Technical Report No. 08-02

Aquatic Biomonitoring at Red Dog Mine, 2007

National Pollution Discharge Elimination System
Permit No. AK-003865-2

by Alvin G. Ott and William A. Morris

Juvenile Dolly Varden, Buddy Creek
Photograph by Al Ott 2007

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Alaska Department of Natural Resources
Office of Habitat Management and Permitting

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Executive Director
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Table of Contents

List of Tables

List of Figures

List of Figures (concluded)

Acknowledgements

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Dr. Phyllis Weber Scannell (Scannell Technical Services) updated our long-term water quality data base with 2007 information. Ms. Nora Foster (NRF Taxonomic Services) was responsible for sorting and identification of aquatic invertebrates collected with drift nets.

Executive Summary

●Metals concentrations in Mainstem Red Dog Creek clearly exceed those found in North Fork Red Dog, Ikalukrok, and Buddy creeks. There are no apparent trends for increasing metal concentrations in Mainstem Red Dog Creek, except for a slight increase in Ni that is from Rachael Creek located upstream of the mine. Specifically, Cd, Pb, and Zn are now lower in Mainstem Red Dog Creek than they were pre-mining. Total dissolved solids (TDS), conductivity, and sulfate are higher than baseline data, but these 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 good measure of productivity in streams in the area of the Red Dog Mine. Higher densities of aquatic invertebrates were found in the Bons and Buddy Creek sites than in the NPDES sample sites. At NPDES sample sites, higher aquatic invertebrate densities were found in North Fork Red Dog Creek nearly every year. The percentage of Ephemoptera, Plecoptera, and Tricoptera (EPT) varied among sample sites, but generally was highest at Station 9 in Ikalukrok Creek upstream of the mouth of Mainstem Red Dog Creek. No apparent differences are seen in taxa richness among sample sites or among sample years.

●Juvenile Dolly Varden are collected each year from selected sites and are analyzed for whole body metal concentrations. The purpose of the sample effort is two fold: (1) to determine if differences exist among sample sites that can be linked with background water quality; and (2) to track change over time. Based on our results to date, we believe that whole body concentrations of selected metals in juvenile Dolly Varden do reflect water quality differences among sample sites (fish from Mainstem Red Dog have higher metal concentrations) and are useful in tracking change over time. These data are a useful tool for monitoring fish in terms of metals concentrations.

●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.

Executive Summary (concluded)

●The number of Dolly Varden is estimated each fall in the Wulik River. Estimates vary annually. 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. Counts of adult chum salmon after mine development in 1990 and 1991 were much lower than reported in baseline studies. Aerial surveys were initiated in 1995, with the highest count being 4,185 in 2006. Fairly large returns of chum salmon since 1995 have been seen in 2001, 2002, 2006, and 2007.

●Catch of juvenile Dolly Varden varies considerably among sample sites and years. Catches peak in late summer/early fall as fish move to rearing habitats. While most Dolly Varden are believed to be from anadromous parents, a resident component exists that moves into North Fork Red Dog Creek with Arctic grayling each spring. The two most productive sample sites for juvenile Dolly Varden continue to be Anxiety Ridge and Buddy creeks. Juvenile Dolly Varden use Mainstem Red Dog Creek for rearing, but catches from 2000 through 2007 have been low. Catches of age 0 and 1 Dolly Varden were high in Buddy Creek in fall 2007.

●The Arctic grayling spring migration of fish into North Fork Red Dog Creek was strong in spring 2007. Length frequency distribution for immature Arctic grayling was bimodal with several strong age classes present, suggesting the potential for substantial recruitment to the adult spawning population. Seven of the 41 fish recaptured in North Fork Red Dog Creek were Arctic grayling originally tagged in Bons Pond. Water temperatures warmed quickly in late May, and spawning was judged to be essentially completed by June 3. After spawning, water temperatures stayed warm and there was little rainfall until mid-August. Large numbers of Arctic grayling fry were observed in North Fork Red Dog Creek and in Mainstem Red Dog Creek near Station 10.

●Premining slimy sculpin abundance is unknown, but baseline data reports indicated that this species was numerous in the Ikalukrok Creek drainage. Highest catches of slimy sculpin occur in Ikalukrok Creek near Dudd Creek. Increasing numbers of slimy sculpin from 2000 to 2005 seemed to track with improved water quality due to natural decreases in the Cub Creek seep located upstream of Mainstem Red Dog Creek.

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 and facilities and 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. (TCAK) 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 became effective August 28, 1998. The NPDES Permit was modified effective August 23, 2003, to include ADEC's authorization of two mixing zones for total dissolved solids in Mainstem Red Dog and Ikalukrok creeks.

The NPDES Permit requires biomonitoring of fish, aquatic invertebrates, and periphyton in streams downstream of 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 Natural Resources (ADNR) in 2007 and comparisons of the 2007 data set with previous years.

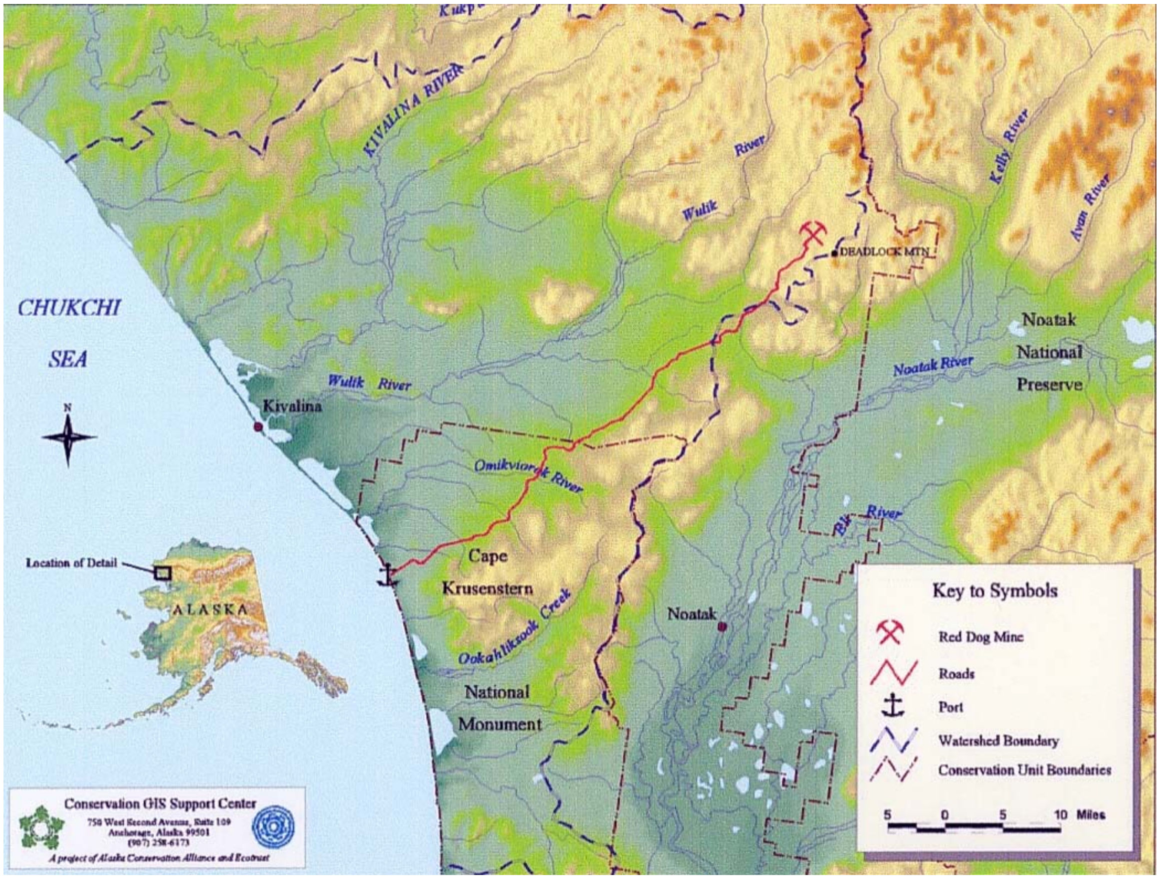

Figure 1. Location of the Red Dog Mine in northwestern Alaska. Map used with permission of Conservation GIS Support Center, Anchorage, Alaska.

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 adult Dolly Varden (*Salvelinus malma*) 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 of 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.

