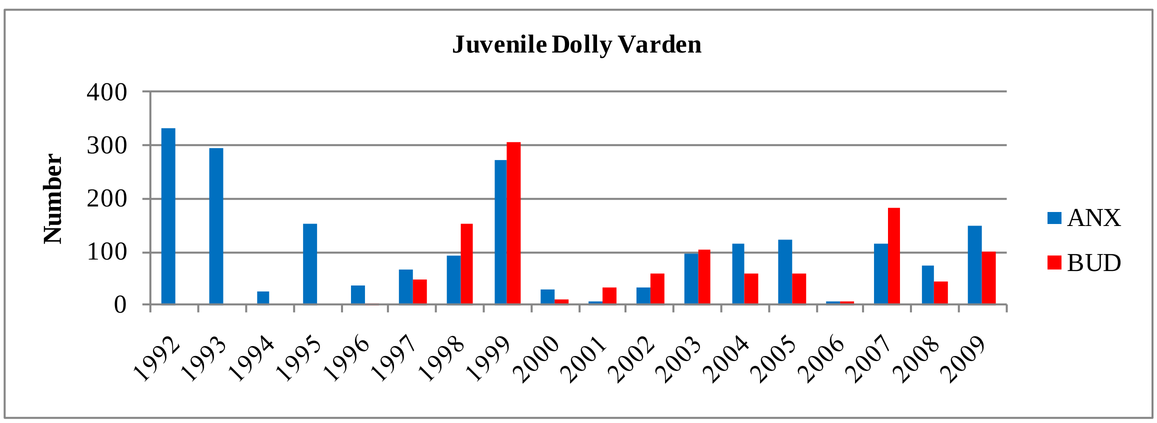

Figure 69. Catch of juvenile Dolly Varden in Anxiety Ridge (ANX) and Buddy (BUD) creeks in late July to early August.

With almost 20 years of sampling for juvenile Dolly Varden in streams near the Red Dog Mine, we have developed the following conclusions: abundance is higher in the upper reaches of each sample stream; peak use occurs from late July to late August; and although catches vary annually, juvenile Dolly Varden are most abundant in Anxiety Ridge and Buddy creeks.

Catches of juvenile Dolly Varden from 1997 through 2009 in Anxiety Ridge (ANX) and Mainstem Red Dog (MS) are shown in Figure 70. Anxiety Ridge Creek is considered a reference site with no direct effects from the wastewater discharge while Mainstem Red Dog Creek (sample reach just downstream of North Fork Red Dog Creek) is directly affected by water from the clean water bypass channel and the effluent from the treatment plant. Historically, prior to the Red Dog Mine, there were essentially no fish in Mainstem Red Dog Creek. Catches of juvenile Dolly Varden are consistently higher in Anxiety Ridge Creek. We did catch rearing juvenile Dolly Varden in Mainstem Red Dog Creek every year with the catch ranging from 2 to 86 (Figure 70).

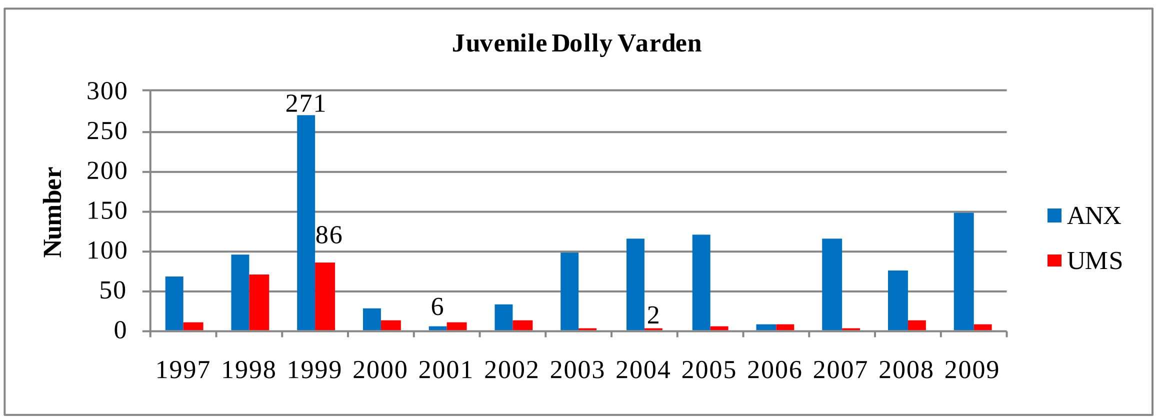

Figure 70. Catches of juvenile Dolly Varden in Anxiety Ridge (ANX) and upper Mainstem Red Dog (UMS) creeks in late July to early August.

We have sampled two reaches of Mainstem Red Dog Creek each year since 1997. The lower reach is located just upstream of the mouth and encompasses Station 10. Sampling is conducted twice each summer with catches always higher later in the summer. Catches were highest in 1998 and 1999, but have been low every year since 1999 (Figure 71). Catches of juvenile Dolly Varden were similarly, quite high in 1998 and 1999 in Buddy and Anxiety Ridge creeks.

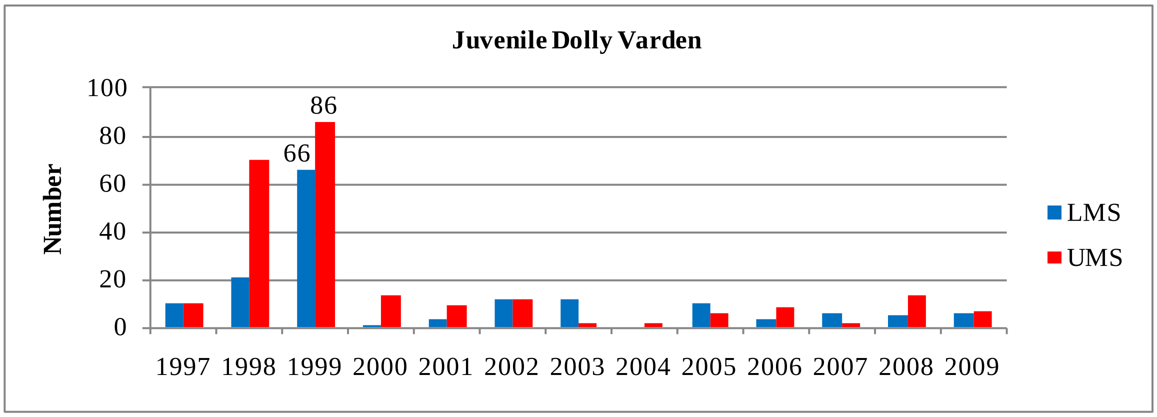

Figure 71. Catches of juvenile Dolly Varden in upper Mainstem Red Dog (UMS) and lower Mainstem Red Dog (LMS) creeks, in late July to early August.

Each spring (2000 through 2009), we catch resident Dolly Varden moving upstream with the Arctic grayling in fyke nets in North Fork Red Dog Creek. In spring 2009, we caught 14 Dolly Varden (Figure 72). Most of these fish were presumed to be resident fish due to size (larger than smolts), obvious parr marks, and distinct orange/pink dots. It is unknown whether this consistent change in fish use compared with baseline data is related to water quality improvements in Mainstem Red Dog Creek or simply due to increased sampling effort and the use of fyke nets. It is highly probable that these resident Dolly Varden are following Arctic grayling to feed on Arctic grayling eggs. One additional observation that we have made is that our catches of these larger Dolly Varden occur very early in the sampling event and then decline toward the end. The end of sampling occurs when Arctic grayling spawning is substantially complete.

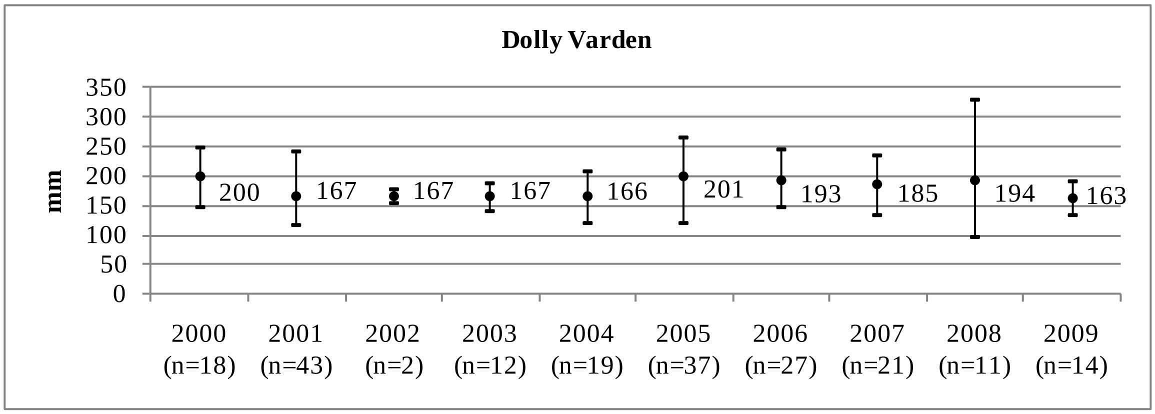

Figure 72. Dolly Varden caught in fyke nets fished in North Fork Red Dog Creek in spring during the Arctic grayling spawning run.

The length frequency distribution of juvenile Dolly Varden, especially the presence of fry, indicates successful reproduction and survival. Dolly Varden less than 60 mm long in late July to mid-August probably are age 0 fry (Houghton and Hilgert 1983, DeCicco 1985). Fry caught in drift nets in Wulik River tributaries in early July were less than 30 mm long. Smolting can occur as early as age 2, but more commonly at age 3 (DeCicco 1990a). Our catch in early August 2009 from the 9 sample reaches in the Ikalukrok Creek drainage was 315 fish – there appears to be 3 age classes represented (Figure 73). Length frequency distributions for the 2008 and 2007 sampling events are shown in Figures 74 and 75. The dominant size group in 2009 probably are age 3 fish that were prevalent in 2007. These age 3 juvenile Dolly Varden will most likely smolt in spring 2010. The length frequency distribution for the 2009 sample indicates the presence of two additional age classes (probably 1 and 2). In 2010, we plan to retain a representative sample of the fish collected for age validation.

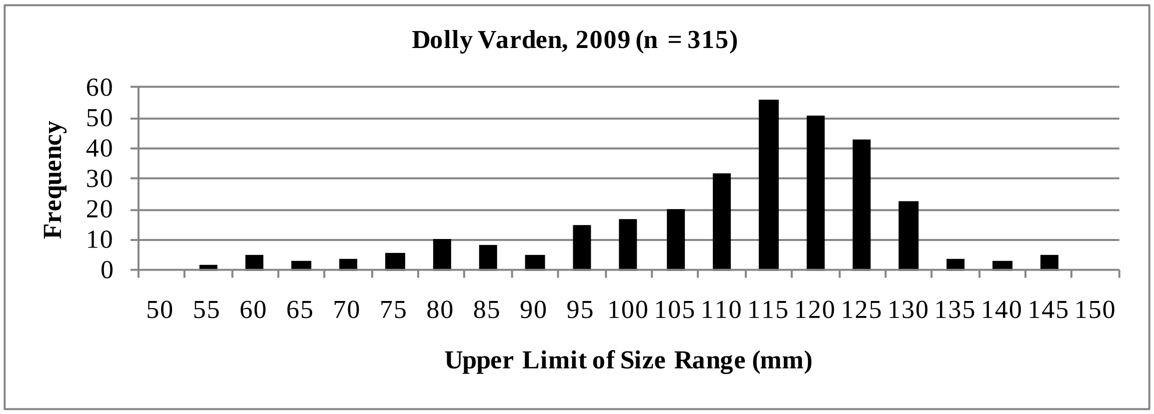

Figure 73. Length frequency distribution of Dolly Varden caught in minnow traps in fall 2009 in the Ikalukrok Creek drainage.

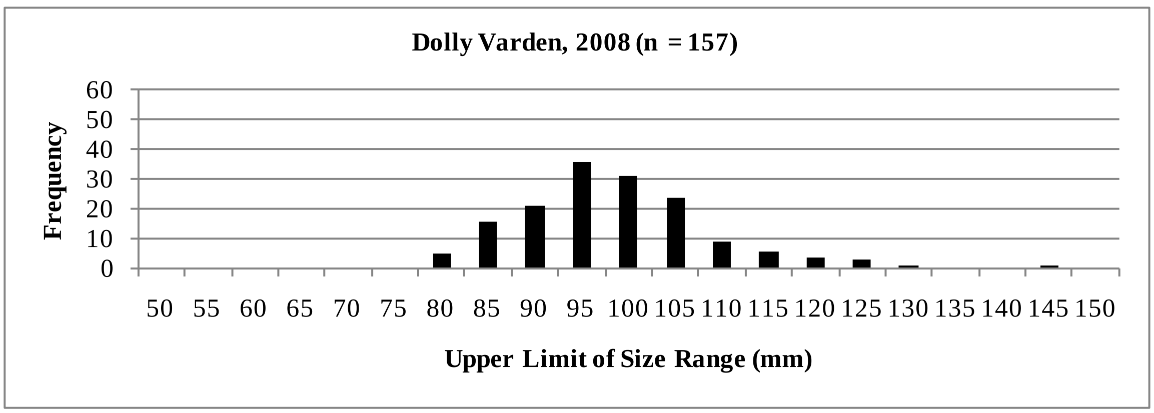

Figure 74. Length frequency distribution of Dolly Varden caught in minnow traps in fall 2008 in the Ikalukrok Creek drainage.

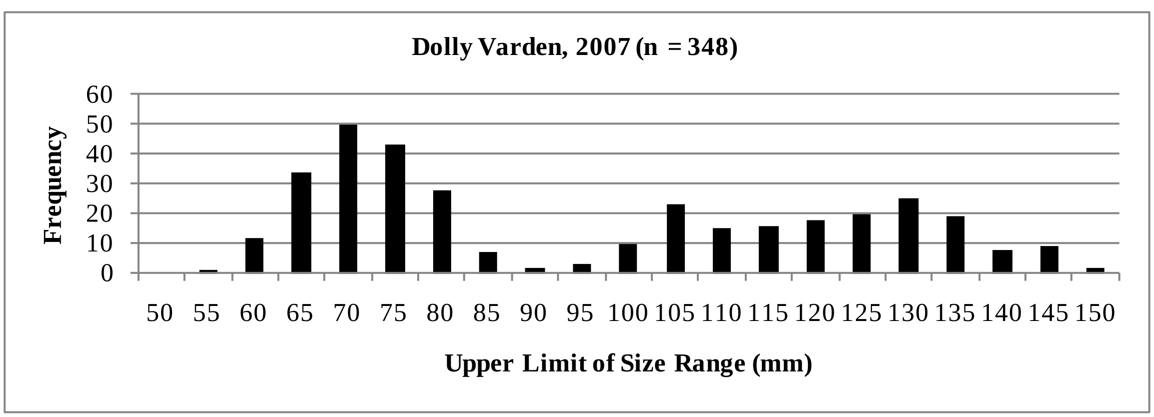

Figure 75. Length frequency distribution of Dolly Varden caught in minnow traps in fall 2007 in the Ikalukrok Creek drainage.

Arctic Grayling

Before mine development, Arctic grayling adults migrated through Mainstem Red Dog Creek in spring when flows were high and metals concentrations were low (Ward and Olsen 1980, EVS and Ott Water Engineers 1983, and Houghton and Hilgert 1983). Arctic grayling moved through Mainstem Red Dog Creek to spawn in North Fork Red Dog Creek. None of these reports stated or indicated that Arctic grayling spawned in Mainstem Red Dog Creek. Arctic grayling fry reared in North Fork Red Dog Creek and were displaced downstream by high-water events or outmigrated as water temperatures cooled in the fall. Before Red Dog Mine operations, very few, if any, juvenile Arctic grayling were found rearing in North Fork Red Dog Creek. Mortalities of fry were reported in Mainstem Red Dog Creek by EVS Consultants and Ott Water Engineers (1983) and Ward and Olsen (1980). Since 1994, we have consistently documented Arctic grayling use (migration, spawning, and rearing) of Mainstem Red Dog Creek (Appendix 14).

Arctic Grayling Spawning

We have monitored Arctic grayling spawning during spring in North Fork Red Dog and Mainstem Red Dog creeks since 2001. The purpose of this sampling effort is to document when spawning has been substantially completed in Mainstem Red Dog Creek. Water temperature is the most likely factor determining spawning time, emergence of fry, first year growth, and survival. High flows during or immediately following spawning have a substantial negative effect on fry survival.

Discharge volume and quality from the wastewater treatment facility at Red Dog are regulated to meet permit conditions (NPDES Permit AK-003865-2, dated August 28, 1998, as modified on August 22, 2003). From 2001 to 2007, total dissolved solids (TDS) concentrations were regulated to be less than 500 mg/L at Station 151 (Station 10) during Arctic grayling spawning. Monitoring of Arctic grayling spawning was performed to determine when spawning was substantially completed thus allowing Teck to increase the TDS concentrations to 1,500 mg/L for the remainder of the ice-free season.

A TDS site-specific criterion (SSC) of 1,500 mg/L during Arctic grayling spawning was issued by ADEC and became effective on February 15, 2006. The US Environmental Protection Agency (EPA) approved the 1,500 mg/L TDS SSC on April 21, 2006. The SSC as developed by ADEC was based on field and laboratory studies conducted with Arctic grayling at the Red Dog Mine site (Brix and Grosell 2005). In 2008 and 2009, Teck regulated the wastewater discharge to ensure that TDS concentrations did not exceed the ADEC and EPA approved 1,500 mg/L at Station 151. However, on May 10, 2009, TDS concentrations did exceed 1,500 mg/L and Teck notified EPA, investigated the incident, and took steps to prevent reoccurrence (Figure 76). It should be noted that in 2009, Arctic grayling spawning probably did not begin until June 8 (Julian Date 159).

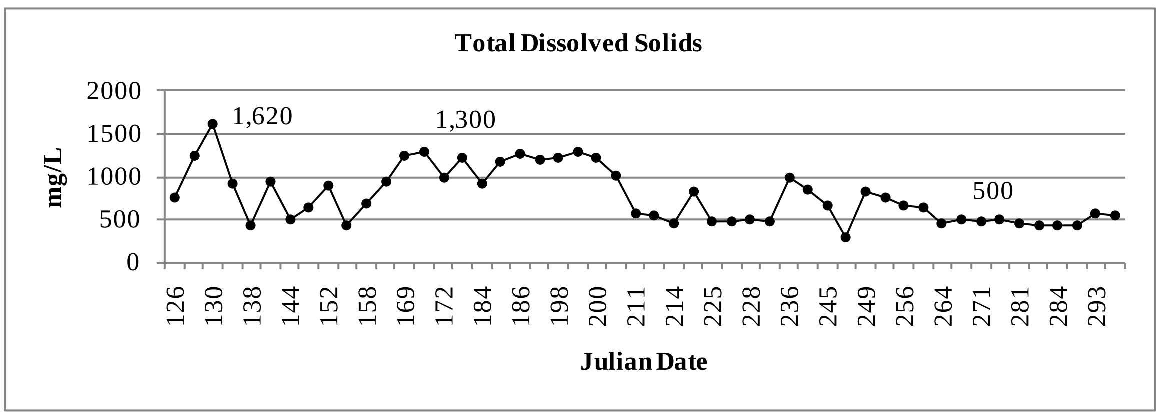

Figure 76. TDS concentrations at Station 151 during 2009. Station 151 is located immediately below the mixing zone in upper Mainstem Red Dog Creek just downstream of the mouth of North Fork Red Dog Creek.

Our spring 2009 trip to the Red Dog Mine was delayed several times due to high water, a delayed breakup, and cold weather which kept water temperatures in North Fork Red Dog Creek below 4°C. On June 11, we set one fyke net in North Fork Red Dog Creek immediately upstream of the confluence of North Fork Red Dog Creek and Mainstem Red Dog Creek (referred to as the Large Net) (Figure 77). The net was set in a backwater with a wing on the east side extending completely across the main current of North Fork Red Dog Creek. This net captures Arctic grayling moving upstream for spawning and rearing, but also catches Arctic grayling that have spawned in Mainstem Red Dog Creek and continued to move upstream into North Fork Red Dog Creek. A second fyke net was set June 13 just upstream of the Large Net (Figure 78).

Figure 77. Large fyke net in North Fork Red Dog Creek, June 2009.

Figure 78. Small fyke net in North Fork Red Dog Creek, June 2009.

The second fyke net was set with the west wing oriented parallel with the main current and the east wing tied off to the streambank (referred to as the Connex Net). The Connex Net captures some of the fish that have been caught in the Large Net, but is set primarily to catch fish leaving North Fork Red Dog Creek. Fish leaving the system tend to mill in the pool/run upstream of the Large Net and are caught in the Connex Net. The fyke nets are checked twice each day and provide catch data that help characterize the spawning event in Mainstem Red Dog Creek. Fyke net catches on June 13 indicated that some spawning had already occurred in Mainstem Red Dog Creek, but it was not until June 15 that catches of fish increased (Figure 79). Our highest catches of female Arctic grayling occurred on June 15 and 16; however, of the few mature females captured prior to June 15, most were spent. All of these fish were caught in the Large Net and thus represent fish that had moved into North Fork Red Dog Creek from Mainstem Red Dog Creek.

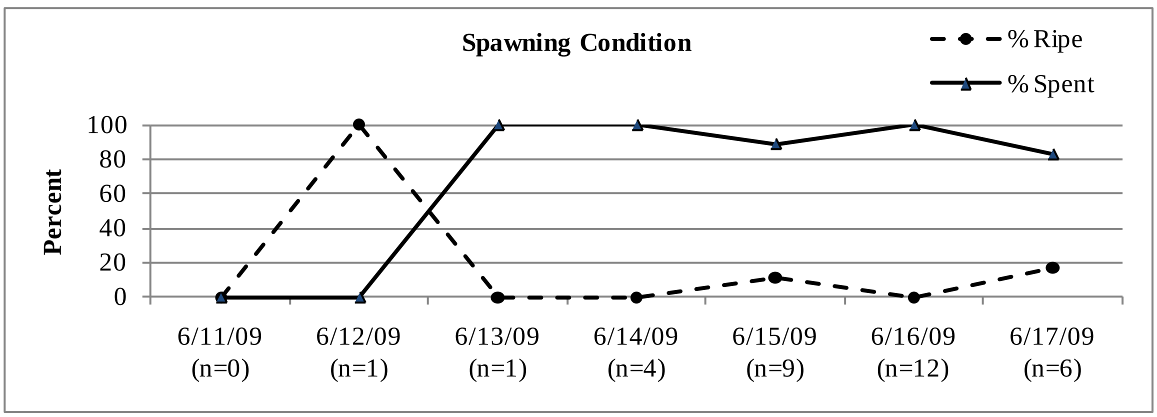

Figure 79. Spawning condition of female Arctic grayling, North Fork Red Dog Creek, June 2009. Total count of females each day, with the net being checked twice daily.

Our catches of Arctic grayling in the Large Net in North Fork Red Dog Creek peaked on June 16 (Figure 80). The percentage of males and females versus immature fish remained fairly consistent throughout the sample period.

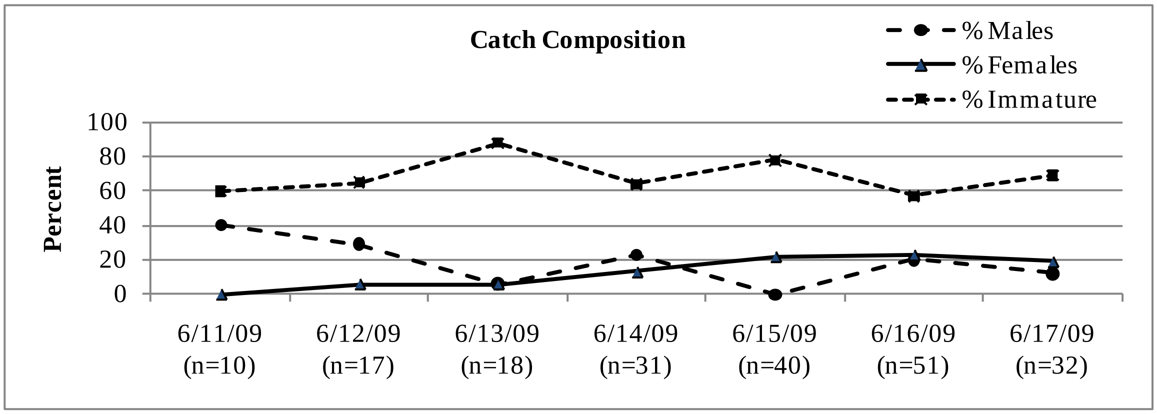

Figure 80. Catch composition of Arctic grayling caught in the Large Net fished in North Fork Red Dog Creek in spring 2009.

On June 8, 2009, the water temperature at Station 10 in lower Mainstem Red Dog Creek exceeded 4°C for the first time (Figure 81). Temperatures first exceeded 3°C on May 31, when they reached 3.1°C. Based on the daily catch compositions and the percentage of spent females caught in the Large Net, we believe that spawning started around June 8 and was substantially completed by the evening of June 12.

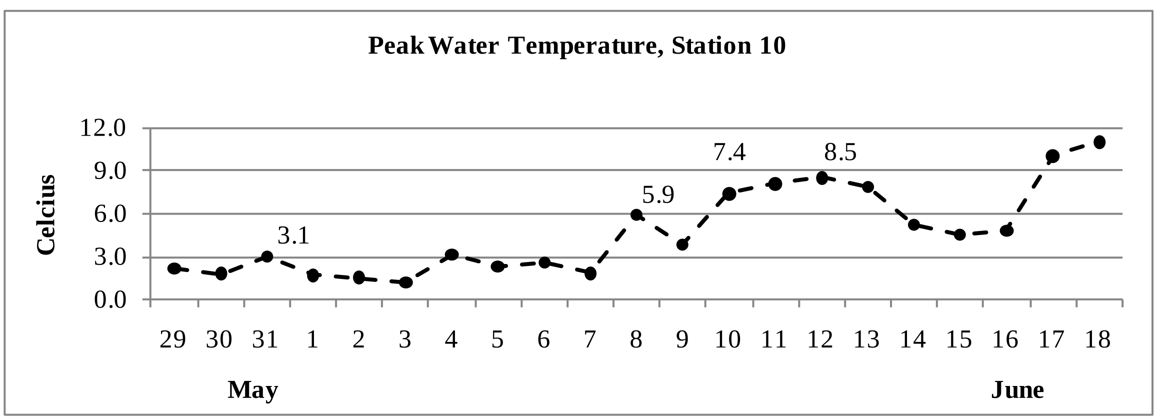

Figure 81. Peak daily water temperature in Mainstem Red Dog Creek at Station 10.

In 2009, spawning success in the Red Dog Creek drainage was poor. Very few fry were seen in North Fork Red Dog and Mainstem Red Dog creeks in early July; however, in late July, some fry were observed. Although numbers were low, the highest density of fry was observed in Mainstem Red Dog Creek in the area immediately upstream of Station 151 (Table 6). Fry in this area are likely from Arctic grayling that spawned in North Fork Red Dog Creek.

Table 6. Relative abundance of Arctic grayling fry in North Fork Red Dog Creek (1992 to 2009).

Year	Relative Abundance of Fry	Comments
1992	high	100's of fry, late July
1993	low	Few fry in early August, high water
1994	low	High water after spawning probably displaced fry
1995	low	Fry small (<25 mm) in mid-July
1996	high	Schools of 50 to 200 fry common
1997	high	Average size of fry was 10 mm greater than in 1996
1998	low	Cold water, late breakup, high water after spawning
1999	high	Low flows, warm water after spawning, schools of 50 to 100 fry common
2000	low	Cold water, late breakup, spawning 90% done June 13/14, fry small (<25 mm) and rare in mid-July
2001	low	Cold water, late breakup, spawning 90% done June 19, fry small (<25 mm) and rare in mid-July
2002	low	High flows, spawning 90% done June 8, fry small (<35 mm) in early August and rare, more fry seen in Ikalukrok Creek in early July, probably displaced by high water
2003	low	Cold water, late breakup, spawning 90% done June 14, fry small (<25 mm) and rare in early August
2004	low	Early breakup, spawning 90% done by May 31, fry (<30 mm) on July 10
2005	low	Spawning 90% done by June 7, fry present in early July, several groups of 25 to 30 observed to high water

Table 6 (concluded). Relative abundance of Arctic grayling fry in North Fork Red Dog Creek (1992 to 2009).

2006	low	Spawning partially abandoned due to cold water temperatures, no fry observed in early August, July surveys not possible due
2007	high	Spawning 90% done by June 3, followed by low water with very little rainfall until mid-August, fry numerous, hundreds seen in shallow water along stream margin, fry averaged 64 mm in early August
2008	low	Spawning 90% done by June 9, most fish probably spawned in Mainstem Red Dog Creek, no fry seen along stream margins
2009	low	Most fish probably spawned in Mainstem Red Dog Creek, breakup late, very few fry seen in July or August, fry observed in the reach just upstream of Station 151 indicate some spawning success in North Fork Red Dog Creek

A summary of Arctic grayling spawning in Mainstem Red Dog Creek from spring 2001 to 2009 is presented in Table 7. The earliest spawning was judged to substantially complete was May 31 in 2004 and the latest was June 15 in both 2001 and 2006. A complete description of each year's work with Arctic grayling spawning is available from ADF&G. Limited spawning could start at 3°C, but most likely does not start until temperatures reach 4°C.

We also monitored Arctic grayling spawning in Bons Pond and its tributaries. Spawning is concentrated in the outlet of Bons Pond and in Bons Creek. A fyke net was set in Bons Creek about 0.2 km upstream of Bons Pond on June 11. The fyke net was set to capture fish moving upstream and the net was checked once each day until removed on June 17. Bons Pond was 90% ice covered when sampling began and the pond was not ice free until June 17. Most of the fish caught in spring 2009 were captured by angling.

Water temperature in Bons Creek was 4.5°C on June 11 when active spawning was observed in the reach where our fyke net was set. Active spawning was seen in the outlet channel from Bons Pond in late afternoon on June 13 – the water temperature was 4.0°C and the pond was still partially covered with ice. We also checked Bons Pond outlet the

Table 7. Summary of Arctic grayling spawning in Mainstem Red Dog Creek.

Year	Date When Limited Spawning Started (3°C)	Date When Spawning Complete (Condition of Females)	Number of Days Peak Temperatures Exceeded 4°C[1]
2001	June 6	June 15	6
2002	May 29	June 8	8
2003	June 7	June 14	6
2004	May 25	May 31	4
2005	May 27	June 6	9
2006	May 30	June 15	10
2007	May 26	June 3	8
2008	June 1	June 9	9
2009	June 8	June 13	4

[1]Does not include the day spawning was judged to be complete since the fyke net is worked in the early morning prior to peak temperatures on that day.

next several days but did not see any more spawning activity. We conclude that most of the spawning in the outlet occurred on June 13. Fry were not seen in early July in either Bons Creek or in Bons Pond outlet channel and no fry were caught in the drift nets set in Bons Creek.

Arctic Grayling Catches and Metrics

In spring 2009, we caught 237 Arctic grayling in the Red Dog Creek drainage. All fish were captured with two fyke nets except for 2 Arctic grayling caught by angling. Length frequencies for the mature and immature fish are presented in Figures 82 and 83. In Bons Pond we caught 241 mature Arctic grayling – these fish are smaller than those in the Red Dog Creek drainage and mature at a much smaller size (Figure 84). This pattern between the Red Dog Creek drainage and Bons Pond has been consistent. Most of the North Fork Red Dog Creek fish > 350 mm fork length were mature; however, there were at least 5 fish less than 350 mm that were judged to be mature. All Arctic grayling from Bons Pond and Bons Creek > 250 mm were mature.

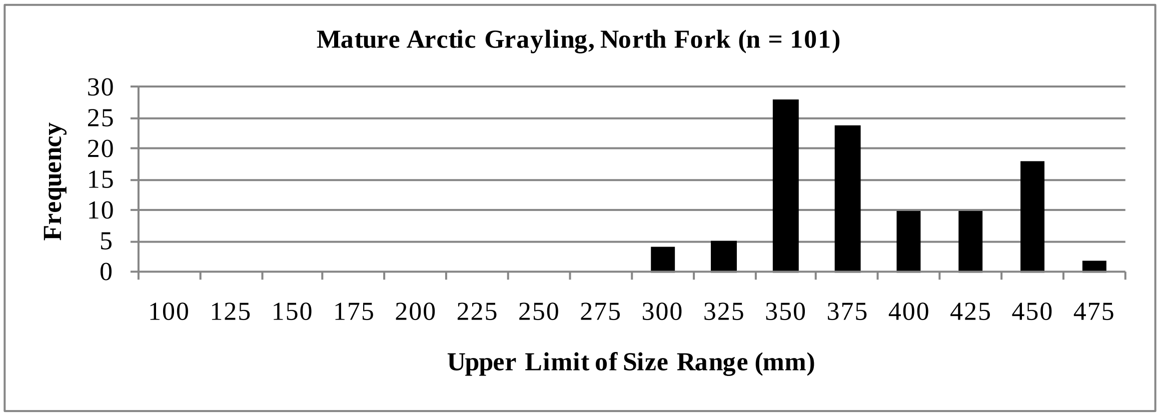

Figure 82. Length frequency distribution of mature Arctic grayling in the Red Dog Creek drainage in spring 2009.

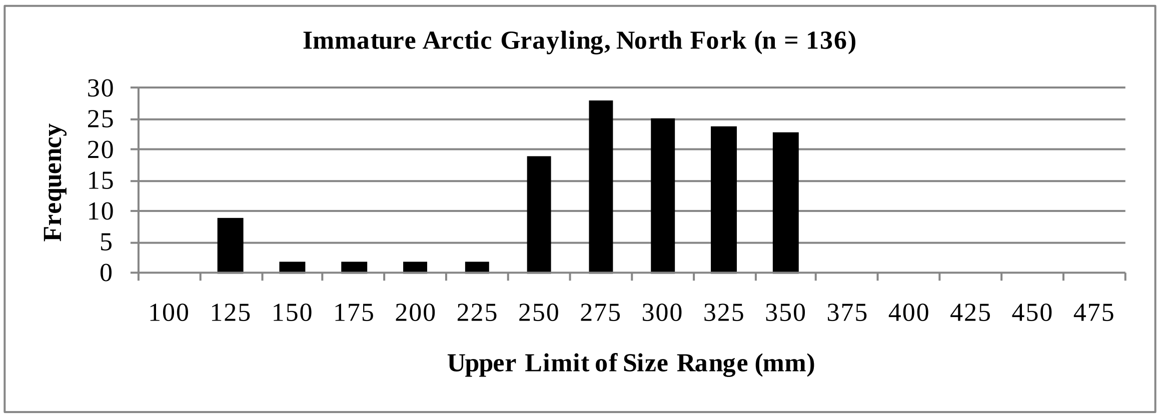

Figure 83. Length frequency distribution of immature Arctic grayling in the Red Dog Creek drainage in spring 2009.

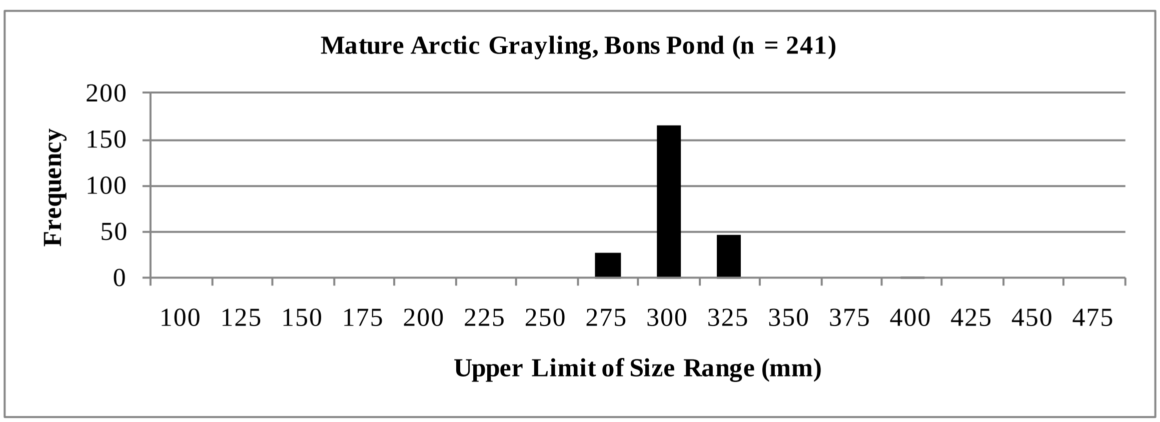

Figure 84. Length frequency distribution of mature Arctic grayling in Bons Pond and Bons Creek in spring 2009.

Strong potential recruitment to the North Fork Red Dog Creek adult population has been seen for three consecutive years (2007, 2008, and 2009). A portion of this recruitment is attributable to Arctic grayling leaving Bons Pond, entering the Ikalukrok Creek drainage, and then returning to North Fork Red Dog Creek in the spring. The Bons Pond population is the result of a fish transplant of Arctic grayling from North Fork Red Dog Creek in 1994 and 1995. The percentage of marked fish coming from Bons Pond in our North Fork Red Dog Creek spring sample has been 12, 18, and 13 in 2007, 2008, and 2009 (Table 8).

Table 8. Arctic grayling recaptures in 2009 in North Fork Red Dog Creek that came from the Bons Pond population.

Tag Number	Color	Gear Type	Length (mm)	Sex	Date Captured	Site Captured	Recapture Date	Recapture Site	Length (mm)
11042	Orange	Fyke Net	233	Male	7/6/2003	Bons Pond	6/11/2009	North Fork	371
12901	Gray	Fyke Net	288	Female	6/9/2008	Bons Pond	6/12/2009	North Fork	317
15361	White	Fyke Net	205	Immature	7/8/2005	Bons Pond	6/12/2009	North Fork	290
12856	Gray	Fyke Net	300	Male	6/8/2008	Bons Pond	6/13/2009	North Fork	318
12466	Gray	Fyke Net	254	Female	6/2/2007	Bons Pond	6/13/2009	North Fork	274
16125	White	Fyke Net	214	Immature	7/1/2006	Bons Pond	8/14/2007	Bons Pond	252
							6/14/2009	North Fork	286
15776	White	Fyke Net	244	Male	6/1/2005	Bons Pond	8/5/2008	North Fork	345
							6/14/2009	North Fork	358
14117	White	Fyke Net	221	Immature	6/1/2004	Bons Pond	6/3/2007	North Fork	280
							6/15/2009	North Fork	326
15153	White	Fyke Net	252	Male	8/24/2004	Bons Pond	6/8/2008	Bons Pond	287
							6/16/2009	North Fork	322
14730	White		233	Female	6/7/2004	Bons Pond	8/20/2004	Bons Pond	257
							6/2/2007	North Fork	315
							6/17/2009	North Fork	354
15670	White		308		6/3/2004	Bons Pond	8/14/2007	Bons Pond	312
							6/17/2009	North Fork	340

Recruitment of Arctic grayling, in the past, has been highly variable in North Fork Red Dog Creek, but with fish now entering from Bons Pond, recruitment has both stabilized and increased. Arctic grayling spawn in the Bons Pond outlet and Bons Creek and the fry have access to Bons Pond. Survival and growth of the Arctic grayling fry in Bons Pond fry are higher than in North Fork Red Dog Creek because of the lentic habitat, much higher concentrations of zooplankton, warmer water temperatures, and high volume of overwintering habitat. In addition, the fry are not as susceptible to displacement downstream because flows are moderated in the pond. We anticipate that Arctic grayling will continue to leave Bons Pond and recruit to the Ikalukrok Creek population.

Growth rates for Arctic grayling in North Fork Red Dog Creek and Bons Pond were calculated using the early spring sample in both 2008 and 2009, thus providing growth that occurred during summer 2008. Average annual growth of marked fish (> 200 mm) is substantially higher in North Fork Red Dog Creek than in Bons Pond (Figures 85 and 86). The Bons Pond fish ranged in size from 259 to 306 mm (n = 24, average 284, SD = 12). The North Fork Arctic grayling ranged in size from 215 to 414 mm (n = 22, average 309, SD = 46.1). Larger Arctic grayling occur in the North Fork drainage due in part to higher quantities of food, cooler water during the summer, and maturation at a larger size.

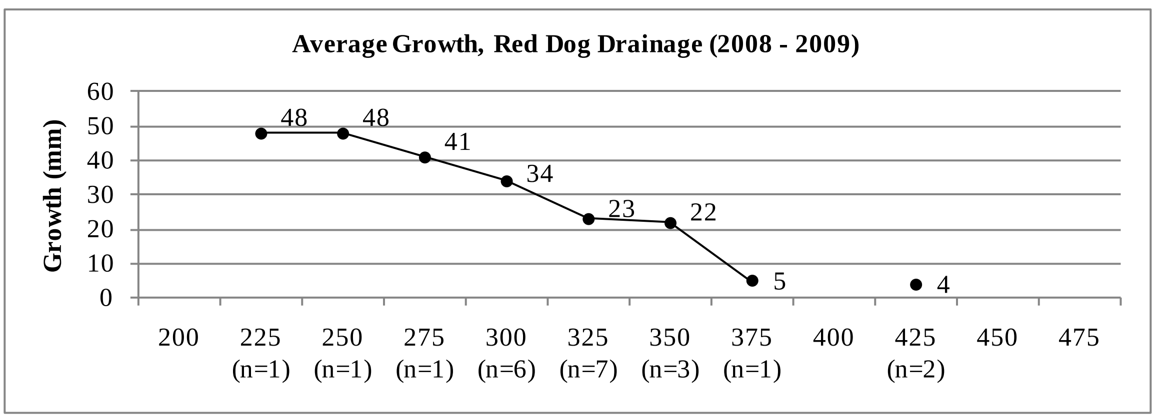

Figure 85. Average growth rates of Arctic grayling in Red Dog Creek drainage (2008 to 2009).

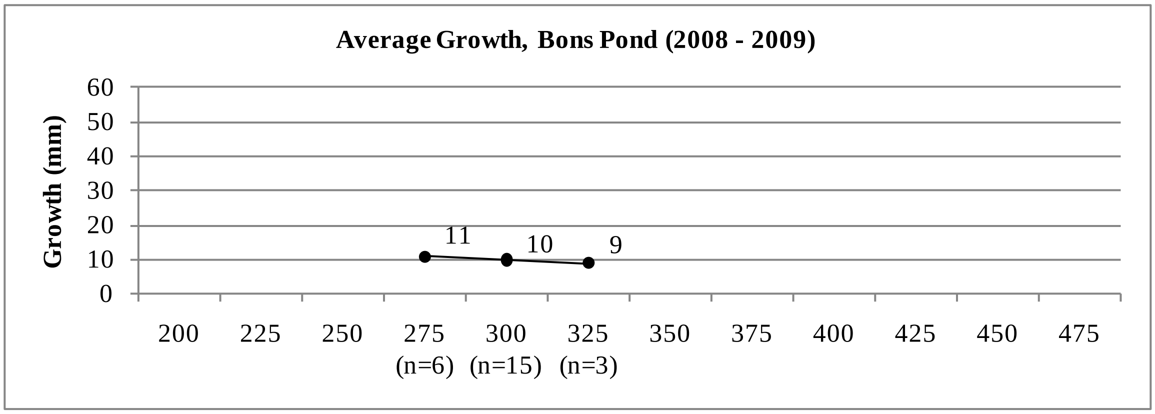

Figure 86. Average growth rates of Arctic grayling in Bons Pond (2008 to 2009).

We selected 4 Arctic grayling that have a long term capture history. The Arctic grayling from Bons Pond were marked in 2003 and recaptured multiple times including their capture in 2009. The total growth over a 6 year period was 78 mm for the male and 59 mm for the female (Table 9). The Arctic grayling from North Fork Red Dog Creek were tracked over a longer period of time. The male grew 156 mm from 1995 to 2004 while the female grew 144 mm over a 12 year period (Table 9). Once Arctic grayling mature, their growth slows dramatically.

Arctic Grayling Population Estimate

We estimated the Bons Pond Arctic grayling population for fish >200 mm fork length using the summer of 2008 as the mark event (n_1 = 213) and spring 2009 as the recapture event (n_2 = 258). In spring 2009 we had 24 recaptures (m_2) of fish seen in summer 2008. Our estimated population using Chapman's modification of the Lincoln-Petersen two-sample mark-recapture model (Chapman 1951) for summer 2008 was 2,216 fish (Figure 87). Seber (1982) was used for our calculation of the 95% confidence interval. Ott and Morris (2009) indicated that they expected the population to continue to decline for at least two more years (2008 and 2009).

Table 9. Individual Arctic grayling, mark and recapture data.

Tag Number	Color	Length (mm)	Date Captured	Capture Location	Sex
11759	Orange	214	7/8/2003	Bons Pond	Male
		230	6/2/2004	Bons Pond	
		251	8/23/2004	Bons Pond	
		265	6/16/2006	Bons Pond	
		280	6/3/2007	Bons Pond	
		284	8/12/2007	Bons Pond	
		292	6/11/2009	Bons Pond	
11769	Orange	211	7/7/2003	Bons Pond	Female
		218	8/12/2003	Bons Pond	
		260	6/3/2007	Bons Pond	
		270	6/12/2009	Bons Pond	
1509	White	229	6/26/1995	North Fork	Male
		237	7/17/1995	North Fork	
		335	7/1/1998	North Fork	
		364	6/15/2001	North Fork	
		377	6/1/2002	Mainstem	
		385	5/28/2004	North Fork	
1745	White	238	7/20/1995	North Fork	Female
		272	7/13/1996	North Fork	
		348	7/13/1999	North Fork	
		382	5/31/2007	North Fork	

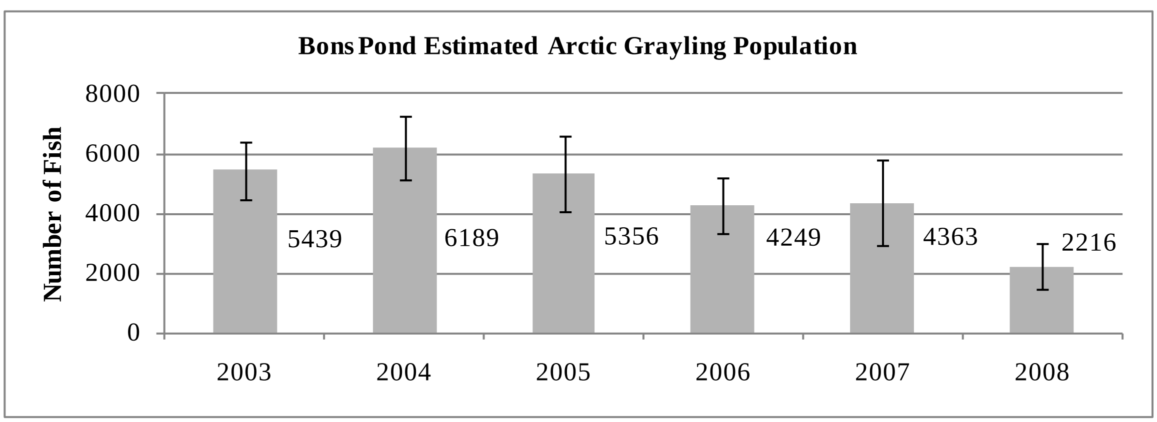

Figure 87. Estimated Arctic grayling population in Bons Pond.

However, based on a limited catch in July 2009, there are indications that some recruitment did occur in prior years (Figure 88). In early July, 14 of the 92 Arctic grayling marked were between 200 and 225 mm long and we saw fairly large numbers of smaller fish along the margins of the pond and in the outlet channel. It is possible that the trend for decreasing population size could begin to moderate in 2009; however, numbers of small fish available to recruit to the population still appears low.

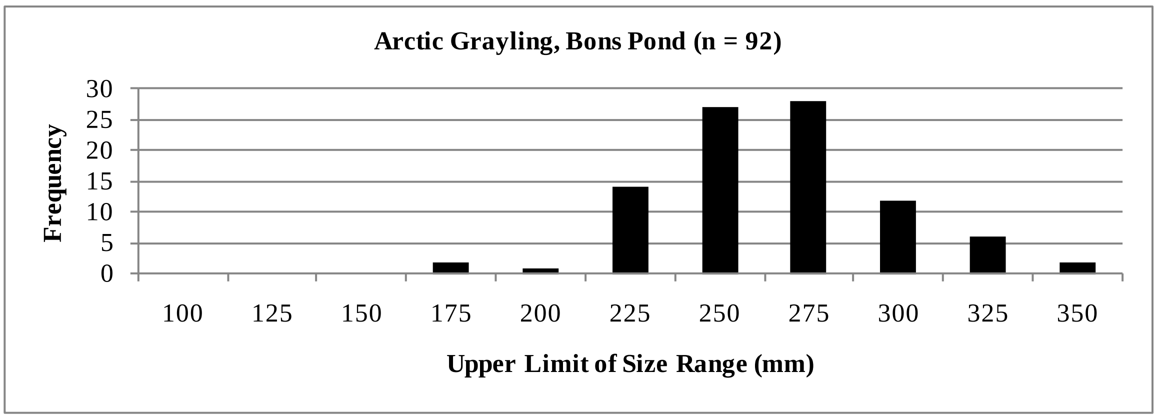

Figure 88. Length frequency distribution of Arctic grayling in Bons Pond in July 2009.

Slimy Sculpin

Houghton and Hilgert (1983) found slimy sculpin in Ikalukrok Creek and Dudd Creeks, but none were seen or caught in the Red Dog Creek drainage. In 1995, we caught slimy sculpin in Mainstem Red Dog and North Fork Red Dog creeks (Weber Scannell and Ott 1998). Slimy sculpin are infrequently caught in the Red Dog Creek drainage; however, we did catch 3 large slimy sculpin (133, 129, and 132 mm) in spring 2008 and 4 large slimy sculpin (132, 134, 136, and 142) in spring 2009 in the North Fork Red Dog Creek fyke net. The minnow trap catch per unit of effort (CPUE is for 10 traps for one sample period) since 1997 is presented in Figure 99. The overall trend appears to be for an increasing number of slimy sculpin in Mainstem Red Dog Creek. Slimy sculpin are generally believed to require good water thus these data suggest that conditions in the system have improved over time.

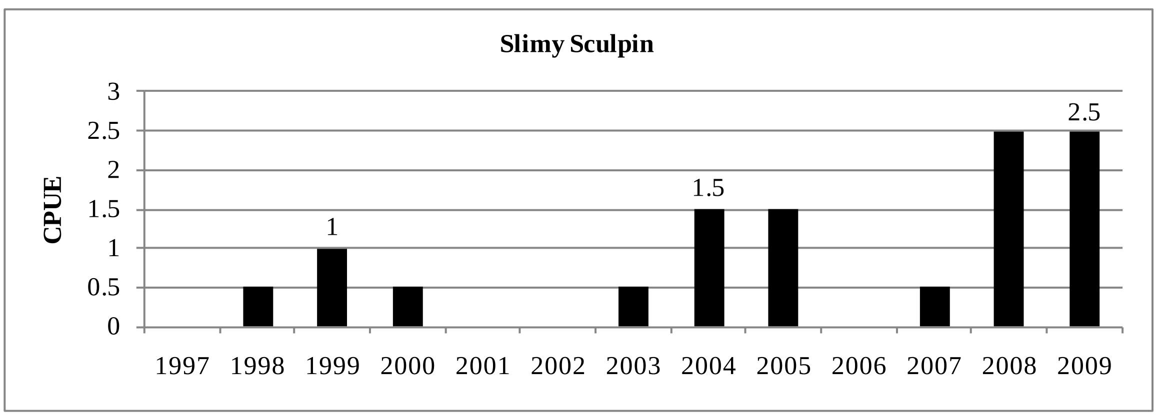

Figure 89. Slimy sculpin caught in Mainstem Red Dog Creek at two sample reaches – one just downstream of North Fork Red Dog Creek and the second in the vicinity of Station 10 near the mouth of Mainstem Red Dog Creek.

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Appendix 1. Summary of Mine Development and Operations

1982

- Baseline studies initiated, Cominco agreement with NANA finalized

1983

- EIS process initiated, alternatives for mine and road to port site identified

1984

- Stream surveys conducted along proposed road by private consultant

1985

- Permit applications prepared for regulatory agencies
- Implementation of wastewater treatment plant deferred to ADEC by ADF&G
- Wastewater discharge limited to summer
- Potential for acid rock drainage and metals mobilization not recognized

1986

- ADEC solid waste permit and bonding not required
- ADEC permit preceded solid waste regulations
- AIDEA bonds to build road and port site issued

1987

- Construction of road began, budget request to AIDEA prepared by ADF&G
- Reimbursement agreement for logistics with ADF&G to monitor construction made by AIDEA

1988

- Ore body developed
- Road and port site construction began
- Notice of Violation issued to AIDEA by ADF&G for failed road crossing bypasses
- Uniform Summons and Complaint issued for illegal water removal
- AIDEA provided funding to ADF&G for monitoring
- Rehabilitation plans for streams developed and implemented

Appendix 1 (continued)

1989

- Agreement to close-out old solid waste site finalized with Cominco
- Civil work on ore body and surface water drainage control begun
- Complaints about water quality in Ikalukrok Creek received
- Tailing dam becomes full, Cominco's request to siphon untreated water over the dam denied by State
- Elevated metals concentrations identified by red precipitation, were observed in Ikalukrok Creek below the mine
- Winter discharge of treated water authorized by State
- State regulatory agencies and Cominco in disagreement over whether metals exceeded background conditions

1990

- Biomonitoring of fish populations proposed and initiated by ADF&G
- Dead fish from the Wulik River were discovered by the public
- ADF&G sampling indicated very few fish remaining in Ikalukrok Creek
- Installation of sumps and pumps by Cominco prevented metals-laden water from entering Red Dog Creek
- Baseline and current water quality data reviewed by ADF&G
- Clean water bypass system requested by ADF&G
- Zinc levels in Ikalukrok Creek exceeded 40 mg/L
- State regulatory agencies and Cominco in disagreement over cause and extent of water quality problems
- Compliance Order by Consent for water quality violations affecting anadromous fish issued by ADEC
- Notice of Violation for water quality violations affecting anadromous fish issued by ADF&G
- Cominco directed to design and construct a clean water bypass system
- Perceived impairment to the subsistence fishery initiated involvement by the community of Kivalina

1991

- Clean water bypass system designed by Cominco, approved by state agencies
- ADF&G fisheries study funded by Cominco
- Clean water bypass system built
- Clean water bypass system repaired
- Improvements to water quality were documented

Appendix 1 (continued)

1992

- Fish study continued
- Water quality improvements to downstream receiving water continued
- Increasing water volume in tailing impoundment continued
- Water from dirty water collection system entering tailing impoundment increased volume
- Water treatment plant modifications made

1993

- Fish study continued
- Sand filters to remove particulate zinc installed

1994

- Fish study continued
- Use attainability studies of several streams initiated for reclassification
- Water treatment capacity increased by thickening tank conversion
- Wastewater discharge increased from 7.5 cfs to 23 cfs
- Ore processing capability expanded by Cominco
- 107 juvenile and adult Arctic grayling transplanted from North Fork Red Dog Creek to Bons Pond in late June
- 79 juvenile Dolly Varden transplanted from Anxiety Ridge Creek to Bons Pond in late June

1995

- Fish study expanded to include other aquatic biota
- Work on stream reclassification and site-specific criteria continued by ADF&G
- Metals concentrations in the clean water bypass system increased; contributing sources were identified: Hilltop Creek (Zn), Shelly Creek (Cd), and Rachel Creek (Al)
- Clean water bypass system extended to collect water from Hilltop Creek
- Reserves were doubled after exploration drilling located more ore
- Possible metals contamination in Bons Creek identified by ADF&G
- About 200 Arctic grayling fry (40 to 45 mm) were moved from North Fork Red Dog Creek to Bons Pond in August

1996

- Public notice for stream reclassification sent out
- Bons Creek water samples from above and below the Kivalina shale dump collected
- Fish and aquatic biota study continued

Appendix 1 (continued)

1997

- Stream reclassification incorporated into regulation (18 AAC 70.50)
- Fish barrier constructed across Middle Fork Red Dog Creek
- Water bypass around the Kivalina shale dump and interceptor trench at the head of the tailing impoundment built
- Gray-white precipitate observed in Middle Fork Red Dog Creek
- Heavy red staining and precipitate seen in Ikalukrok Creek; originated from seep near headwaters of Ikalukrok Creek, located upstream of mining activity
- Laboratory experiments of TDS on egg fertilization and early egg development initiated
- Fish and aquatic biota studies continue
- US EPA brings enforcement action for water quality violations; Cominco initiates Supplemental Environmental Projects
- Two-year aquatic community study in upper Ikalukrok Creek, above and below the Red Dog Mine discharge initiated by ADF&G
- Ground water monitoring wells installed and monitored below tailing dam by Cominco

1998

- Wet fertilization studies to test effects of TDS on fish embryos continued
- Draft 401 certification for a new NPDES permit prepared by ADEC and reviewed by ADF&G
- Discussed extension of the clean water bypass system up Shelly and Connie Creeks to ensure bypass of clean water and collection of seepage water from newly disturbed areas
- Heavy red staining in headwaters of Ikalukrok Creek, originating from seep in headwaters of Ikalukrok Creek, upstream of mining activity, staining extends downstream about 30 km
- Site-specific criteria for Zn in Mainstem Red Dog and Ikalukrok Creeks approved by EPA
- Heavy rains cause an unanticipated release of water into Bons Creek from the Kivalina stockpile
- Plans to increase port site capacity for direct loading of ships released to public
- NPDES permit (AK-003865-2) issued by US EPA became effective August 28, 1998 and was certified by ADEC (Certificate of Reasonable Assurance)
- Two-year aquatic community study completed
- Biomonitoring, including studies of fish and aquatic biota, required under 1998 NPDES permit

Appendix 1 (continued)

1999

- Two-year drilling program (Shelly and Connie Creeks) proposed
- New station 7 on Ikalukrok Creek established by Cominco, USGS, and ADF&G
- Fish and aquatic biota study expanded to upper North Fork Red Dog, Ikalukrok, and Ferric creeks
- Biomonitoring and USGS gauging work proposals submitted to Cominco
- Study of periphyton communities exposed to different concentrations of TDS in Mainstem Red Dog Creek done by ADF&G and Cominco Alaska Inc.
- Request to increase TDS for periphyton colonization experiment not approved
- Effects to Ikalukrok Creek from Alvinella Creek seepage water continued to below Dudd Creek mouth
- Arctic grayling females in ripe spawning condition collected from North Fork Red Dog Creek for selenium analysis of livers and ovaries

2000

- Effects to Ikalukrok Creek from Cub Creek seep continued; red stain and precipitate observed several km below mouth of Mainstem Red Dog Creek
- North Fork Red Dog Creek silty at breakup, previously not observed
- Minimal precipitate in Middle Fork Red Dog Creek below effluent outfall observed
- Civil work performed in Connie Creek to isolate surface from subsurface flows and bypass flow through disturbed areas
- Effectiveness of pump back system at the Kivalina rock dump verified by presence of juvenile Arctic grayling in creek immediately south of dump
- Site-specific criteria for TDS requested by Cominco
- Biomonitoring study continued
- Baseline fish and aquatic biota studies in streams located in the vicinity of the Anarraaq Prospect begun

Appendix 1 (continued)

2001

- Effects to Ikalukrok Creek from Cub Creek seep continued, red stain and precipitate observed in Ikalukrok Creek to Station 8 below Mainstem Red Dog Creek, affects minor near mouth of Dudd Creek
- North Fork Red Dog Creek, siltation (natural) less than in summer 2000
- Minimal precipitate in Middle Fork Red Dog Creek below effluent outfall
- Water quality was monitored in Shelley, Rachel, Connie, and Middle Fork Red Dog creeks upstream and downstream of surface disturbance, catch-box and pipeline (about 430 m) placed in Shelley Creek to move water pass disturbance
- Juvenile Arctic grayling observed in Bons Creek just south of the Kivalina rock dump, pump-back system working based on fish use
- Fish weir repairs made during 2000, no problems observed in 2001
- Stream survey of cross drainage structures made along the Delong Mountains Transportation System, some minor work at some crossings identified
- Site-specific criteria for TDS still being worked, data on Arctic grayling spawning/water temperature collected in North Fork Red Dog and Mainstem Red Dog creeks, supplemental data gathered at the Ft. Knox mine
- Studies expanded to include the Delong Mountains Transportation System based on a National Park Service report that metals concentrations adjacent to road were elevated, water sites established upstream and downstream of road and sampled by Teck Cominco, juvenile Dolly Varden samples collected in Omikviorok River and Aufeis Creek, vegetation sampling started by Teck Cominco
- New haul trucks brought on site, hard-covered trucks to minimize loss of zinc and lead concentrates during transport
- Exploratory drilling (ore and shallow gas) continued, focus on North Fork Red Dog Creek and Wulik River basins near Anarraaq and Lik, including west of the Wulik River, another ore prospect found northwest of Anarraaq, shallow gas results promising
- State and Teck Cominco agree to start the state's large mine team to work on issues, key issue identified was development of a solid waste permit with bonding for the tailing dam, other issues include site-specific criterion for total dissolved solids, clean-water bypass system, waste rock dumps (acid-rock drainage, and truck wash to minimize metal transport)
- Biomonitoring study continued, baseline fish and aquatic biota studies in streams located in the vicinity of the Anarraaq Prospect continued for the second field season, four new sites added (tributaries on west side of Wulik in the area of the Lik Deposit and potential shallow gas development)

Appendix 1 (continued)

2002

- Effects to Ikalukrok Creek from Cub Creek seep continued, red stain and precipitate observed in Ikalukrok Creek to Station 8 below Mainstem Red Dog Creek, affects minor near mouth of Dudd Creek
- North Fork Red Dog Creek, siltation minor during summer 2002
- Minor precipitate in Middle Fork Red Dog Creek below effluent outfall
- Fish weir operating as designed
- Data on Arctic grayling spawning/water temperature collected in North Fork Red Dog Creek, supplemental data gathered at Ft. Knox
- Pit expansion continues to the north of the clean-water bypass system, road crossing added for access
- A bypass was installed for Connie Creek during winter 2001/2002. The bypass captures the upstream creek and carries the water in a pipe to the clean-water bypass system
- The bypass system for Shelly Creek was modified during summer 2002 to correct an overflow problem that occurred during breakup (the overflow water was captured in the pit and did not affect downstream waters). The modification involved adding a lined ditch to contain overflowing clean water and direct the water to the clean-water bypass system
- Juvenile Dolly Varden collected at eight sites located upstream and downstream of the Delong Mountains Regional Transportation System, whole body metals analyses for Cd, Pb, Se, and Zn
- Site-specific criteria for total dissolved solids is still being worked
- State and Teck Cominco continue to work on key issues, e.g., solid waste permit with bonding for the tailing dam, site-specific criterion for total dissolved solids, clean-water bypass system, waste rock dumps (acid-rock drainage, and truck wash to minimize metal transport)
- Biomonitoring study continued, baseline fish and aquatic biota studies in streams located in the vicinity of the Anarraaq Prospect and shallow gas exploration
- Arctic grayling adults remained in North Fork Red Dog Creek through early August, only the second time since 1992 that most of the adults stayed in the creek during summer, most years adults outmigrate shortly after spawning in spring
- Arctic grayling adults present in Buddy Creek just below the falls, about 50 adult fish in sample reach (0.3 km) in early July, all gone by early August
- About 50 to 60 adult Dolly Varden in Ikalukrok Creek at mouth of Dudd Creek from early July through late August
- Effluent discharge ceased on October 5, 2002, to allow time to winterize the water treatment plant

Appendix 1 (continued)

2003

- Effects to Ikalukrok Creek from Cub Creek seep continued but were much less than seen in the last two to three years
- North Fork Red Dog Creek, natural siltation throughout most of the summer was minor in summer 2003
- Minor precipitate in Middle Fork Red Dog Creek below effluent outfall
- Fish weir operating as designed
- Data on Arctic grayling spawning/water temperature collected in North Fork Red Dog Creek, supplemental data gathered at Ft. Knox
- Site-specific criteria for total dissolved solids was finalized
- USEPA modified the NPDES effective August 22, 2003, to incorporate the ADEC Site Specific Criteria and mixing zones for total dissolved solids in Mainstem Red Dog and Ikalukrok creeks with conditions that ensure total dissolved solids are at or below 500 mg/L during Arctic grayling spawning in Mainstem Red Dog Creek and during chum salmon and Dolly Varden spawning in Ikalukrok Creek, the modified permit was appealed by the Kivalina Relocation Planning Committee
- State and Teck Cominco continue to work on key issues, e.g., solid waste permit with financial assurance for the tailing dam, site-specific criterion for total dissolved solids, clean-water bypass system, waste rock dumps (acid-rock drainage, and truck wash to minimize metal transport)
- Arctic grayling adult returns to North Fork Red Dog Creek were low, number of adult Arctic grayling seen in the Ikalukrok Creek drainage was the lowest seen since aerial surveys were begun in the late 1990s
- Arctic grayling population estimate was completed for Bons Pond the site of a fish transplant made in 1994 and 1995, estimated population in the reservoir was 6,773
- Modification to Shelly Creek bypass ditch completed, a better designed and constructed lined ditch was built and commissioned in August, 2003
- A permanent lined ditch was constructed parallel to the Connie Creek diversion pipeline to avoid spring freeze-up issues
- A permanent monitoring station was established at the end of the mixing zone in Mainstem Red Dog Creek, the location designation is Station 151, and is fitted with real time total dissolved solids and flow determination equipment and telemetry to link the station directly into the mill process control system
- Station 150, at the end of the mixing zone in Ikalukrok Creek, was fitted with real time total dissolved solids and flow determination equipment and telemetry to link the station directly into the mill process control system

Appendix 1 (continued)

2004

- Wastewater discharge began on May 20, ended on September 26, total discharge about one billion gallons
- Effects to Ikalukrok Creek from Cub Creek seep continued but were minor
- North Fork Red Dog Creek, natural siltation minor during ice-free season
- Minor precipitate in Middle Fork Red Dog Creek below effluent outfall
- Fish weir operating as designed
- Arctic grayling spawning/water temperature data collected, Arctic grayling from North Fork Red Dog Creek used for TDS fertilization experiment
- State and Teck Cominco continued to work on key issues associated with the solid waste permit and closure plan for the mine
- Arctic grayling adult returns to North Fork Red Dog Creek were low, number of adults seen in Ikalukrok Creek drainage remained low as in summer 2003
- Bons Pond (the site of a fish transplant made in 1994 and 1995), estimated Arctic grayling population for summer 2003 was 6,773 and for summer 2004 was 5,739
- Chinook salmon juveniles were documented for the first time in Ikalukrok Creek, near Dudd Creek, and in Anxiety Ridge Creek
- Age-1 Arctic grayling were caught in minnow traps fished in Ikalukrok, Mainstem, and Buddy creeks, since age-1 fish are seldom captured in minnow traps this may indicate good survival of fry spawned in spring 2003
- Red Dog Creek diversion (clean water ditch) was realigned to the west side of the pit. Realigned configuration is a combination of large diameter culvert and open lined ditch

2005

- Wastewater discharge began on May 10, 2005, ended on October 6, 2005, total discharge about 1.501 billion gallons
- Major precipitate observed on streambed in Middle Fork Red Dog Creek below effluent outfall in July and August, precipitates (gray colored) evident for at least 1 km downstream of effluent outfall
- Fish weir operating as designed
- Effects to Ikalukrok Creek from Cub Creek seep substantially greater than seen for past several years, water opaque and streambed coated with red precipitate at confluence with Mainstem Red Dog Creek, TCAK water sample from Cub Creek seep with a pH of 3.3
- Arctic grayling spawning/water temperature data collected, Arctic grayling from North Fork Red Dog Creek used for TDS fertilization experiment
- Attended and participated in a NPDES permit renewal meeting in Seattle with EPA, TCAK, and NANA, identified and discussed key issues

Appendix 1 (continued)

2005

- Red Dog Creek diversion (clean water ditch) mine engineering drawings (r4) were provided by TCAK showing the culverts and lined ditch that carry water from tributaries and Middle Fork Red Dog Creek through the pit area
- Recommendations for changes to the Red Dog biomonitoring program based on field data collection and analyses since 1999 were made for possible incorporation into the renewed NPDES permit or ADEC's solid waste permit for the tailing impoundment
- TCAK distributed the 2005 draft report on Arctic grayling fertilization studies that concluded TDS concentrations at or below 1,500 mg/L at Station 10 in Mainstem Red Dog Creek would provide for proper protection of Arctic grayling in the Red Dog Creek drainage, OHMP supported these findings in a letter to Pete McGee (ADEC) dated August 17, 2005
- Dr. Weber Scannell prepared comments on fish tissue data (Dolly Varden from Wulik and Kivalina rivers) collected by Maniilaq Association and compared these data with existing information from other sources in both Alaska and nationwide
- OHMP prepared a summary report (letter to Jim Kulas dated August 23, 2005) on temperature/spawning data collected for Arctic grayling in Mainstem Red Dog and North Fork Red Dog creeks from 2001 through 2005, a recommendation for determining start and completion of spawning based on temperature was developed for Mainstem Red Dog Creek
- State and TCAK continued to work on key issues associated with the solid waste permit and closure plan for the mine ADEC
- Wastewater Treatment Plant (WTP) #3 began operations in late summer 2005 to treat mine sump water and drainage from waste rock dumps prior to placement of these waters into the tailing impoundment; purpose is to improve water quality in tailing impoundment over time
- Exploratory drilling and flow testing for gas in North Fork Red Dog Creek basin was conducted, access road and pads inspected, corrugated pipes installed to provide cross drainage, no evidence of erosion noted along road to and connecting the drill pads
- A road was constructed to Station 151 (end of mixing zone in Mainstem Red Dog Creek
- Work to expand and relocate the water treatment plant sand filters was initiated
- Bons Pond (the site of a fish transplant made in 1994 and 1995), estimated Arctic grayling population for summer 2003 was 6,773 - for summer 2004 was 5,739 – and for summer 2005 was 5,356

Appendix 1 (continued)

2006

- ADEC amended the site-specific criteria (SSC) for TDS in Mainstem Red Dog Creek, the 500 mg/L limit during Arctic grayling spawning was removed and replaced with a 1,500 mg/L limit on February 15, 2006, and EPA approved the new SSC in April 2006
- North Fork Red Dog Creek, extensive areas of aufeis existed, turbidity and organic debris high due to erosion and thermal degradation, in several reaches flow was not in stream channel due to aufeis
- Arctic grayling spawning/water temperature data collected, early spring warming followed by cold weather, adult Arctic grayling entered North Fork Red Dog Creek in late May and due to cold water temperatures abandoned spawning and outmigrated from the creek in mid-June
- Four Arctic grayling captured in North Fork Red Dog Creek in spring 2006 were fish that had been marked in Bons Pond
- Review of ADEC's draft 401 certification to the renewal of the NPDES was completed and we provided a letter of support (March 10, 2006) to ADEC, including our concurrence with ADEC's decision to not require Whole Effluent Toxicity (WET) limits
- Effects to Ikalukrok Creek from Cub Creek seep continued, but were minor
- Major precipitate observed on streambed in Middle Fork Red Dog Creek below effluent outfall in August, precipitates (orange colored) evident for at least 1 km downstream of effluent outfall and precipitates continued upstream through the clean water bypass to Connie and Rachel creeks
- Fish weir operating as designed
- Work continued on the design for the Red Dog tailing backdam, the dam will be located on the south side of the tailing pond and will be constructed of earth fill with a concrete/soil aggregate/bentonite cutoff wall, the dam will be constructed to a final height of 986 ft., construction anticipated during 2006 and 2007
- In July, windrows of dead capelin were documented at the Port Site, die off after spawning is normal, only a small percentage survive spawning
- Total count of chum salmon in Ikalukrok Creek on August 16 was 4,185, the highest number reported since 1990
- In 2006, slightly elevated Zn concentrations persisted and TCAK initiated a field investigation comprised of sampling along the clean water bypass, although not definitive, results indicated that the Mine Sump might have been the source of increased Zn concentrations, modifications were made in operational procedures to ensure containment of contaminated waters in the Mine Sump
- Bons Pond (the site of a fish transplant made in 1994 and 1995), estimated Arctic grayling population for summer 2006 was 4,249

Appendix 1 (continued)

2007

- ADEC issued the Certificate of Reasonable Assurance for NPDES Permit AK-003865-2 on February 12, 2007. EPA issued the proposed NPDES permit for the Red Dog Mine discharge on March 7, 2007. Both actions were appealed and on September 28, 2007, EPA signed the NPDES Permit withdrawal. EPA intends to reissue the NPDES Permit upon completion of the Supplemental EIS for Aqqaluk Extension. In the interim, TCAK will operate under the 1998 NPDES Permit
- OHMP completed Technical Report No. 07-04 which summarized aquatic biomonitoring in Bons and Buddy creeks from 2004 to 2006. OHMP recommended that aquatic biomonitoring at four sites in Bons and Buddy Creeks and field work to estimate the Arctic grayling population in Bons Pond continue
- On May 17, 2007, ADNR issued the Certificate of Approval to Construct a Dam Red Dog Back Dam (AK00303)
- On May 24, we notified EPA that open flow existed in North Fork and Mainstem Red Dog creeks. TCAK received written permission from EPA to begin discharge from Outfall 001 and discharge was initiated on May 25
- Two fyke nets were fished in North Fork Red Dog Creek in spring 2007 to determine when Arctic grayling spawning was finished. Based on net catches, observed spawning activity in Mainstem Red Dog Creek, outmigration of mature fish from Mainstem Red Dog Creek as observed on June 3, and the lack of any spawning activity in Mainstem Red Dog Creek on June 3, OHMP determined that spawning was completed on June 2
- On June 6, EPA notified TCAK that the TDS load in Mainstem Red Dog Creek could be increased to 1,500 mg/L due to the fact that Arctic grayling spawning was complete
- Seven Arctic grayling captured in North Fork Red Dog Creek in spring 2007 were fish that had been marked in Bons Pond. Recruitment of Arctic grayling to North Fork Red Dog Creek from the Bons Pond population is occurring
- Fish weir, on Middle Fork Red Dog Creek, is operating as designed
- Arctic grayling spawning success, as determined by presence of fry, was very good in 2007 due to early spawning, low water following spawning for most of the summer, and warm water temperatures. Numerous fry were seen in North Fork Red Dog, Mainstem Red Dog, Ikalukrok, and Bons creeks. Arctic grayling fry in mid-August average 64 mm long (n = 26, 58 to 71 mm, SD = 3.1)
- Middle Fork Red Dog Creek contained an orange, tan colored precipitate that extended both above and below the waste water discharge point and was visible downstream to the fish weir

Appendix 1 (continued)

2007

- Our two estimates for adult chum salmon in Ikalukrok Creek (downstream of Station 160) were 1,408 and 1,998 along with about 100 adult Dolly Varden and 8 Chinook salmon
- Work on a Supplemental EIS for the Aqqaluk Extension project began with a draft scoping document in August, public meetings in early October, and draft alternatives scoping in December
- TCAK continued to make improvements to the mine's clean water bypass system. In October, galvanized culvert was installed replacing sections of HDPE lined ditch in Middle Fork Red Dog Creek upstream of Shelly Creek and continued upstream to the Rachel Creek confluence. In addition, the section of HDPE lined ditch in Connie Creek was converted to culvert as well

Appendix 1 (continued)

2008

- Work on the SEIS for the Aqqaluk Extension continued during 2008. Input via the State's LMPT coordinator was made periodically with emphasis on the alternatives being considered, the aquatic biology background section, and the monitoring plan for both the Red Dog and Bons/Buddy Creek drainages
- On May 5, 2008, we distributed copies of our technical report titled "Aquatic biomonitoring at Red Dog Mine, 2007 National Pollution Discharge Elimination System Permit No. AK-003865-2" covering work done in summer 2007
- On May 13, 2008, we notified ADEC that based on information provided by TCAK that open water flow existed in North Fork Red Dog, Mainstem Red Dog, and Ikalukrok creeks and that wastewater discharge could commence under the conditions of state and federal permits
- On May 28, 2008, TCAK reported to EPA that TDS on May 16 exceeded the permit limits in effect at the time of the discharge
- In spring 2008, Kivalina residents and NANA collected a number of adult Dolly Varden in the Wulik River and planned to have the fish analyzed for metals by Columbia Analytical Lab. Input regarding sampling protocol for adult Dolly Varden was provided to TCAK and NANA on June 6
- June 24, 2008, we reported to TCAK the successful completion of spring work on Arctic grayling in North Fork Red Dog and Mainstem Red Dog creeks and Bons Creek/Bons Pond. In spring 2008, we had at least three age classes of immature fish present in our North Fork Red Dog Creek sample and 18% of these recaptures were fish originally marked in Bons Pond. Our estimated population of Arctic grayling in Bons Pond for summer 2007 was 4,363 fish • 200 mm
- On July 9, 2008, we participated in a teleconference with TCAK and Tetra Tech (contractor for the Aqqaluk SEIS) to discuss the potential impacts to Mainstem Red Dog Creek if the wastewater discharge was moved to the ocean. A short narrative describing possible changes to Mainstem Red Dog Creek was prepared and distributed
- On July 16, 2008, ADF&G sent a letter to TCAK that summarized results of our early July field work when we sampled periphyton, aquatic invertebrates, and fish at the NPDES and ADEC sample sites
- In early August, 2008, ADF&G Commissioner Denby Lloyd spent several days at Red Dog that included a briefing, tour of mine facilities, and an overflight of the project area including Ikalukrok Creek, Wulik River, Port Site, and the haul road from the port to the mine

Appendix 1 (continued)

2008

• On August 13, 2008, ADF&G sent to TCAK a summary of fish work done in early August. Using a helicopter, we estimated 3,820 chum salmon in Ikalukrok Creek on August 6 – one of our highest counts since surveys began in 1990
• On August 21, 2008, ADF&G sent to TCAK a summary of Arctic grayling spawning in Mainstem Red Dog and North Fork Red Dog creeks that covered from 2001 to 2008. The report includes a temperature-based criterion for determining when the majority of Arctic grayling spawning in Mainstem Red Dog Creek is substantially complete
• On September 3, 2008, a settlement was reached between all five plaintiffs residents of Kivalina and TECK on a lawsuit that alleged violations of the mine's NPDES permit. On October 23, 2008, a Consent Decree was entered with the Department of Justice as required under a CWA lawsuit. Principle to the agreement was a commitment (barring certain requirements) by TECK to design, permit and construct a pipeline to carry treated mine effluent to the ocean
• TCAK prepared and submitted on August 26, 2008, a draft Fugitive Dust Risk Management Plan
• On October 3, 2008, ADF&G sent by letter to TCAK results of the fall Dolly Varden overwintering survey in the Wulik River. Overall the count of Dolly Varden was lower than in the recent past; however, it was noted that very few small fish (first year migrants) were present. More chum salmon (16,215) were seen from Sivu to Driver's Camp – more chum salmon than have been seen before
• TCAK prepared and submitted a draft monitoring plan for state agency review in early November 2008. The objective is to develop one comprehensive monitoring plan for all state and federal permits pertaining to the mine site as defined by the ambient air boundary. In November and December, we provided input to the States LMPT on the monitoring plan which when completed will be incorporated by reference into the 401 Certification and the ADEC Waste Management Permit
• Adult Dolly Varden and juvenile Dolly Varden for selected metals analyses were prepared and sent to Columbia Analytical Laboratory in mid-November
• November 24, 2008, the SEIS for Red Dog Aqqaluk Extension was released by EPA for public review
• On December 22, 2008, we received a CD for the Red Dog Mine Closure and Reclamation Plan – the final draft for agency review. The closure and reclamation plan are the result of over six years of work by TCAK in consultation with state and federal agencies and the public

Appendix 1 (continued)

2009

- Continued to review and provide comments on the SEIS for the Red Dog Aqqaluk Extension project with emphasis on the monitoring plan prepared by Teck that covers both the Bons/Buddy Creek and Red Dog Creek drainages
- During 2009, Teck continued construction of the back dam/cutoff wall and the next raise of the main dam
- On February 10, 2009, the National Park Service issued a news release that they had released a report titled "Assessment of Metals Exposure and Sub-Lethal Effects in Voles and Small Birds Captured Near the Delong Mountain Regional Transportation System Road, Cape Krusenstern National Monument, Alaska, 2006"
- On February 12, 2009, we received notification that the legal company name for Red Dog was now changed to Teck Alaska Incorporated and in simple form will be known as Teck
- On May 1, 2009, ADF&G distributed copies of the report titled "Aquatic Biomonitoring at Red Dog Mine, 2008 National Pollution Discharge Elimination System Permit No. AK-003865-2"
- On May 5, 2009, ADF&G by email stated that we have no objection to Teck beginning the discharge of treated water to Middle Fork Red Dog Creek
- On May 6, 2009, ADF&G provided written input to ADEC on Teck's Monitoring Plan
- Several field inspections of the fish weir on Middle Fork Red Dog Creek were made by ADF&G - the weir was operating in compliance with the Fish Habitat Permit
- In early June, ADF&G monitored the Arctic grayling spawning run in Mainstem Red Dog and North Fork Red Dog creeks. Six adult Dolly Varden were collected in the Wulik River near Tutak Creek by Teck
- In early July we successfully completed collection of periphyton, aquatic invertebrates and fish at all NPDES required sample sites as well as 4 sites located in the Bons/Buddy Creek drainages
- Due to extremely low flows, Teck ceased the discharge at Outfall 001 from July 22 around 0600 hr to August 2 around 1400 hr. In our sample reach at Station 151 in Mainstem Red Dog Creek, we observed hundreds of Arctic grayling fry and caught 7 juvenile Dolly Varden in minnow traps. At Station 10 in Mainstem Red Dog Creek we observed several Arctic grayling fry and two adults and caught 6 juvenile Dolly Varden and 5 slimy sculpin. The Arctic grayling fry observed were actively feeding and showed no sign of stress. These results were obtained from July 29 to 31, 2009, and represent conditions in the creek without water from the wastewater discharge

Appendix 1 (continued)

2009

- On August 19, 2009, we reported to Teck the successful completion of spring work on Arctic grayling in North Fork Red Dog and Mainstem Red Dog creeks and Bons Creek/Bons Pond. In spring 2009, we again saw strong recruitment of Arctic grayling to North Fork Red Dog Creek and 13% of these recaptures were fish originally marked in Bons Pond. Our estimated population of Arctic grayling in Bons Pond for summer 2008 was 2,216 • 200 mm – a fairly substantial decrease from the summer 2007 estimate of 4,363
- Provided to Teck via email on September 3 the protocols that should be used to handle a fish for pathological work
- On September 25, 2009, Mr. Fred DeCicco (Fisheries Services and Supplies) and Mr. Brendon Scanlon (ADF&G) conducted aerial surveys for Dolly Varden in the Wulik River and chum salmon in Ikalukrok Creek
- On November 24, 2009, ADF&G transmitted to Teck by letter a summary of Arctic grayling spawning in Mainstem Red Dog and North Fork Red Dog creeks (2001 through 2009)
- On December 2, 2009, ADNR issued the Reclamation Plan Approval for the Red Dog Mine and ADEC issued Waste Management Permit No. 0132-BA002 for the Red Dog Mine. Both actions are subject to appeal by third parties
- On December 15, 2009, the ADEC issued the Certificate of Reasonable Assurance for the NPDES Permit AK-003865-2 to regulate the discharge of treated wastewater and stormwater from Red Dog Mine.