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

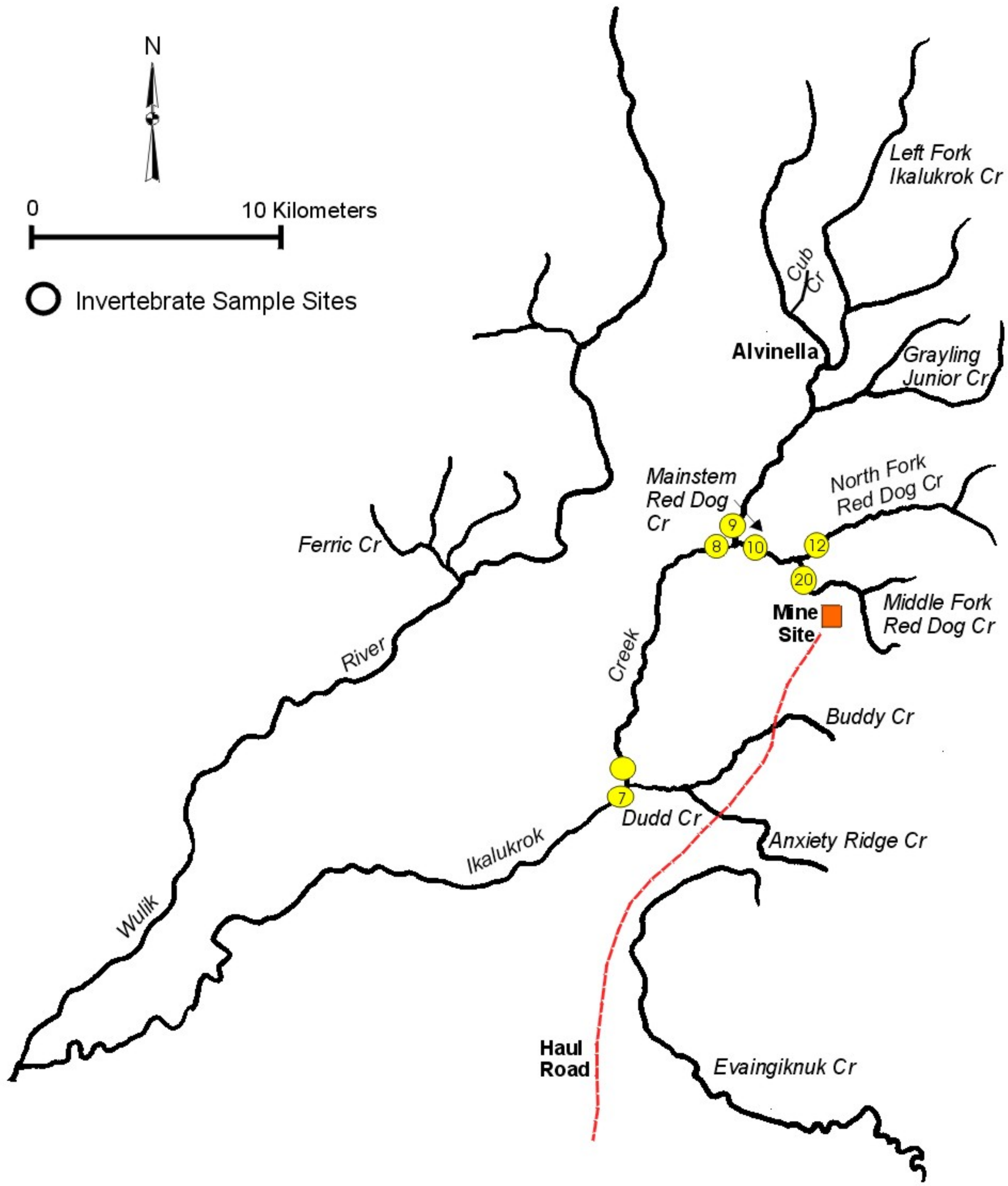

Figure 2. Location of sample sites in the Ikalukrok Creek drainage for aquatic invertebrate and periphyton sampling. The site in Ikalukrok Creek immediately upstream of Dudd Creek does not have a numerical designation.

Supplemental biomonitoring in the Bons and Buddy Creek drainages is conducted under a voluntary agreement between TCAK and the ADEC. Water quality data are collected at sites in these drainages by TCAK and our office conducts biological sampling at four sites in the Bons and Buddy Creek drainages (Figure 3).

- Bons Creek, about 200 m upstream of Bons Pond (referred to as Bons Up);
- 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 waterfalls that is a barrier to upstream movement of fish (referred to as Buddy Down).

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 Buddy Creek drainages by an impassable waterfall located about 1.6 km below Bons Pond.

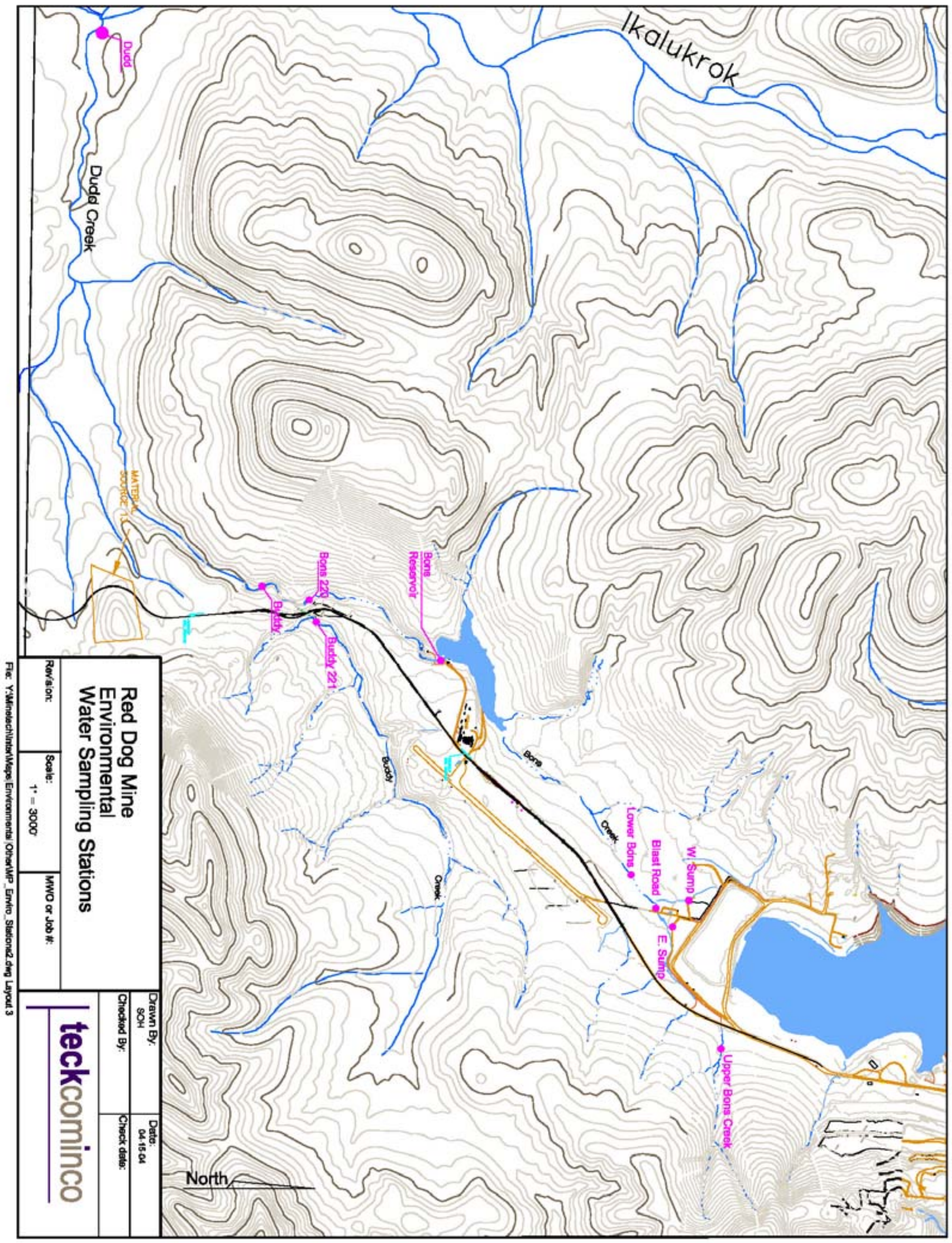

Figure 3. Bons and Buddy creeks and Bons Pond (map provided by TCAK).

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 TCAK. 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 2007.

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) and Middle Fork Red Dog (20) Creeks	periphyton (as chlorophyll-a, mg/m^2) aquatic invertebrates (taxa richness, density) fish presence and use
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 2007.