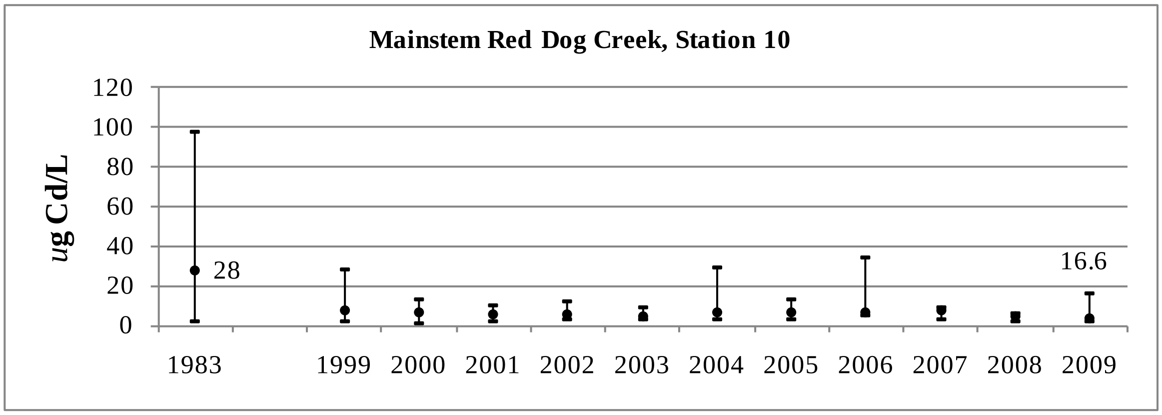
Appendix 1 (concluded)

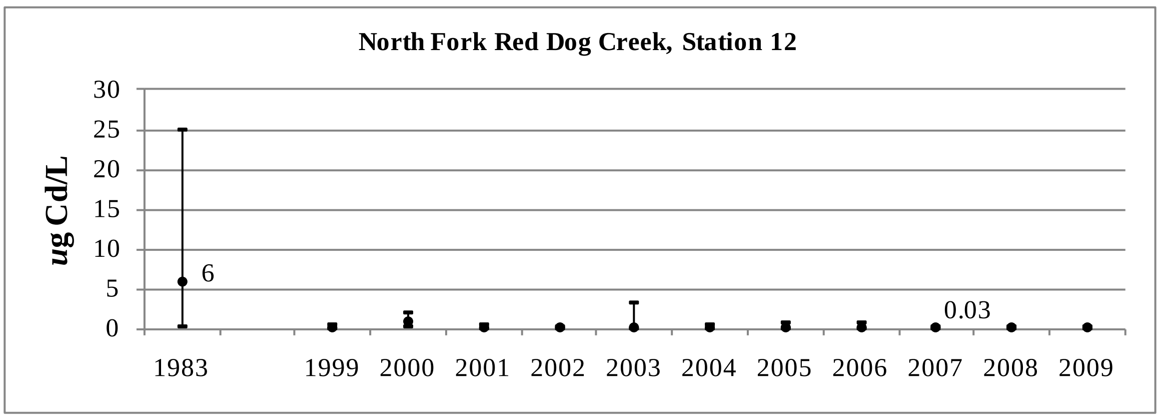
2010

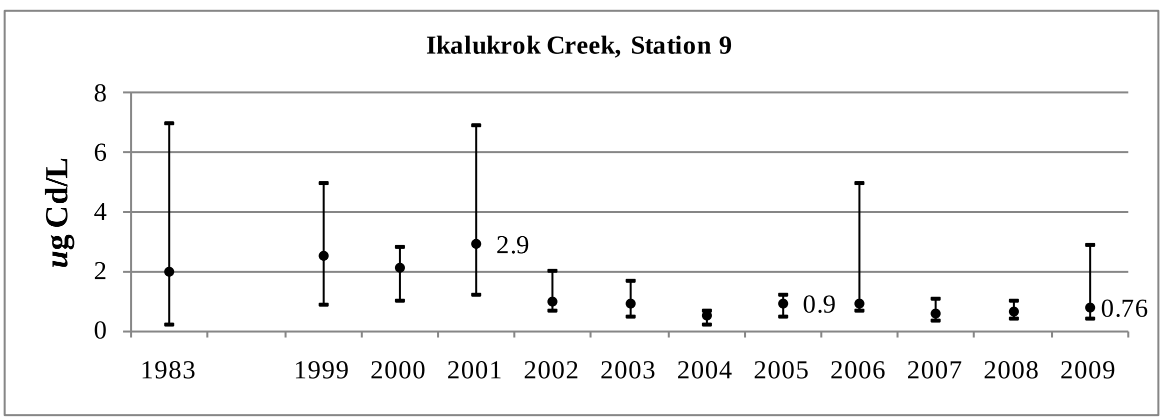
- On January 8, 2010, the EPA issued NPDES Permit No. AK-003865-2. The permit shall become effective on March 1, 2010.
- On January 15, 2010, two nonprofit law firms, representing local tribes and environmental groups, filed an appeal of the state's 401 certification, asserting that certain provisions do not comply with the Clean Water Act.
- On February 16, 2010, the same two nonprofit law firms filed a petition for review of the EPA permit with the Environmental Appeals Board. In a letter dated February 26, 2010, EPA stayed several contested conditions of NPDES Permit No. AK-003865-2.
- On March 11, 2010, the US Department of the Army issued permit POA-1984-12-M45 to Teck which would authorize development of the Aqqaluk Pit at the Red Dog Mine.
- On March 17, 2010, EPA Region 10 withdrew conditions from the 2010 NPDES Permit No. AK-003865-2, including: Part IA.1, Table 1 effluent limits for lead (monthly average limit), selenium (daily maximum limit), zinc, and weak acid dissociable (WAD) cyanide, and; Part IA.7.a – effluent limitations for Total Dissolved Solids (TDS). Those permit conditions not withdrawn, which include the entire permit except the conditions identified above, became fully effective and enforceable on March 31, 2010. As a result of this withdrawal, the following conditions in the 1998 NPDES Permit No. AK003865-2 remain in effect until further agency action: Part IA.1 – effluent limitations for lead (monthly average limit, selenium (daily maximum limit), zinc, TDS, and total cyanide.

Appendix 2. Water Quality Data, Cadmium, Lead, Selenium, and Zinc

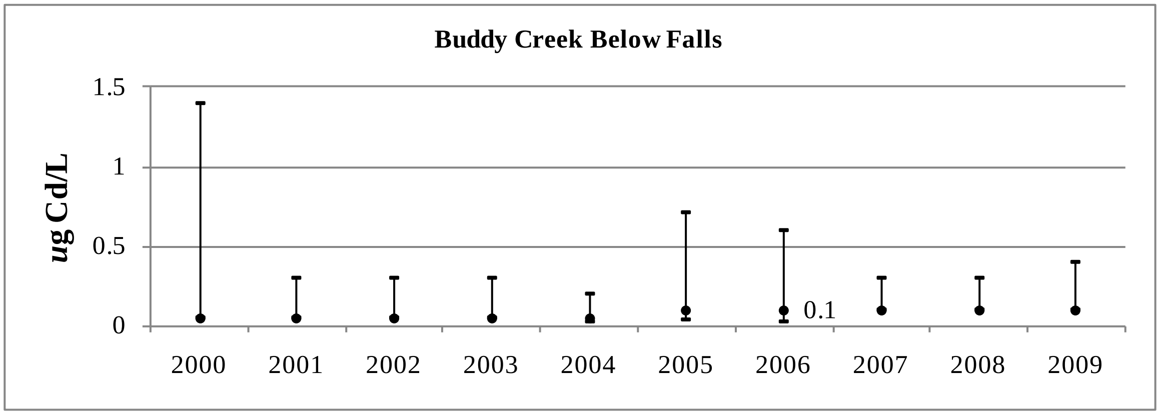
Maximum, median, and minimum concentrations, selected median concentrations shown.

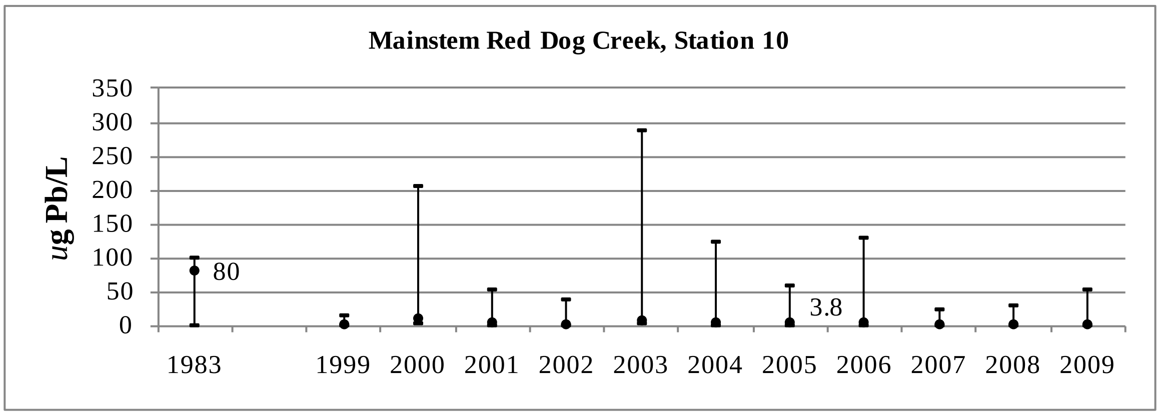


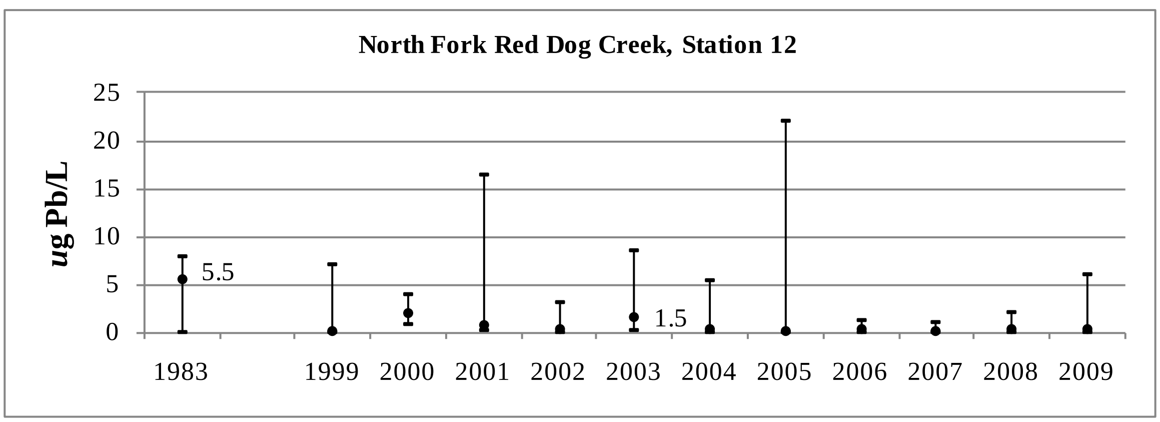




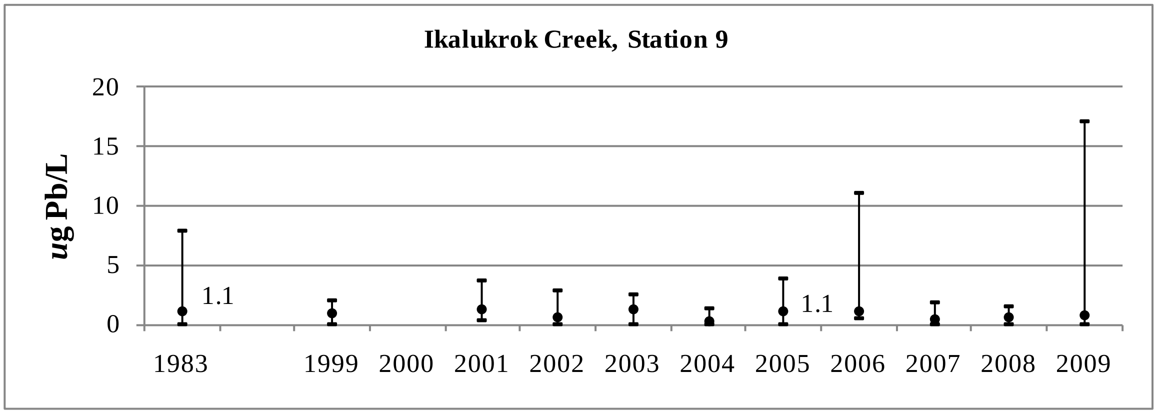
Appendix 2 (continued)

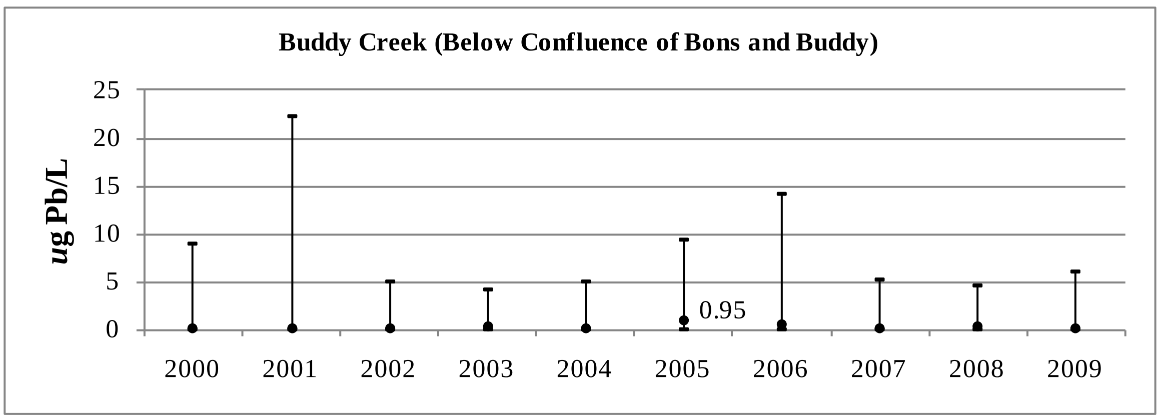


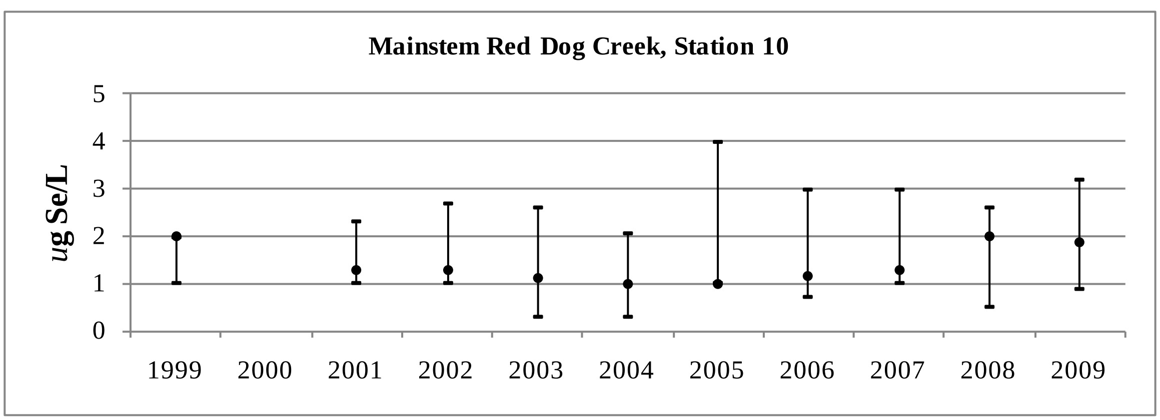




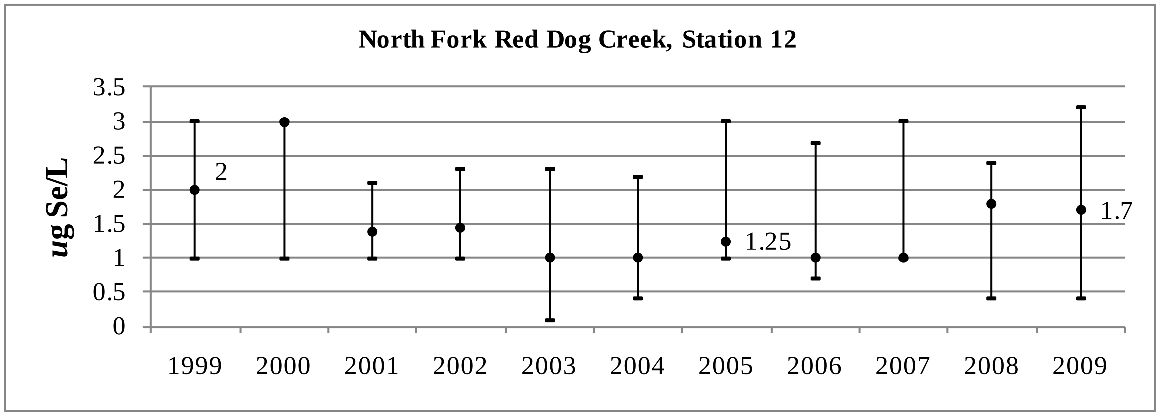
Appendix 2 (continued)

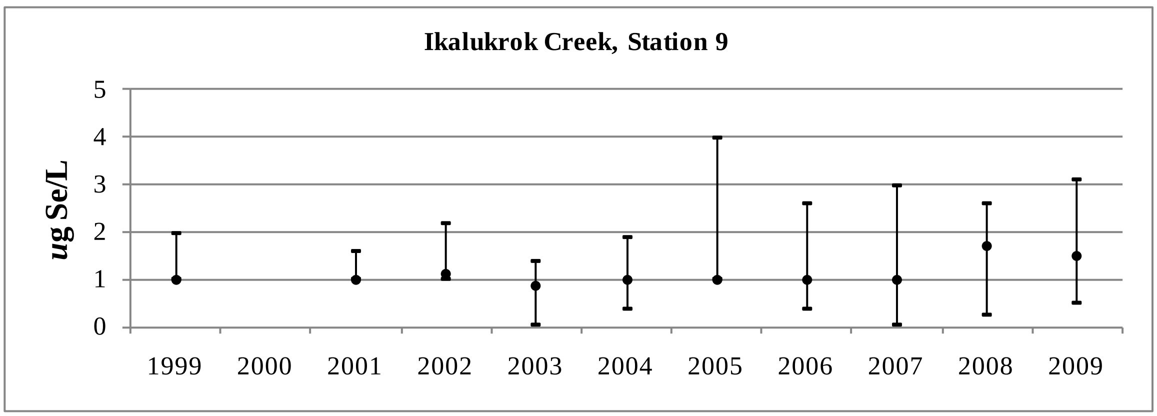


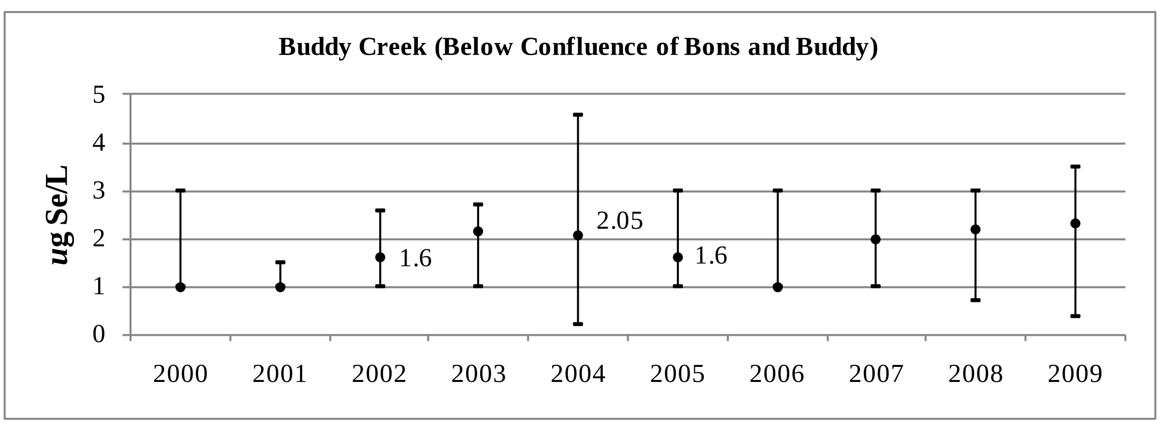




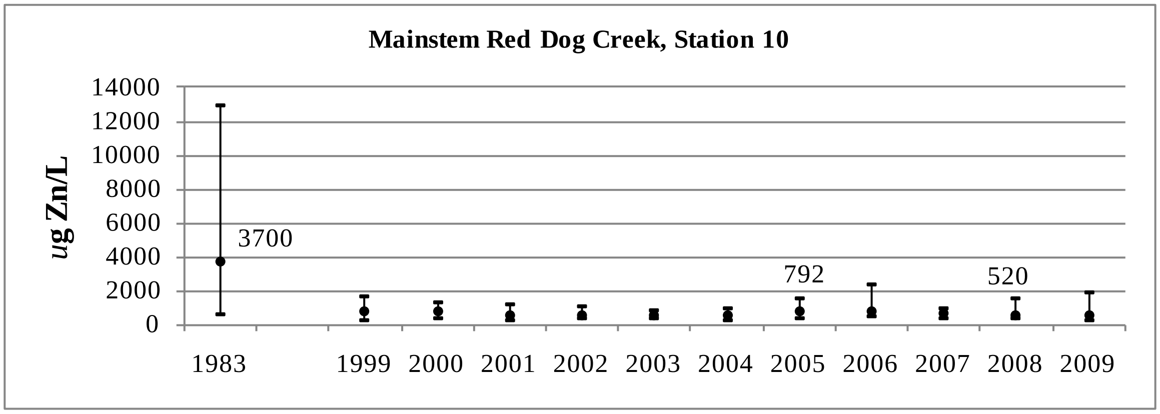
Appendix 2 (continued)

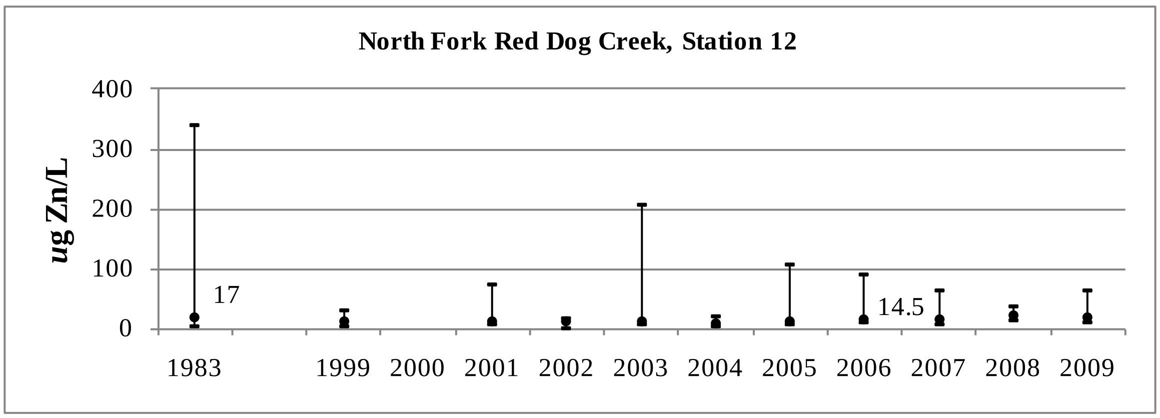


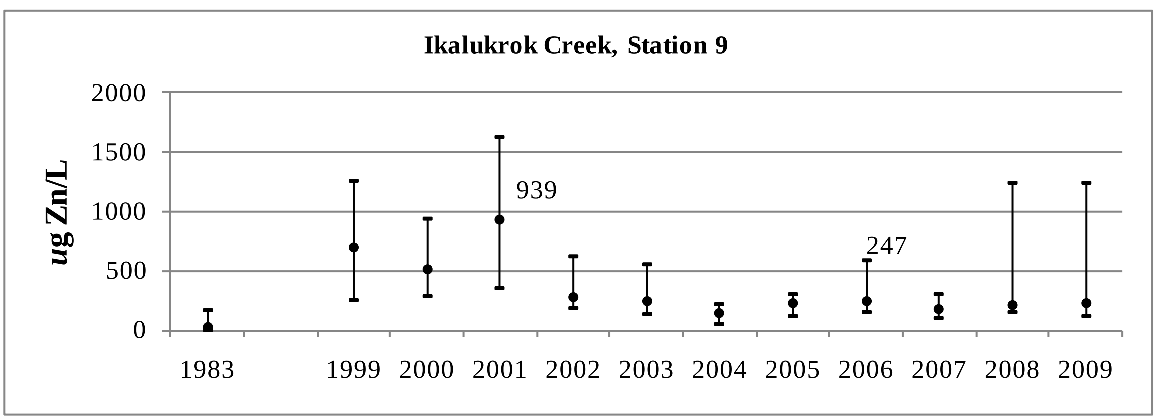




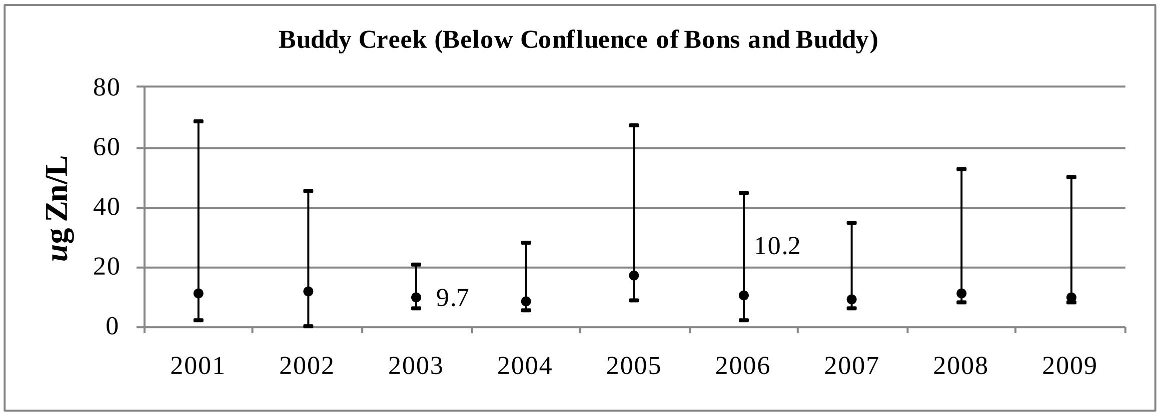
Appendix 2 (continued)



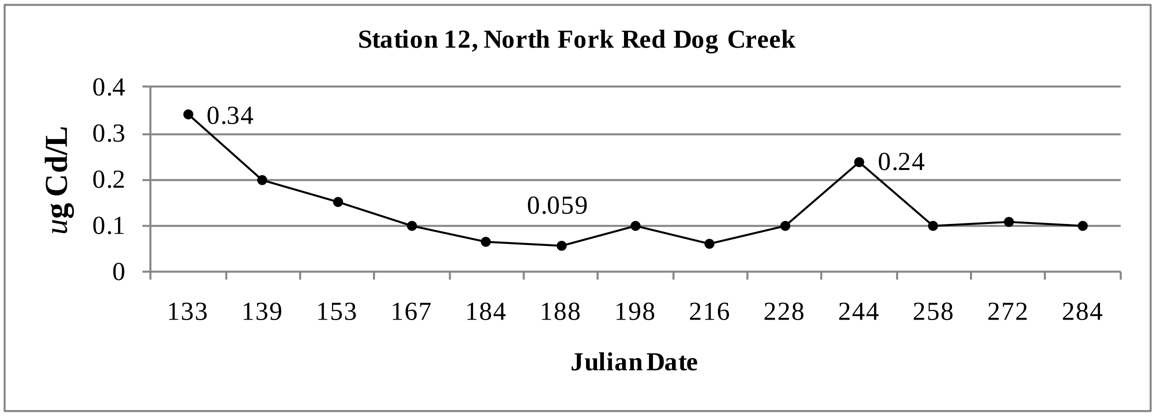


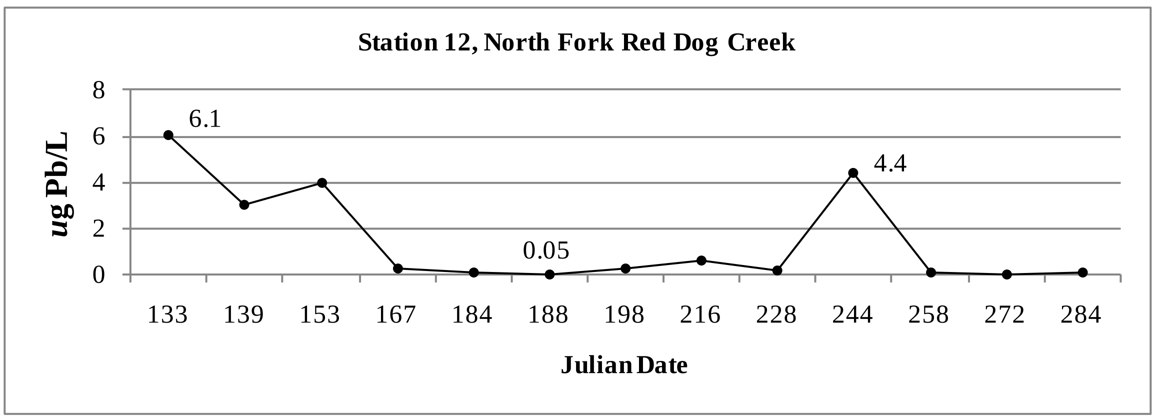


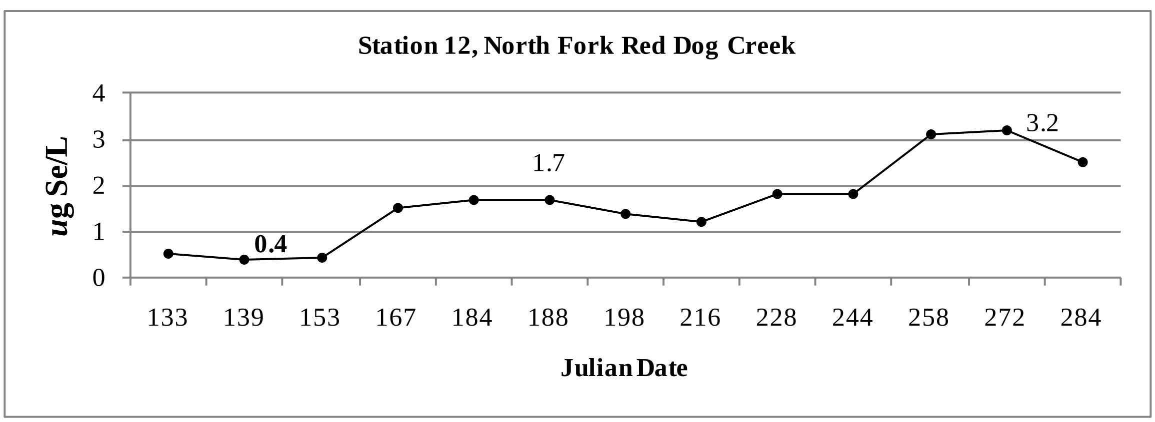
Appendix 2 (concluded)



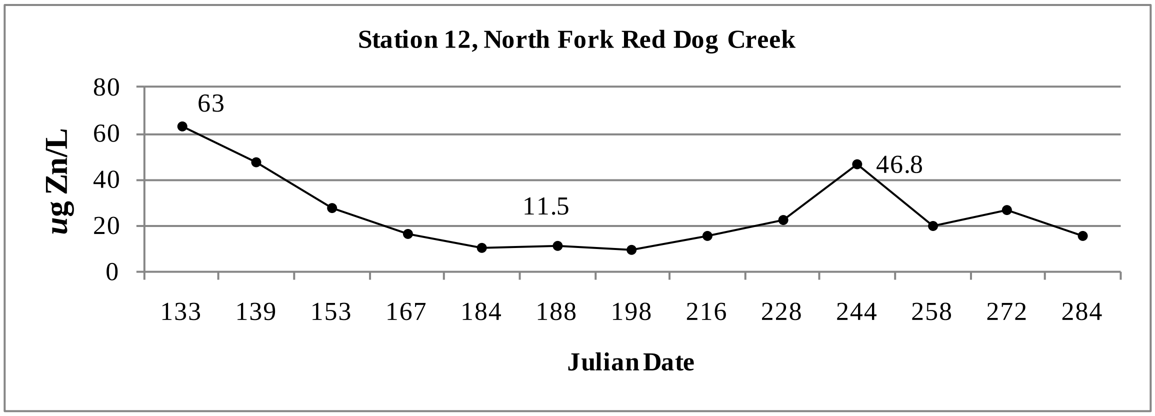
Appendix 3. Water Quality Data, North Fork Red Dog Creek, Cadmium, Lead, Selenium, and Zinc (May 13 to October 11, 2009)





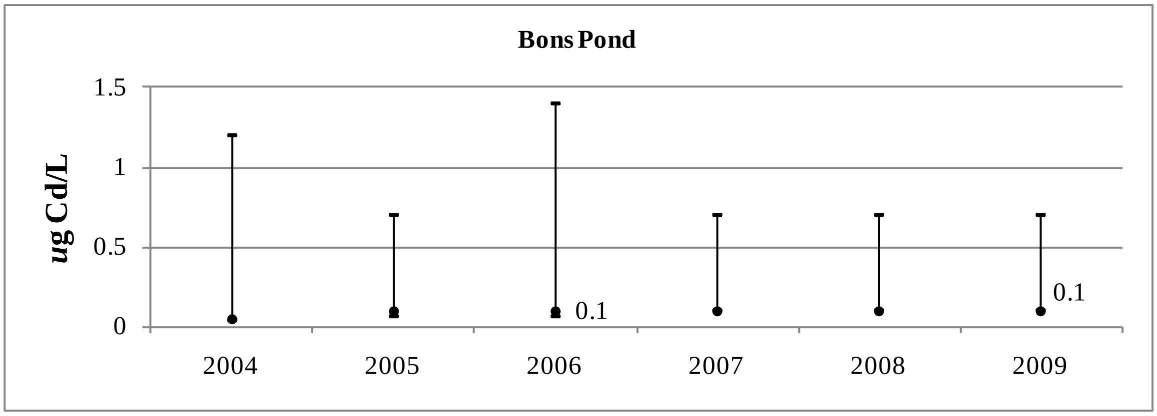


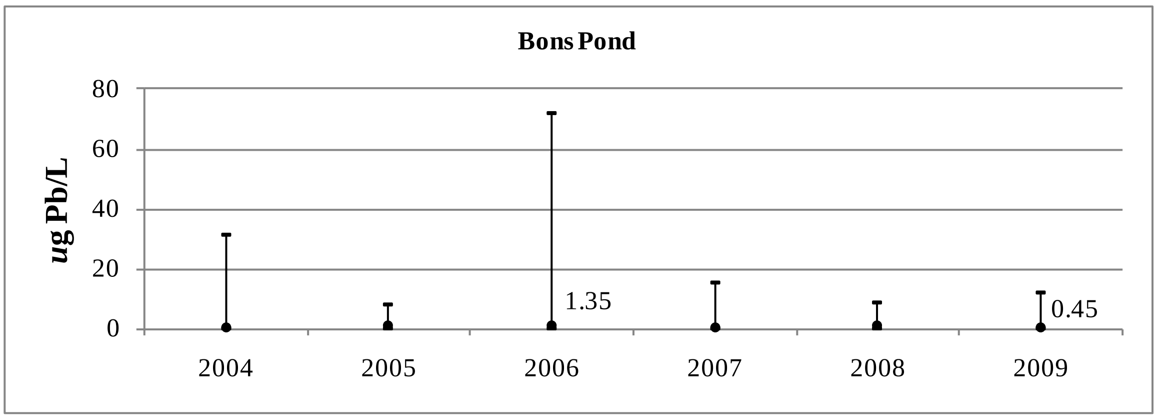
Appendix 3 (concluded)

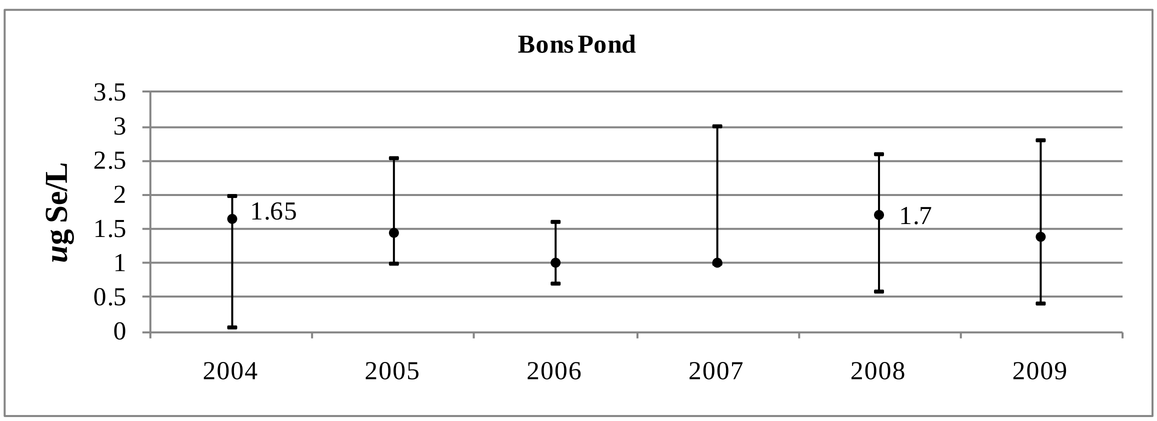


Appendix 4. Water Quality Data, Bons Pond, Cadmium, Lead, Selenium, and Zinc

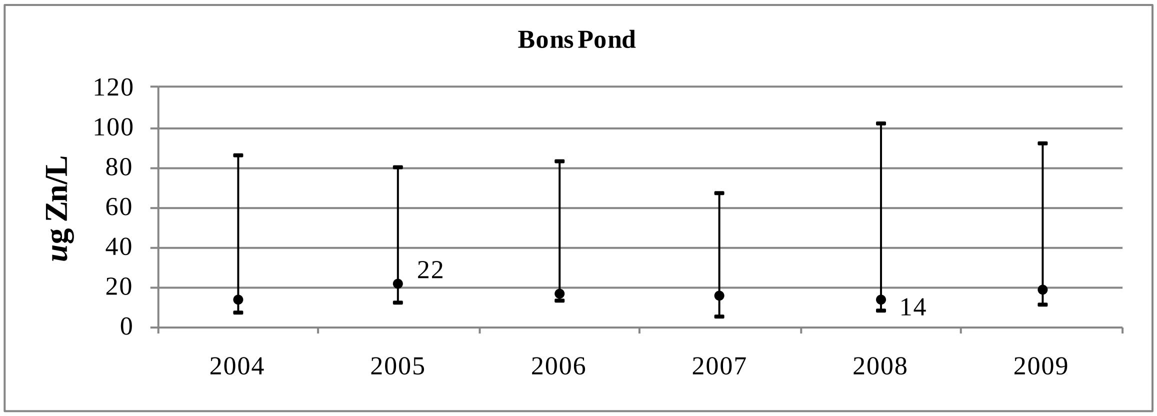
Maximum, median, and minimum concentrations, selected median concentrations shown.