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. 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 TCAK. 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 TCAK at a number of sites, including those required under the NPDES Permit. Sampling occurs twice each month during the open water season. In past reports, we have presented water quality data collected by TCAK for each of the 7 NPDES sites, but in this year's report we focus on several sites that provide a reasonable assessment of whether water quality conditions are changing and how these compare with pre-mining data. Mainstem Red Dog Creek (Stations 10 and 151), North Fork Red Dog Creek (Station 12), Ikalukrok Creek upstream of Red Dog Creek (Station 9), and Buddy Creek (Station 221) are key sites. Mainstem Red Dog Creek is sampled at Stations 10 and 151. At Station 151 we sample for fish, but at Station 10 sampling includes periphyton, benthic invertebrates, and fish (Figure 4).

Figure 4. Aquatic invertebrate drift nets fishing in Mainstem Red Dog Creek at Station 10 in July 2007.

TCAK continued to make improvements to the mine's clean water bypass system. In October 2007, galvanized culvert was installed replacing sections of High-Density Polyethylene (HDPE) lined ditch that existed in Middle Fork Red Dog Creek upstream of Shelly Creek and continued upstream to the Rachael Creek confluence. In addition, the section of HDPE lined ditch in Connie Creek was converted to culvert as well. Pb and Zn concentrations at Station 10 indicate that both of these elements are lower now than they were pre-mining, with the exception of several maximum values for Pb (Figures 5 and 6, Appendix 2). Even for Pb, the median concentrations are consistently lower than pre-mining (Figure 5).

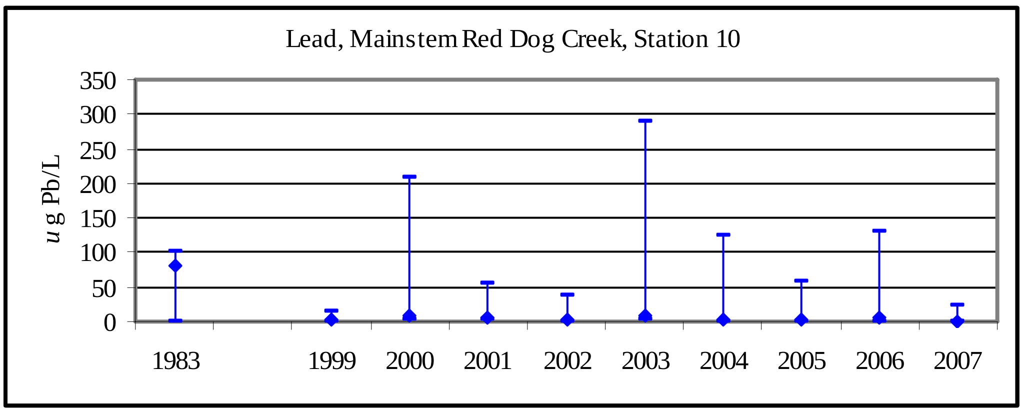

Figure 5. Median, maximum, and minimum concentrations of Pb at Station 10.

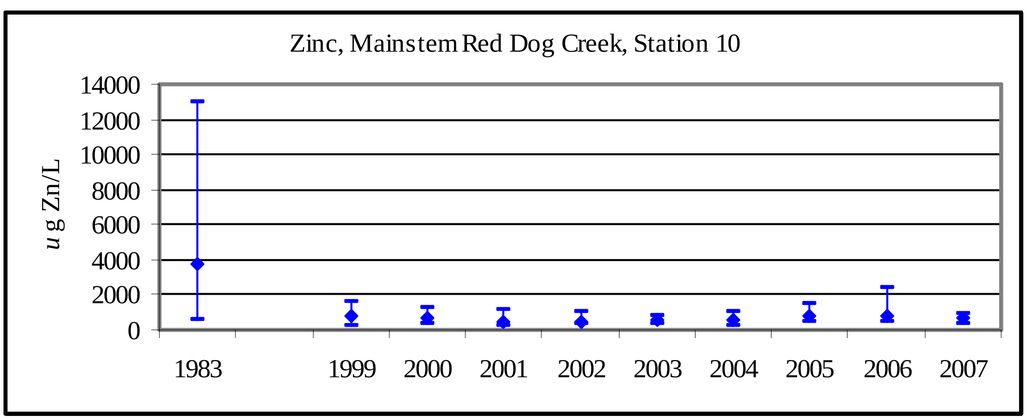

Figure 6. Median, maximum, and minimum concentrations of Zn at Station 10.

Cd, Pb, and Zn concentrations in Mainstem Red Dog Creek are higher than in North Fork Red Dog, Ikalukrok, and Buddy creeks (Appendix 2). Median Pb concentrations are low in North Fork Red Dog, Ikalukrok, and Buddy creeks, but peak values are seen in all three. Zn concentrations are low in both North Fork Red Dog and Buddy creeks, but higher in Ikalukrok Creek. Higher Zn concentrations in Ikalukrok Creek at Station 9 are the direct result of input from natural mineral seeps upstream of the sample site (i.e., the most obvious seep is located at Cub Creek (Figure 7).

Figure 7. Cub Creek, located in upper Ikalukrok Creek, about 10 km upstream of Station 9.

We continued to evaluate water quality data being collected in Mainstem Red Dog Creek as part of the ongoing monitoring program by TCAK to determine whether changes might be occurring. Median Al concentrations are lower than pre-mining with a few peak values near what was measured before mining began (Figure 8). Cd concentrations at Station 10 in Mainstem Red Dog Creek are consistently lower than pre-mining (Figure 9).

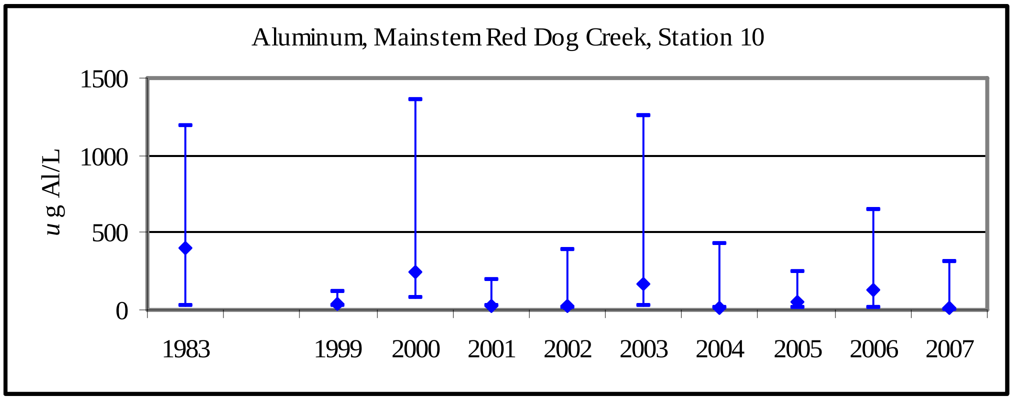

Figure 8. Median, maximum, and minimum concentrations of Al at Station 10.

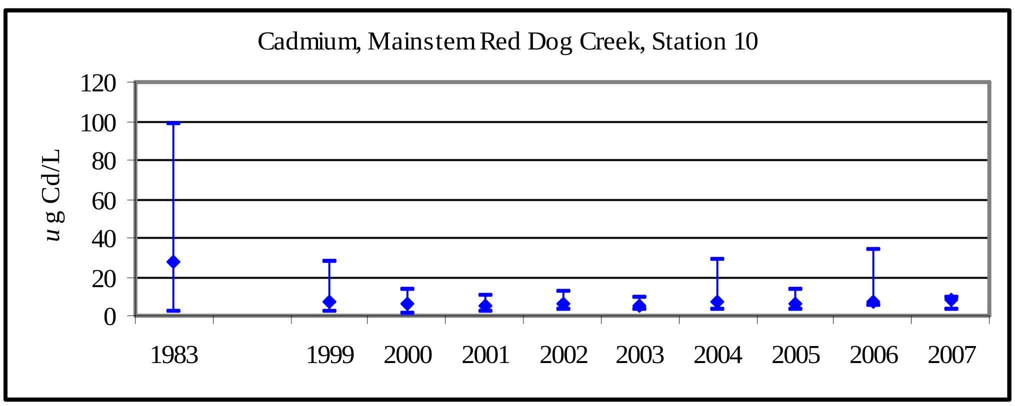

Figure 9. Median, maximum, and minimum concentrations of Cd at Station 10.

Specific conductance at Station 10 is higher than pre-mining, but has remained unchanged from 1999 through 2007 (Figure 10). Higher specific conductance measurements are directly related to higher TDS associated with the treated wastewater discharge. Median Cu concentrations are comparable with pre-mining data or in some years lower (Figure 11).