Appendix 4 (concluded)



Appendix 5. Periphyton Standing Crop

2009 Chloro Results - Red Dog NPDES and Bons Biomonitoring											
								Phaeo Corrected			
			Date	Date	Vial	**Chl a**	**Below Method**	**Chl a**	**664/665**	Chl b	Chl c
Daily	Site/Volume (liters)	Station /Site	Collected	Analyzed	Chl a	**mg/m2**	**Detection Limit**	**mg/m2**	**Ratio**	mg/m2	mg/m2
Vial #							**(0.09 Vial Chl a)**				
							OR				
							Above Linear Check				
							(15.9 Vial Chl a)				
1	BLANK	BLANK		12/02/09	0.00	**0.00**	**Below Detection**			0.00	0.00
2	STA20	STA20	7/09	12/02/09	0.01	**0.04**	**Below Detection**			0.05	0.06
3	STA20	STA20	7/09	12/02/09	0.01	**0.05**	**Below Detection**			0.00	0.00
4	STA20	STA20	7/09	12/02/09	0.00	**0.00**	**Below Detection**			0.00	0.00
5	STA20	STA20	7/09	12/02/09	0.01	**0.04**	**Below Detection**			0.05	0.06
6	STA20	STA20	7/09	12/02/09	0.01	**0.04**	**Below Detection**			0.05	0.06
7	STA20	STA20	7/09	12/02/09	0.00	**0.00**	**Below Detection**			0.00	0.00
8	STA20	STA20	7/09	12/02/09	0.01	**0.04**	**Below Detection**			0.05	0.06
9	STA20	STA20	7/09	12/02/09	0.00	**0.00**	**Below Detection**			0.00	0.00
10	STA20	STA20	7/09	12/02/09	0.00	**0.00**	**Below Detection**			0.00	0.00
11	STA20	STA20	7/09	12/02/09	0.00	**0.00**	**Below Detection**			0.00	0.00
12	STA12	STA12	7/09	12/02/09	0.52	**2.09**		**2.03**	1.70	0.09	0.05
13	STA12	STA12	7/09	12/02/09	1.13	**4.51**		**4.38**	1.69	0.75	0.00
14	STA12	STA12	7/09	12/02/09	0.44	**1.76**		**1.71**	1.70	0.25	0.10
15	STA12	STA12	7/09	12/02/09	0.85	**3.42**		**3.31**	1.70	0.08	0.11
16	STA12	STA12	7/09	12/02/09	0.26	**1.05**		**1.07**	1.77	0.05	0.03
17	STA12	STA12	7/09	12/02/09	0.20	**0.82**		**0.85**	1.80	0.08	0.00
18	STA12	STA12	7/09	12/02/09	0.49	**1.94**		**1.92**	1.72	0.24	0.04
19	STA12	STA12	7/09	12/02/09	0.22	**0.87**		**0.85**	1.73	0.00	0.11
20	STA12	STA12	7/09	12/02/09	0.50	**2.00**		**2.03**	1.76	0.05	0.10
21	STA12	STA12	7/09	12/02/09	0.52	**2.09**		**2.14**	1.77	0.09	0.05
22	Lwr Bons blw WRD	Lwr Bons blw WRD	7/09	12/02/09	1.04	**4.15**		**4.17**	1.75	0.04	0.17
23	Lwr Bons blw WRD	Lwr Bons blw WRD	7/09	12/02/09	0.91	**3.63**		**3.52**	1.70	0.21	0.18
24	Lwr Bons blw WRD	Lwr Bons blw WRD	7/09	12/02/09	0.83	**3.32**		**3.20**	1.70	0.13	0.12
25	Lwr Bons blw WRD	Lwr Bons blw WRD	7/09	12/02/09	0.60	**2.42**		**2.35**	1.69	0.53	0.34
26	Lwr Bons blw WRD	Lwr Bons blw WRD	7/09	12/02/09	0.12	**0.49**		**0.53**	1.83	0.15	0.07
27	Lwr Bons blw WRD	Lwr Bons blw WRD	7/09	12/02/09	0.54	**2.18**		**2.14**	1.71	0.12	0.11
28	Lwr Bons blw WRD	Lwr Bons blw WRD	7/09	12/02/09	0.38	**1.50**		**1.60**	1.83	0.06	0.06
29	Lwr Bons blw WRD	Lwr Bons blw WRD	7/09	12/02/09	0.58	**2.32**		**2.35**	1.76	0.14	0.06
30	Lwr Bons blw WRD	Lwr Bons blw WRD	7/09	12/02/09	0.82	**3.27**		**3.20**	1.71	0.24	0.00
31	Lwr Bons blw WRD	Lwr Bons blw WRD	7/09	12/02/09	1.41	**5.64**		**5.34**	1.68	0.19	0.20
32	BLANK			12/02/09	0.00	**0.00**	**Below Detection**			0.00	0.00
25	Double	Lwr Bons blw WRD	7/09	12/02/09	0.60	**2.42**		**2.24**	1.64	0.52	0.44
1	BLANK			12/03/09	0.00	**0.00**	**Below Detection**			0.00	0.00
2	Bons us Conf w/ Buddy	STA 220	7/09	12/03/09	0.51	**2.03**		**2.03**	1.73	0.36	0.07
3	Bons us Conf w/ Buddy	STA 220	7/09	12/03/09	2.52	**10.07**		**9.93**	1.71	1.97	0.27
4	Bons us Conf w/ Buddy	STA 220	7/09	12/03/09	0.94	**3.78**		**3.63**	1.68	0.70	0.04
5	Bons us Conf w/ Buddy	STA 220	7/09	12/03/09	1.17	**4.66**		**4.70**	1.73	1.05	0.09
6	Bons us Conf w/ Buddy	STA 220	7/09	12/03/09	0.89	**3.55**		**3.52**	1.73	0.10	0.05
7	Bons us Conf w/ Buddy	STA 220	7/09	12/03/09	1.11	**4.45**		**4.38**	1.71	0.93	0.02
8	Bons us Conf w/ Buddy	STA 220	7/09	12/03/09	0.05	**0.18**	**Below Detection**			0.00	0.00
9	Bons us Conf w/ Buddy	STA 220	7/09	12/03/09	0.88	**3.53**		**3.52**	1.73	0.34	0.06
10	Bons us Conf w/ Buddy	STA 220	7/09	12/03/09	0.71	**2.83**		**2.78**	1.72	0.00	0.15
11	Bons us Conf w/ Buddy	STA 220	7/09	12/03/09	0.95	**3.80**		**3.84**	1.75	0.44	0.13

Appendix 5 (continued)

2009 Chloro Results - Red Dog NPDES and Bons Biomonitoring											
							Phaeo Corrected				
			Date	Date	Vial	**Chl a**	**Below Method**	**Chl a**	**664/665**	Chl b	Chl c
Daily	Site/Volume (liters)	Station /Site	Collected	Analyzed	Chl a	**mg/m2**	**Detection Limit**	**mg/m2**	**Ratio**	mg/m2	mg/m2
Vial #							**(0.09 Vial Chl a)**				
							OR				
							Above Linear Check				
							(15.9 Vial Chl a)				
12	IK us Dudd	Ik us Dudd	7/09	12/03/09	0.86	**3.43**		**3.52**	1.79	0.00	0.20
13	IK us Dudd	Ik us Dudd	7/09	12/03/09	0.17	**0.69**		**0.75**	1.88	0.00	0.07
14	IK us Dudd	Ik us Dudd	7/09	12/03/09	0.29	**1.15**		**1.17**	1.79	0.00	0.04
15	IK us Dudd	Ik us Dudd	7/09	12/03/09	0.10	**0.41**		**0.96**		0.04	0.04
16	IK us Dudd	Ik us Dudd	7/09	12/03/09	0.35	**1.42**		**1.50**	1.82	0.00	0.14
17	IK us Dudd	Ik us Dudd	7/09	12/03/09	0.30	**1.19**		**1.28**	1.86	0.00	0.04
18	IK us Dudd	Ik us Dudd	7/09	12/03/09	0.37	**1.47**		**1.50**	1.78	0.00	0.03
19	IK us Dudd	Ik us Dudd	7/09	12/03/09	0.13	**0.50**		**0.53**	1.83	0.00	0.00
20	IK us Dudd	Ik us Dudd	7/09	12/03/09	0.16	**0.64**		**0.75**	2.00	0.01	0.00
21	IK us Dudd	Ik us Dudd	7/09	12/03/09	0.16	**0.64**		**0.75**	2.00	0.00	0.08
22	Buddy us Road	STA 221	7/09	12/3/2009	0.52	**2.10**		**2.14**	1.77	0.01	0.08
23	Buddy us Road	STA 221	7/09	12/3/2009	0.72	**2.88**		**2.88**	1.75	0.00	0.14
24	Buddy us Road	STA 221	7/09	12/3/2009	0.82	**3.29**		**3.31**	1.76	0.00	0.22
25	Buddy us Road	STA 221	7/09	12/3/2009	0.99	**3.96**		**4.06**	1.78	0.04	0.23
26	Buddy us Road	STA 221	7/09	12/3/2009	0.70	**2.78**		**2.78**	1.74	0.00	0.06
27	Buddy us Road	STA 221	7/09	12/3/2009	0.34	**1.36**		**1.50**	1.88	0.04	0.11
28	Buddy us Road	STA 221	7/09	12/3/2009	1.57	**6.29**		**6.30**	1.75	0.03	0.25
29	Buddy us Road	STA 221	7/09	12/3/2009	0.67	**2.70**		**2.78**	1.79	0.00	0.00
30	Buddy us Road	STA 221	7/09	12/3/2009	0.58	**2.33**		**2.35**	1.76	0.00	0.12
31	Buddy us Road	STA 221	7/09	12/3/2009	1.12	**4.47**		**4.59**	1.78	0.00	0.09
32	BLANK			12/3/2009	0.00	**0.01**	**Below Detection**			0.00	0.00
3	DOUBLE	STA 220	7/09	12/03/09	2.50	**10.01**		**9.83**	1.70	2.08	0.25
1	BLANK			12/21/2009	0.00	**0.00**	**Below Detection**			0.00	0.00
2	IK ds Dudd	STA 7	7/09	12/21/2009	0.23	**0.91**		**1.07**	2.00	0.03	0.08
3	IK ds Dudd	STA 7	7/09	12/21/2009	0.53	**2.10**		**2.14**	1.77	0.00	0.11
4	IK ds Dudd	STA 7	7/09	12/21/2009	0.21	**0.82**		**0.85**	1.80	0.00	0.12
5	IK ds Dudd	STA 7	7/09	12/21/2009	1.03	**4.10**		**4.17**	1.76	0.06	0.18
6	IK ds Dudd	STA 7	7/09	12/21/2009	0.39	**1.55**		**1.60**	1.79	0.03	0.16
7	IK ds Dudd	STA 7	7/09	12/21/2009	0.24	**0.96**		**0.96**	1.75	0.01	0.07
8	IK ds Dudd	STA 7	7/09	12/21/2009	0.33	**1.32**		**1.28**	1.71	0.00	0.00
9	IK ds Dudd	STA 7	7/09	12/21/2009	0.32	**1.28**		**1.28**	1.75	0.01	0.06
10	IK ds Dudd	STA 7	7/09	12/21/2009	0.30	**1.19**		**1.17**	1.73	0.00	0.10
11	IK ds Dudd	STA 7	7/09	12/21/2009	0.82	**3.29**		**3.31**	1.76	0.00	0.22
12	IK ds Red Dog Creek	STA 8	7/09	12/21/2009	0.35	**1.41**		**1.28**	1.63	0.02	0.11
13	IK ds Red Dog Creek	STA 8	7/09	12/21/2009	0.43	**1.73**		**1.82**	1.81	0.01	0.20
14	IK ds Red Dog Creek	STA 8	7/09	12/21/2009	0.25	**1.00**		**0.96**	1.69	0.06	0.13
15	IK ds Red Dog Creek	STA 8	7/09	12/21/2009	0.42	**1.68**		**1.71**	1.76	0.04	0.20
16	IK ds Red Dog Creek	STA 8	7/09	12/21/2009	0.22	**0.86**		**0.96**	1.90	0.05	0.08
17	IK ds Red Dog Creek	STA 8	7/09	12/21/2009	0.16	**0.63**		**0.64**	1.75	0.08	0.05
18	IK ds Red Dog Creek	STA 8	7/09	12/21/2009	0.17	**0.69**		**0.75**	1.88	0.00	0.07
19	IK ds Red Dog Creek	STA 8	7/09	12/21/2009	0.27	**1.09**		**1.17**	1.85	0.09	0.18
20	IK ds Red Dog Creek	STA 8	7/09	12/21/2009	0.27	**1.09**		**1.17**	1.85	0.03	0.02
21	IK ds Red Dog Creek	STA 8	7/09	12/21/2009	0.16	**0.64**		**0.64**	1.75	0.01	0.00

Appendix 5 (concluded)

2009 Chloro Results - Red Dog NPDES and Bons Biomonitoring											
								Phaeo Corrected			
			Date	Date	Vial	**Chl a**	**Below Method**	**Chl a**	**664/665**	Chl b	Chl c
Daily	Site/Volume (liters)	Station /Site	Collected	Analyzed	Chl a	**mg/m2**	**Detection Limit**	**mg/m2**	**Ratio**	mg/m2	mg/m2
Vial #							**(0.09 Vial Chl a)**				
							OR				
							Above Linear Check				
							(15.9 Vial Chl a)				
22	Mainstem Red Dog	STA 10	7/09	12/21/2009	1.14	**4.54**		**4.59**	1.74	0.88	0.00
23	Mainstem Red Dog	STA 10	7/09	12/21/2009	0.07	**0.27**	**Below Detection**			0.03	0.00
24	Mainstem Red Dog	STA 10	7/09	12/21/2009	0.47	**1.87**		**1.92**	1.78	0.03	0.15
25	Mainstem Red Dog	STA 10	7/09	12/21/2009	0.82	**3.29**		**3.20**	1.70	0.54	0.06
26	Mainstem Red Dog	STA 10	7/09	12/21/2009	0.80	**3.22**		**3.10**	1.69	0.23	0.30
27	Mainstem Red Dog	STA 10	7/09	12/21/2009	0.05	**0.18**	**Below Detection**	**0.43**		0.00	0.04
28	Mainstem Red Dog	STA 10	7/09	12/21/2009	0.21	**0.82**		**0.85**	1.80	0.00	0.12
29	Mainstem Red Dog	STA 10	7/09	12/21/2009	0.07	**0.27**	**Below Detection**			0.02	0.10
30	Mainstem Red Dog	STA 10	7/09	12/21/2009	0.03	**0.14**	**Below Detection**			0.02	0.00
31	Mainstem Red Dog	STA 10	7/09	12/21/2009	0.52	**2.09**		**2.14**	1.77	0.09	0.05
32	BLANK			12/21/2009	0.00	**0.00**	**Below Detection**			0.00	0.00
15	DOUBLE	STA 8	7/09	12/21/2009	0.42	**1.68**		**1.71**	1.76	0.05	0.11
1	BLANK			12/23/2009	0.00	**0.00**	**Below Detection**	**0.00**		0.00	0.00
2	Buddy Blw Falls	Buddy Blw Falls	7/09	12/23/2009	0.86	**3.43**		**3.52**	1.77	0.56	0.01
3	Buddy Blw Falls	Buddy Blw Falls	7/09	12/23/2009	0.85	**3.40**		**3.31**	1.70	0.33	0.11
4	Buddy Blw Falls	Buddy Blw Falls	7/09	12/23/2009	0.58	**2.30**		**2.35**	1.76	0.30	0.09
5	Buddy Blw Falls	Buddy Blw Falls	7/09	12/23/2009	0.31	**1.23**		**1.28**	1.80	0.03	0.07
6	Buddy Blw Falls	Buddy Blw Falls	7/09	12/23/2009	1.14	**4.54**		**4.59**	1.73	1.42	0.08
7	Buddy Blw Falls	Buddy Blw Falls	7/09	12/23/2009	0.39	**1.55**		**1.50**	1.70	0.00	0.09
8	Buddy Blw Falls	Buddy Blw Falls	7/09	12/23/2009	0.31	**1.22**		**1.39**	1.93	0.12	0.04
9	Buddy Blw Falls	Buddy Blw Falls	7/09	12/23/2009	0.40	**1.58**		**1.50**	1.67	0.17	0.09
10	Buddy Blw Falls	Buddy Blw Falls	7/09	12/23/2009	0.20	**0.81**		**0.85**	1.80	0.07	0.09
11	Buddy Blw Falls	Buddy Blw Falls	7/09	12/23/2009	2.09	**8.35**		**8.22**	1.71	1.26	0.06
12	IK us Red Dog	STA 9	7/09	12/23/09	0.10	**0.41**				0.00	0.00
13	IK us Red Dog	STA 9	7/09	12/23/09	0.33	**1.32**		**1.39**	1.81	0.00	0.00
14	IK us Red Dog	STA 9	7/09	12/23/09	0.30	**1.19**		**1.28**	1.86	0.00	0.01
15	IK us Red Dog	STA 9	7/09	12/23/09	0.22	**0.86**		**0.96**	1.90	0.04	0.18
16	IK us Red Dog	STA 9	7/09	12/23/09	0.39	**1.55**		**1.60**	1.79	0.00	0.09
17	IK us Red Dog	STA 9	7/09	12/23/09	0.23	**0.92**		**0.96**	1.82	0.00	0.01
18	IK us Red Dog	STA 9	7/09	12/23/09	0.25	**1.00**		**1.07**	1.83	0.00	0.06
19	IK us Red Dog	STA 9	7/09	12/23/09	0.46	**1.83**		**1.82**	1.74	0.00	0.08
20	IK us Red Dog	STA 9	7/09	12/23/09	0.23	**0.92**		**0.96**	1.82	0.00	0.01
21	IK us Red Dog	STA 9	7/09	12/23/09	0.29	**1.14**		**1.07**	1.67	0.00	0.01
22	BLANK			12/23/09	0.00	**0.00**	**Below Detection**			0.00	0.00
11	DOUBLE	Buddy Blw Falls	7/09	12/23/09	2.08	**8.33**		**8.22**	1.71	1.40	0.20

Appendix 6. Aquatic Invertebrate Drift Samples

Middle Fork Red Dog Creek, Station 20, Drift Samples Invertebrates											
	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Total aquatic taxa	15	15	19	15	28	23	20	16	26	25	15
Tot. Ephemeroptera	9	0	17	4	6	44	41	7	23	29	16
Tot. Plecoptera	3	5	43	20	34	38	28	9	11	13	4
Tot. Trichoptera	0	0	0	0	0	0	1	0	1	1	1
Total Aq. Diptera	104	40	153	121	449	28	92	6	80	72	45
Misc.Aq.sp	9	17	73	17	55	46	177	5	82	52	38
% Ephemeroptera	8%	0%	6%	2%	1%	28%	12%	26%	12%	17%	15%
% Plecoptera	3%	7%	15%	13%	7%	24%	8%	35%	6%	8%	4%
% Trichoptera	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%
% Aq. Diptera	83%	64%	53%	75%	83%	18%	27%	22%	41%	43%	43%
% other	7%	28%	26%	10%	10%	29%	52%	18%	42%	31%	37%
% EPT	10%	8%	21%	15%	7%	52%	21%	60%	18%	25%	20%
% Chironomidae	80%	36%	51%	73%	73%	16%	24%	15%	35%	39%	38%
% Dominant Aquatic Taxon	46%	36%	31%	43%	48%	30%	42%	37%	22%	22%	37%
Volume of water (m3)	378	551	933	310	702	880	302	296	384	249	285
average water/net	76	110	187	62	140	176	60	59	77	50	57
StDev of water volume	24	26	89	14	38	91	26	9	52	8	11
Estimated total inverts/m^3 water	2.92	0.6	1.7	6.2	6.6	1.1	19.4	0.6	7.4	16.2	23.2
Estimated aquatic inverts/m^3 water	1.7	0.6	1.5	2.6	3.9	0.9	5.6	0.4	2.6	3.4	1.8
average inv/m^3	3.2	0.6	1.8	6.1	6.4	1.2	19.5	0.6	10.5	16.3	24.1
average aq. Invertebrates/m^3 water	1.8	0.57	1.64	2.59	3.74	0.95	5.33	0.45	3.53	3.39	1.8
Stdev of aq. Inv. Den.	1.3	0.21	0.38	0.58	1.07	0.27	0.97	0.21	1.86	0.7	0.25
Total aquatic invertebrates	627	309	1431	810	2719	783	1694	133	980	835	523
Total. terrestrial invertebrates	477	10	185	1115	1889	170	4158	59	1875	3210	6096
Total invertebrates	1104	319	1616	1925	4608	953	5852	192	2855	4045	6619
% Sample aquatic	57%	97%	89%	42%	59%	82%	29%	69%	34%	21%	8%
% Sample terrestrial	43%	3%	11%	58%	41%	18%	71%	31%	66%	79%	92%
Average # aquatic inverts / net	125	62	286	162	544	157	339	27	196	167	105
stdev aq inv/net	59	20	111	56	242	69	178	11	20	35	30
Average # terr. inverts / net	95	2	37	223	378	34	832	12	375	642	1219
Average # inverts / net	221	64	323	385	922	191	1170	38	571	809	1324
stdev inv/net	68	21	127	156	376	85	532	13	55	191	259
Total Larval Arctic Grayling/site	0	0	0	0	0	0	0	0	0	0	0
Total Larval Slimy Sculpin/site	0	0	0	0	0	0	0	0	0	0	0
Total Larval Dolly Varden/site	0	0	0	0	0	0	0	0	0	0	0

Appendix 6 (continued)

North Fork Red Dog Creek, Station 12, Drift Samples Invertebrates											
Date:	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Total aquatic taxa	13	13	18	16	26	20	21	15	21	23	19
Tot. Ephemeroptera	67	14	20	170	194	38	198	882	163	57	66
Tot. Plecoptera	23	94	117	40	64	5	5	19	11	77	18
Tot. Trichoptera	4	6	6	0	4	0	0	0	1	4	1
Total Aq. Diptera	700	314	1134	116	716	27	333	755	641	1574	2113
Misc.Aq.sp	30	69	226	43	188	17	39	32	135	320	251
% Ephemeroptera	8%	3%	1%	46%	16%	44%	34%	52%	17%	3%	3%
% Plecoptera	3%	19%	8%	11%	6%	5%	1%	1%	1%	4%	1%
% Trichoptera	1%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%
% Aq. Diptera	85%	63%	75%	31%	62%	31%	58%	45%	67%	77%	86%
% other	4%	14%	15%	12%	16%	19%	7%	2%	14%	16%	10%
% EPT	11%	23%	9%	57%	23%	50%	35%	53%	18%	7%	3%
% Chironomidae	54%	36%	57%	22%	27%	25%	36%	14%	61%	32%	55%
% Dominant Aquatic Taxon	45%	32%	43%	46%	35%	48%	34%	44%	36%	45%	43%
Volume of water (m^3)	559	221	747	226	672	672	380	368	297	329	681
average water/net	112	44	149	45	134	134	76	74	59	66	136
StDev of water volume	80	12	54	23	37	64	54	10	24	20	45
Estimated total inverts/m^3 water	9.2	11.8	10.2	13.5	9.3	0.9	12.4	23.6	18.3	33.2	28
Estimated aquatic inverts/m^3 water	7.4	11.2	10.0	8.1	8.7	0.6	7.6	23.0	16.0	30.9	18
average inv/m^3	14.2	11.5	10.2	15.0	10.0	0.8	16.3	23.5	19.9	33.5	28.1
average aq. Invertebrates/m^3 water	11.4	10.9	10.0	9.1	9.4	0.6	11.8	22.8	17.5	31.1	18.4
Stdev of aq. Inv. Den.	8.3	5.7	1.5	5.3	5.2	0.2	9.4	3.9	6.6	7.8	2.83
Total aquatic invertebrates	4120	2486	7509	1839	5827	435	2875	8442	4750	10159	12242
Total. terrestrial invertebrates	1044	129	117	1211	426	159	1833	248	670	745	6843
Total invertebrates	5164	2615	7626	3050	6254	594	4708	8691	5420	10904	19085
% Sample aquatic	80%	95%	98%	60%	93%	73%	61%	97%	88%	93%	64%
% Sample terrestrial	20%	5%	2%	40%	7%	27%	39%	3%	12%	7%	36%
Average # aquatic inverts / net	824	497	1502	368	1165	87	575	1688	950	2032	2448
stdev aq inv/net	138	352	545	161	409	60	278	448	265	802	764
Average # terr. inverts / net	209	26	23	242	85	32	367	50	134	149	1369
Average # inverts / net	1033	523	1525	610	1251	119	942	1738	1084	2181	3817
stdev inv/net	274	339	560	188	434	97	587	447	308	848	1480
Total Larval Arctic Grayling/site	1	3	1	0	0	0	0	0	9	0	0
Total Larval Slimy Sculpin/site	0	0	0	0	0	0	0	0	0	0	0
Total Larval Dolly Varden/site	0	0	0	0	0	0	0	0	0	0	0

Appendix 6 (continued)

Mainstem Red Dog Creek, Station 10, Drift Samples Invertebrates											
	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Total aquatic taxa	11	7	19	12	21	17	15	20	22	24	17
Tot. Ephemeroptera	2	0	6	14	313	24	54	77	56	25	10
Tot. Plecoptera	35	16	34	30	292	16	36	45	144	50	15
Tot. Trichoptera	0	1	3	0	1	0	7	0	1	3	1
Total Aq. Diptera	182	20	676	129	438	37	396	87	558	1301	347
Misc.Aq.sp	3	2	82	8	58	9	82	73	141	106	49
% Ephemeroptera	1%	1%	1%	8%	28%	28%	9%	27%	6%	2%	2%
% Plecoptera	16%	41%	4%	17%	27%	18%	6%	16%	16%	3%	4%
% Trichoptera	0%	3%	0%	0%	0%	0%	1%	0%	0%	0%	0%
% Aq. Diptera	82%	52%	84%	71%	40%	43%	69%	31%	62%	88%	82%
% other	1%	4%	10%	4%	5%	11%	14%	26%	16%	7%	12%
% EPT	17%	44%	5%	25%	55%	47%	17%	43%	22%	5%	6%
% Chironomidae	69%	25%	79%	62%	24%	39%	36%	22%	60%	55%	60%
% Dominant Aquatic Taxon	61%	42%	64%	52%	29%	30%	33%	23%	42%	52%	43%
Volume of water (m3)	869	356	1323	255	688	1239	665	417	422	384	378
average water/net	174	71	265	51	138	248	133	83	84	77	76
StDev of water volume	122	27	56	15	39	54	65	13	20	10	24
Estimated total inverts/m3 water	1.4	0.6	3.1	3.8	8.2	0.5	7.5	4.8	13.5	22.6	9.2
Estimated aquatic inverts/m3 water	1.3	0.5	3.0	3.6	8.0	0.3	4.3	3.4	10.7	19.4	5.6
average inv/m3	1.9	0.7	3.2	4.2	8.6	0.5	8.2	5.0	14.0	22.8	8.8
average aq. inverts/m3 water	1.8	0.6	3.1	4.0	8.4	0.4	4.6	3.5	11.1	19.5	5.3
Stdev of aq. Inv. Den.	1.3	0.3	0.8	2.1	1.9	0.0	1.6	1.4	2.3	3.6	1.4
Total aquatic invertebrates	1111	192	4003	910	5503	427	2875	1410	4497	7427	2109
Total. terrestrial invertebrates	136	21	121	49	121	173	2119	609	1218	1252	1351
Total invertebrates	1247	213	4123	959	5624	600	4993	2018	5715	8679	3461
% Sample aquatic	89%	90%	97%	95%	98%	71%	58%	70%	79%	86%	61%
% Sample terrestrial	11%	10%	3%	5%	2%	29%	42%	30%	21%	14%	39%
Average # aquatic inverts / net	222	38	801	182	1101	85	575	282	899	1485	422
stdev aq inv/net	126	25	182	47	152	16	311	66	83	227	242
Average # terr. inverts / net	27	4	24	10	24	35	424	122	244	250	270
Average # inverts / net	249	43	825	192	1125	120	999	404	1143	1736	692
stdev inv/net	153	27	171	51	152	25	529	69	111	218	358
Total Larval Arctic Grayling/site	5	5	0	2	1	0	0	0	0	45	2
Total Larval Slimy Sculpin/site	0	0	0	0	0	0	0	0	0	0	0
Total Larval Dolly Varden/site	0	0	0	0	0	0	0	0	0	0	0

Appendix 6 (continued)

Ikalukrok Creek, Station 9, Drift Samples Invertebrates											
	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Total aquatic taxa	8	9	15	13	21	16	13	18	20	20	24
Tot. Ephemeroptera	11	63	267	213	138	208	571	67	225	122	151
Tot. Plecoptera	17	13	159	24	54	30	189	57	98	64	21
Tot. Trichoptera	0	0	0	0	0	0	1	0	1	0	0
Total Aq. Diptera	10	58	1252	285	485	196	185	56	217	193	370
Misc.Aq.sp	9	8	56	5	23	23	23	25	24	162	125
% Ephemeroptera	24%	44%	15%	40%	19%	45%	59%	33%	40%	23%	23%
% Plecoptera	36%	9%	9%	5%	8%	7%	19%	28%	17%	12%	3%
% Trichoptera	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
% Aq. Diptera	22%	41%	72%	54%	70%	43%	19%	27%	39%	36%	56%
% other	19%	6%	3%	1%	3%	5%	2%	12%	4%	30%	19%
% EPT	60%	54%	25%	45%	27%	52%	79%	60%	57%	34%	26%
% Chironomidae	21%	39%	69%	52%	65%	25%	15%	18%	35%	28%	31%
% Dominant Aquatic Taxon	32%	45%	65%	44%	57%	36%	37%	24%	35%	20%	24%
Volume of water (m^3)	260	478	833	575	450	2772	555	352	382	390	601
average water/net	52	96	167	115	90	554	111	70	76	78	120
StDev of water volume	25	16	106	29	23	161	12	16	23	22	46
Estimated total inverts/m^3 water	1.5	1.6	10.7	4.9	8.7	1.4	11.4	3.8	9.0	11.3	8.4
Estimated aquatic inverts/m^3 water	0.9	1.5	10.4	4.6	7.8	0.8	8.7	2.9	7.4	6.9	5.5
average inv/m^3	1.6	1.6	12	5	8.9	1.4	11.4	3.9	9.5	13.7	8.4
average aq inverts/m^3 water	1.0	1.5	11.7	4.7	7.9	0.9	8.7	3.0	7.9	8.3	5.5
Stdev of aq. inv. Den.	0.6	0.3	4.6	0.8	1.0	0.1	1.7	1.2	2.5	6.2	1.3
Total aquatic invertebrates	232	714	8668	2635	3497	2288	4848	1028	2822	2707	3330
Total. terrestrial invertebrates	159	66	220	168	403	1507	1482	325	606	1704	1741
Total invertebrates	391	780	8888	2803	3900	3795	6330	1353	3427	4410	5071
% Sample aquatic	59%	92%	98%	94%	90%	60%	77%	76%	82%	61%	66%
% Sample terrestrial	41%	8%	2%	6%	10%	40%	23%	24%	18%	39%	34%
Average # aquatic inverts / net	46	143	1734	527	699	458	970	206	564	541	666
stdev aq inv/net	26	46	822	102	115	90	255	81	120	266	347
Average # terr. inverts / net	32	13	44	34	81	301	296	65	121	341	348
Average # inverts / net	78	156	1778	561	780	759	1266	271	685	882	1014
stdev inv/net	51	50	849	99	110	158	296	94	173	424	491
Total Larval Arctic Grayling/site	1	1	0	0	0	0	0	0	0	0	0
Total Larval Slimy Sculpin/site	0	0	0	0	0	1	0	0	0	0	0
Total Larval Dolly Varden/site	0	0	0	0	0	0	0	0	0	0	0

Appendix 6 (continued)

Ikalukrok Creek, Station 8, Drift Samples Invertebrates											
Year Sampled	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Total Aquatic Taxa	12	10	23	13	24	17	24	24	24	25	25
Tot. Ephemeroptera	2	4	157	35	204	53	356	22	159	146	285
Tot. Plecoptera	7	4	106	19	92	16	164	110	76	117	65
Tot. Trichoptera	0	0	1	0	0	0	2	0	0	2	1
Total Aq. Diptera	27	16	458	87	907	47	313	66	185	440	499
Misc. Aq. Sp.	1	1	55	2	77	10	41	20	29	298	406
% Ephemeroptera	5%	16%	20%	24%	16%	42%	41%	10%	35%	15%	23%
% Plecoptera	19%	17%	14%	13%	7%	12%	19%	50%	17%	12%	5%
% Tricoptera	1%	2%	0%	0%	0%	0%	0%	0%	0%	0%	0%
% Aq. Diptera	73%	63%	59%	61%	71%	38%	36%	30%	41%	44%	40%
% Other	3%	2%	7%	1%	6%	8%	5%	9%	6%	30%	32%
% EPT	24%	35%	34%	38%	23%	55%	60%	60%	52%	26%	28%
% Chironomidae	60%	51%	54%	56%	65%	30%	30%	21%	38%	24%	24%
% Dominant Aquatic Taxon	56%	34%	42%	41%	44%	27%	28%	47%	30%	22%	24%
Volume of Water (m^3)	273	371	1207	547	646	1391	706	428	281	491	1282
average water/net	55	74	241	109	129	278	141	86	56	98	256
StDev of water volume	27	56	71	34	40	35	66	20	18	21	10
Estimated total inverts/m^3 water	0.8	0.4	3.3	1.4	11.2	0.6	8.1	3.9	11.2	14.5	7.1
Estimated aquatic inverts/m^3 water	0.7	0.4	3.2	1.3	9.9	0.5	6.2	2.5	8.0	10.2	4.9
average inv/m^3	1.1	0.6	3.6	1.4	11.1	0.6	8.9	4.1	12.1	14.7	7.1
average aq inverts/m^3 water	0.9	0.5	3.5	1.3	9.8	0.5	6.7	2.7	8.6	10.3	4.9
StDev of aq. Inv. Density	0.7	0.2	1.3	0.3	1.3	0.1	1.4	0.9	2.8	1.6	0.5
Total aquatic invertebrates	183	128	3883	715	6398	625	4382	1089	2248	5012	6282
Total terrestrial invertebrates	46	27	113	33	823	257	1355	582	892	2127	2750
Total invertebrates	229	155	3996	748	7221	882	5736	1671	3140	7139	9032
% sample aquatic	80%	83%	97%	96%	89%	71%	76%	65%	72%	70%	70%
% sample terrestrial	20%	17%	3%	4%	11%	29%	24%	35%	28%	30%	30%
Average # aquatic inverts/net	37	26	777	143	1280	125	876	218	450	1002	1256
StDev aq inverts/net	14	7	181	45	461	21	231	60	104	226	122
Average # terr. inverts/net	9	5	23	7	165	51	271	116	178	425	550
Average # inverts/net	46	31	799	150	1444	176	1147	334	628	1428	1806
StDev inverts/net	17	10	173	49	511	40	245	78	133	296	170
Total Larval Arctic Grayling/site	0	1	0	1	0	0	0	0	0	1	0
Total Larval Slimy Sculpin/site	0	0	0	0	0	0	0	0	0	0	0
Total Larval Dolly Varden/site	0	0	0	0	0	0	0	0	0	0	0

Appendix 6 (continued)

Ikalukrok Creek, Station 7U (upstream of Dudd Creek), Drift Samples Invertebrates											
Year Sampled	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Total aquatic taxa	14	17	19	19	16	21	15	22	19	23	18
Tot. Ephemeroptera	4	0	269	9	27	45	175	35	106	1	28
Tot. Plecoptera	66	74	75	20	26	38	15	31	21	7	8
Tot. Trichoptera	1	0	1	0	0	1	2	0	4	2	0
Total Aq. Diptera	149	269	249	199	775	210	696	215	754	335	389
Misc.Aq.sp	23	24	52	18	67	26	25	44	156	34	30
% Ephemeroptera	2%	0%	42%	4%	3%	14%	19%	11%	10%	0%	6%
% Plecoptera	27%	20%	12%	8%	3%	12%	2%	9%	2%	2%	2%
% Trichoptera	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
% Aq. Diptera	61%	73%	39%	81%	87%	66%	76%	66%	72%	89%	85%
% other	9%	7%	8%	7%	8%	8%	3%	13%	15%	9%	7%
% EPT	29%	20%	53%	12%	6%	26%	21%	20%	13%	2%	8%
% Chironomidae	59%	53%	33%	30%	20%	49%	40%	40%	62%	29%	29%
% Dominant Aquatic Taxon	51%	48%	42%	50%	66%	30%	36%	30%	37%	59%	56%
Volume of water (m^3)	966	255	1069	698	824	2644	945	560	402	355	625
average water/net	193	51	214	140	165	529	189	112	80	71	125
StDev of water volume	103	14	37	21	45	264	54	47	20	27	44
Estimated total inverts/m^3 water	2.0	9.7	3.3	2.3	5.7	1.0	6.9	3.9	16.4	7.0	4.8
Estimated aquatic inverts/m^3 water	1.3	7.2	3.0	1.8	5.4	0.6	4.8	2.9	12.9	5.3	3.6
average inv/m^3	2.8	10.6	3.2	2.4	6.0	1.1	7.1	4.1	17.6	7.8	4.7
average aq inverts/m^3 water	1.8	7.5	3.0	1.8	5.8	0.7	4.7	3.0	13.9	6.0	3.6
StDev of aq. Inv. Density	1.9	1.6	0.4	0.3	1.6	0.2	0.9	0.7	5.0	2.6	0.6
Total aquatic invertebrates	1210	1840	3229	1231	4475	1600	4564	1621	5206	1889	2278
Total. terrestrial invertebrates	673	640	245	403	212	938	1994	578	1394	580	705
Total invertebrates	1883	2480	3474	1634	4687	2538	6558	2199	6600	2469	2982
% Sample aquatic	64%	74%	93%	75%	96%	63%	70%	74%	79%	77%	76%
% Sample terrestrial	36%	26%	7%	25%	4%	37%	30%	26%	21%	23%	24%
Average # aquatic inverts / net	242	368	646	246	895	320	913	324	1041	378	456
stdev aq inv/net	168	79	154	30	130	120	407	125	150	109	208
Average # terr. inverts / net	135	128	49	81	42	188	399	116	279	116	141
Average # inverts / net	377	496	695	327	937	508	1312	440	1320	494	596
stdev inv/net	241	48	168	42	140	125	424	159	250	113	260
Total Larval Arctic Grayling/site	0	3	0	3	1	0	0	0	1	13	2
Total Larval Slimy Sculpin/site	0	0	0	0	0	0	1	3	0	0	0
Total Larval Dolly Varden/site	0	0	0	0	0	0	0	0	0	0	0

Appendix 6 (continued)

Ikalukrok Creek below Dudd Creek Station 7											
Year Sampled	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Total aquatic taxa	10	12	18	9	18	24	18	22	18	24	19
Tot. Ephemeroptera	1	4	138	12	59	23	152	114	126	17	33
Tot. Plecoptera	9	102	43	12	37	8	4	29	21	21	8
Tot. Trichoptera	0	1	1	0	1	2	0	2	1	1	0
Total Aq. Diptera	38	319	262	111	1054	95	529	323	1356	1335	1558
Misc.Aq.sp	3	105	22	2	36	44	8	83	187	119	28
% Ephemeroptera	1%	1%	30%	8%	5%	13%	22%	21%	7%	1%	2%
% Plecoptera	17%	19%	9%	8%	3%	4%	1%	5%	1%	1%	1%
% Trichoptera	0%	0%	0%	0%	0%	1%	0%	0%	0%	0%	0%
% Aq. Diptera	75%	60%	56%	81%	89%	55%	76%	59%	80%	89%	96%
% other	7%	20%	5%	1%	3%	26%	1%	15%	11%	8%	2%
% EPT	18%	20%	39%	17%	8%	19%	22%	26%	9%	3%	3%
% Chironomidae	66%	39%	51%	36%	22%	43%	59%	43%	68%	18%	14%
% Dominant Aquatic Taxon	63%	39%	46%	46%	67%	31%	38%	27%	58%	71%	82%
Volume of water (m^3)	190	513	617	359	866	1182	303	617	502	491	659
average water/net	38	103	123	72	173	236	61	123	100	98	132
StDev of water volume	23	54	40	23	19	114	14	35	33	56	46
Estimated total inverts/m^3 water	1.8	5.7	3.9	2.2	7.2	1.0	15.3	5.2	23.1	17.7	13.6
Estimated aquatic inverts/m^3 water	1.3	5.2	3.8	1.9	6.9	0.7	11.4	4.5	16.9	15.2	12.3
average inv/m^3	2.5	6.0	4.1	2.3	7.3	1.0	15.4	5.6	26.1	17.9	14.1
average aq inverts/m^3 water	1.7	5.4	4.0	2.0	7.0	0.8	11.4	4.9	18.8	15.6	13
StDev of aq. Inv. Density	1.0	1.3	1.0	0.8	1.5	0.1	3.4	2.0	7.6	1.8	2.7
Total aquatic invertebrates	253	2657	2335	684	5940	857	3465	2759	8455	7466	8136
Total. terrestrial invertebrates	90	291	54	114	291	279	1181	428	3112	1224	791
Total invertebrates	343	2948	2389	798	6232	1136	4646	3187	11567	8689	8927
% Sample aquatic	74%	90%	98%	86%	95%	75%	75%	87%	73%	86%	91%
% Sample terrestrial	26%	10%	2%	14%	5%	25%	25%	13%	27%	14%	9%
Average # aquatic inverts / net	51	531	467	137	1188	171	693	552	1691	1493	1627
stdev aq inv/net	27	309	64	56	167	63	292	111	209	842	421
Average # terr. inverts / net	18	58	11	23	58	56	236	86	622	245	158
Average # inverts / net	69	590	478	160	1246	227	929	637	2313	1738	1785
stdev inv/net	29	328	66	53	167	84	352	130	276	1012	487
Total Larval Arctic Grayling/site	0	2	0	14	1	0	0	0	0	0	0
Total Larval Slimy Sculpin/site	0	0	0	0	1	0	0	1	0	0	0
Total Larval Dolly Varden/site	0	0	0	0	0	7	0	0	0	0	0

Appendix 6 (continued)

Bons Creek below Blast Road, upstream of Bons Pond						
Year Sampled	2004	2005	2006	2007	2008	2009
Total aquatic taxa	17	23	16	14	19	14
Tot. Ephemeroptera	3	15	7	6	6	9
Tot. Plecoptera	1	1	1	1	3	1
Tot. Trichoptera	0	0	0	0	0	0
Total Aq. Diptera	39	82	23	367	347	251
Misc.Aq.sp	7	66	10	56	114	17
% Ephemeroptera	6%	9%	17%	1%	1%	6%
% Plecoptera	2%	1%	2%	0%	1%	3%
% Trichoptera	0%	0%	0%	0%	0%	0%
% Aq. Diptera	77%	50%	56%	86%	74%	0%
% other	14%	40%	25%	13%	24%	90%
% EPT	8%	10%	19%	2%	2%	4%
% Chironomidae	68%	27%	43%	72%	20%	81%
% Dominant Aquatic Taxon	60%	38%	38%	50%	53.0%	76%
Volume of water (m^3)	349	104	68	86	79	87
average water/net	70	21	14	17	16	17
StDev of water volume	10	11	3	3	8	12
Estimated total inverts/m^3 water	1.3	23.0	4.6	31.5	55.4	25.7
Estimated aquatic inverts/m^3 water	0.7	7.9	3.1	24.8	29.9	16.1
average inv/m^3	1.3	23.0	4.6	31.5	57.6	31.8
average aq inverts/m^3 water	0.7	9.6	3.2	25.0	30.4	19
StDev of aq. Inv. Density	0.5	4.9	1.3	8.4	4.6	8.5
Total aquatic invertebrates	251	823	208	2147	2354	1392
Total. terrestrial invertebrates	209	1564	105	574	2012	834
Total invertebrates	460	2387	313	2721	4365	2226
% Sample aquatic	55%	34%	66%	79%	54%	63%
% Sample terrestrial	45%	66%	34%	21%	46%	37%
Average # aquatic inverts / net	50	165	42	429	471	278
stdev aq inv/net	40	58	14	154	218	135
Average # terr. inverts / net	42	313	21	115	402	167
Average # inverts / net	92	477	63	544	873	445
stdev inv/net	79	336	17	207	428	169
Total Larval Arctic Grayling/site	0	10	0	78	0	0
Total Larval Slimy Sculpin/site	0	0	0	0	0	0
Total Larval Dolly Varden/site	0	0	0	0	0	0

Appendix 6 (continued)

Bons Creek (Station 220), just upstream of confluence with Buddy Creek									
Year Sampled	2004	2005	2006a	2006b	2007a	2007b	2008a	2008b	2009
Total aquatic taxa	20	18	17	19	16	17	19	20	19
Tot. Ephemeroptera	7	51	17	17	95	95	63	63	130
Tot. Plecoptera	3	5	8	8	8	8	29	29	7
Tot. Trichoptera	1	1	0	0	4	4	4	4	0
Total Aq. Diptera	48	63	122	122	1391	1391	2112	2112	1044
Misc.Aq.sp	3	8	241	5255	34	1590	134	1322	95
% Ephemeroptera	11%	40%	4%	0%	6%	3%	3%	2%	10%
% Plecoptera	5%	4%	2%	0%	1%	0%	1%	1%	1%
% Trichoptera	2%	1%	0%	0%	0%	0%	0%	0%	0%
% Aq. Diptera	77%	50%	31%	2%	91%	45%	90%	60%	82%
% other	5%	40%	62%	97%	2%	51%	6%	37%	7%
% EPT	18%	44%	7%	0%	7%	3%	4%	3%	11%
% Chironomidae	46%	43%	30%	2%	35%	17%	72%	48%	50%
% Dominant Aquatic Taxon	45%	43%	53%	89%	56%	50%	67%	48%	45%
Volume of water (m^3)	698	76	612	612	150	150	317	317	216
average water/net	140	15	122	122	30	30	63	63	43
StDev of water volume	59	7	44	44	21	21	20	20	12
Estimated total inverts/m^3 water	0.8	11.2	5.0	46.0	63.7	115.6	41.7	60.5	36.2
Estimated aquatic inverts/m^3 water	0.4	8.4	3.2	44.2	51.1	103.0	37.0	55.8	29.6
average inv/m^3	0.9	11.2	5.0	46.0	130.0	222.4	42.3	61.4	35.2
average aq inverts/m^3 water	0.4	8.1	3.3	46.4	107.4	199.8	37.8	56.8	28.6
StDev of aq. Inv. Density	0.2	2.2	0.8	21.5	136.8	232.8	11.0	11.0	12.4
Total aquatic invertebrates	312	636	1943	27013	7654	15436	11706	17648	6375
Total. terrestrial invertebrates	273	217	1143	1143	1892	1892	1494	1494	1427
Total invertebrates	585	853	3086	28156	9546	17328	13200	19142	7802
% Sample aquatic	53%	75%	63%	96%	80%	89%	89%	92%	82%
% Sample terrestrial	47%	25%	37%	4%	20%	11%	11%	8%	18%
Average # aquatic inverts / net	62	127	389	5403	1531	3087	2341	3530	1275
stdev aq inv/net	56	66	108	2101	854	2008	766	993	833
Average # terr. inverts / net	55	43	229	229	378	378	299	299	285
Average # inverts / net	117	171	617	5631	1909	3466	2640	3828	1560
stdev inv/net	59	88	239	2183	1108	2288	872	1098	992
Total Larval Arctic Grayling/site	0	0	0	0	1	1	0	0	0
Total Larval Slimy Sculpin/site	0	0	0	0	0	0	0	0	0
Total Larval Dolly Varden/site	0	0	0	0	0	0	0	0	0
2006a is without Daphniids and 2006b is with Daphniids									
2007a is without Ostracods and 2007b is with Ostracods									
2008a is without Ostracods and 2008b is with Ostracods									

Appendix 6 (continued)

Buddy Creek (Station 221), upstream of haul road						
Year Sampled	2004	2005	2006	2007	2008	2009
Total aquatic taxa	20	20	19	23	22	17
Tot. Ephemeroptera	2042	232	515	385	110	18
Tot. Plecoptera	20	18	28	130	86	30
Tot. Trichoptera	0	1	0	1	0	1
Total Aq. Diptera	195	423	476	965	1632	489
Misc.Aq.sp	25	47	84	98	204	73
% Ephemeroptera	89%	32%	47%	24%	5%	3%
% Plecoptera	1%	3%	3%	8%	4%	5%
% Trichoptera	0%	0%	0%	0%	0%	0%
% Aq. Diptera	9%	59%	43%	61%	80%	80%
% other	1%	32%	8%	6%	10%	12%
% EPT	90%	35%	49%	33%	10%	8%
% Chironomidae	5%	38%	25%	43%	39%	39%
% Dominant Aquatic Taxon	89%	28%	44%	24%	41%	41%
Volume of water (m^3)	771	235	600	242	489	318
average water/net	154	47	120	48	98	64
StDev of water volume	146	18	65	30	18	34
Estimated total inverts/m^3 water	16.2	22.0	11.5	39.7	24.6	19
Estimated aquatic inverts/m^3 water	14.8	15.3	9.2	32.7	20.8	9.6
average inv/m^3	20.1	22.0	11.5	47.0	25.0	22.3
average aq inverts/m^3 water	18.1	17.2	9.3	38.9	21.0	11.1
StDev of aq. Inv. Density	10.1	7.5	2.1	16.1	4.2	4.7
Total aquatic invertebrates	11414	3607	5515	7892	10161	3050
Total. terrestrial invertebrates	1074	1572	1404	1698	1900	2971
Total invertebrates	12488	5179	6918	9590	12061	6021
% Sample aquatic	91%	70%	80%	82%	84%	51%
% Sample terrestrial	9%	30%	20%	18%	16%	49%
Average # aquatic inverts / net	2283	721	1103	1578	2032	610
stdev aq inv/net	1459	176	575	555	391	144
Average # terr. inverts / net	215	314	281	340	380	594
Average # inverts / net	2498	1036	1384	1918	2412	1204
stdev inv/net	1540	323	752	683	394	380
Total Larval Arctic Grayling/site	0	0	0	1	0	0
Total Larval Slimy Sculpin/site	0	0	0	0	0	0
Total Larval Dolly Varden/site	0	0	0	0	0	0

Appendix 6 (concluded)

Buddy Creek (below falls), downstream of the canyon and haul road							
Year Sampled	2004	2005	2006a	2006b	2007	2008	2009
Total aquatic taxa	18	19	16	18	25	20	13
Tot. Ephemeroptera	578	328	253	253	1316	124	776
Tot. Plecoptera	9	12	32	32	92	21	18
Tot. Trichoptera	1	2	0	0	7	2	0
Total Aq. Diptera	363	855	199	199	2284	2011	4424
Misc.Aq.sp	71	19	125	2461	444	206	153
% Ephemeroptera	57%	27%	42%	9%	32%	5%	14%
% Plecoptera	1%	1%	5%	1%	2%	1%	0%
% Trichoptera	0%	0%	0%	0%	0%	0%	0%
% Aq. Diptera	35%	70%	33%	7%	55%	85%	82%
% other	7%	2%	21%	84%	11%	9%	3%
% EPT	58%	28%	47%	10%	34%	6%	15%
% Chironomidae	11%	64%	22%	4%	40%	67%	69%
% Dominant Aquatic Taxon	56%	43%	33%	69%	30%	46%	50%
Volume of water (m^3)	1326	271	612	612	593	633	347
average water/net	265	54	122	122	119	127	69
StDev of water volume	160	12	29	29	63	57	19
Estimated total inverts/m^3 water	4.5	35.9	7.3	26.4	42.4	20.8	81.5
Estimated aquatic inverts/m^3 water	3.9	22.5	5.0	24.1	34.9	18.7	77.4
average inv/m^3	4.4	35.9	7.3	26.4	47.5	26.4	83.4
average aq inverts/m^3 water	3.9	22.6	5.0	24.8	39.4	23.6	79
StDev of aq. Inv. Density	2.2	3.3	1.6	9.7	16.0	15.3	11.9
Total aquatic invertebrates	5109	6085	3041	14723	20713	11820	26860
Total. terrestrial invertebrates	876	3645	1400	1400	4439	1320	1431
Total invertebrates	5985	9730	4441	16123	25152	13140	28291
% Sample aquatic	85%	63%	68%	91%	82%	90%	95%
% Sample terrestrial	15%	37%	32%	9%	18%	10%	5%
Average # aquatic inverts / net	1022	1217	608	2945	4143	2364	5372
stdev aq inv/net	744	279	222	1201	1812	352	1247
Average # terr. inverts / net	175	729	280	280	888	264	286
Average # inverts / net	1197	1946	888	3225	5030	2628	5658
stdev inv/net	893	494	322	1224	2337	432	1244
Total Larval Arctic Grayling/site	0	0	0	0	1	0	0
Total Larval Slimy Sculpin/site	0	0	0	0	0	0	0
Total Larval Dolly Varden/site	0	1	0	0	0	0	0
2006a is without Daphniids and 2006b is with Daphniids							

Appendix 7. Juvenile Dolly Varden Whole Body Metal Concentrations, 1998 to 2009

								Method	200.80	200.8	7471A	7740.0	200.8	
								analyte	Cd	Pb	Hg	Se	Zn	
Collector	Sample			Date	Fish	Length	Weight		total	total	total	total	total	%
	Number	Stream	Site	Collected	Spp	(mm)	(g)	MRL	0.05	0.02	0.02	1.0	0.5	Solids
ADF&G	080798MSDVJ1	Red Dog	Mainstem	8/7/1998	DV	132		Juvenile	1.97	5.04		6.46		25.5
ADF&G	080798MSDVJ2	Red Dog	Mainstem	8/7/1998	DV	145		Juvenile	3.62	15.00		7.27		26.8
ADF&G	080798MSDVJ3	Red Dog	Mainstem	8/7/1998	DV	124		Juvenile	3.62	16.20		6.40		23.8
ADF&G	080798MSDVJ4	Red Dog	Mainstem	8/7/1998	DV	124		Juvenile	3.04	10.60		5.23		23.7
ADF&G	080798MSDVJ5	Red Dog	Mainstem	8/7/1998	DV	110		Juvenile	3.07	6.97		5.73		24.3
ADF&G	080798MSDVJ6	Red Dog	Mainstem	8/7/1998	DV	130		Juvenile	1.89	4.17		7.29		24.1
ADF&G	080798MSDVJ7	Red Dog	Mainstem	8/7/1998	DV	143		Juvenile	0.42	3.95		6.88		25.6
ADF&G	080798MSDVJ8	Red Dog	Mainstem	8/7/1998	DV	130		Juvenile	2.54	21.20		8.68		23.3
ADF&G	080798MSDVJ9	Red Dog	Mainstem	8/7/1998	DV	132		Juvenile	3.08	6.48		7.26		23.3
ADF&G	080798MSDVJ10	Red Dog	Mainstem	8/7/1998	DV	132		Juvenile	1.04	7.97		7.62		24.2
ADF&G	081299MSDVJ01	Red Dog	Mainstem	8/10/1999	DV	140		Juvenile	4.62	8.91		6.89		23.9
ADF&G	081299MSDVJ02	Red Dog	Mainstem	8/10/1999	DV	121		Juvenile	3.90	8.78		7.13		22.6
ADF&G	081299MSDVJ03	Red Dog	Mainstem	8/10/1999	DV	125		Juvenile	3.75	8.68		8.90		22.2
ADF&G	081299MSDVJ04	Red Dog	Mainstem	8/10/1999	DV	127		Juvenile	4.14	3.11		7.26		24.1
ADF&G	081299MSDVJ05	Red Dog	Mainstem	8/10/1999	DV	130		Juvenile	3.19	4.97		6.87		20.8
ADF&G	081299MSDVJ06	Red Dog	Mainstem	8/10/1999	DV	134		Juvenile	1.28	3.18		7.30		24.1
ADF&G	081299MSDVJ07	Red Dog	Mainstem	8/10/1999	DV	139		Juvenile	3.84	6.52		8.89		22.8
ADF&G	081299MSDVJ08	Red Dog	Mainstem	8/10/1999	DV	145		Juvenile	3.17	10.40		6.30		23.3
ADF&G	081299MSDVJ09	Red Dog	Mainstem	8/10/1999	DV	143		Juvenile	0.54	1.09		5.66		26.0
ADF&G	081299MSDVJ10	Red Dog	Mainstem	8/10/1999	DV	120		Juvenile	2.47	9.94		4.24		23.2
ADF&G	072800MSDVJ01	Red Dog	Mainstem	7/28/2000	DV	131	17.9	Juvenile	2.69	6.80		6.8		22.5
ADF&G	072800MSDVJ02	Red Dog	Mainstem	7/28/2000	DV	117	12.3	Juvenile	3.45	13.0		10.8		25.1
ADF&G	072800MSDVJ03	Red Dog	Mainstem	7/28/2000	DV	140	21.8	Juvenile	4.75	9.75		9.1		22.7
ADF&G	072800MSDVJ04	Red Dog	Mainstem	7/28/2000	DV	110	11.2	Juvenile	2.91	13.4		12.5		24.6
ADF&G	072800MSDVJ05	Red Dog	Mainstem	7/28/2000	DV	125	16	Juvenile	6.40	15.8		8.9		20.9
ADF&G	080501MSRDDVJ01	Red Dog	Mainstem	7/31/2001	DV	92	6.93	Juvenile	5.92	46.6		12.3	333	22.0
ADF&G	080501MSRDDVJ02	Red Dog	Mainstem	7/31/2001	DV	133	16.11	Juvenile	3.88	16.8		7.6	244	20.8
ADF&G	080501MSRDDVJ03	Red Dog	Mainstem	7/31/2001	DV	94	6.22	Juvenile	3.42	25.0		15.2	327	24.9
ADF&G	080501MSRDDVJ04	Red Dog	Mainstem	7/31/2001	DV	132	15.98	Juvenile	1.15	1.95		6.7	117	21.4
ADF&G	080501MSRDDVJ05	Red Dog	Mainstem	7/31/2001	DV	134	21.74	Juvenile	3.83	9.79		14.4	210	22.8
ADF&G	080501MSRDDVJ06	Red Dog	Mainstem	7/31/2001	DV	117	12.7	Juvenile	2.78	4.43		10.5	226	20.7
ADF&G	080501MSRDDVJ07	Red Dog	Mainstem	7/31/2001	DV	106	9.69	Juvenile	2.80	5.62		11.1	210	21.5
ADF&G	080501MSRDDVJ08	Red Dog	Mainstem	7/31/2001	DV	106	9.3	Juvenile	3.52	11.4		13.1	188	23.2
ADF&G	081002MSRDDV01	Red Dog	Mainstem	7/28/2002	DV	112	13.99	Juvenile	6.63	20.7		9.4	271	23.8
ADF&G	081002MSRDDV02	Red Dog	Mainstem	7/28/2002	DV	100	11.75	Juvenile	5.62	8.89		13	276	25.1
ADF&G	081002MSRDDV03	Red Dog	Mainstem	7/28/2002	DV	127	20.25	Juvenile	6.16	14.6		16.1	404	25.4
ADF&G	081002MSRDDV04	Red Dog	Mainstem	7/28/2002	DV	128	20.53	Juvenile	6.17	29.2		12.7	402	23.6
ADF&G	081002MSRDDV05	Red Dog	Mainstem	7/28/2002	DV	90	6.22	Juvenile	1.83	6.77		6.6	195	22.9
ADF&G	081002MSRDDV06	Red Dog	Mainstem	7/28/2002	DV	106	10.88	Juvenile	3.39	9.33		13	230	25.1
ADF&G	081002MSRDDV07	Red Dog	Mainstem	7/28/2002	DV	104	10.93	Juvenile	4.82	8.39		17.2	314	24.9
ADF&G	081002MSRDDV08	Red Dog	Mainstem	7/28/2002	DV	98	8.74	Juvenile	3.13	6.42		17	210	24.2
ADF&G	081002MSRDDV09	Red Dog	Mainstem	7/28/2002	DV	119	16.71	Juvenile	2.82	5		14.2	205	26.1
ADF&G	081002MSRDDV10	Red Dog	Mainstem	7/28/2002	DV	95	9.04	Juvenile	3.65	16.9		9.2	218	23.4
ADF&G	081002MSRDDV11	Red Dog	Mainstem	7/29/2002	DV	134	23.22	Juvenile	3.05	8.4		9.8	219	24.7
ADF&G	081002MSRDDV12	Red Dog	Mainstem	7/29/2002	DV	116	13.21	Juvenile	2.31	5.26		8.7	180	20.5
ADF&G	081002MSRDDV13	Red Dog	Mainstem	7/29/2002	DV	99	9.67	Juvenile	2.64	3.02		11.2	218	25.3
ADF&G	081002MSRDDV14	Red Dog	Mainstem	7/29/2002	DV	100	10.6	Juvenile	3.11	8.12		13.3	221	24
ADF&G	081002MSRDDV15	Red Dog	Mainstem	7/29/2002	DV	96	8.36	Juvenile	2.04	10.1		8.2	177	24

Appendix 7 (continued)

								Method		200.80		200.8		7471A		7740.0		200.8	
								analyte		Cd		Pb		Hg		Se		Zn	
Collector	Sample			Date	Fish	Length	Weight			total		total		total		total		total	%
	Number	Stream	Site	Collected	Spp	(mm)	(g)	MRL		0.05		0.02		0.02		1.0		0.5	Solids
ADNR	080803MSDVJ01	Red Dog	Mainstem	8/8/2003	DV	150	30	Juvenile		4.98		10.7				11.8		233	25.4
ADNR	080803MSDVJ02	Red Dog	Mainstem	8/8/2003	DV	128	16.7	Juvenile		5.48		8.4				11.5		208	24.5
ADNR	081003MSDVJ03	Red Dog	Mainstem	8/10/2003	DV	112	13.5	Juvenile		6.56		15.2				10.1		271	23.2
ADNR	081003MSDVJ04	Red Dog	Mainstem	8/10/2003	DV	111	13.6	Juvenile		3.86		2.42				10.0		220	25.2
ADNR	081003MSDVJ05	Red Dog	Mainstem	8/10/2003	DV	119	15.5	Juvenile		3.41		1.72				10.1		166	24.2
ADNR	081003MSDVJ06	Red Dog	Mainstem	8/10/2003	DV	108	12	Juvenile		2.82		3.41				10.0		197	23
ADNR	081003MSDVJ07	Red Dog	Mainstem	8/10/2003	DV	106	11.3	Juvenile		5.92		9.26				10.4		331	23.3
ADNR	081003MSDVJ08	Red Dog	Mainstem	8/10/2003	DV	108	11.2	Juvenile		4.65		4.51				11.0		212	24.6
ADNR	081003MSDVJ09	Red Dog	Mainstem	8/10/2003	DV	112	12.3	Juvenile		2.96		4.66				8.5		185	24.6
ADNR	081003MSDVJ10	Red Dog	Mainstem	8/10/2003	DV	118	16.3	Juvenile		5.15		16.3				12.7		258	24.3
ADNR	081003MSDVJ11	Red Dog	Mainstem	8/10/2003	DV	111	11.9	Juvenile		4.37		12.7				9.6		234	24.7
ADNR	081003MSDVJ12	Red Dog	Mainstem	8/10/2003	DV	109	11.6	Juvenile		1.29		1.87				10.1		153	24.7
ADNR	081003MSDVJ13	Red Dog	Mainstem	8/10/2003	DV	106	15.5	Juvenile		1.86		0.97				8.2		140	24.9
ADNR	081003MSDVJ14	Red Dog	Mainstem	8/10/2003	DV	110	12.8	Juvenile		3.53		4.42				13.7		249	25.5
ADNR	082004MSDVJ01	Red Dog	Mainstem	8/20/2004	DV	91	6.5	Juvenile		4.72		24.7		0.06		5.7		265	20.1
ADNR	082004MSDVJ02	Red Dog	Mainstem	8/20/2004	DV	110	10.7	Juvenile		1.23		2.4		0.03		3.9		208	21.9
ADNR	082704MSDVJ03	Red Dog	Mainstem	8/27/2004	DV	128	18.1	Juvenile		0.76		1.63	<	0.02		3.2		120	26.2
ADNR	082704MSDVJ04	Red Dog	Mainstem	8/27/2004	DV	116	11.8	Juvenile		3.74		147		0.04		6.8		282	22.2
ADNR	072805MSRDDVJ01	Red Dog	Mainstem	7/28/2005	DV	109	11.52	Juvenile		3.48		3.05		0.03		10.8		167	24.1
ADNR	072805MSRDDVJ02	Red Dog	Mainstem	7/28/2005	DV	111	11.79	Juvenile		2.5		2.06		0.02		9.7		173	24.3
ADNR	072805MSRDDVJ03	Red Dog	Mainstem	7/28/2005	DV	123	16.36	Juvenile		1.48		2.72		0.03		8.5		176	24.3
ADNR	072805MSRDDVJ04	Red Dog	Mainstem	7/28/2005	DV	131	19	Juvenile		1.4		2.13		0.04		9.8		159	22.3
ADNR	072805MSRDDVJ05	Red Dog	Mainstem	7/28/2005	DV	116	15.75	Juvenile		1.66		1.63		0.03		7.8		190	24.1
ADNR	072805MSRDDVJ06	Red Dog	Mainstem	7/28/2005	DV	103	10.96	Juvenile		2.87		7.03		0.04		7.7		214	23
ADNR	072905MSRDDVJ07	Red Dog	Mainstem	7/29/2005	DV	122	15.89	Juvenile		1.67		1.91		0.03		10.2		147	24.2
ADNR	072905MSRDDVJ08	Red Dog	Mainstem	7/29/2005	DV	107	12.47	Juvenile		2.11		0.95		0.03		9.2		166	24.6
ADNR	072905MSRDDVJ09	Red Dog	Mainstem	7/29/2005	DV	119	15.9	Juvenile		3.27		1.93		0.03		9.6		171	21.7
ADNR	072905MSRDDVJ10	Red Dog	Mainstem	7/29/2005	DV	109	13.15	Juvenile		1.71		1.62		0.04		8.7		199	23.8
ADNR	072905MSRDDVJ11	Red Dog	Mainstem	7/29/2005	DV	136	22.93	Juvenile		2.09		1.73		0.02		9.5		163	25.6
ADNR	072905MSRDDVJ12	Red Dog	Mainstem	7/29/2005	DV	107	11.31	Juvenile		1.6		2.19		0.03		4.6		202	22.8
ADNR	072905MSRDDVJ13	Red Dog	Mainstem	7/29/2005	DV	114	13.03	Juvenile		2.74		0.78		0.02		8.8		145	22.7
ADNR	072905MSRDDVJ14	Red Dog	Mainstem	7/29/2005	DV	106	10.9	Juvenile		1.96		1.72		0.04		7.6		181	23.2
ADNR	072905MSRDDVJ15	Red Dog	Mainstem	7/29/2005	DV	113	14.66	Juvenile		1.87		1.05		0.03		8.7		164	24
ADNR	081106MSRDDVJ01	Red Dog	Mainstem	8/11/2006	DV	109	11.94	Juvenile		3.15		1.84		0.04		5.7		288	23.1
ADNR	081106MSRDDVJ02	Red Dog	Mainstem	8/11/2006	DV	110	14.47	Juvenile		3		5.49		0.04		6.9		349	24.5
ADNR	081106MSRDDVJ03	Red Dog	Mainstem	8/11/2006	DV	108	11.77	Juvenile		2.8		1.15		0.04		6.2		284	24.4
ADNR	081206MSRDDVJ04	Red Dog	Mainstem	8/12/2006	DV	94	8.33	Juvenile		4.52		12		0.06		6.3		569	20
ADNR	081206MSRDDVJ05	Red Dog	Mainstem	8/12/2006	DV	112	13.17	Juvenile		3.35		3.99		0.04		8		305	24.1
ADNR	081206MSRDDVJ06	Red Dog	Mainstem	8/12/2006	DV	110	13.27	Juvenile		3.68		4.81		0.03		6.6		229	23.4
ADNR	081206MSRDDVJ07	Red Dog	Mainstem	8/12/2006	DV	112	13.14	Juvenile		2.18		1.28		0.04		7.4		260	22
ADNR	081206MSRDDVJ08	Red Dog	Mainstem	8/12/2006	DV	108	11.03	Juvenile		2.28		1.31		0.03		6.7		317	22.2
ADNR	081206MSRDDVJ09	Red Dog	Mainstem	8/12/2006	DV	127	18.64	Juvenile		1.77		1.53		0.05		7.4		294	22
ADNR	081206MSRDDVJ10	Red Dog	Mainstem	8/12/2006	DV	95	8.65	Juvenile		3.76		1.24		0.03		7.4		513	22.4
ADNR	081206MSRDDVJ11	Red Dog	Mainstem	8/12/2006	DV	102	9.75	Juvenile		3.17		16		0.02		6.4		529	21.6
ADNR	081007MSRDDVJ01	Red Dog	Mainstem	8/10/2007	DV	124	15.67	Juvenile		5.88		13.3		0.03		7.4		540	24.8
ADNR	081007MSRDDVJ02	Red Dog	Mainstem	8/10/2007	DV	110	11.81	Juvenile		5.58		2.89		0.03		6.2		463	24.2
ADNR	081007MSRDDVJ03	Red Dog	Mainstem	8/10/2007	DV	123	15.89	Juvenile		4.89		0.93		0.04		4.4		192	26.7
ADNR	081007MSRDDVJ04	Red Dog	Mainstem	8/10/2007	DV	78	4.42	Juvenile		1.06		0.87		0.04		2.6		239	27.1
ADNR	081007MSRDDVJ05	Red Dog	Mainstem	8/10/2007	DV	120	14.32	Juvenile		2.71		3		0.04		5.5		220	23.8
ADNR	081107MSRDDVJ06	Red Dog	Mainstem	8/11/2007	DV	78	4.3	Juvenile		6.35		3.26		0.03		6.8		359	25.3
ADNR	081207MSRDDVJ07	Red Dog	Mainstem	8/12/2007	DV	119	15.25	Juvenile		5.43		20.9		0.06		4.9		497	24
ADNR	081207MSRDDVJ08	Red Dog	Mainstem	8/12/2007	DV	107	11.83	Juvenile		1.88		6.32	<	0.02		3.3		351	26.1
ADNR	081307MSRDDVJ09	Red Dog	Mainstem	8/12/2007	DV	63	2	Juvenile		1.19		2.75	<	0.18		3.5		250	21.3
ADNR	081307MSRDDVJ10	Red Dog	Mainstem	8/12/2007	DV	65	2.31	Juvenile		0.72		1.24	<	0.02		2.9		176	22.2
ADNR	081307MSRDDVJ11	Red Dog	Mainstem	8/12/2007	DV	65	2.36	Juvenile		1.83		1.7	<	0.02		4.5		366	21.4

Appendix 7 (continued)

								Method		200.80		200.8		7471A		7740.0		200.8	
								analyte		Cd		Pb		Hg		Se		Zn	
Collector	Sample			Date	Fish	Length	Weight			total		total		total		total		total	%
	Number	Stream	Site	Collected	Spp	(mm)	(g)	MRL		0.05		0.02		0.02		1.0		0.5	Solids
ADF&G	080408MSRDDVJ01	Red Dog	Mainstem	8/4/2008	DV	95	5.7	Juvenile		2.01		1.43		0.03		5.6		233	21.1
ADF&G	080408MSRDDVJ02	Red Dog	Mainstem	8/4/2008	DV	118	12.2	Juvenile		0.89		0.46		0.04		4.1		247	21.8
ADF&G	080408MSRDDVJ03	Red Dog	Mainstem	8/4/2008	DV	108	9.2	Juvenile		3.21		2.37		0.05		4.9		220	23.3
ADF&G	080408MSRDDVJ04	Red Dog	Mainstem	8/4/2008	DV	108	10.5	Juvenile		2.05		0.67		0.06		4.8		166	23.8
ADF&G	080408MSRDDVJ05	Red Dog	Mainstem	8/4/2008	DV	115	13.4	Juvenile		1.76		2.96		0.04		5.3		291	21.3
ADF&G	080408MSRDDVJ06	Red Dog	Mainstem	8/4/2008	DV	108	17.6	Juvenile		1.63		6.41		0.06		4.4		218	20.5
ADF&G	080408MSRDDVJ07	Red Dog	Mainstem	8/4/2008	DV	118	21.6	Juvenile		2.99		2.77		0.06		7.4		300	23.5
ADF&G	080408MSRDDVJ08	Red Dog	Mainstem	8/4/2008	DV	102	16.2	Juvenile		1.47		1.63		0.04		7.1		229	23
ADF&G	080408MSRDDVJ09	Red Dog	Mainstem	8/4/2008	DV	100	15.9	Juvenile		1.27		1.4		0.03		5.7		223	22.2
ADF&G	080408MSRDDVJ10	Red Dog	Mainstem	8/4/2008	DV	113	20.2	Juvenile		2.3		2.58		0.04		7.1		236	24
ADF&G	080408MSRDDVJ11	Red Dog	Mainstem	8/4/2008	DV	96	14.4	Juvenile		1.67		1.53		0.03		6.3		215	22.2
ADF&G	080408MSRDDVJ12	Red Dog	Mainstem	8/4/2008	DV	104	15.5	Juvenile		1.55		1.82		0.05		4.9		259	22.6
ADF&G	080408MSRDDVJ13	Red Dog	Mainstem	8/4/2008	DV	93	13.6	Juvenile		2.32		2.32		0.03		5.6		290	22.1
ADF&G	080408MSRDDVJ14	Red Dog	Mainstem	8/4/2008	DV	118	22.2	Juvenile		1.94		3.77		0.03		6.3		263	16.1
ADF&G	080408MSRDDVJ15	Red Dog	Mainstem	8/4/2008	DV	97	14.9	Juvenile		2.56		9.92		0.03		5.5		274	23.2
ADF&G	073009MSRDDVJ01	Red Dog	Mainstem	7/30/2009	DV	67	2	Juvenile		1.16		0.99	<	0.1		4.4		199	23.2
ADF&G	073009MSRDDVJ02	Red Dog	Mainstem	7/30/2009	DV	93	6.5	Juvenile		1.45		1.33		0.03		10.9		172	22.6
ADF&G	073009MSRDDVJ03	Red Dog	Mainstem	7/30/2009	DV	84	5	Juvenile		0.79		1.10		0.03		5.6		140	20.7
ADF&G	073009MSRDDVJ04	Red Dog	Mainstem	7/30/2009	DV	57	1.5	Juvenile		0.51		0.33	<	0.11		3.9		180	22.5
ADF&G	073009MSRDDVJ05	Red Dog	Mainstem	7/30/2009	DV	83	5	Juvenile		1.46		1.57		0.03		3.9		160	26.7
ADF&G	073009MSRDDVJ06	Red Dog	Mainstem	7/30/2009	DV	98	6.5	Juvenile		0.60		0.40		0.04		4.1		166	20.7
ADF&G	073009MSRDDVJ07	Red Dog	Mainstem	7/30/2009	DV	80	7	Juvenile		0.31		0.57		0.03		3.4		121	22.7
ADF&G	073009MSRDDVJ08	Red Dog	Mainstem	7/30/2009	DV	113	12.5	Juvenile		3.15		2.35		0.03		9.5		139	24.5
ADF&G	073009MSRDDVJ09	Red Dog	Mainstem	7/30/2009	DV	112	12	Juvenile		1.54		1.40		0.03		11.8		136	25.3
ADF&G	073009MSRDDVJ10	Red Dog	Mainstem	7/30/2009	DV	99	9.5	Juvenile		0.51		0.23		0.02		4.0		167	24.9
ADF&G	073009MSRDDVJ11	Red Dog	Mainstem	7/30/2009	DV	105	10	Juvenile		1.35		0.78		0.04		11.2		162	24.8
ADF&G	073009MSRDDVJ12	Red Dog	Mainstem	7/30/2009	DV	57	1.5	Juvenile		0.85		0.83	<	0.1		3.4		156	24.6
ADF&G	073009MSRDDVJ13	Red Dog	Mainstem	7/30/2009	DV	58	1.75	Juvenile		0.70		1.14	<	0.11		3.6		156	23.1
ADF&G	073009MSRDDVJ14	Red Dog	Mainstem	7/30/2009	DV	64	2	Juvenile		0.66		0.81	<	0.1		3.5		154	23.9
ADF&G	073009MSRDDVJ15	Red Dog	Mainstem	7/30/2009	DV	57	1.5	Juvenile		0.57		5.04	<	0.1		3.2		164	24.5

Appendix 7 (continued)