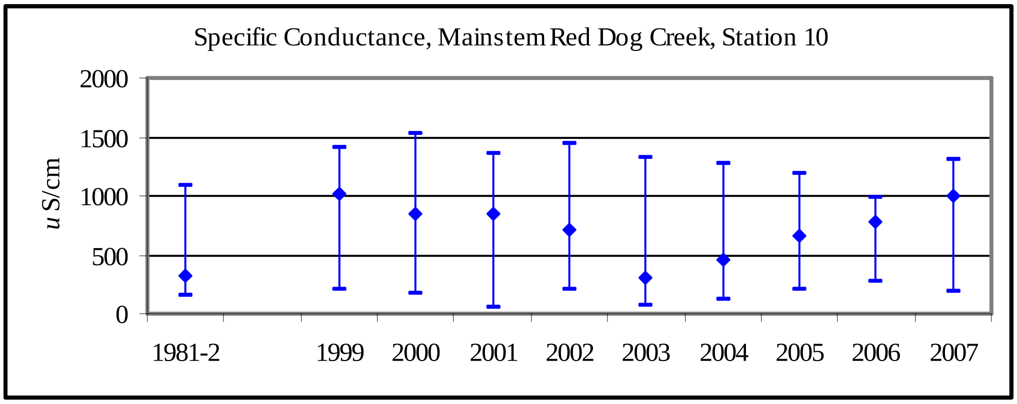

Figure 10. Median, maximum, and minimum specific conductance at Station 10.

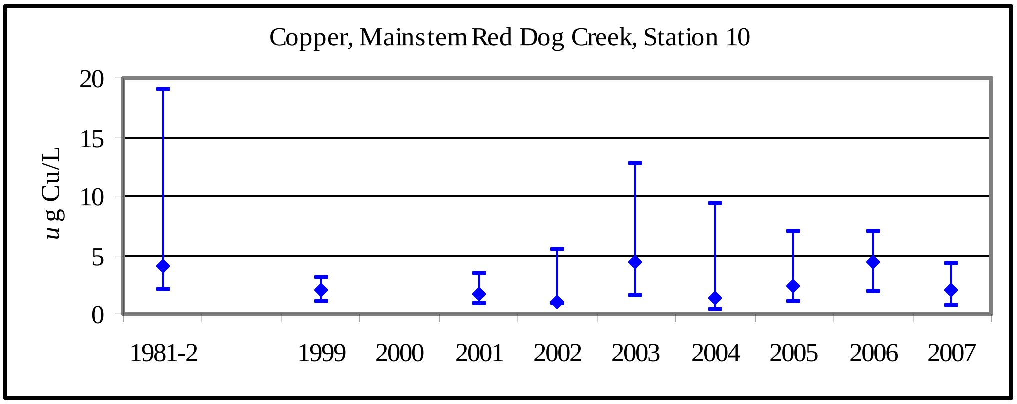

Figure 11. Median, maximum, and minimum concentrations of Cu at Station 10.

Baseline data for Fe and Ni are not available. There is no apparent trend for an increase or decrease in the concentration of Fe (Figure 12). Median values were highest in 2000 (827 *u*g/L) and in 2006 (326 *u*g/L). Median Ni concentrations in 2006 and 2007 exceeded those reported in pre-mining data (Figure 13). Higher Ni concentrations were first noted in summer 2006 in Rachael Creek which is a tributary to the clean water bypass system. The clean water bypass system carries water from Middle Fork Red Dog Creek upstream of the ore body and through the disturbed ground in the pit area.

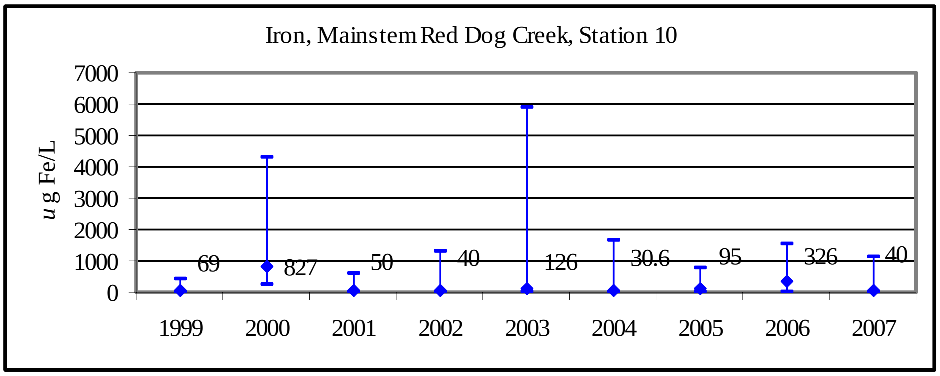

Figure 12. Median, maximum, and minimum concentrations of Fe at Station 10. Median values are shown in this figure.

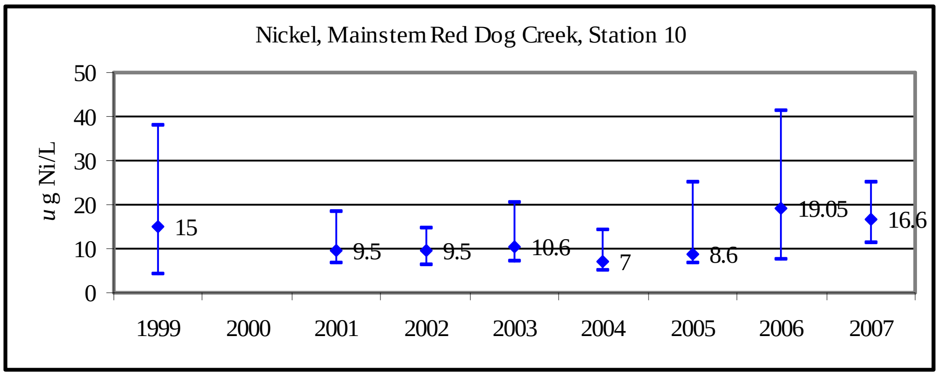

Figure 13. Median, maximum, and minimum concentrations of Ni at Station 10. Median values are shown in this figure.

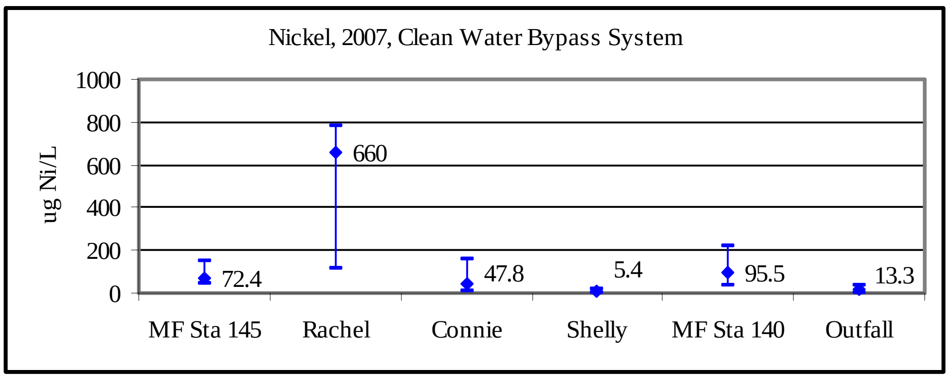

Figure 14. Median, maximum, and minimum concentrations of Ni in clean water bypass. Median values are shown in this figure.

Station 140 is located downstream of the clean water bypass and just upstream from Outfall 001 (discharge point for treated water). Three major tributaries to the clean water bypass are Rachael, Connie, and Shelly creeks. A major source for the increase in Ni at Station 10 in Mainstem Red Dog Creek is Rachael Creek upstream of mining related activities (Figure 15). Rachael Creek flows through the Ikalukrok Fm, a mafic igneous rock high in Nickel (Clark pers. com. February 2, 2008). It is likely the cause of increased Ni observed in recent years.

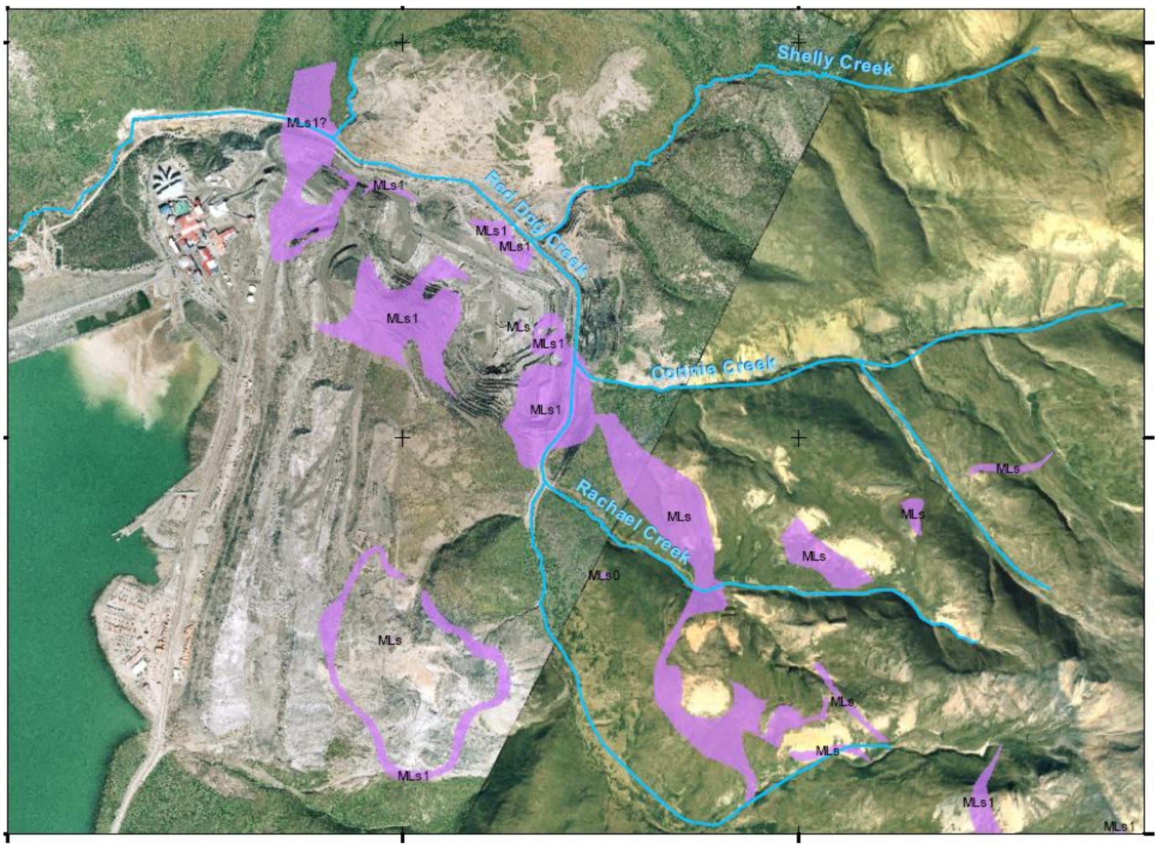

Figure 15. Red Dog Mine drainages and outcrop areas of Ikalukrok Fm (Map provided by TCAK).

The pH at Station 10 has been fairly consistent since 1999 (Figure 16). Generally, the pH is slightly more basic than pre-mining and never drops below 6 as seen in 1990, prior to construction of the clean water bypass have not occurred since. The clean water bypass was built during the winter prior to spring breakup in 1991. Modifications to the bypass have been made since the initial construction (key construction and maintenance events are included in Appendix 1, summary of mine development and operations).

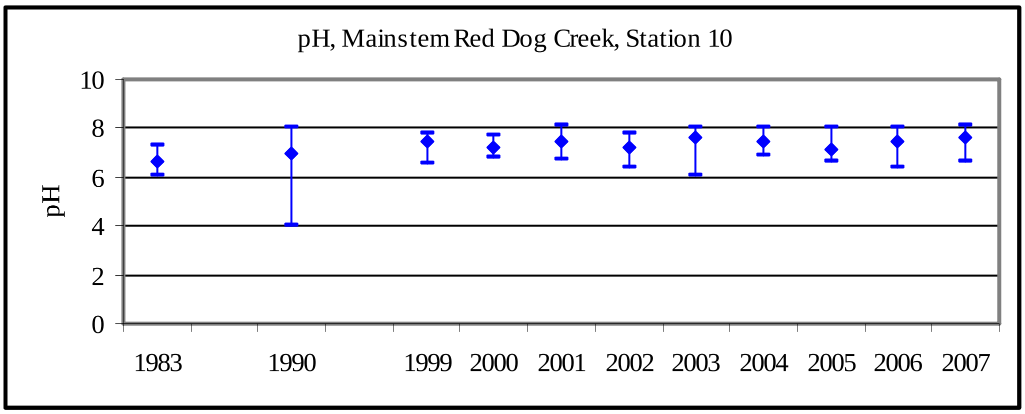

Figure 16. Median, maximum, and minimum pH values at Station 10.

Pre-mining Se data are not available. Median Se concentrations have been similar since 1999 (Figure 17). Sulfate concentrations at Station 10 have varied among the sample years and are higher compared with baseline data (Figure 18). Higher sulfate concentrations are directly related to higher TDS in the treated water effluent (Figure 19).

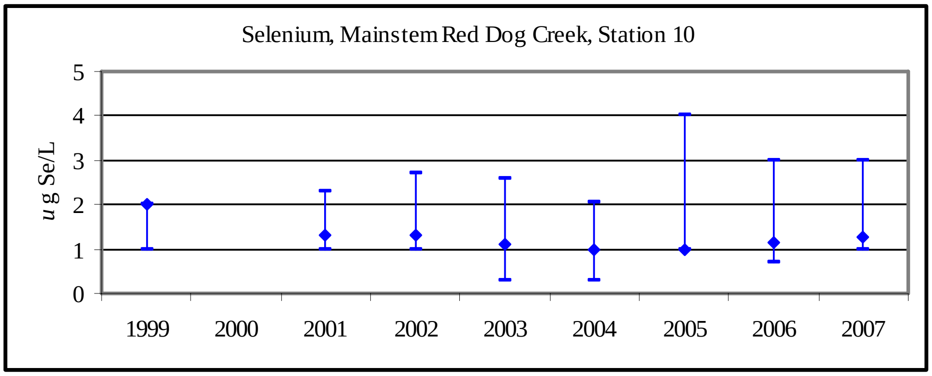

Figure 17. Median, maximum, and minimum concentrations of Se at Station 10.

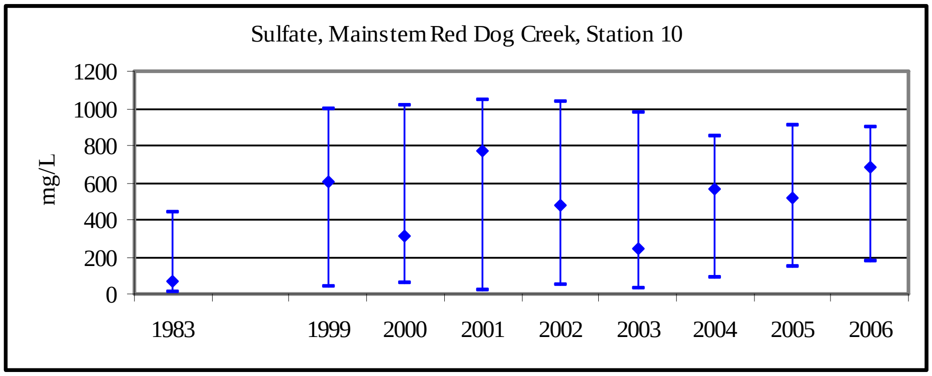

Figure 18. Median, maximum, and minimum concentrations of sulfate at Station 10.

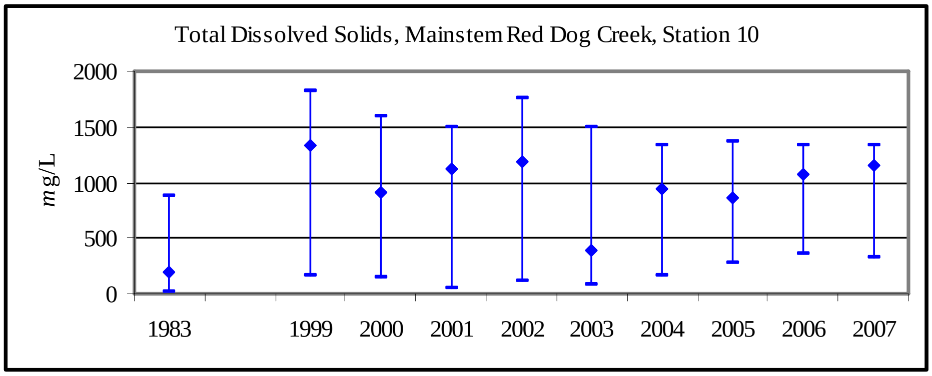

Figure 19. Median, maximum, and minimum TDS concentrations at Station 10, TDS primarily is calcium sulfate.