								Method	200.80	200.8	7471A	7740.0	200.8	
								analyte	Cd	Pb	Hg	Se	Zn	
Collector	Sample			Date	Fish	Length	Weight		total	total	total	total	total	%
	Number	Stream	Site	Collected	Spp	(mm)	(g)	MRL	0.05	0.02	0.02	1.0	0.5	Solids
ADNR	072905BUDVJ01	Buddy	D/S Road	7/29/2005	DV	104	10.91	Juvenile	1.53	0.18	0.03	8	149	24.4
ADNR	072905BUDVJ02	Buddy	D/S Road	7/29/2005	DV	106	12	Juvenile	0.5	0.1	0.02	6.9	134	24.3
ADNR	072905BUDVJ03	Buddy	D/S Road	7/29/2005	DV	115	14.17	Juvenile	1.37	0.16	0.03	6.8	132	24
ADNR	072905BUDVJ04	Buddy	D/S Road	7/29/2005	DV	102	9.86	Juvenile	0.6	0.1	0.03	7.4	141	25.9
ADNR	072905BUDVJ05	Buddy	D/S Road	7/29/2005	DV	110	11.92	Juvenile	0.41	0.15	0.02	5.6	114	24.4
ADNR	072905BUDVJ06	Buddy	D/S Road	7/29/2005	DV	134	18.55	Juvenile	0.2	0.1	0.03	7	131	24.4
ADNR	072905BUDVJ07	Buddy	D/S Road	7/29/2005	DV	105	10.61	Juvenile	0.58	0.09	0.02	6.4	145	23
ADNR	072905BUDVJ08	Buddy	D/S Road	7/29/2005	DV	120	16.02	Juvenile	0.26	0.1	0.02	5.7	110	25
ADNR	072905BUDVJ09	Buddy	D/S Road	7/29/2005	DV	102	10.07	Juvenile	0.87	0.17	0.03	7.1	137	23.1
ADNR	072905BUDVJ10	Buddy	D/S Road	7/29/2005	DV	101	9.7	Juvenile	1.23	0.13	0.04	5.9	159	22.9
ADNR	072905BUDVJ11	Buddy	D/S Road	7/29/2005	DV	125	17.42	Juvenile	0.58	0.28	0.04	5.9	106	25.8
ADNR	072905BUDVJ12	Buddy	D/S Road	7/29/2005	DV	114	12.1	Juvenile	0.61	0.14	0.03	7.4	144	21.1
ADNR	072905BUDVJ13	Buddy	D/S Road	7/29/2005	DV	105	9.44	Juvenile	0.77	0.19	< 0.02	5.8	135	21
ADNR	072905BUDVJ14	Buddy	D/S Road	7/29/2005	DV	103	9.02	Juvenile	0.45	0.14	0.02	5.6	131	22.6
ADNR	072905BUDVJ15	Buddy	D/S Road	7/29/2005	DV	105	11.2	Juvenile	0.62	0.13	0.03	7.2	123	24.6
ADNR	081506BUDVJ01	Buddy	D/S Road	8/15/2006	DV	93	7.32	Juvenile	1.69	0.38	0.08	5.2	227	19.8
ADNR	081506BUDVJ02	Buddy	D/S Road	8/15/2006	DV	98	9.72	Juvenile	1.64	0.47	0.04	6.3	215	23.6
ADNR	081506BUDVJ03	Buddy	D/S Road	8/15/2006	DV	82	5.84	Juvenile	2.18	1.36	0.05	5.2	230	23.8
ADNR	081506BUDVJ04	Buddy	D/S Road	8/15/2006	DV	95	8.76	Juvenile	0.81	0.38	0.04	5.4	236	24.2
ADNR	081506BUDVJ05	Buddy	D/S Road	8/15/2006	DV	92	8.53	Juvenile	1.07	2.27	0.03	6.2	205	22.6
ADNR	081107BUDVJ01	Buddy	D/S Road	8/11/2007	DV	114	12.85	Juvenile	0.77	0.66	0.04	4.8	142	27.2
ADNR	081107BUDVJ02	Buddy	D/S Road	8/11/2007	DV	118	14.01	Juvenile	0.27	0.11	0.04	4.8	113	25.7
ADNR	081107BUDVJ03	Buddy	D/S Road	8/11/2007	DV	121	15.94	Juvenile	0.44	0.21	0.04	4.7	129	26.1
ADNR	081107BUDVJ04	Buddy	D/S Road	8/11/2007	DV	104	9.89	Juvenile	0.69	0.14	0.05	4.1	125	25.2
ADNR	081107BUDVJ05	Buddy	D/S Road	8/11/2007	DV	103	10.22	Juvenile	0.80	0.12	0.04	4	154	24.9
ADNR	081107BUDVJ06	Buddy	D/S Road	8/11/2007	DV	131	18.92	Juvenile	0.74	2.19	0.02	3.6	181	24.8
ADNR	081107BUDVJ07	Buddy	D/S Road	8/11/2007	DV	112	13.06	Juvenile	0.57	0.66	0.04	4.7	137	26.4
ADNR	081107BUDVJ08	Buddy	D/S Road	8/11/2007	DV	115	12.65	Juvenile	0.8	0.11	0.04	4.9	146	25.1
ADNR	081107BUDVJ09	Buddy	D/S Road	8/11/2007	DV	112	12.37	Juvenile	0.76	0.42	0.05	5.7	130	25.2
ADNR	081107BUDVJ10	Buddy	D/S Road	8/11/2007	DV	135	20.43	Juvenile	0.43	0.19	0.06	3.7	116	24.9
ADNR	081107BUDVJ11	Buddy	D/S Road	8/11/2007	DV	111	11.43	Juvenile	0.94	0.1	0.03	4.7	132	25.8
ADNR	081107BUDVJ12	Buddy	D/S Road	8/11/2007	DV	131	18.77	Juvenile	0.28	0.23	0.06	5.6	129	24.3
ADNR	081107BUDVJ13	Buddy	D/S Road	8/11/2007	DV	105	10.34	Juvenile	0.35	1.02	0.1	4.5	133	24.7
ADNR	081107BUDVJ14	Buddy	D/S Road	8/11/2007	DV	109	11.18	Juvenile	0.47	2.23	0.03	4	134	26
ADNR	081107BUDVJ15	Buddy	D/S Road	8/11/2007	DV	93	7.37	Juvenile	0.67	0.26	0.04	3.7	126	23.9
ADFG	080508BUDVJ01	Buddy	D/S Road	8/5/2008	DV	103	9.7	Juvenile	2.15	0.21	0.04	6.2	180	25.6
ADFG	080508BUDVJ02	Buddy	D/S Road	8/5/2008	DV	97	7.5	Juvenile	1.72	1.15	0.05	5.3	219	23.5
ADFG	080508BUDVJ03	Buddy	D/S Road	8/5/2008	DV	97	7.2	Juvenile	1.68	0.51	0.05	5.4	200	23.1
ADFG	080508BUDVJ04	Buddy	D/S Road	8/5/2008	DV	102	9	Juvenile	0.83	0.5	0.04	4.4	165	22.3
ADFG	080508BUDVJ05	Buddy	D/S Road	8/5/2008	DV	98	7.3	Juvenile	0.59	0.35	0.04	4.8	195	21.9
ADFG	080508BUDVJ06	Buddy	D/S Road	8/5/2008	DV	111	11.7	Juvenile	0.78	0.68	0.05	4.8	144	22.9
ADFG	080508BUDVJ07	Buddy	D/S Road	8/5/2008	DV	93	6.1	Juvenile	1.25	0.27	0.05	7.7	197	23.3
ADFG	080508BUDVJ08	Buddy	D/S Road	8/5/2008	DV	104	9.2	Juvenile	0.67	0.28	0.04	5.5	208	21.8
ADFG	080508BUDVJ09	Buddy	D/S Road	8/5/2008	DV	94	8	Juvenile	0.59	0.27	0.05	5.4	182	23.2
ADFG	080508BUDVJ10	Buddy	D/S Road	8/5/2008	DV	103	9.7	Juvenile	0.94	1.27	0.04	5.9	169	22.7
ADFG	080508BUDVJ11	Buddy	D/S Road	8/5/2008	DV	114	11.6	Juvenile	0.68	0.31	0.04	4.9	166	25
ADFG	080508BUDVJ12	Buddy	D/S Road	8/5/2008	DV	95	7.8	Juvenile	0.34	0.3	0.05	5.8	220	23.2
ADFG	080508BUDVJ13	Buddy	D/S Road	8/5/2008	DV	103	9.6	Juvenile	0.41	0.15	0.04	5.7	162	23.4
ADFG	080508BUDVJ14	Buddy	D/S Road	8/5/2008	DV	98	7.1	Juvenile	1.13	0.25	0.06	4.5	251	21.6
ADFG	080508BUDVJ15	Buddy	D/S Road	8/5/2008	DV	96	7.9	Juvenile	0.49	0.09	0.05	4.4	170	23

Appendix 7 (continued)

								Method	200.80	200.8	7471A	7740.0	200.8	
								analyte	Cd	Pb	Hg	Se	Zn	
Collector	Sample			Date	Fish	Length	Weight		total	total	total	total	total	%
	Number	Stream	Site	Collected	Spp	(mm)	(g)	MRL	0.05	0.02	0.02	1.0	0.5	Solids
ADFG	073109BUDVJ01	Buddy	D/S Road	7/31/2009	DV	123	15.5	Juvenile	0.19	0.38	0.06	8.4	132	25.8
ADFG	073109BUDVJ02	Buddy	D/S Road	7/31/2009	DV	125	18.5	Juvenile	1.21	0.52	0.04	10.7	143	27.9
ADFG	073109BUDVJ03	Buddy	D/S Road	7/31/2009	DV	121	16	Juvenile	0.80	0.89	0.09	11.3	134	26.3
ADFG	073109BUDVJ04	Buddy	D/S Road	7/31/2009	DV	107	12	Juvenile	1.77	0.34	0.04	8.4	141	24.8
ADFG	073109BUDVJ05	Buddy	D/S Road	7/31/2009	DV	121	16.5	Juvenile	0.75	0.50	0.05	9.3	113	24.7
ADFG	073109BUDVJ06	Buddy	D/S Road	7/31/2009	DV	112	12	Juvenile	0.97	0.35	0.04	8.7	136	25.1
ADFG	073109BUDVJ07	Buddy	D/S Road	7/31/2009	DV	118	14	Juvenile	0.98	0.48	0.06	8.5	155	23.5
ADFG	073109BUDVJ08	Buddy	D/S Road	7/31/2009	DV	104	7.5	Juvenile	0.85	0.34	0.05	6.2	220	20.5
ADFG	073109BUDVJ09	Buddy	D/S Road	7/31/2009	DV	129	17.5	Juvenile	0.38	0.41	0.05	6.7	129	24.6
ADFG	073109BUDVJ10	Buddy	D/S Road	7/31/2009	DV	95	7.5	Juvenile	0.38	0.51	0.04	9.1	127	24.3
ADFG	073109BUDVJ11	Buddy	D/S Road	7/31/2009	DV	120	15.5	Juvenile	0.78	0.96	0.04	10.3	163	25.2
ADFG	073109BUDVJ12	Buddy	D/S Road	7/31/2009	DV	120	15	Juvenile	0.66	0.20	0.06	7.2	124	24.8
ADFG	073109BUDVJ13	Buddy	D/S Road	7/31/2009	DV	109	12	Juvenile	0.40	0.78	0.06	7.8	141	23.6
ADFG	073109BUDVJ14	Buddy	D/S Road	7/31/2009	DV	109	11.5	Juvenile	1.26	0.48	0.04	9.0	177	24.5
ADFG	073109BUDVJ15	Buddy	D/S Road	7/31/2009	DV	124	16.5	Juvenile	0.87	0.34	0.05	9.1	143	24.5

Appendix 7 (continued)

								Method		200.80		200.8		7471A		7740.0		200.8	
								analyte		Cd		Pb		Hg		Se		Zn	
Collector	Sample			Date	Fish	Length	Weight			total		total		total		total		total	%
	Number	Stream	Site	Collected	Spp	(mm)	(g)	MRL		0.05		0.02		0.02		1.0		0.5	Solids
ADNR	073105AXDVJ01	Anxiety	Haul Road	7/31/2005	DV	118	15.05	Juvenile		0.45		0.42		0.04		3.8		126	23.8
ADNR	073105AXDVJ02	Anxiety	Haul Road	7/31/2005	DV	135	21.32	Juvenile		0.13		0.14		0.05		3.7		107	23.4
ADNR	073105AXDVJ03	Anxiety	Haul Road	7/31/2005	DV	102	9.25	Juvenile		0.26		0.22		0.05		7.2		135	22.1
ADNR	073105AXDVJ04	Anxiety	Haul Road	7/31/2005	DV	114	13.41	Juvenile		0.17		0.15		0.06		5		117	22.1
ADNR	073105AXDVJ05	Anxiety	Haul Road	7/31/2005	DV	121	16.7	Juvenile		0.11		0.17		0.06		4.1		129	22.7
ADNR	073105AXDVJ06	Anxiety	Haul Road	7/31/2005	DV	101	8.91	Juvenile		0.27		0.2		0.06		5.3		124	21.1
ADNR	073105AXDVJ07	Anxiety	Haul Road	7/31/2005	DV	119	14.76	Juvenile		0.1		0.06		0.07		4.6		106	22.4
ADNR	073105AXDVJ08	Anxiety	Haul Road	7/31/2005	DV	110	11.91	Juvenile		0.12		0.24		0.05		4.2		107	23
ADNR	073105AXDVJ09	Anxiety	Haul Road	7/31/2005	DV	109	11.62	Juvenile		0.14		0.1		0.06		5.2		114	23.2
ADNR	073105AXDVJ10	Anxiety	Haul Road	7/31/2005	DV	123	15.22	Juvenile		0.61		0.17		0.04		6		157	20.6
ADNR	073105AXDVJ11	Anxiety	Haul Road	7/31/2005	DV	114	13.02	Juvenile		1.75		0.23	<	0.02		7.6		175	22.9
ADNR	073105AXDVJ12	Anxiety	Haul Road	7/31/2005	DV	113	11.67	Juvenile		0.19		0.26		0.08		5.7		188	21.1
ADNR	073105AXDVJ13	Anxiety	Haul Road	7/31/2005	DV	105	10.96	Juvenile		0.35		0.13		0.03		4.9		137	23
ADNR	073105AXDVJ14	Anxiety	Haul Road	7/31/2005	DV	108	10.94	Juvenile		0.28		0.27		0.07		5.1		168	21.8
ADNR	073105AXDVJ15	Anxiety	Haul Road	7/31/2005	DV	102	8.47	Juvenile		0.13		0.13		0.05		4.2		144	20.8
ADNR	081406AXDVJ01	Anxiety	Haul Road	8/14/2006	DV	120	16.69	Juvenile		0.57		0.78		0.1		3.9		158	23.1
ADNR	081406AXDVJ02	Anxiety	Haul Road	8/14/2006	DV	112	13.87	Juvenile		0.27		0.44		0.08		3.8		120	24.9
ADNR	081406AXDVJ03	Anxiety	Haul Road	8/14/2006	DV	92	7.91	Juvenile		0.65		1.03		0.09	<	1.0		164	23.2
ADNR	081406AXDVJ04	Anxiety	Haul Road	8/14/2006	DV	87	6.39	Juvenile		0.33		0.44		0.09		6.1		169	23.7
ADNR	081406AXDVJ05	Anxiety	Haul Road	8/14/2006	DV	109	12.42	Juvenile		0.54		1.25		0.09		4.1		141	23.7
ADNR	081406AXDVJ06	Anxiety	Haul Road	8/14/2006	DV	90	7.22	Juvenile		0.32		1.36		0.09		3.7		245	23.2
ADNR	081406AXDVJ07	Anxiety	Haul Road	8/14/2006	DV	93	8.38	Juvenile		0.57		0.11		0.07		4.4		157	25
ADNR	081406AXDVJ08	Anxiety	Haul Road	8/14/2006	DV	103	10.84	Juvenile		0.56		1.3		0.1		2.9		147	22.8
ADNR	081406AXDVJ09	Anxiety	Haul Road	8/14/2006	DV	116	15.94	Juvenile		0.49		1.04		0.15		4.7		129	22.9
ADNR	081406AXDVJ10	Anxiety	Haul Road	8/14/2006	DV	90	7.67	Juvenile		0.31		0.45		0.05		3.2		142	24
ADNR	081406AXDVJ11	Anxiety	Haul Road	8/14/2006	DV	93	8.73	Juvenile		0.48		3.69		0.07		5.9		171	25
ADNR	081406AXDVJ12	Anxiety	Haul Road	8/14/2006	DV	123	19.77	Juvenile		0.64		0.95		0.12		3.7		155	24.9
ADNR	081406AXDVJ13	Anxiety	Haul Road	8/14/2006	DV	84	6.29	Juvenile		0.62		0.92		0.08		4		144	24.3
ADNR	081007AXDVJ01	Anxiety	Haul Road	8/10/2007	DV	113	12.48	Juvenile		0.25		0.25		0.14		4.4		133	23
ADNR	081007AXDVJ02	Anxiety	Haul Road	8/10/2007	DV	93	7.7	Juvenile		0.32		0.22		0.07		3.1		93.9	27.3
ADNR	081007AXDVJ03	Anxiety	Haul Road	8/10/2007	DV	128	18.42	Juvenile		0.25		0.2		0.09		4.6		102	24.1
ADNR	081007AXDVJ04	Anxiety	Haul Road	8/10/2007	DV	132	21.02	Juvenile		0.29		0.27		0.1		3.6		99.4	26.4
ADNR	081007AXDVJ05	Anxiety	Haul Road	8/10/2007	DV	125	15.85	Juvenile		0.18		0.14		0.07		4		114	24.1
ADNR	081007AXDVJ06	Anxiety	Haul Road	8/10/2007	DV	128	18.64	Juvenile		0.22		0.16		0.05		3.6		141	24.1
ADNR	081007AXDVJ07	Anxiety	Haul Road	8/10/2007	DV	126	16.43	Juvenile		0.09		0.15		0.07		1.3		101	26.5
ADNR	081007AXDVJ08	Anxiety	Haul Road	8/10/2007	DV	128	17.58	Juvenile		0.21		0.38		0.05		3.5		106	23.5
ADNR	081007AXDVJ09	Anxiety	Haul Road	8/10/2007	DV	100	10.27	Juvenile		0.21		0.52		0.05		3.4		107	26.7
ADNR	081007AXDVJ10	Anxiety	Haul Road	8/10/2007	DV	104	10.22	Juvenile		0.38		1.07		0.05		3.2		114	26.3
ADNR	081007AXDVJ11	Anxiety	Haul Road	8/10/2007	DV	96	8.23	Juvenile		0.26		0.77		0.08		3.8		89.8	28.5
ADNR	081007AXDVJ12	Anxiety	Haul Road	8/10/2007	DV	103	10.15	Juvenile		0.19		0.32		0.08		3.4		119	25.4
ADNR	081007AXDVJ13	Anxiety	Haul Road	8/10/2007	DV	129	18.73	Juvenile		0.13		0.84		0.09		3.2		113	25.3
ADNR	081007AXDVJ14	Anxiety	Haul Road	8/10/2007	DV	102	9.33	Juvenile		0.19		0.14		0.08		3.7		78.8	27.9
ADNR	081007AXDVJ15	Anxiety	Haul Road	8/10/2007	DV	129	19.29	Juvenile		0.17		0.2		0.08		3.4		97.2	24.7

Appendix 7 (concluded)

								Method		200.80		200.8		7471A		7740.0		200.8	
								analyte		Cd		Pb		Hg		Se		Zn	
Collector	Sample			Date	Fish	Length	Weight			total		total		total		total		total	%
	Number	Stream	Site	Collected	Spp	(mm)	(g)	MRL		0.05		0.02		0.02		1.0		0.5	Solids
ADFG	080508AXDVJ01	Anxiety	Haul Road	8/5/2008	DV	94	6.6	Juvenile		0.18		0.43		0.07		3.8		112	23.4
ADFG	080508AXDVJ02	Anxiety	Haul Road	8/5/2008	DV	101	8.8	Juvenile		0.17		0.09		0.06		4.8		136	22.6
ADFG	080508AXDVJ03	Anxiety	Haul Road	8/5/2008	DV	118	14.5	Juvenile		0.33		0.26		0.09		5.5		121	22.5
ADFG	080508AXDVJ04	Anxiety	Haul Road	8/5/2008	DV	95	6.8	Juvenile		0.18		0.31		0.06		4.1		124	22.9
ADFG	080508AXDVJ05	Anxiety	Haul Road	8/5/2008	DV	122	14.0	Juvenile		0.12		0.07		0.12		1.9		139	24.3
ADFG	080508AXDVJ06	Anxiety	Haul Road	8/5/2008	DV	98	8.2	Juvenile		0.14		0.18		0.07		3.6		122	21.3
ADFG	080508AXDVJ07	Anxiety	Haul Road	8/5/2008	DV	94	7.1	Juvenile		0.15		0.52		0.09		3.2		150	22.9
ADFG	080508AXDVJ08	Anxiety	Haul Road	8/5/2008	DV	100	8.8	Juvenile		0.11		0.13		0.07		3.6		161	22.6
ADFG	080508AXDVJ09	Anxiety	Haul Road	8/5/2008	DV	103	9.4	Juvenile		0.19		0.21		0.1		3.8		126	23
ADFG	080508AXDVJ10	Anxiety	Haul Road	8/5/2008	DV	93	6.9	Juvenile		0.20		0.22		0.08		4.2		114	23.6
ADFG	080508AXDVJ11	Anxiety	Haul Road	8/5/2008	DV	101	8	Juvenile		0.19		0.39		0.07		5.6		120	22.8
ADFG	080508AXDVJ12	Anxiety	Haul Road	8/5/2008	DV	93	6.4	Juvenile		0.26		0.12		0.07		4.8		109	23.2
ADFG	080508AXDVJ13	Anxiety	Haul Road	8/5/2008	DV	90	6.2	Juvenile		0.21		0.21		0.06		4		142	22.7
ADFG	080508AXDVJ14	Anxiety	Haul Road	8/5/2008	DV	94	6.7	Juvenile		0.28		0.37		0.07		3.9		176	22.3
ADFG	080508AXDVJ15	Anxiety	Haul Road	8/5/2008	DV	104	7.8	Juvenile		0.3		0.59		0.26		5.3		199	21.4
ADF&G	073109AXDVJ01	Anxiety	Haul Road	7/31/2009	DV	80	5.5	Juvenile		0.32		0.62		0.09		5.9		109	25.7
ADF&G	073109AXDVJ02	Anxiety	Haul Road	7/31/2009	DV	113	12	Juvenile		0.16		1.02		0.10		5.3		155	23.2
ADF&G	073109AXDVJ03	Anxiety	Haul Road	7/31/2009	DV	108	12	Juvenile		0.21		0.35		0.09		6.6		117	24.7
ADF&G	073109AXDVJ04	Anxiety	Haul Road	7/31/2009	DV	122	14.5	Juvenile		0.33		0.68		0.15		5.5		139	23.5
ADF&G	073109AXDVJ05	Anxiety	Haul Road	7/31/2009	DV	120	14.5	Juvenile		0.19		0.47		0.07		5.7		129	22.8
ADF&G	073109AXDVJ06	Anxiety	Haul Road	7/31/2009	DV	114	13.5	Juvenile		0.15		1.42		0.14		4.5		125	24.4
ADF&G	073109AXDVJ07	Anxiety	Haul Road	7/31/2009	DV	121	14.5	Juvenile		0.12		0.31		0.11		4.1		118	23.6
ADF&G	073109AXDVJ08	Anxiety	Haul Road	7/31/2009	DV	112	11	Juvenile		0.11		0.37		0.08		5.2		98.4	24.5
ADF&G	073109AXDVJ09	Anxiety	Haul Road	7/31/2009	DV	112	11	Juvenile		0.24		0.98		0.09		4.3		153	22.1
ADF&G	073109AXDVJ10	Anxiety	Haul Road	7/31/2009	DV	113	11.5	Juvenile		0.10		0.55		0.11		4.6		139	24.3
ADF&G	073109AXDVJ11	Anxiety	Haul Road	7/31/2009	DV	114	13	Juvenile		0.18		0.47		0.07		5.5		117	25.1
ADF&G	073109AXDVJ12	Anxiety	Haul Road	7/31/2009	DV	116	12.5	Juvenile		0.19		0.71		0.09		7.1		126	23.8
ADF&G	073109AXDVJ13	Anxiety	Haul Road	7/31/2009	DV	119	14.5	Juvenile		0.19		0.63		0.15		4.8		131	22.1
ADF&G	073109AXDVJ14	Anxiety	Haul Road	7/31/2009	DV	105	10.5	Juvenile		0.13		0.36		0.11		4.0		133	23.1
ADF&G	073109AXDVJ15	Anxiety	Haul Road	7/31/2009	DV	122	16	Juvenile		0.11		0.62		0.08		4.8		111	24.6

Appendix 8. Juvenile Dolly Varden Whole Body Metals, Statistical Analyses

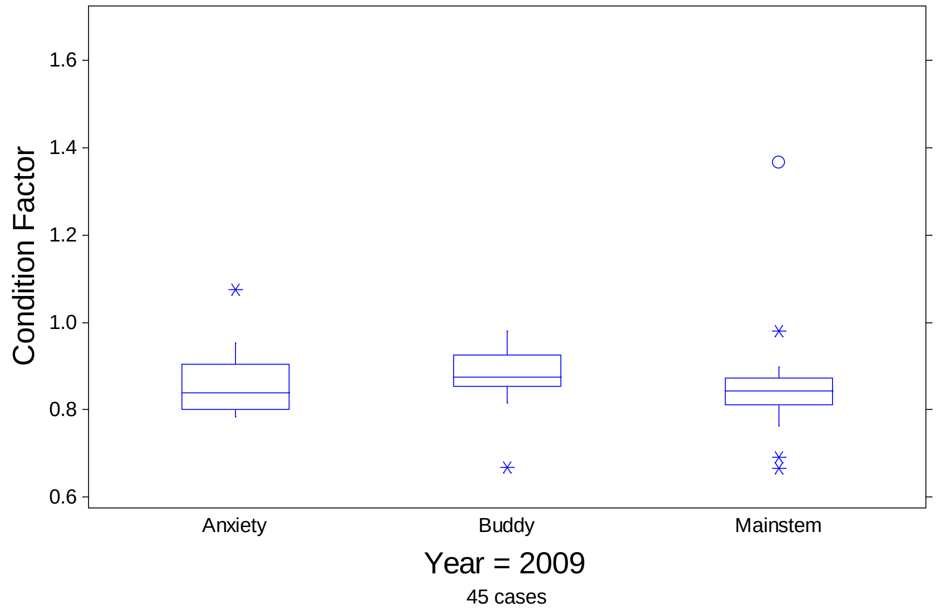


Figure 1. Box whisker plot of condition factor for juvenile Dolly Varden collected for metals analysis from Anxiety Ridge, Buddy and Mainstem Red Dog creeks, 2009.

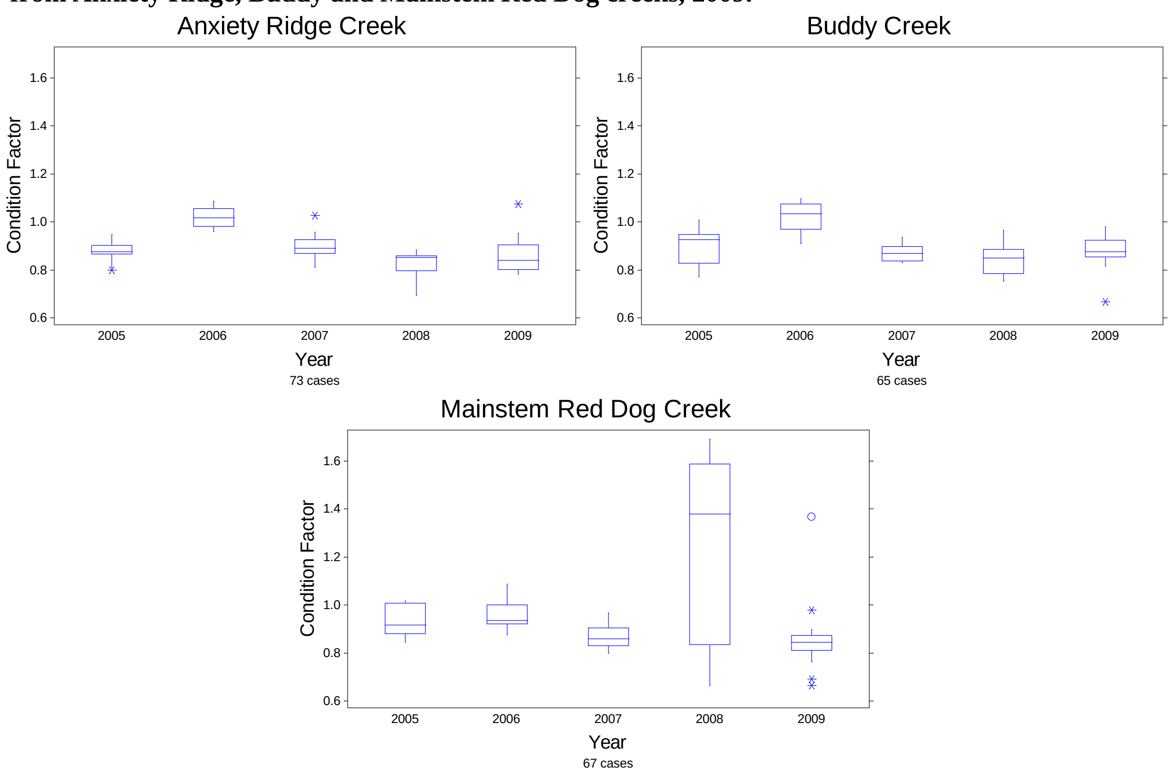


Figure 2. Box whisker plots of condition factor for juvenile Dolly Varden collected for metals analysis from Anxiety Ridge (upper left), Buddy (upper right) and Mainstem Red Dog (bottom) creeks, 2005 – 2009.

Appendix 8 (continued)

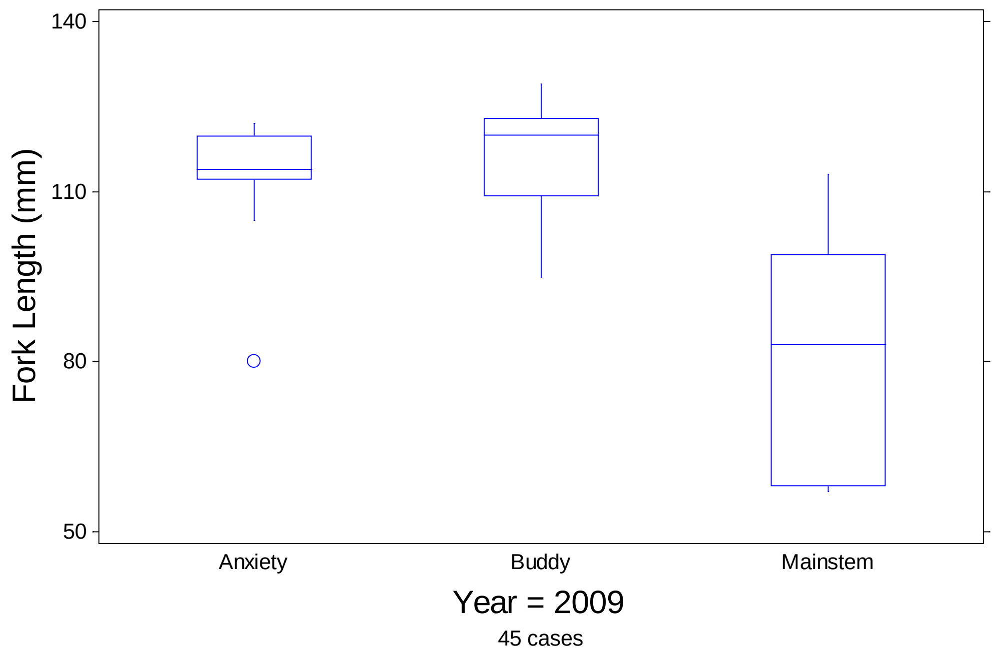
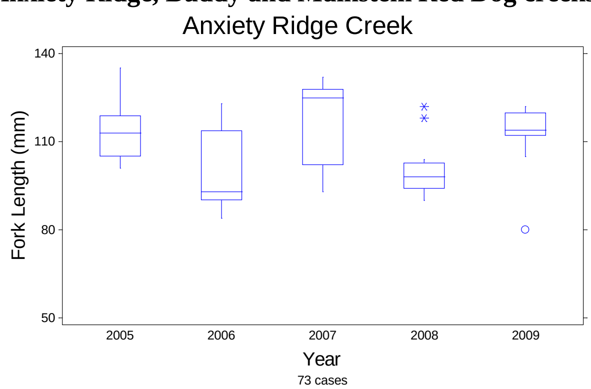
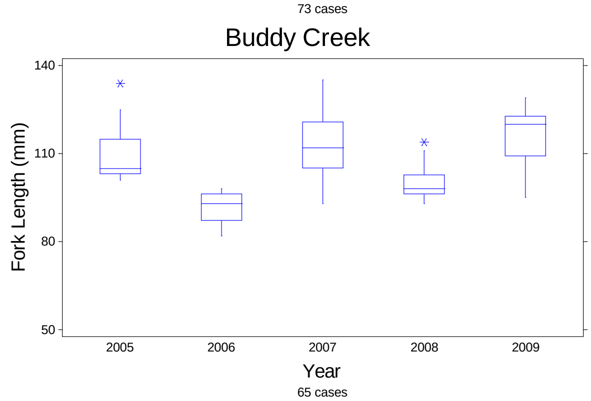


Figure 3. Box whisker plot of fork length for juvenile Dolly Varden collected for metals analysis from Anxiety Ridge, Buddy and Mainstem Red Dog creeks, 2009.





Appendix 8 (continued)

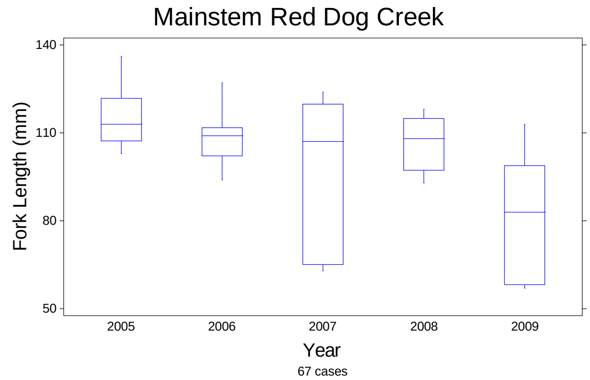


Figure 4. Box whisker plots of fork length for juvenile Dolly Varden collected for metals analysis from Anxiety Ridge (upper left), Buddy (upper right) and Mainstem Red Dog (bottom) creeks, 2005 – 2009.

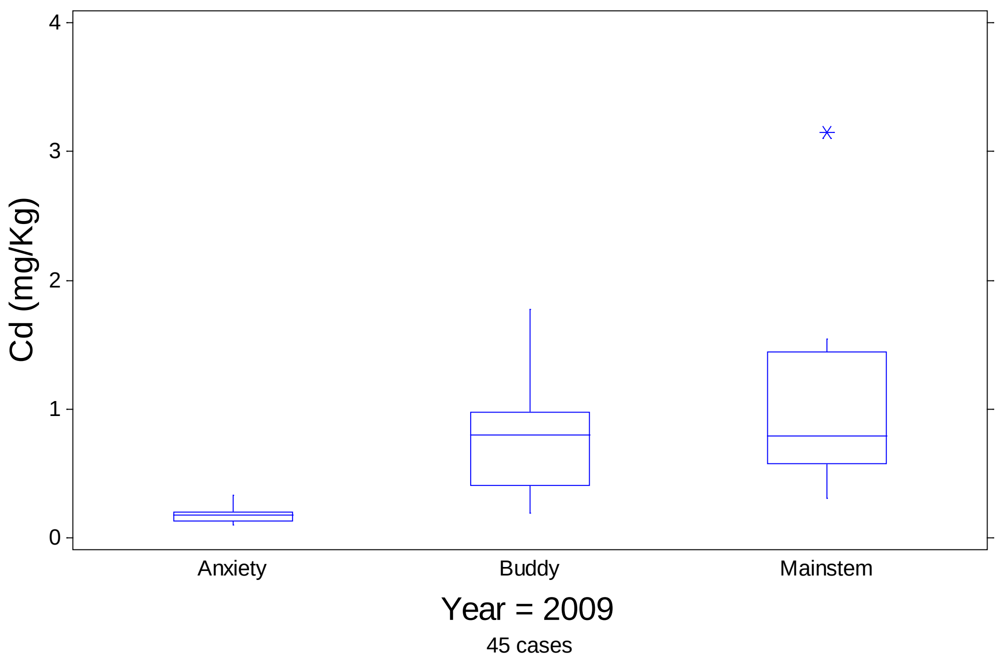


Figure 5. Box whisker plot of cadmium whole body concentration for juvenile Dolly Varden collected for metals analysis from Anxiety Ridge, Buddy and Mainstem Red Dog creeks, 2009. All concentrations are mg/Kg dry weight.

Appendix 8 (continued)

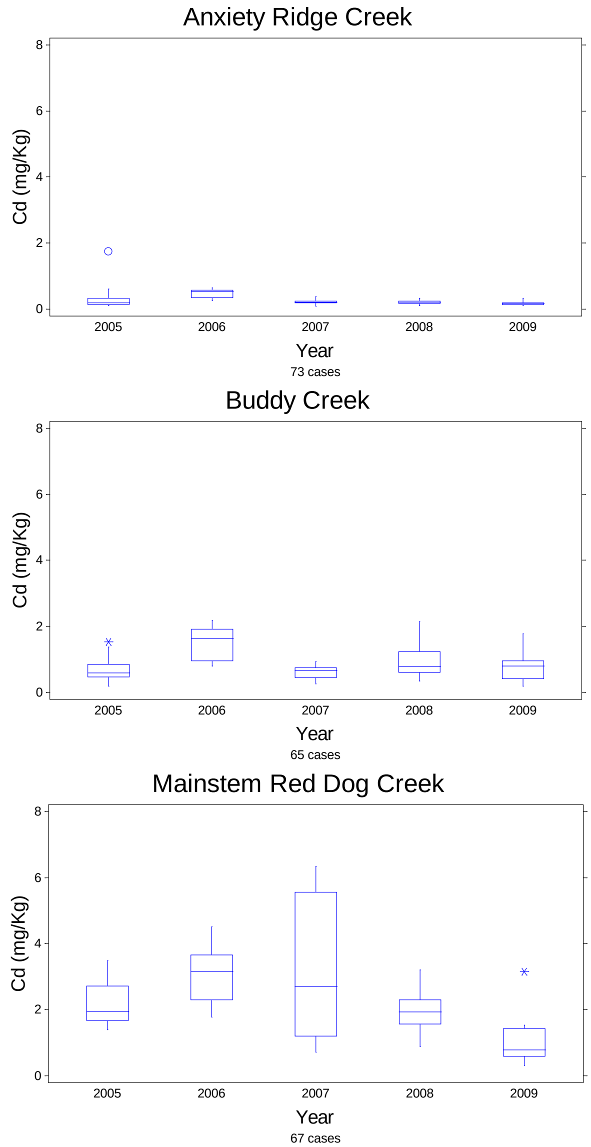


Figure 6. Box whisker plots of cadmium whole body concentrations for juvenile Dolly Varden collected for metals analysis from Anxiety Ridge (upper left), Buddy (upper right) and Mainstem Red Dog (bottom) creeks, 2005 – 2009. All concentrations are mg/Kg dry weight.

Appendix 8 (continued)

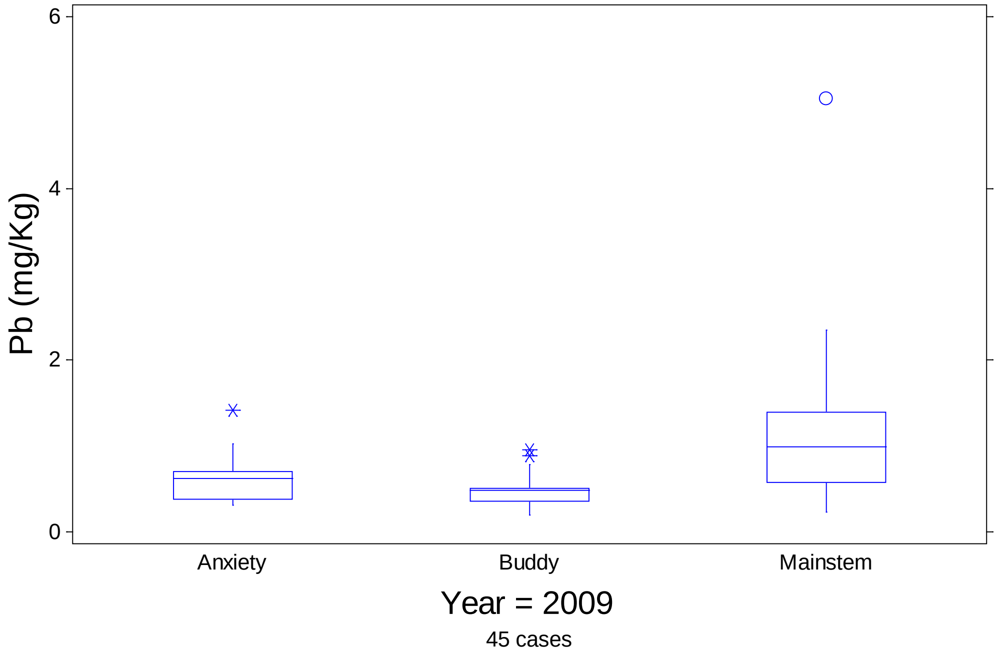


Figure 7. Box whisker plot of lead whole body concentration for juvenile Dolly Varden collected for metals analysis from Anxiety Ridge, Buddy and Mainstem Red Dog creeks, 2009. All concentrations are mg/Kg dry weight.

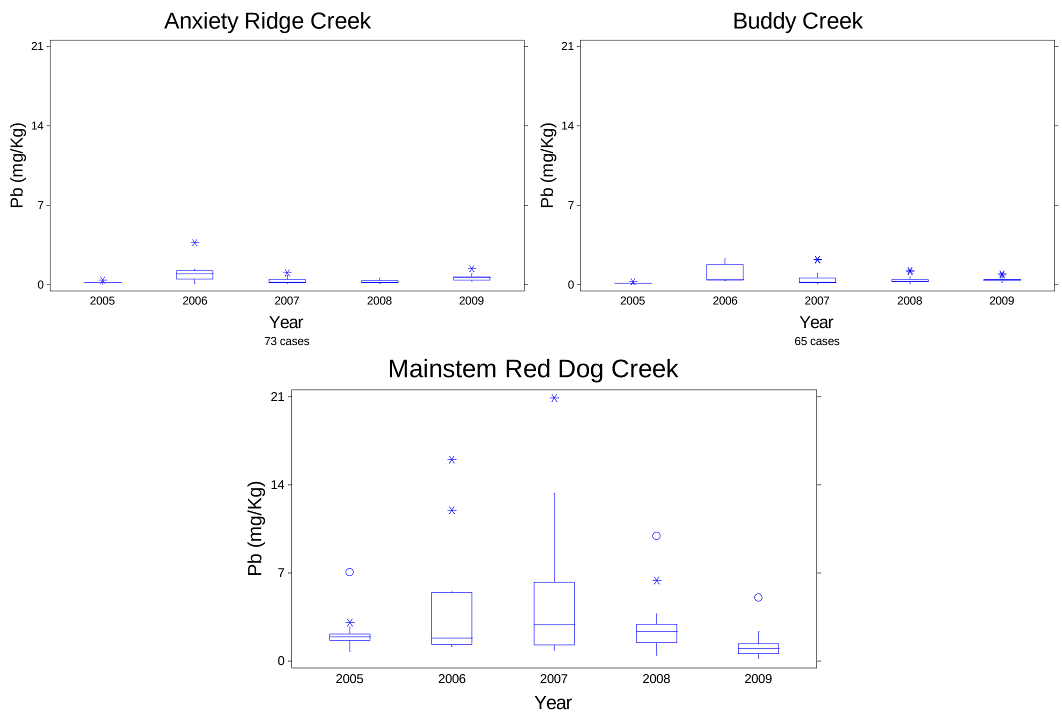


Figure 8. Box whisker plots of lead whole body concentrations for juvenile Dolly Varden collected for metals analysis from Anxiety Ridge (upper left), Buddy (upper right) and Mainstem Red Dog (bottom) creeks, 2005 – 2009. All concentrations are mg/Kg dry weight.