Periphyton Standing Crop

Algal biomass samples, as estimated by chlorophyll-a concentrations (mg/m^2), are collected annually at the 7 NPDES sites. Under the current NPDES Permit, we have collected these samples for 9 years (1999 to 2007). Since 2004, we also have sampled in the Bons and Buddy Creek drainages and where appropriate for comparison, we have included data from these drainages. In all years except 2006, samples were collected in early July. Average chlorophyll-a concentrations in 2007 as well as variability, were highest in North Fork Red Dog Creek (Station 12) and in the Bons and Buddy Creek drainages (Figure 20 and Appendix 3). The lowest chlorophyll-a concentrations were seen in Middle Fork Red Dog and Mainstem Red Dog creeks. Multiple years of sampling indicate that North Fork Red Dog, Bons, and Buddy creeks generally are the most productive stream systems in terms of July periphyton standing crop.

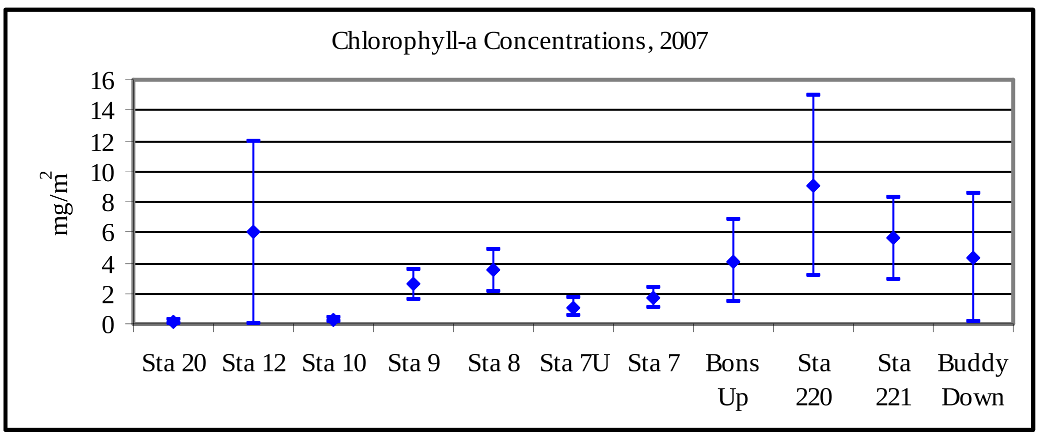

Figure 20. Average concentration of chlorophyll-a, plus and minus one standard deviation, at the NPDES sample sites and in the Bons and Buddy Creek drainages.

Chlorophyll-a concentrations in North Fork Red Dog Creek from 1999 through 2007 are variable among sample years, but generally concentrations are high relative to other NPDES sample sites. Only in one year, 2004, was the average chlorophyll-a concentration less than 2 mg/m^2 in North Fork Red Dog Creek (Figure 21).

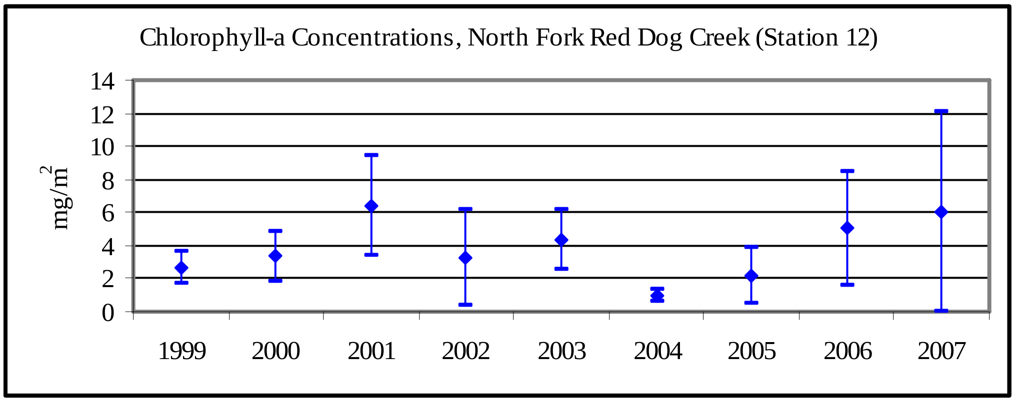

Figure 21. Average concentration of chlorophyll-a, plus and minus one standard deviation, North Fork Red Dog Creek.

In Mainstem Red Dog Creek from 1999 through 2007, chlorophyll-a concentrations varied, but generally were lower than North Fork Red Dog Creek (Figure 22).

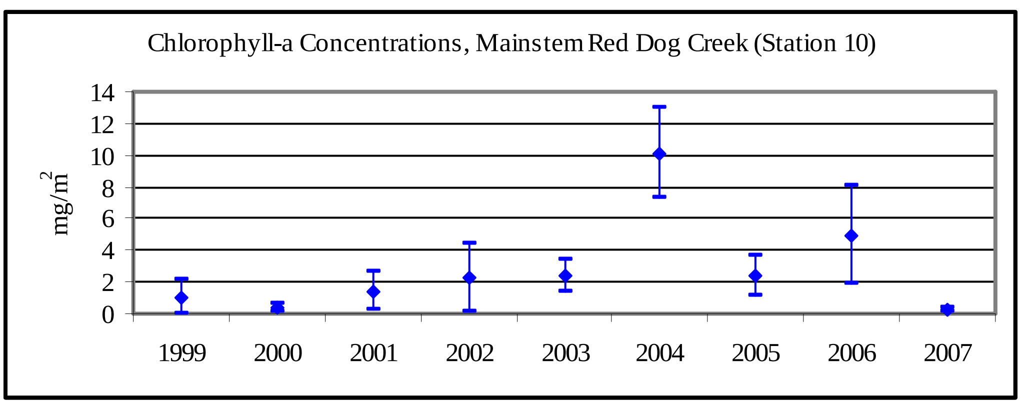

Figure 22. Average concentration of chlorophyll-a, plus and minus one standard deviation, Mainstem Red Dog Creek.

Periphyton data track very closely with Zn and Cd concentrations measured over similar time frames (Figures 23, 24, and 25) at Station 9. Chlorophyll-a concentrations in

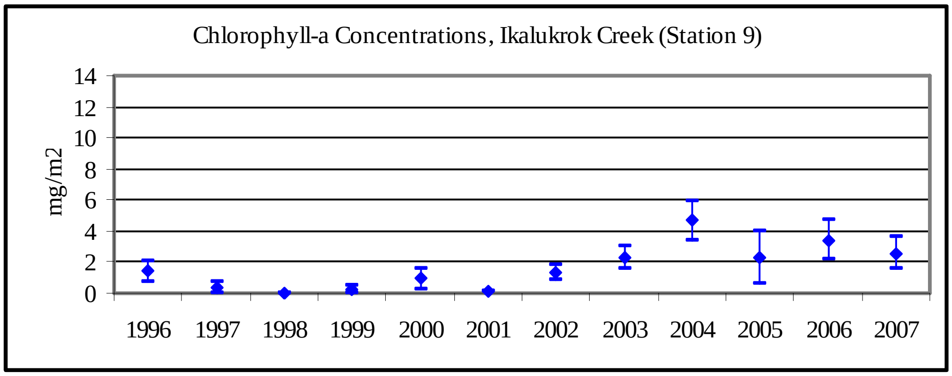

Figure 23. Average concentration of chlorophyll-a, plus and minus one standard deviation, Ikalukrok Creek.

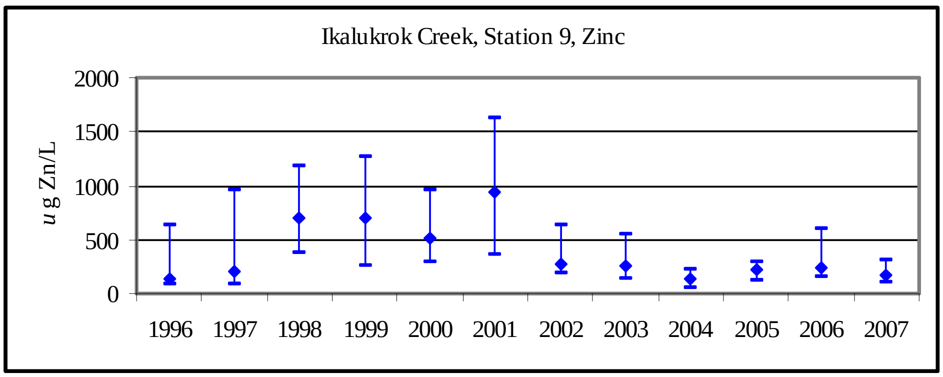

Figure 24. Median, maximum, and minimum concentrations of Zn at Station 9.

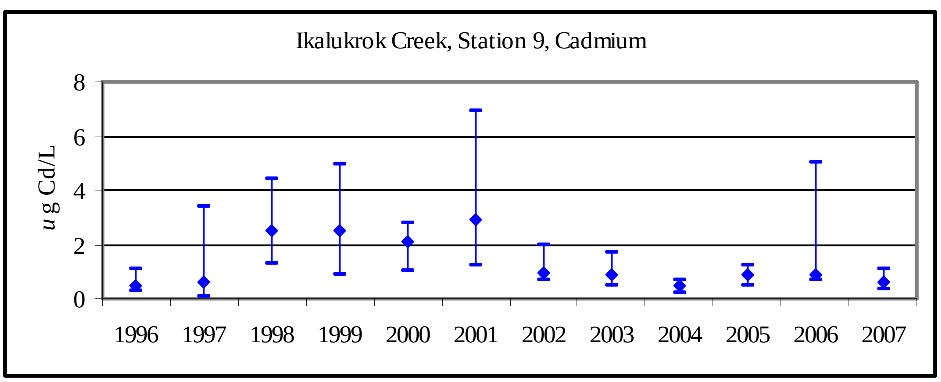

Figure 25. Median, maximum, and minimum concentrations of Cd at Station 9.

Ikalukrok Creek at Station 9, located upstream of the mouth of Mainstem Red Dog Creek, have been collected each year since 1996 (Figure 23). 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). As Zn and Cd concentrations decrease, chlorophyll-a concentrations increase.

Aquatic Invertebrates

Aquatic invertebrate samples are collected annually using drift nets at the NPDES sample sites. We have collected these aquatic invertebrate samples since summer 1999 with sampling done in late-June/early July except in 2006 when, due to rainfall events, samples were collected in August. Beginning in 2004, we also have collected aquatic invertebrate samples at four sites in the Bons and Buddy Creek drainages using the same methods/protocols as at the NPDES sites.

In 2007, the density of aquatic invertebrates was higher in Bons and Buddy creeks than in sample sites located in Middle Fork Red Dog (Station 20), Mainstem Red Dog (Station 10), North Fork Red Dog (Station 12), and Ikalukrok creeks (Stations 9, 8, 7U, and 7) (Figures 26 and 27, Appendix 4). Densities ranged from a high of 200 aquatic invertebrates/m^3 water in Bons Creek below Bons Pond to a low of 4/m^3 in Middle Fork Red Dog Creek. Aquatic invertebrate densities in the two Buddy Creek sites averaged 39/m^3. Generally, the higher density of aquatic invertebrates in the 2007 July samples tracks closely with the periphyton data which also showed higher productivity in the Bons and Buddy Creek drainages.

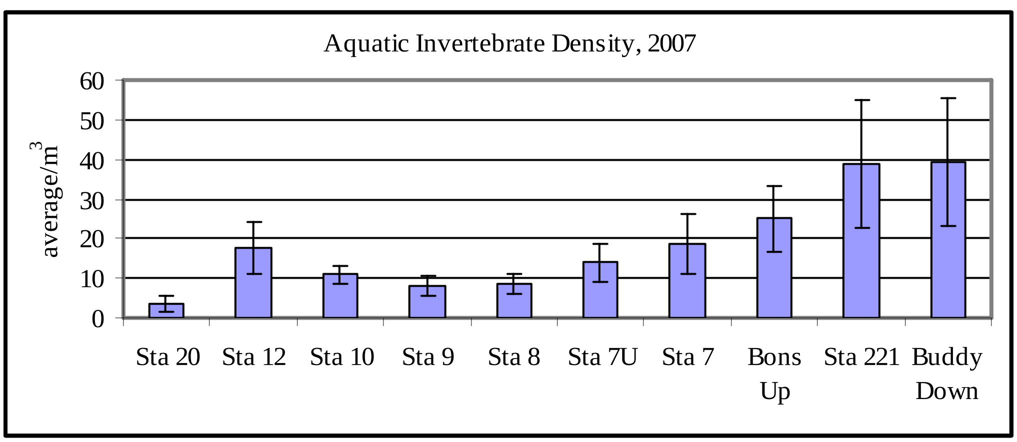

Figure 26. Aquatic invertebrate densities (average plus and minus one standard deviation), at NPDES sample site and in the Bons and Buddy Creek drainages, except for one site (Bons Creek, Station 220).

Breakup was relatively mild in spring 2007 and ambient air temperatures were warm with little rain until mid-August; thus, stream flows were low and water temperatures were warm (e.g., 10 to 14°C) in early July 2007. Bons Creek (Station 220) had extremely high densities of aquatic invertebrates – the highest ever found at any site since sampling began at Red Dog. The Bons Creek Station 220 site is located about 1.6 km downstream of Bons Pond and nearly all water at this site is surface water from Bons Pond that flows over and through the spillway. Flows in Bons Creek downstream of Bons Pond are moderated by the presence of the pond and water temperatures are elevated compared to other streams. None of the other sample sites has a lake/pond type feature in proximity to the sample site. Aquatic invertebrate densities at Station 220 in Bons Creek averaged 200 organisms/m^3 (Figure 27). The extremely high density found at Station 220 was due to large numbers of Simuliidae, Chironomidae (pupae and larvae), and Ostracods.

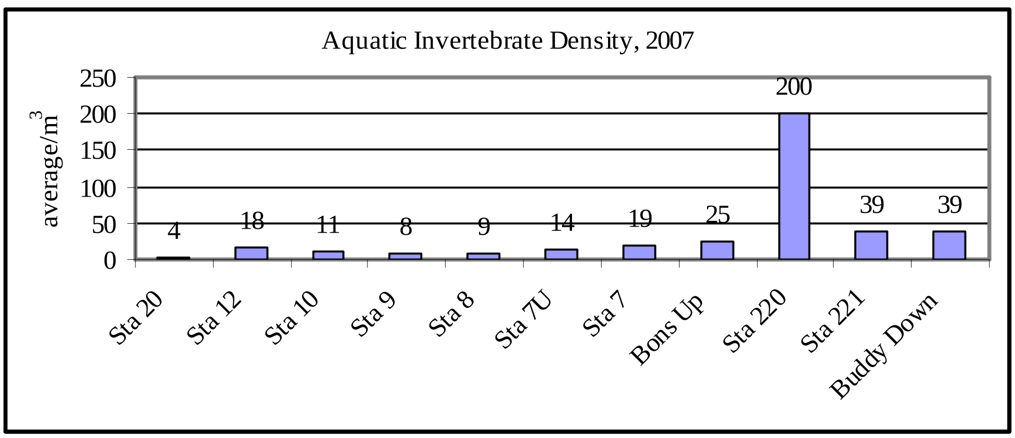

Figure 27. Aquatic invertebrate density, at NPDES sample sites and in the Bons and Buddy Creek drainages.

Aquatic invertebrate densities for North Fork Red Dog, Mainstem Red Dog, and Ikalukrok creeks from 1999 through 2007 are presented in Figures 28, 29, and 30. Aquatic invertebrate densities generally are higher in North Fork Red Dog Creek and although variable, densities in both Mainstem Red Dog and Ikalukrok creeks are similar. A very low density occurred, for unknown reasons, at all three sites in 2004.

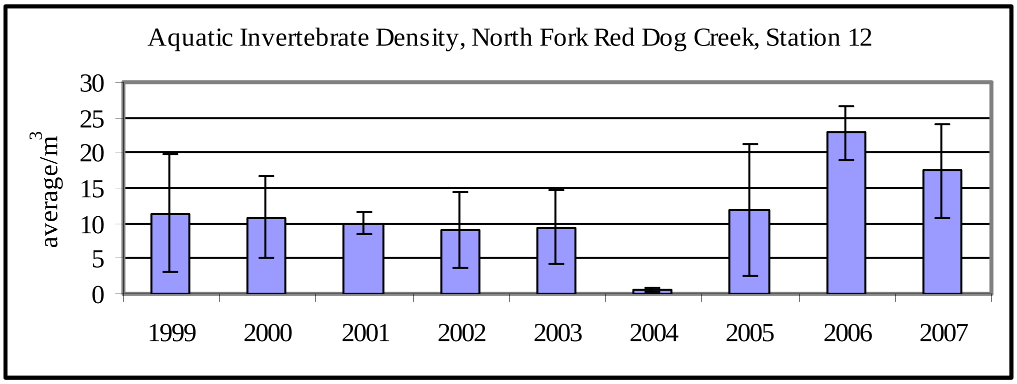

Figure 28. Aquatic invertebrate density (average plus and minus one standard deviation), North Fork Red Dog Creek, Station 12.