Appendix 8 (continued)

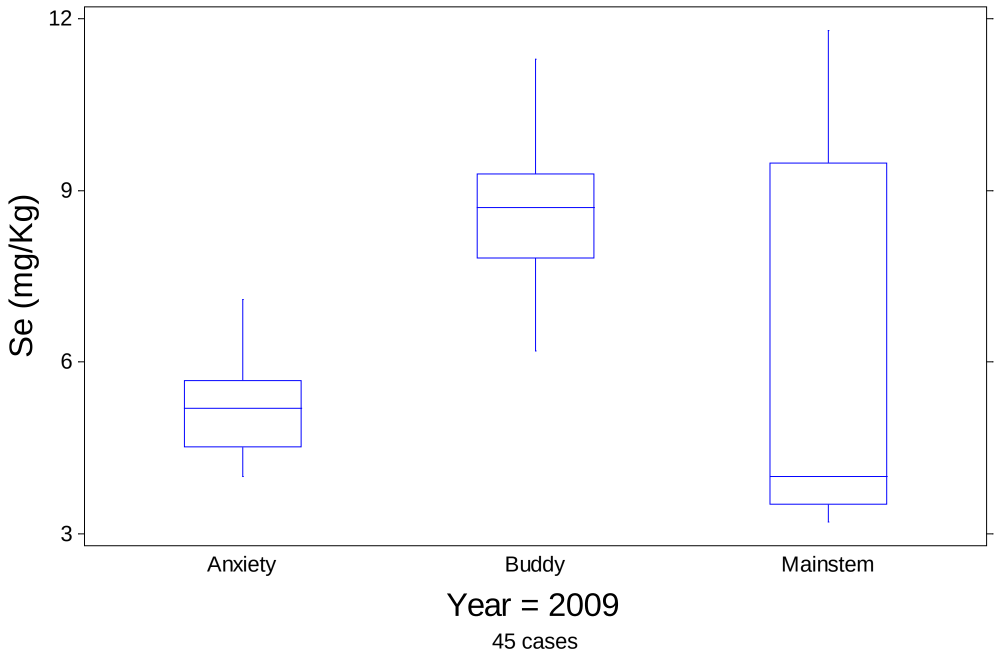


Figure 9. Box whisker plot of selenium whole body concentration for juvenile Dolly Varden collected for metals analysis from Anxiety Ridge, Buddy and Mainstem Red Dog creeks, 2009. All concentrations are mg/Kg dry weight.

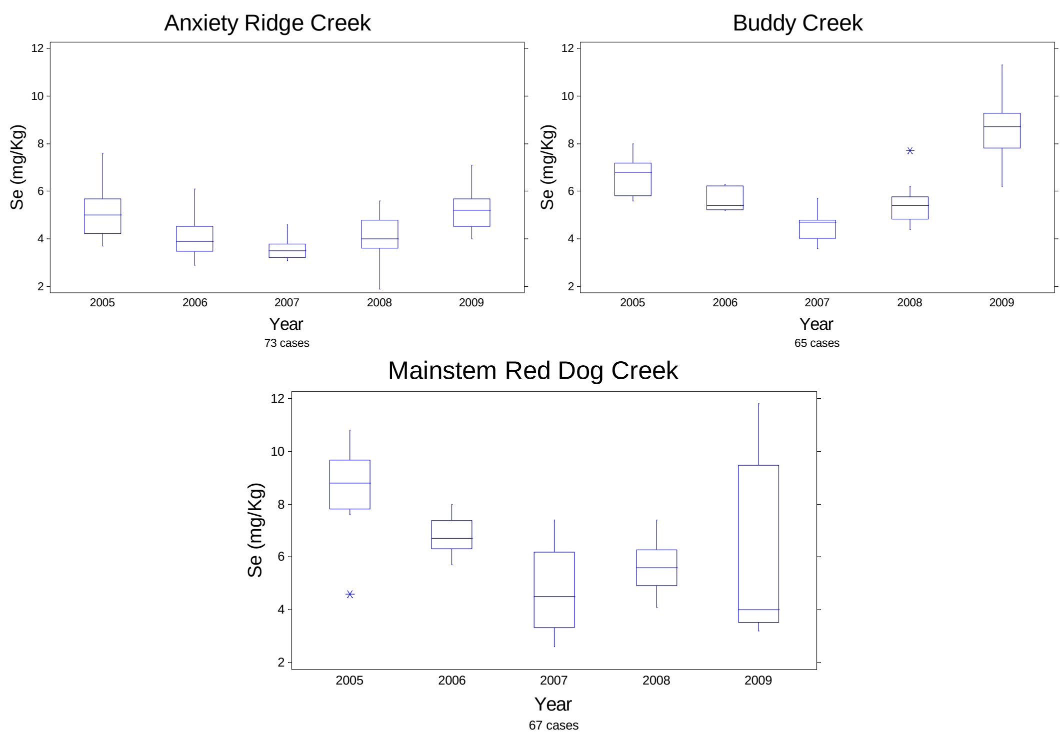


Figure 10. Box whisker plots of selenium whole body concentrations for juvenile Dolly Varden collected for metals analysis from Anxiety Ridge (upper left), Buddy (upper right) and Mainstem Red Dog (bottom) creeks, 2005 – 2009. All concentrations are mg/Kg dry weight.

Appendix 8 (continued)

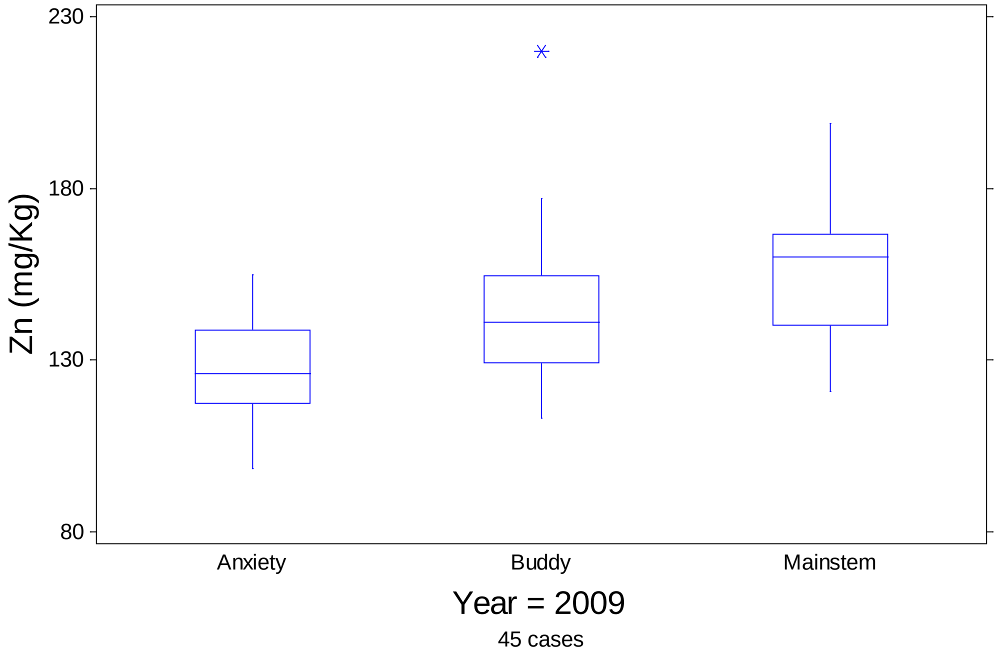


Figure 11. . Box whisker plot of zinc whole body concentration for juvenile Dolly Varden collected for metals analysis from Anxiety Ridge, Buddy and Mainstem Red Dog creeks, 2009. All concentrations are mg/Kg dry weight.

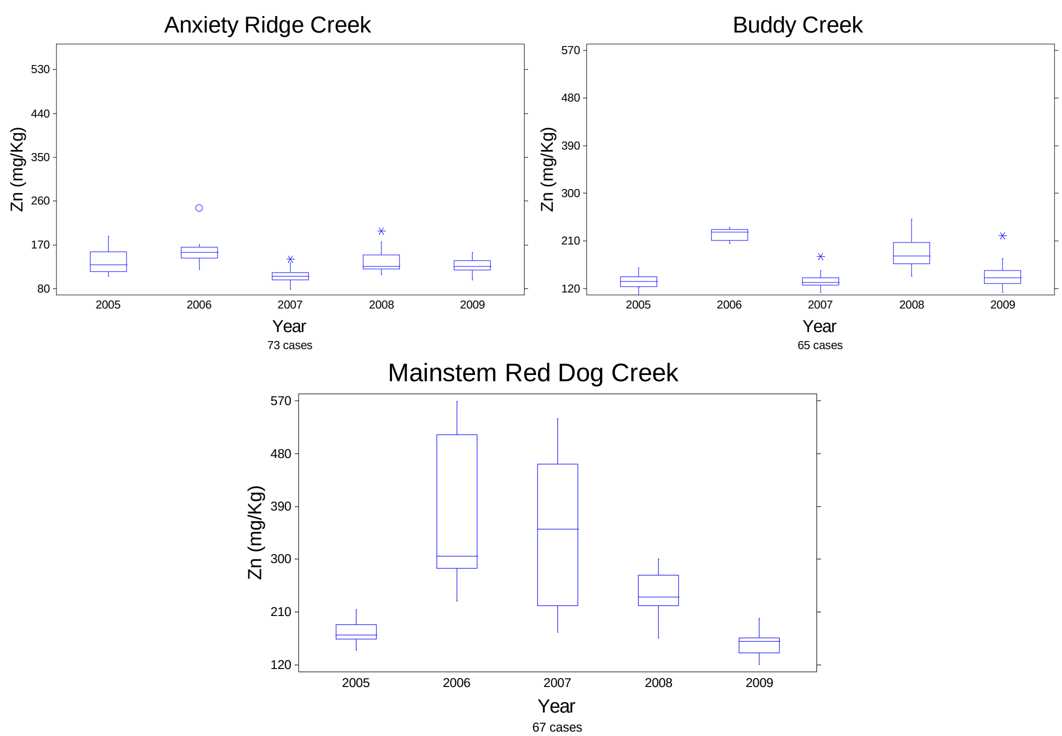


Figure 12. Box whisker plots of zinc whole body concentrations for juvenile Dolly Varden collected for metals analysis from Anxiety Ridge (upper left), Buddy (upper right) and Mainstem Red Dog (bottom) creeks, 2005 – 2009. All concentrations are mg/Kg dry weight.

Appendix 8 (continued)

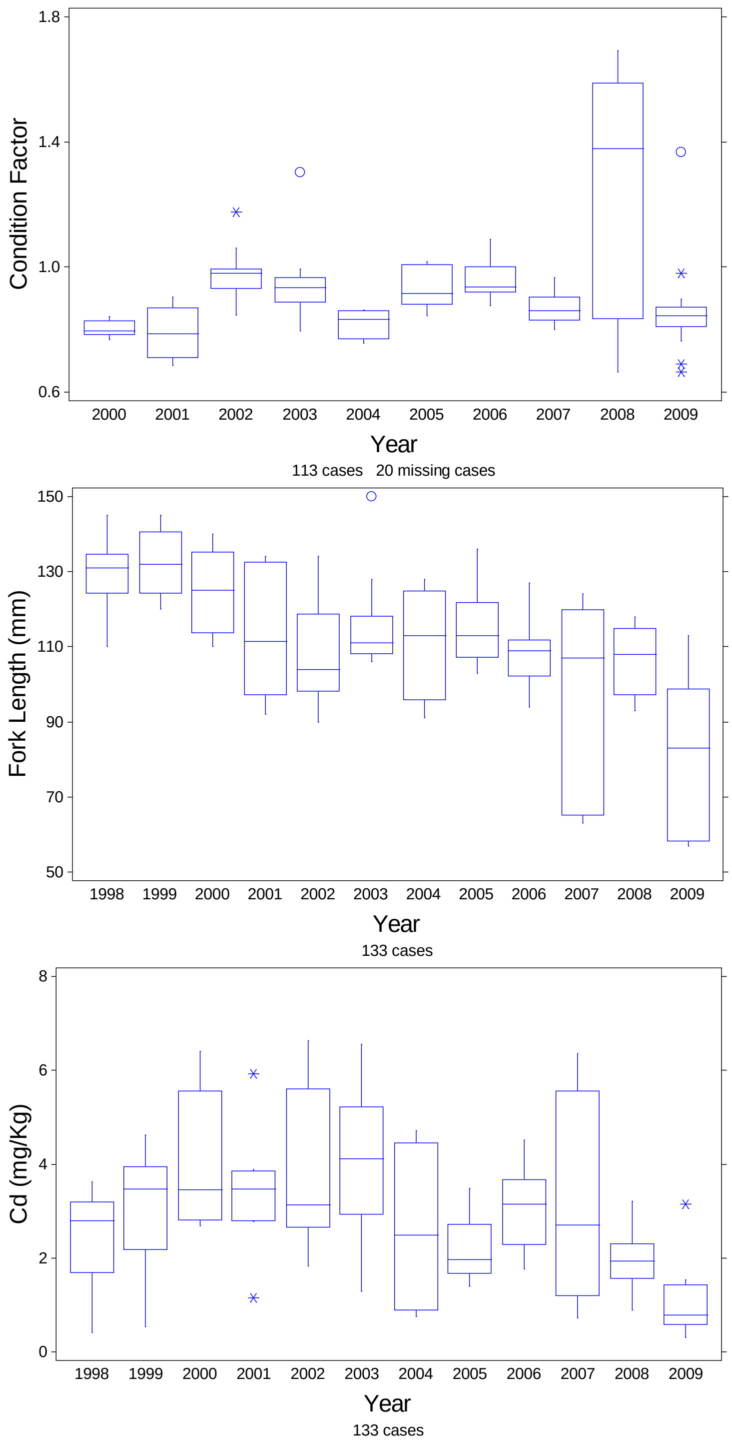


Figure 13. Box whisker plots for the period of record for condition factor (top), fork length (middle) and cadmium whole body concentrations for juvenile Dolly Varden retained for metals analysis from Mainstem Red Dog Creek.

Appendix 8 (continued)

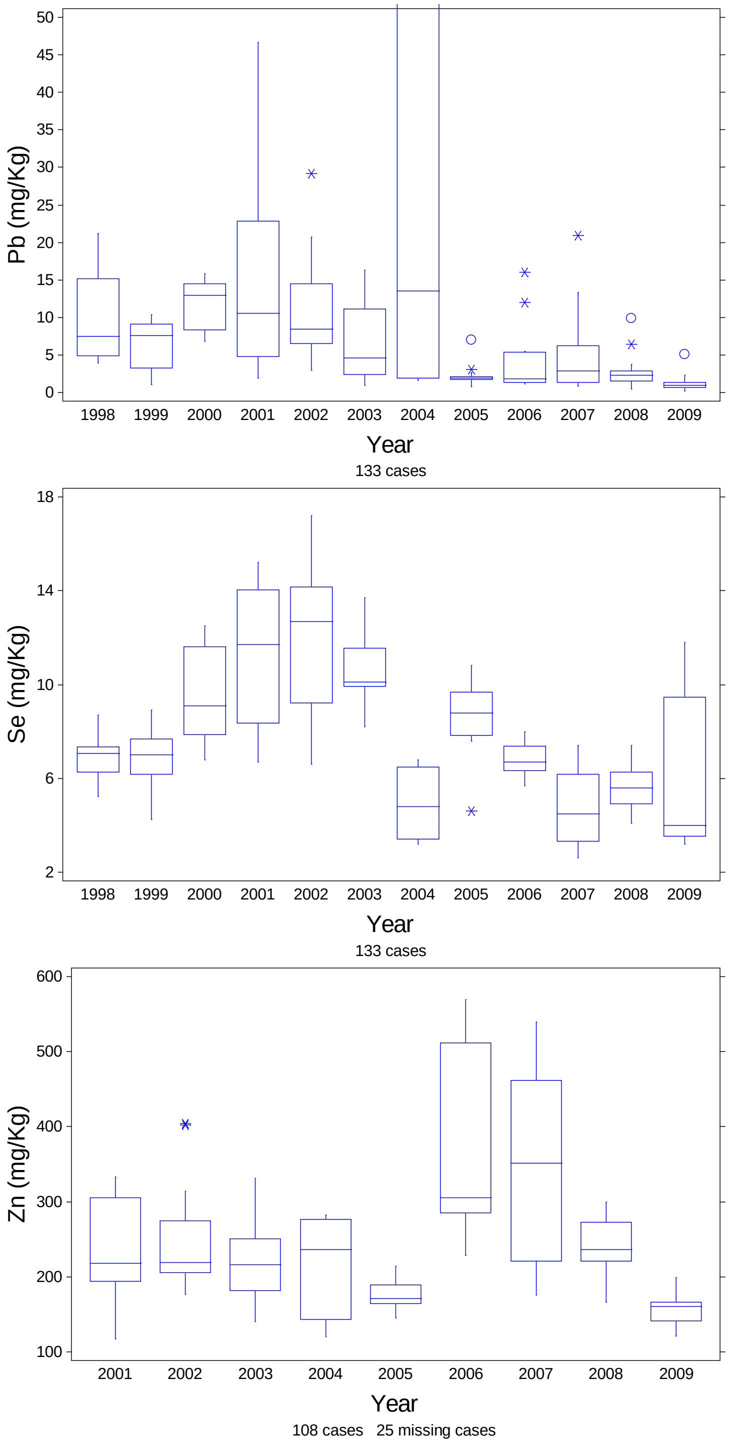


Figure 14. Box whisker plots for the period of record for lead (top), selenium (middle) and zinc whole body concentrations for juvenile Dolly Varden retained for metals analysis from Mainstem Red Dog Creek.

Appendix 8 (continued)

Table 1. Linear regression analysis of fish condition, cadmium, lead, selenium, and zinc vs. the independent variable fish fork length for all juvenile Dolly Varden retained for metals analyses from 2005 through 2009.

	Mainstem, Anxiety, Buddy 2005-2009	Mainstem 2005-2009	Anxiety 2005-2009	Buddy 2005-2009
CF	p = 0.2752	p = 0.3993	p = 0.009 Adj R^2 = 0.0789	p = 0.0199 Adj R^2 = 0.0685
Cd	p = 0.8629	p = 0.001 Adj R^2 = 0.143	p = 0.3934	p = 0.0004 Adj R^2 = 0.1663
Pb	p = 0.77	p = 0.1840	p = 0.1380	p = 0.6325
Se	p = 0.0002 Adj R^2 = 0.0629	p = 0.0000 Adj R^2 = 0.3332	p = 0.8694	p = 0.0657
Zn	p = 0.0238 Adj R^2 = 0.02	p = 0.3563	p = 0.0246 Adj R^2 = 0.056	p = 0.0000 Adj R^2 = 0.3585

CF= Condition Factor, Cd = Cadmium, Pb = Lead, Se = Selenium, Zn = Zinc

Table 2. Linear regression analysis of fish condition, cadmium, lead, selenium, and zinc vs. the independent variable fish fork length for all juvenile Dolly Varden between 90 and 140 mm length, retained for metals analyses from 2005 through 2009.

	Mainstem, Anxiety, Buddy 2005-2009	Mainstem 2005-2009	Anxiety 2005-2009	Buddy 2005-2009
CF	p = 0.0094 Adj R^2 = 0.0307	p = 0.0181 Adj R^2 = 0.0872	p = 0.1322	p = 0.0771
Cd	p = 0.9735	p = 0.3088	p = 0.6505	p = 0.0039 Adj R^2 = 0.1125
Pb	p = 0.9593	p = 0.9773	p = 0.1817	p = 0.9554
Se	p = 0.0572	p = 0.0772	p = 0.6674	p = 0.0831
Zn	p = 0.0267 Adj R^2 = 0.0210	p = 0.2721	p = 0.0223 Adj R^2 = 0.0608	p = 0.0000 Adj R^2 = 0.3204

CF= Condition Factor, Cd = Cadmium, Pb = Lead, Se = Selenium, Zn = Zinc

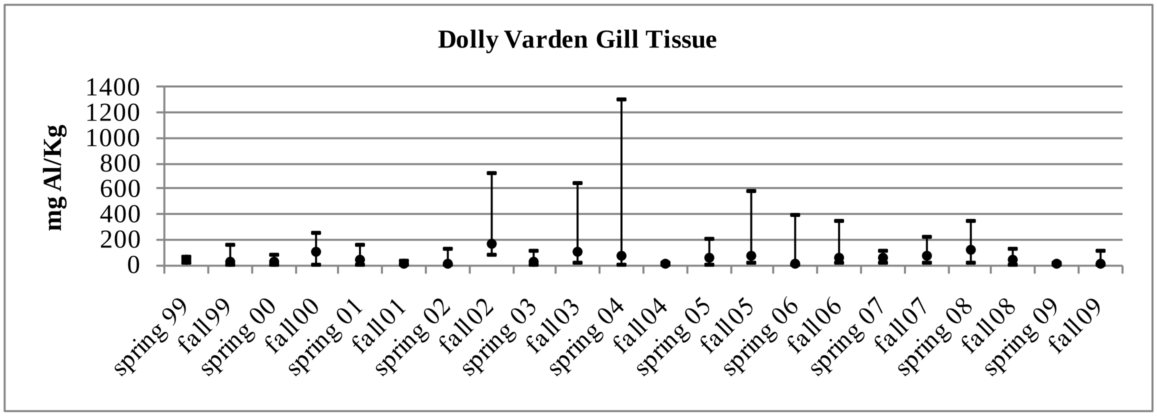
Appendix 8 (concluded)

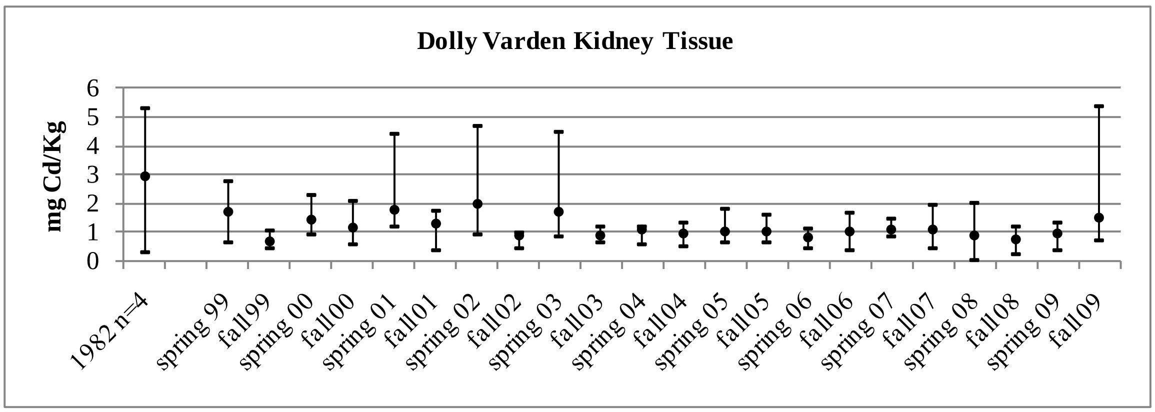
Table 3. Linear regression analysis of fish fork length, fish condition, cadmium, lead, selenium, and zinc vs. the independent variable Sample Year for all juvenile Dolly Varden retained for metals analyses from Mainstem Red Dog Creek over the period of record for each dependent variable, 1998-2009. Periods of significant trends are treated separately by dependent variable.

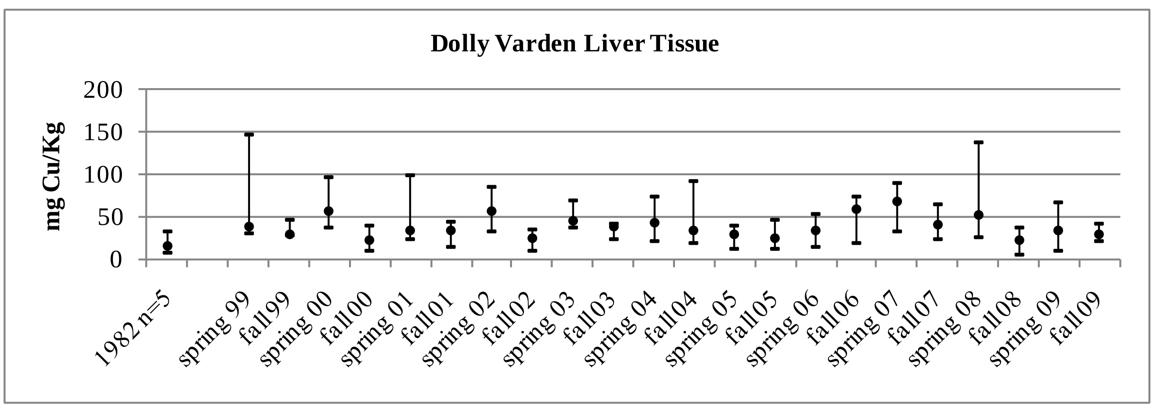
Dependent Variable	Time Period	p Value	Adjusted R^2	Direction of Trend with Year
FL	’98 – ‘09	0.0000	0.3690	Decrease
CF	’98 – ‘09	0.0144	0.0442	Increase
Zn	98-09	0.7651		None
	01-05	0.0015	0.1561	Slight Decrease
	06-09	0.0000	0.4643	Decrease
Se	98-09	0.0000	0.1535	Decrease
	98-03	0.0000	0.3343	Increase
	05-09	0.0001	0.2066	Decrease
Pb	98-09	0.0116	0.0403	Decrease
	06-09	.01	0.1003	Decrease
Cd	98-09	0.0001	0.1107	Decrease
	98-03	0.0054	0.1075	Increase
	04-07	0.0453	0.0757	Increase
	06-09	.0000	0.3196	Decrease

FL = Fork length, CF= Condition Factor, Cd = Cadmium, Pb = Lead, Se = Selenium, Zn = Zinc

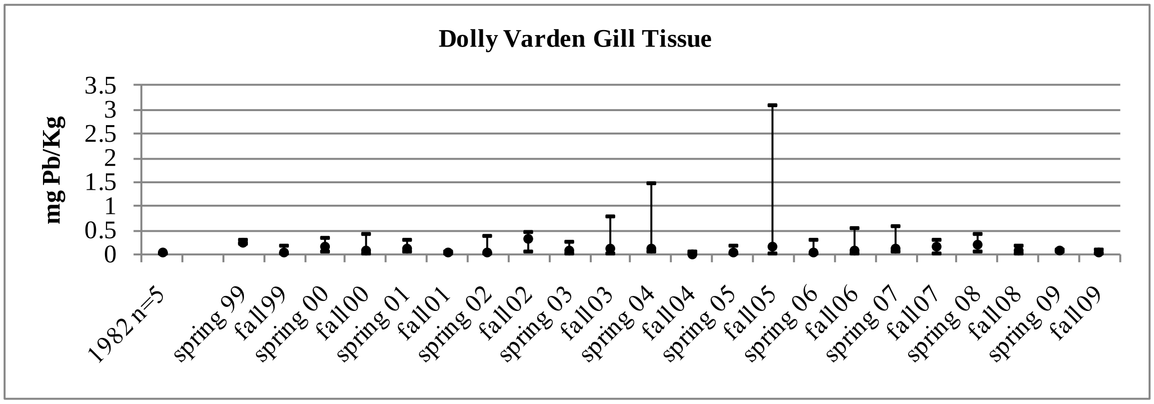
Appendix 9. Dolly Varden Adults, Metals

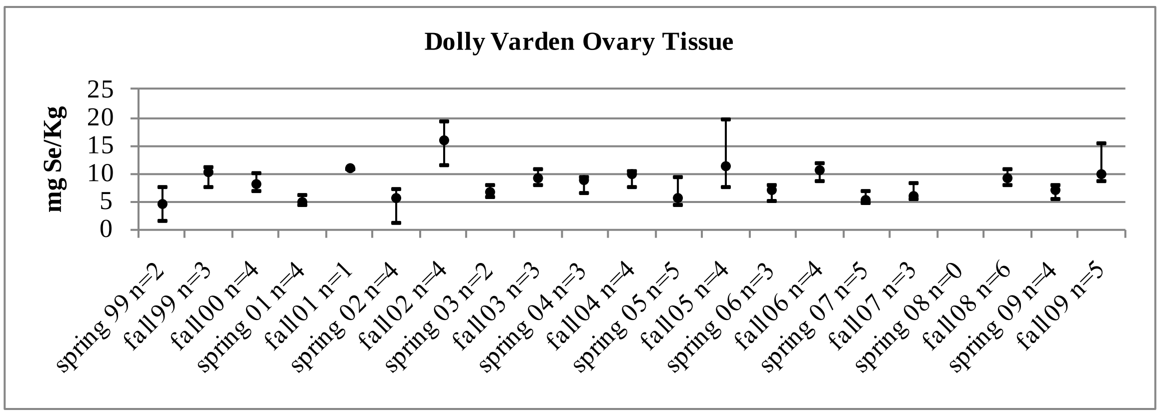


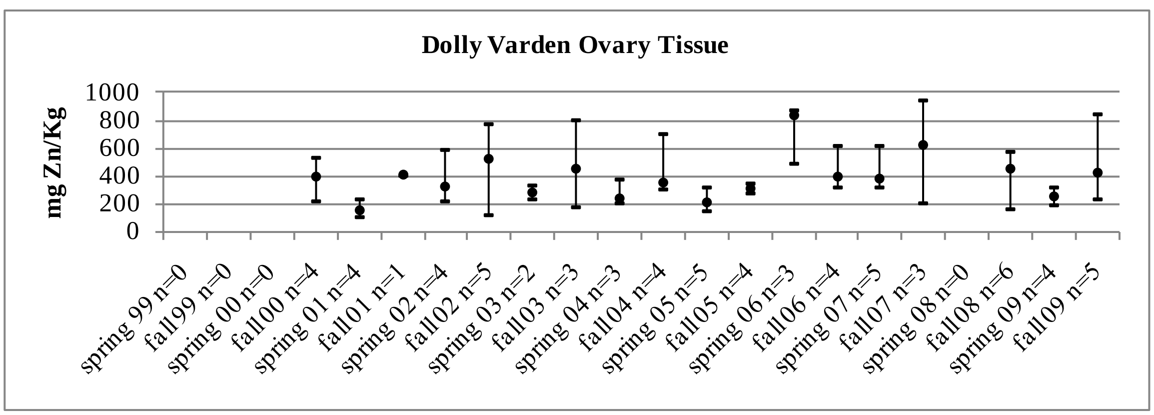




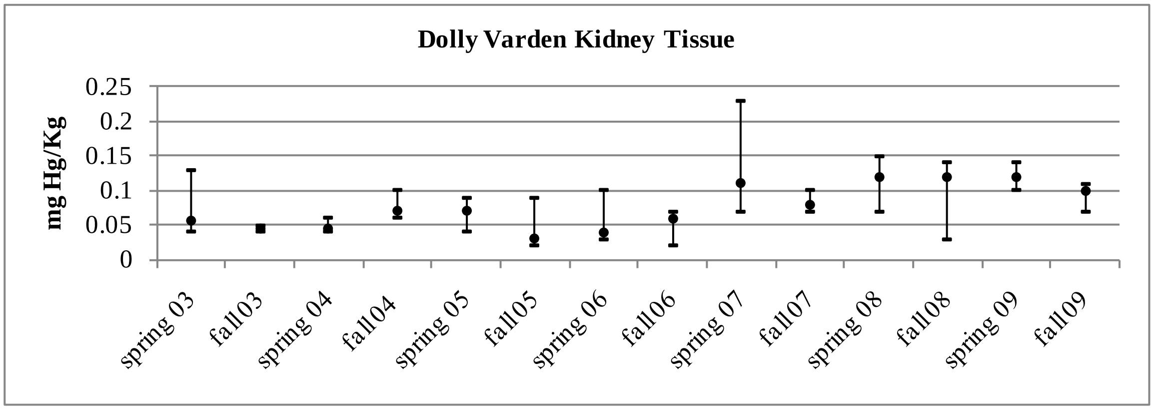
Appendix 9 (continued)







Appendix 9 (continued)



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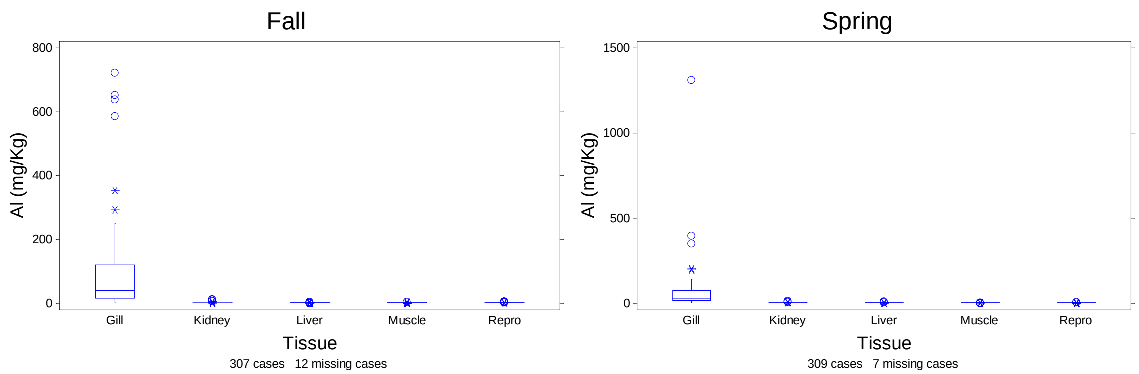

Figure 1. Aluminum concentration (mg/Kg) by tissue in adult Dolly Varden retained from the Wulik River in the fall and spring, 1999 through 2009. Aluminum concentrations are highest overall in gill tissues during both spring and fall. Note difference in scales.

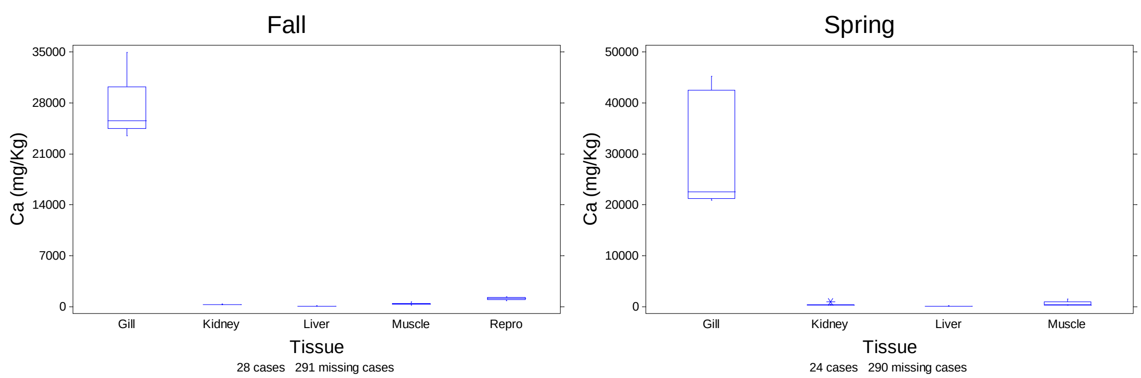

Figure 2. Calcium concentration (mg/Kg) by tissue in adult Dolly Varden retained from the Wulik River in the fall and spring, 1999 through 2009. Calcium concentrations are highest overall in gill tissues during both spring and fall. Note difference in scales.

Appendix 9 (continued)

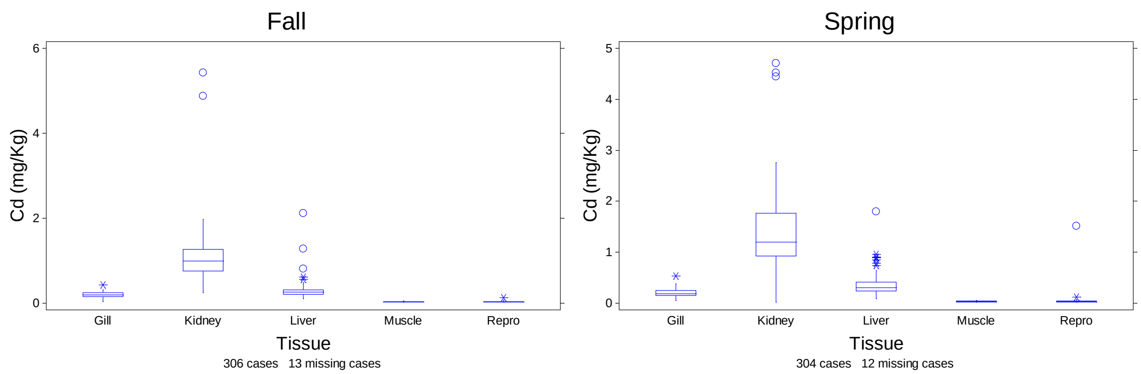

Figure 3. Cadmium concentration (mg/Kg) by tissue in adult Dolly Varden retained from the Wulik River in the fall and spring, 1999 through 2009. Cadmium concentrations are highest overall in kidney tissues during both spring and fall. Note difference in scales.

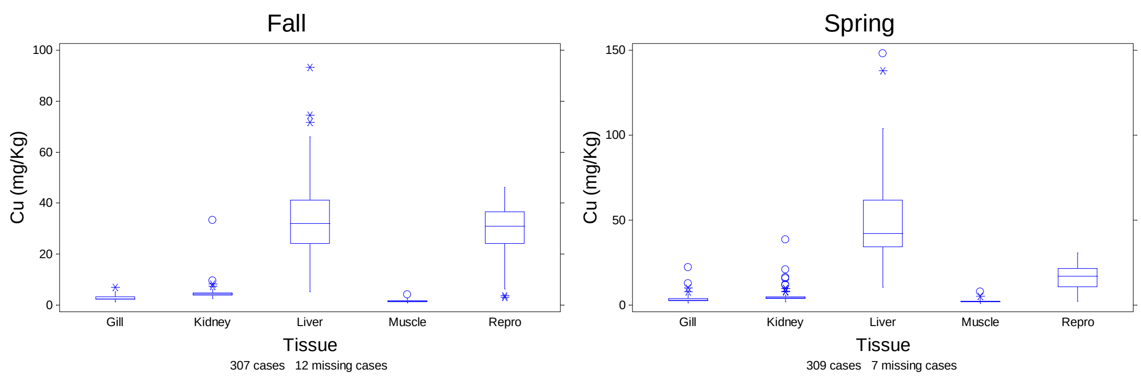

Figure 4. Copper concentration (mg/Kg) by tissue in adult Dolly Varden retained from the Wulik River in the fall and spring, 1999 through 2009. Copper concentrations are highest overall in liver tissues during both spring and fall. However, reproductive tissues are similar to liver in fall caught fish. Note difference in scales.

Appendix 9 (continued)

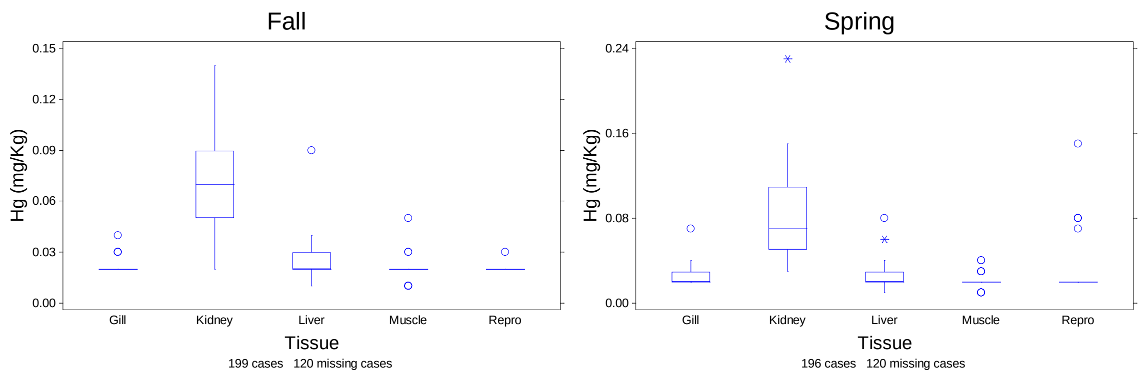

Figure 5. Mercury concentration (mg/Kg) by tissue in adult Dolly Varden retained from the Wulik River in the fall and spring, 1999 through 2009. Mercury concentrations are highest overall in kidney tissues during both spring and fall. Note difference in scales.

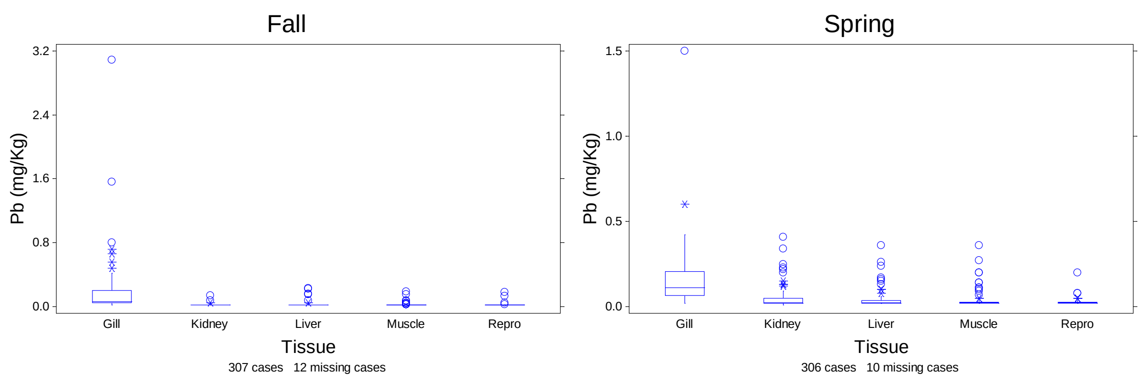

Figure 6. Lead concentration (mg/Kg) by tissue in adult Dolly Varden retained from the Wulik River in the fall and spring, 1999 through 2009. Lead concentrations are highest overall in gill tissues during both spring and fall. Note difference in scales.

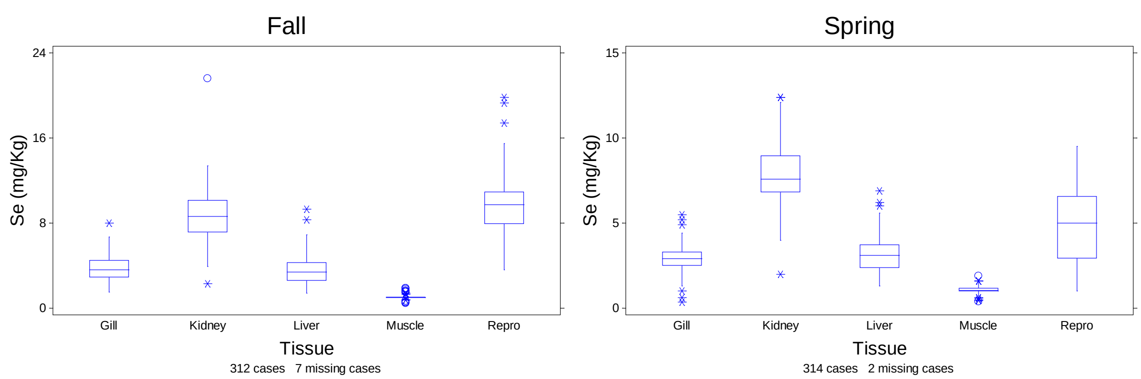

Figure 7. Selenium concentration (mg/Kg) by tissue in adult Dolly Varden retained from the Wulik River in the fall and spring, 1999 through 2009. Selenium concentrations are highest overall in kidney and reproductive tissues during both spring and fall. Note difference in scales.

Appendix 9 (continued)

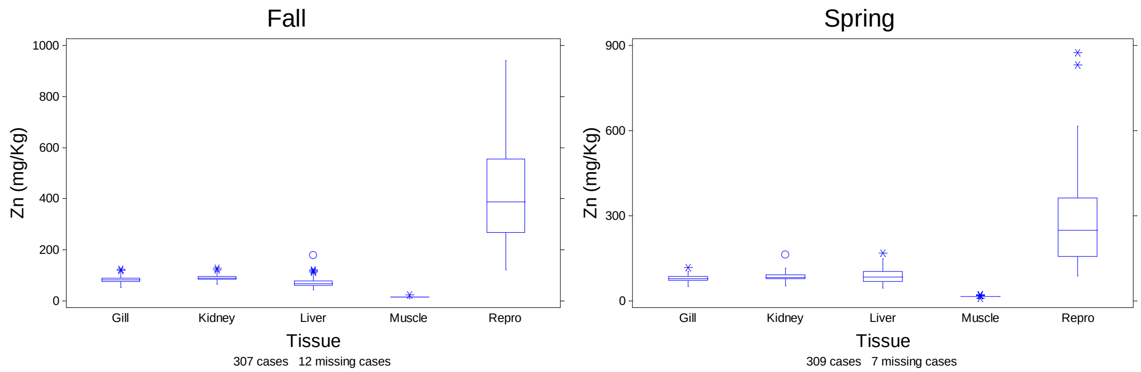

Figure 8. Zinc concentration (mg/Kg) by tissue in adult Dolly Varden retained from the Wulik River in the fall and spring, 1999 through 2009. Zinc concentrations are highest overall in reproductive tissues during both spring and fall. Note difference in scales.

Table 1. Kruskal-Wallis non-parametric analysis of variance comparing individual tissue metals concentrations between spring and fall caught fish, 1999 – 2009. Each entry consists of the Kruskal Wallis (KW) statistic and accompanying p value in the following format (KW Statistic = top entry p value = bottom entry). For tissue/metal combinations with significantly different results between spring and fall caught fish the season with highest values is listed.

Tissue	Aluminum	Cadmium	Calcium	Copper	Mercury	Lead	Selenium	Zinc
Muscle KW p	1.5277 0.2165	1.00 0.000	0.9231 0.3367	**14.988** **0.001**	0.390 0.5318	3.2689 0.0706	0.0084 0.9271	1.4938 0.2216
				SPRING				
Gill KW p	1.99714 0.1603	0.0549 0.8148	0.6433 0.4225	**8.5061** **0.0035**	**5.4411** **0.0197**	2.8022 0.0941	**19.0477** **0.0000**	**5.3609** **0.0206**
				SPRING	**SPRING**		**FALL**	**FALL**
Kidney KW p	**4.1020** **0.0428**	**7.4828** **0.0062**	1.2564 0.2623	0.1587 0.6903	1.9814 0.1592	**4.0366** **0.0445**	3.6989 0.0544	**8.2216** **0.0041**
	SPRING	**SPRING**				**SPRING**		**FALL**
Liver KW p	3.5211 0.0606	**5.1887** **0.0227**	0.4103 0.5218	**17.223** **0.0000**	0.0398 0.8418	1.1106 0.2920	2.6058 0.1065	**11.4954** **0.0007**
		SPRING		**SPRING**				**SPRING**
Repro KW p	0.1115 0.7385	0.0466 0.8291	0.8571 0.3545	**30.5874** **0.0000**	3.6492 0.0561	**4.5629** **0.0327**	**46.5179** **0.0000**	**12.0485** **0.0005**
				FALL		**SPRING**	**FALL**	**FALL**

Appendix 9 (continued)

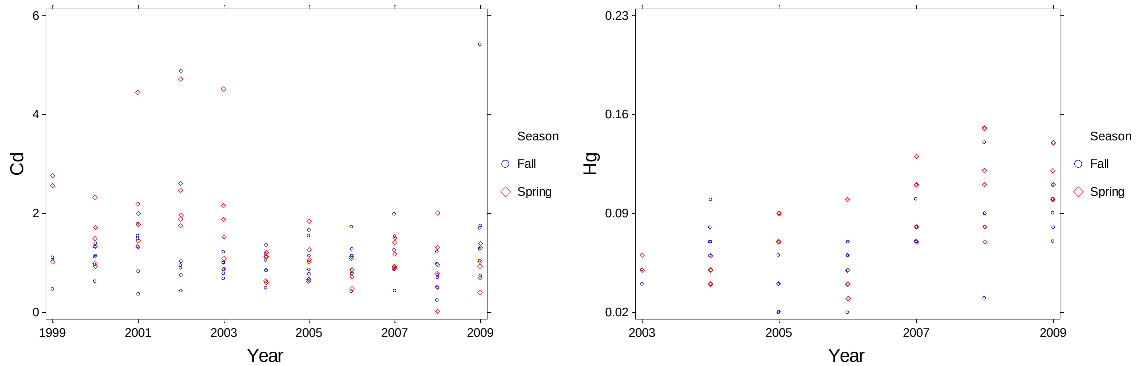

Figure 9. Kidney cadmium concentration (mg/Kg) (left) and mercury concentration (mg/Kg) plotted by year and by season. Cadmium concentrations may be decreasingly slightly with time for spring caught fish while kidney mecury concentrations may be increasing slightly with time for both spring and fall caught fish (see fitted line regressions below, Figure 10 and Figure 11).

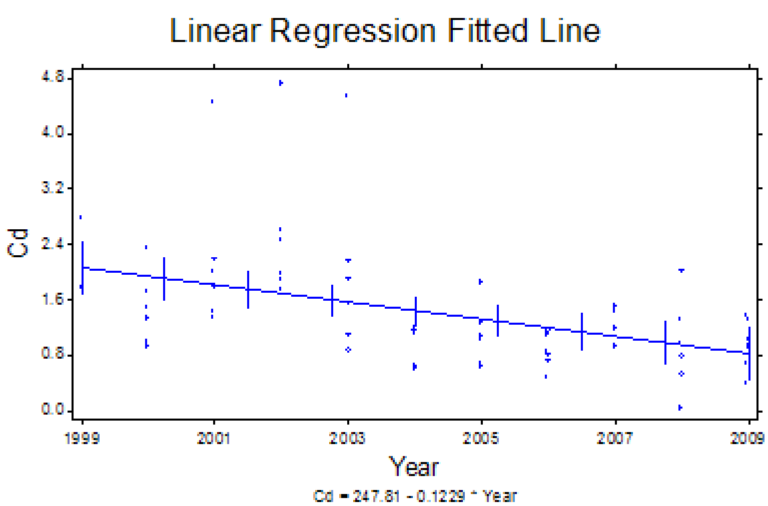

Figure 10. Linear regression of kidney cadmium concentration over time for spring caught adult Dolly Varden. Cadmium concentrations in adult Dolly Varden kidney tissue appears to be decreasing slightly with time (p_year = 0.002, Adjusted R^2 = 0.1777); however, year of sampling explains less than 18% of the variation observed in kidney cadmium concentrations. This suggests that while cadmium is decreasing, the slope of the line is distinguishable from zero, the magnitude of the difference from zero is slight.

Appendix 9 (continued)

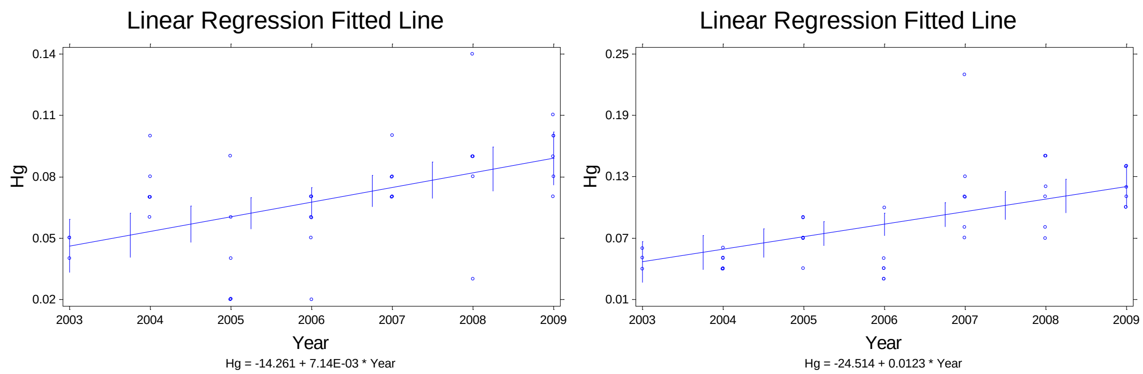

Figure 11. Linear regressions of kidney mercury concentrations over time. Mercury concentration in Dolly Varden kidney samples appears to be increasing with time for adult Dolly Varden captured in fall (left) (p_year = 0.001, adjusted R^2 = 0.2722) and spring (right) (p_year = 0.0001, adjusted R^2 = 0.3222). Year of sampling explains about 30% of the variability in mercury concentrations observed in the uncompressed dataset.

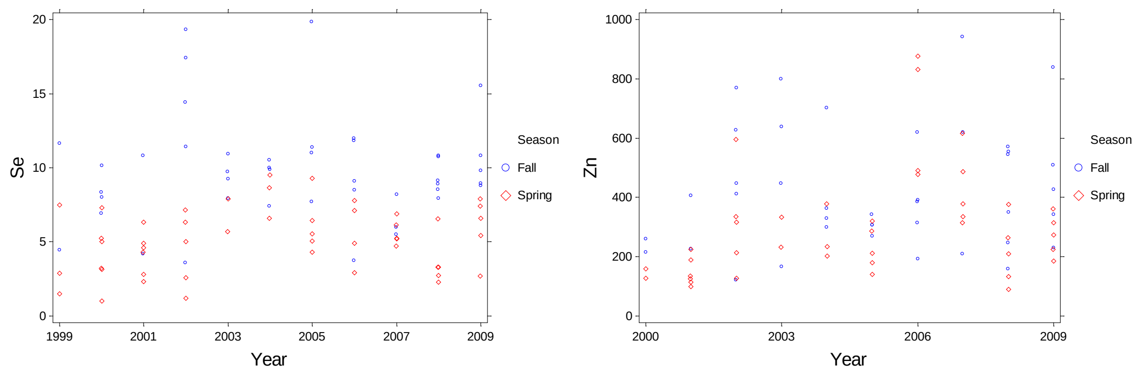

Figure 1. Reproductive tissue selenium concentration (mg/Kg) (left) and zinc concentration (mg/Kg) (right) plotted by year and by season. Selenium concentrations have increased slightly with time for spring caught fish (see Figure 13) while zinc concentrations have remained constant for spring and fall caught fish.

Appendix 9 (continued)

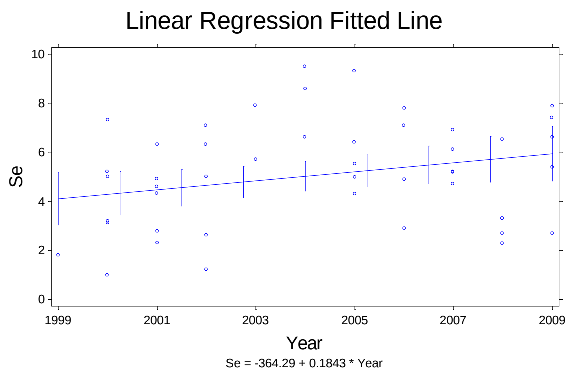

Figure 13. Linear regression of reproductive tissue selenium concentration over time from spring caught adult Dolly Varden. Reproductive tissue selenium concentrations appear to be increasing slightly over the period of analysis (p_year = 0.0462, adjusted R^2 = 0.0597). Visual analysis of the linear relationship suggests a period of increase followed by a period of decrease since 2006, not a linear increase. Generally, the regression analysis suggests poor overall fit.

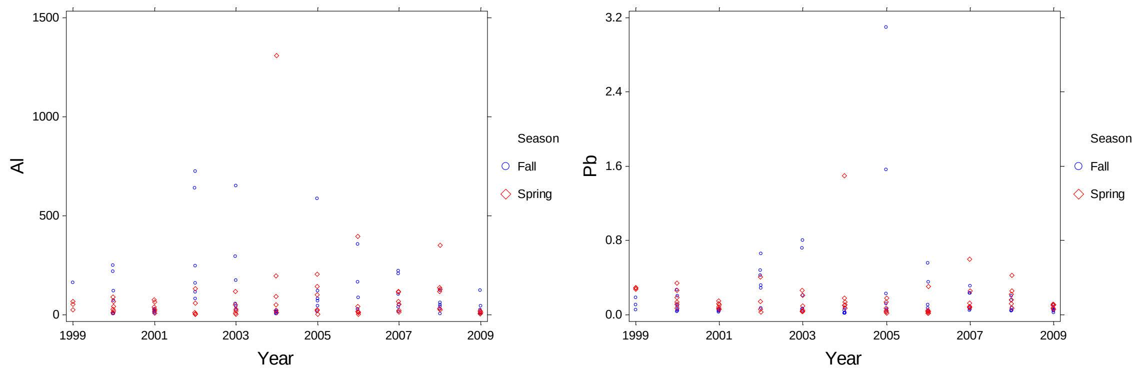

Figure 14. Gill tissue aluminum (mg/Kg) (left) and lead (right) (mg/Kg) concentrations plotted by year and by season for adult Dolly Varden. There is no discernable trend over time for either metal in gill tissue.

Appendix 9 (continued)

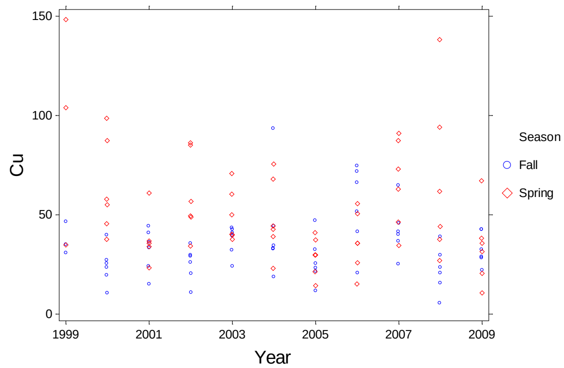

Figure 15. Kidney copper concentration (mg/Kg) plotted by year and by season for adult Dolly Varden. There is no discernable trend with time and kidney copper concentrations.

Statistical Analysis – Kruskal-Wallis Pairwise Comparisons between Tissue Types for all Metals.

Table 2. Synopsis of all Kruskal-Wallis pairwise comparisons of tissues by metal with respect to highest and lowest concentrations. Tissues grouped together are statistically indistinguishable from one another at alpha = 0.05.

Metal	Tissues with Highest Concentration	Tissues with Lowest Concentration
Aluminum	gill	muscle/liver/kidney
Calcium	gill/reproductive	liver/kidney
Cadmium	kidney	muscle/reproductive
Copper	liver	muscle
Mercury	kidney	muscle/liver/reproductive/gill
Lead	gill	muscle/liver/reproductive/gill
Selenium	kidney/reproductive	muscle
Zinc	reproductive	muscle

Appendix 9 (continued)

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Statistix 9.0                   2009 all adult DV 19..., 3/15/2010, 4:15:36 PM
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Kruskal-Wallis All-Pairwise Comparisons Test of Aluminum by Tissue

```
Tissue    Mean  Homogeneous Groups
Gill    542.21  A
Kidney  297.25   B
Repro   247.08   BC
Liver   227.44    C
Muscle  205.67    C

Alpha              0.05
Critical Z Value  2.807     Critical Value for Comparison  61.376 TO 68.855
There are 3 groups (A, B, etc.) in which the means
are not significantly different from one another.
```

```
Statistix 9.0                   2009 all adult DV 19..., 3/15/2010, 4:17:19 PM
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Kruskal-Wallis All-Pairwise Comparisons Test of Calcium by Tissue

```
Tissue    Mean  Homogeneous Groups
Gill    48.500  A
Repro   37.333  AB
Muscle  25.917   B
Kidney  24.083   BC
Liver   6.5833    C

Alpha              0.05
Critical Z Value  2.807     Critical Value for Comparison  18.028 TO 22.080
There are 3 groups (A, B, etc.) in which the means
are not significantly different from one another.
```

```
Statistix 9.0                   2009 all adult DV 19..., 3/15/2010, 4:17:56 PM
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Kruskal-Wallis All-Pairwise Comparisons Test of Cadmium by Tissue

```
Tissue    Mean  Homogeneous Groups
Kidney  534.24  A
Liver   384.89   B
Gill    313.94    C
Repro   125.88     D
Muscle  101.05     D

Alpha              0.05
Critical Z Value  2.807     Critical Value for Comparison  60.779 TO 69.661
There are 4 groups (A, B, etc.) in which the means
are not significantly different from one another.
```

Appendix 9 (continued)

Statistix 9.0 2009 all adult DV 19..., 3/15/2010, 4:18:29 PM

Kruskal-Wallis All-Pairwise Comparisons Test of Copper by Tissue

Tissue	Mean	Homogeneous Groups
Liver	531.71	A
Repro	445.24	B
Kidney	312.40	C
Gill	206.67	D
Muscle	94.523	E

Alpha 0.05
Critical Z Value 2.807 Critical Value for Comparison 61.376 TO 68.855
All 5 means are significantly different from one another.

Statistix 9.0 2009 all adult DV 19..., 3/15/2010, 4:19:17 PM

Kruskal-Wallis All-Pairwise Comparisons Test of Mercury by Tissue

Tissue	Mean	Homogeneous Groups
Kidney	337.90	A
Liver	182.12	B
Gill	168.24	B
Repro	156.25	B
Muscle	133.06	B

Alpha 0.05
Critical Z Value 2.807 Critical Value for Comparison 49.451 TO 54.438
There are 2 groups (A and B) in which the means
are not significantly different from one another.

Statistix 9.0 2009 all adult DV 19..., 3/15/2010, 4:19:55 PM

Kruskal-Wallis All-Pairwise Comparisons Test of Lead by Tissue

Tissue	Mean	Homogeneous Groups
Gill	488.89	A
Kidney	275.11	B
Liver	263.65	B
Muscle	253.86	B
Repro	227.42	B

Alpha 0.05
Critical Z Value 2.807 Critical Value for Comparison 61.193 TO 68.755
There are 2 groups (A and B) in which the means
are not significantly different from one another.

Appendix 9 (concluded)

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Statistix 9.0                    2009 all adult DV 19..., 3/15/2010, 4:20:40 PM
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Kruskal-Wallis All-Pairwise Comparisons Test of Selenium by Tissue

Tissue	Mean	Homogeneous Groups
Kidney	513.50	A
Repro	452.78	A
Liver	284.29	B
Gill	281.13	B
Muscle	71.701	C

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Alpha              0.05
Critical Z Value  2.807     Critical Value for Comparison  62.372 TO 67.803
There are 3 groups (A, B, etc.) in which the means
are not significantly different from one another.
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Statistix 9.0                    2009 all adult DV 19..., 3/15/2010, 4:21:10 PM
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Kruskal-Wallis All-Pairwise Comparisons Test of Zinc by Tissue

Tissue	Mean	Homogeneous Groups
Repro	568.07	A
Kidney	371.13	B
Gill	323.83	BC
Liver	299.31	C
Muscle	66.500	D

```
Alpha              0.05
Critical Z Value  2.807     Critical Value for Comparison  61.376 TO 68.855
There are 4 groups (A, B, etc.) in which the means
are not significantly different from one another.
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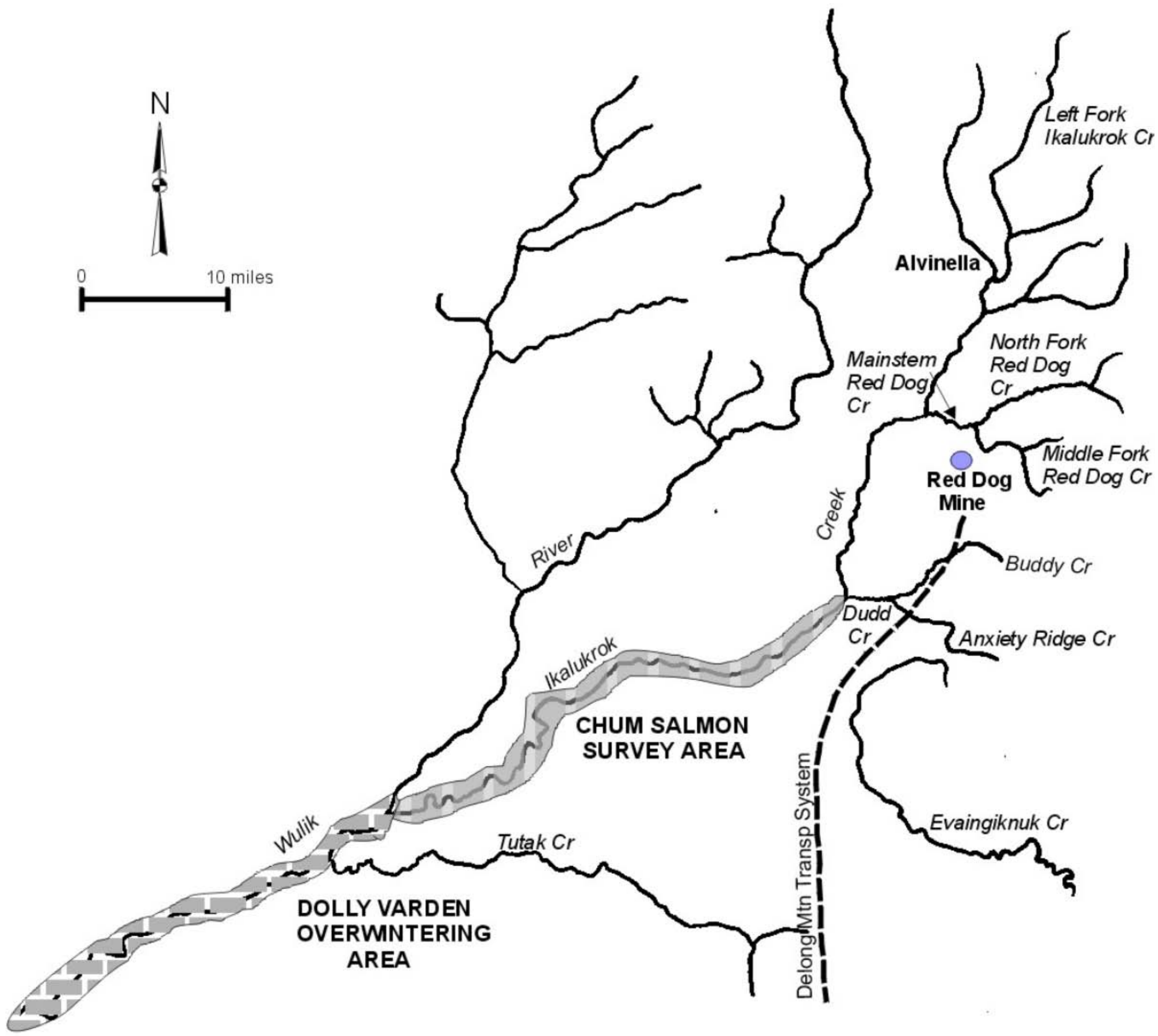
Appendix 10. Dolly Varden Aerial Surveys

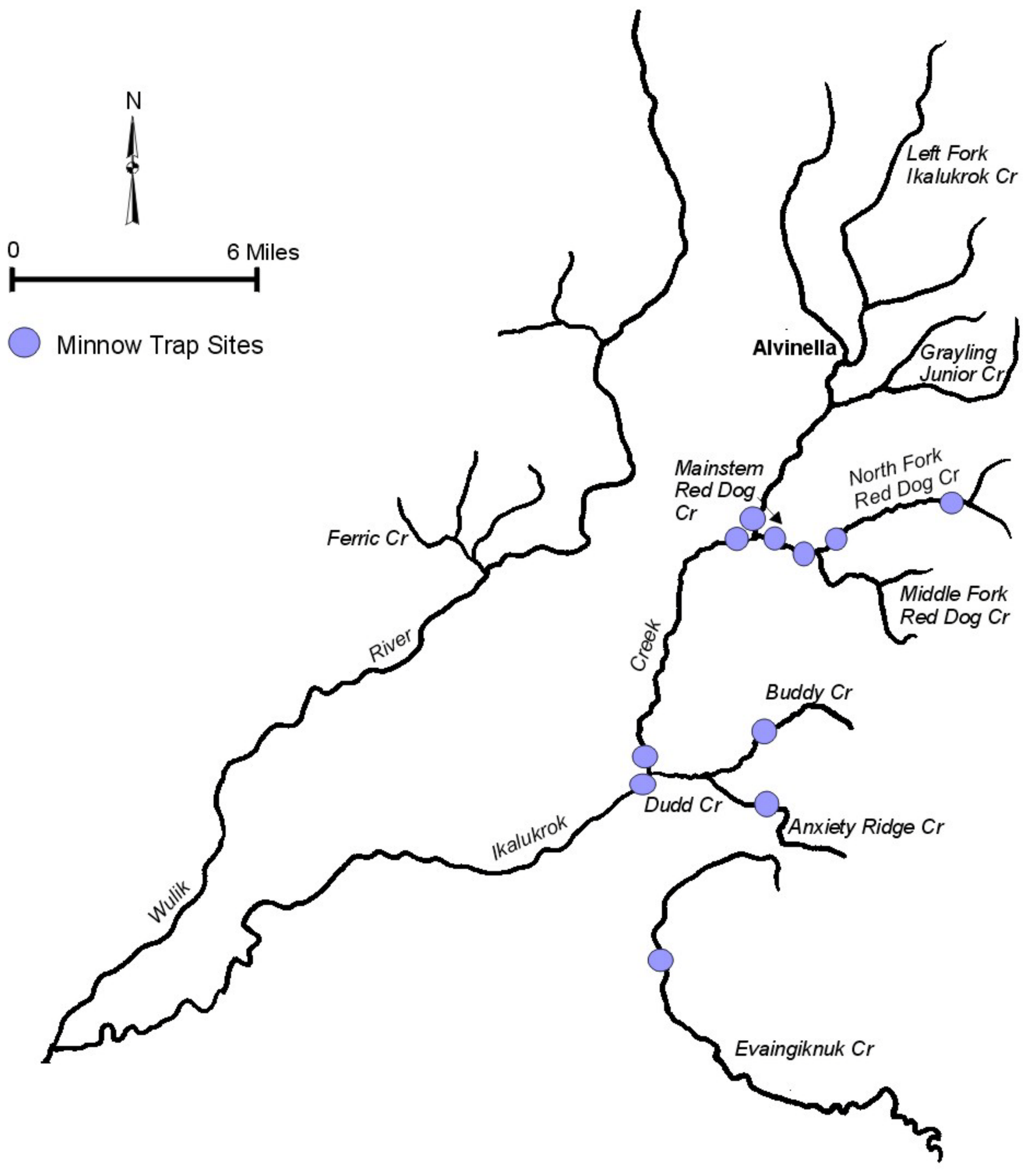
Estimated number of overwintering Dolly Varden in the Wulik River before freezeup. Surveys conducted by ADF&G (DeCicco 1989, 1991-1999, 2001-2002, and 2004-2009.

Year	Wulik River upstream of Ikalukrok Creek	Wulik River downstream of Ikalukrok Creek	Total Fish	Percent of Fish downstream of Ikalukrok Creek
Before Mining				
1979	3,305	51,725	55,030	94
1980	12,486	101,067	113,553	89
1981	4,125	97,136	101,261	96
1982	2,300	63,197	65,497	97
1984	370	30,483	30,853	99
1987	893	60,397	61,290	99
1988	1,500	78,644	80,144	98
During Mining				
1989	2,110	54,274	56,384	96
1991	7,930	119,055	126,985	94
1992	750	134,385	135,135	99
1993	7,650	136,488	144,138	95
1994	415	66,337	66,752	99
1995	240	128,465	128,705	99
1996	1,010	59,995	61,005	98
1997	2,295	93,117	95,412	98
1998	6,350	97,693	104,043	94
1999	2,750	67,954	70,704	96
2001	2,020	90,594	92,614	98
2002	1,675	42,582	44,257	96
2004	16,486	84,320	100,806	84
2005	10,645	110,203	120,848	91
2006	4,758	103,594	108,352	96
2007	5,503	93,808	99,311	94
2008	271	71,222	71,493	99
2009	122	60,876	60,998	99
The population estimate (mark/recapture) for winter 1988/1989 for fish >400 mm				
was 76,892 (DeCicco 1990b)				
The population estimate (mark/recapture) for winter 1994/1995 for fish >400 mm				
was 361,599 (DeCicco 1996c)				
Fall 2000 aerial survey was not made due to weather.				
Fall 2003 aerial survey was not made due to weather.				

Appendix 11. Dolly Varden and Chum Salmon Survey Areas



Appendix 12. Juvenile Dolly Varden Sampling Sites



Appendix 13. Juvenile Dolly Varden Catches

Number of Dolly Varden Caught in Late-July/Early August with ten minnow traps per sample site													
Sample Site Description	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Evaingiknuk (Noatak Tributary)	54	27	38	2	7	20	64	71	29	4	67	21	16
Anxiety Ridge	68	94	271	27	6	33	98	116	121	8	115	75	147
Buddy	48	154	306	11	34	57	104	59	59	5	183	43	100
North Fork Red Dog Creek (Sta 12)	0	12	17	1	1	1	0	1	8	0	1	0	3
Mainstem (below North Fork)	14	70	86	13	9	12	2	2	6	8	2	13	7
Mainstem (Station 10)	10	21	66	1	3	12	12	0	10	3	6	5	6
Ikalukrok Creek (below Dudd)	13	51	55	31	6	17	17	27	36	2	25	7	30
Ikalukrok Creek (above Dudd)	3	53	37	14	0	22	27	11	6	0	4	4	2
Ikalukrok Creek (below Mainstem)	4	19	28	6	11	15	3	2	0	0	5	7	9
Ikalukrok Creek (above Mainstem)	3	44	41	5	2	18	3	12	0	5	7	3	11
Total Catch Dolly Varden	217	545	945	111	79	207	330	301	275	35	415	178	331

Appendix 14. Arctic Grayling, Mainstem Red Dog Creek

Observations and catches of Arctic grayling in Mainstem Red Dog Creek below the confluence of North Fork Red Dog and Middle Fork Red Dog creeks since 1994.

7/27/94 – visual, two adults just below North Fork

6/29/95 – angling, one adult just below North Fork
7/17/95 – angling, two adults near rock bluff 0.8 km below North Fork
7/20/95 – visual, one adult near rock bluff 0.8 km below North Fork
8/11/95 – visual, fry (about 30) below North Fork
8/14/95 – angling, 11 adults marked and released, rock bluff 0.8 km below North Fork

6/19/96 – visual, one adult near Station 10
7/15/96 – angling, seven adults marked and released near Station 10
8/11/96 – visual, fry in shallow eddies at mouth of Mainstem
8/12/96 – visual, fry near rock bluff 0.8 km below North Fork

6/25/97 – visual, two adults at rock bluff 0.8 km below North Fork
6/25/97 – drift net, fry caught at Station 10, 13-15 mm long
6/26/97 – angling, 15 adults marked and released near Station 10
6/27/97 – visual, fry numerous at Station 10
8/10/97 – visual, fry in backwaters
9/29/97 – minnow traps, seven fry caught near Station 10

6/10/98 – visual, no fish seen between North Fork mouth and rock bluff 0.8 km downstream
6/28/98 – visual, one adult feeding at rock bluff (0.8 km below North Fork)

5/29/99 – angling, three adults caught just below North Fork mouth
5/30/99 – fyke net, 32 adults caught about 100 m below North Fork mouth
7/8-9/99 – angling, two adults captured, marked, and released near Station 10
7/8-9/99 – visual, 12 adults and some fry near Station 10
7/8-9/99 – visual, two adults at rock bluff (0.8 km below North Fork)
8/9-10/99 – visual, numerous fry in backwaters and along stream margins

Appendix 14 (continued)

6/11-12/00 – fyke net, adults captured, marked, and released 7/28/00 – visual, several fry in backwaters and along stream margins, not numerous
7/5/00 – visual, two adults feeding at rock bluff (0.8 km below North Fork), juvenile observed
7/6/00 – visual, walked most of creek, tagged three adults near Station 10, most pools held one to three adults

6/15-18/01 – visual, walked creek to check for spawners in proposed mixing zone, none observed, one adult seen feeding at rock bluff (about 0.8 km below North Fork)
6/17/01 – angling, 11 adults marked and released near Station 10, all females spent
7/29-31/01 – visual, very few fry seen (about 20 mm), late breakup, cold temperatures resulted in late spawning

5/31/02 – fyke net, seven adults marked and released near Station 10
6/1/02 – fyke net, 31 adults marked and released near Station 10
6/2/02 – fyke net, eight adults marked and released near Station 10
6/3/02 – fyke net, three adults marked and released near Station 10
6/4/02 – fyke net, three adults and three juveniles marked and released near Station 10
6/7/02 – angling, 10 adults and three juveniles marked and released near Station 10, most of the females were spent
7/27/02 – visual, few fry (<10) seen
7/28/02 – visual, adults present near Station 10, three to four per pool

6/11/03 – aerial, 48 adults, two spawning pairs seen
6/12/03 – visual, ten adults, three active spawning pairs observed near Station 10
6/14/03 – angling, eight adults, one spent male near Station 10
7/7/03 – visual, fry in backwaters near Station 10, one group of 30
7/8/03 – visual, ten adults near Station 10
9/7/03 – visual, two adults and five fry near Station 151

5/25/04 – visual, two adult males near Station 10
5/26/04 – fyke net, four adults near Station 10
7/7/04 – visual, fry common near Station 151
7/7/04 – angling, two adults (333, 325 mm) near Station 151
7/8/04 – visual, fry in all backwaters near Station 10
7/8/04 – angling, three adults (373, 297, 356 mm) near Station 10

Appendix 14 (continued)

6/5/05 – aerial, observed 30 adult Arctic grayling, only two sets paired
6/25 and 26/05 – Houghton reported catching about 60 fish in Mainstem between mouth and North Fork Red Dog Creek
7/4/05 – visual, 8 adults and fry (about 70) observed near Station 10
7/28/05 – visual, small numbers of fry in backwaters near Station 10

6/13/06 – visual, five adult Arctic grayling seen in Mainstem near Station 10
6/16/06 – angling, caught 8 Arctic grayling (260 – 355 mm long) in Mainstem just below mouth of North Fork

6/1/07 – visual, several adult male and female Arctic grayling seen near Station 151
6/2/07 – visual, numerous Arctic grayling spawning at 3rd bend downstream of Station 151 in area of cobbles to gravelly sand
6/3/07 – visual, groups of 4 to 5 adults moving downstream in Station 10 area, caught several spent females, fish obviously moving out of Mainstem
7/1/07 – visual, observed large number of fry in side channels and backwaters near Station 10 and three adult Arctic grayling feeding on drift
7/3/07 – visual, observed one adult Arctic grayling at Station 151 and several fry along stream margins
8/9/07 – visual, observed two adult Arctic grayling at Station 151 and saw 35 fry along stream margins, one group of about 25
8/10/07 – visual, observed quite of few Arctic grayling fry in vicinity of Station 10 and caught fry in minnow traps (n = 10, 59 to 68 mm, average 64.1, SD = 2.8)

6/608 – visual, observed one Arctic grayling near Station 151
6/9/08 – visual and angling, walked Station 151 downstream for about 1.6 km and caught one Arctic grayling (363 mm)
6/10/08 – visual and angling, caught 5 Arctic grayling (325 – 425 mm long) just upstream of Station 10, four males and one partially spent female – saw about six fish that we did not catch
7/3/08 – visual, saw one adult Arctic grayling near Station 10
7/4/08 – visual, fry common along stream margins near Station 10, very small (about 15 mm long)
7/4/08 – minnow traps, caught one 67 mm Arctic grayling near Station 151
8/3/08 – minnow traps, caught one 82 mm Arctic grayling near Station 151

Appendix 14 (concluded)

6/13/09 – caught one 408 mm Arctic grayling in Mainstem Red Dog Creek at first rock bluff below North Fork Red Dog Creek

7/2/09 – observed one adult Arctic grayling near Station 151

7/3/09 – observed 8 adult Arctic grayling in pools just upstream of Station 10

7/29/09 – saw large numbers of Arctic grayling fry virtually everywhere in our sample reach in Mainstem Red Dog Creek upstream of Station 151

7/30/09 – observed a few Arctic grayling fry in Mainstem Red Dog Creek near Station 10