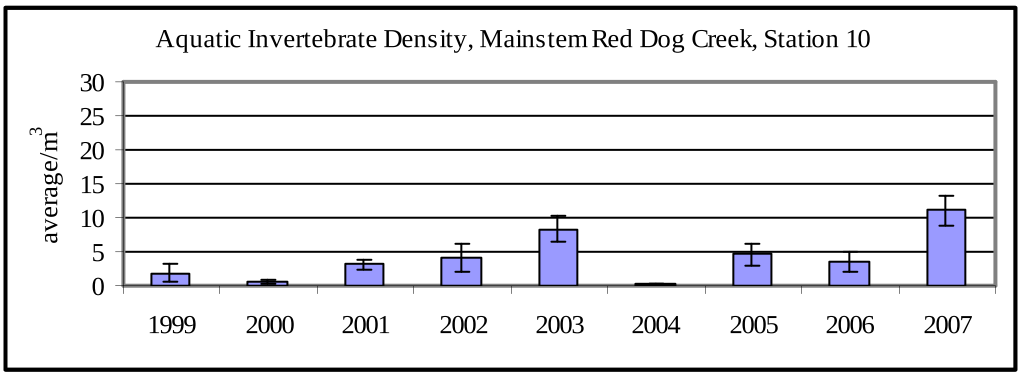

Figure 29. Aquatic invertebrate density (average plus and minus one standard deviation), Mainstem Red Dog Creek, Station 10.

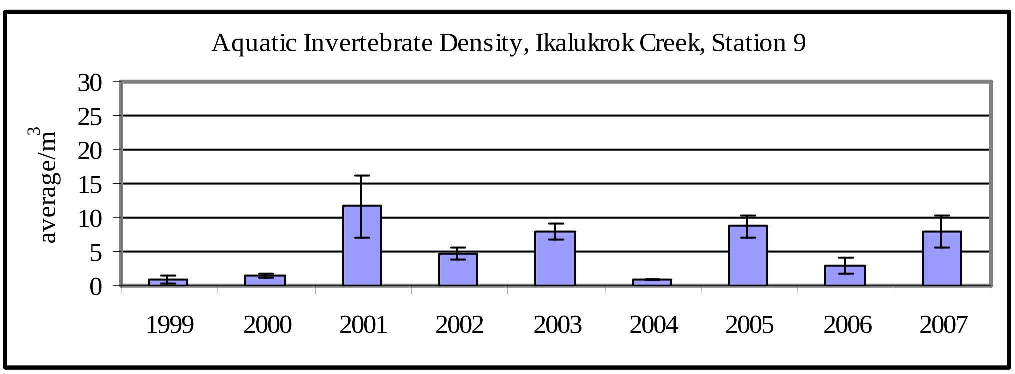

Figure 30. Aquatic invertebrate density (average plus and minus one standard deviation), Ikalukrok Creek, Station 9.

North Fork Red Dog Creek is the most productive of these three stream sites with Mainstem Red Dog Creek and Ikalukrok Creek being lower in productivity. Lower productivity in Mainstem Red Dog and Ikalukrok creeks probably is related to natural mineral seeps that occur upstream of sample sites in both of these systems. Mineral seeps are not apparent upstream of Station 12 in North Fork Red Dog Creek. Fish use of North Fork Red Dog Creek by Arctic grayling and Dolly Varden also is higher than in either Mainstem Red Dog Creek or in Ikalukrok Creek in the vicinity of Station 9.

The percent Ephemoptera, Plecoptera, and Tricoptera (EPT) in North Fork Red Dog, Mainstem Red Dog, and Ikalukrok creeks from 1999 through 2007 are presented in Figures 31, 32, and 33. Variability among sample years is apparent at these three sites, but in general (7 out of 9 years), higher EPT percentages are seen in Ikalukrok Creek at Station 9. Mayflies account for most of the EPT in both North Fork Red Dog and Ikalukrok creeks while both mayflies and stoneflies are more evenly represented in Mainstem Red Dog Creek at Station 10. Caddisflies are an insignificant contributor to EPT at all three of these sample sites. Caddisflies typically represent less than 1% of the EPT.

A major portion of the aquatic invertebrate drift in our samples are Chironomidae (pupae and larvae) and Simuliidae. DeCicco (1985) examined juvenile Dolly Varden stomachs from fish collected in the Noatak and Wulik River drainages and found the most prevalent food item was Chironomid larvae with some mayflies and stoneflies, but a low frequency of caddisflies. In work conducted in the mid 1970s on Arctic grayling in the Kavik River (North Slope), large adult fish were caught with stomachs full of almost exclusively Chironomids (Woodward-Clyde Consultants 1980). Drift nets set in the Kavik River also caught predominately Chironomids.

We looked at the taxa richness for all the NPDES and Bons and Buddy Creek sites for 2005, 2006, and 2007 (Figures 34, 35, and 36). Although variable among sample years, each individual site has years of higher taxa richness. Overall there is no apparent difference in total taxa among the 11 sample sites or among the sample years.

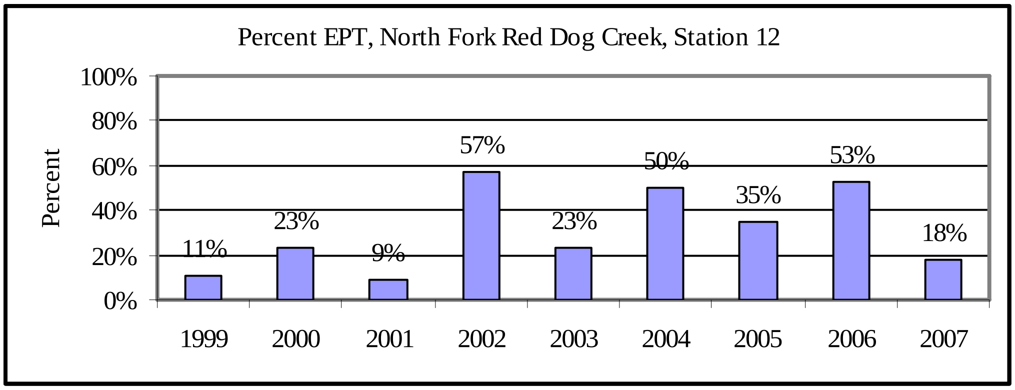

Figure 31. Percent EPT, North Fork Red Dog Creek, Station 12.

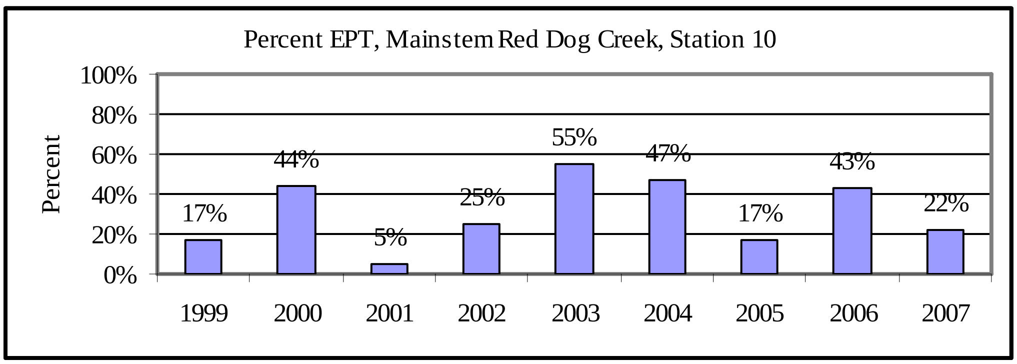

Figure 32. Percent EPT, Mainstem Red Dog Creek, Station 10.

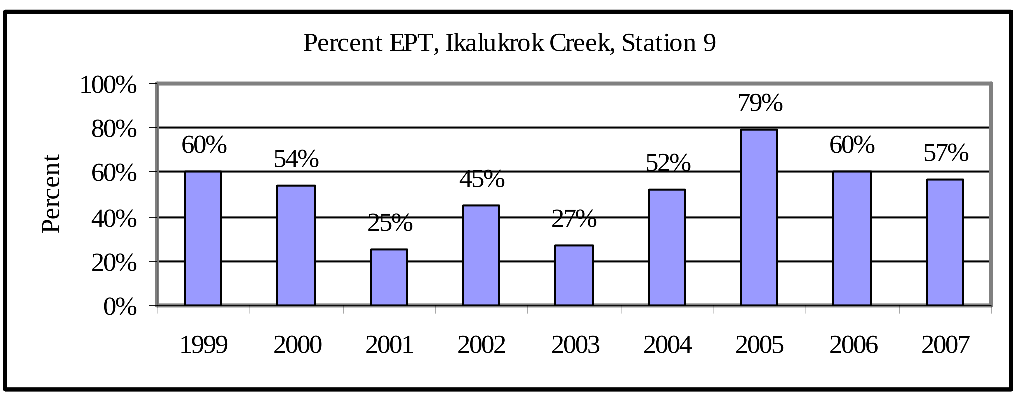

Figure 33. Percent EPT, Ikalukrok Creek, Station 9.

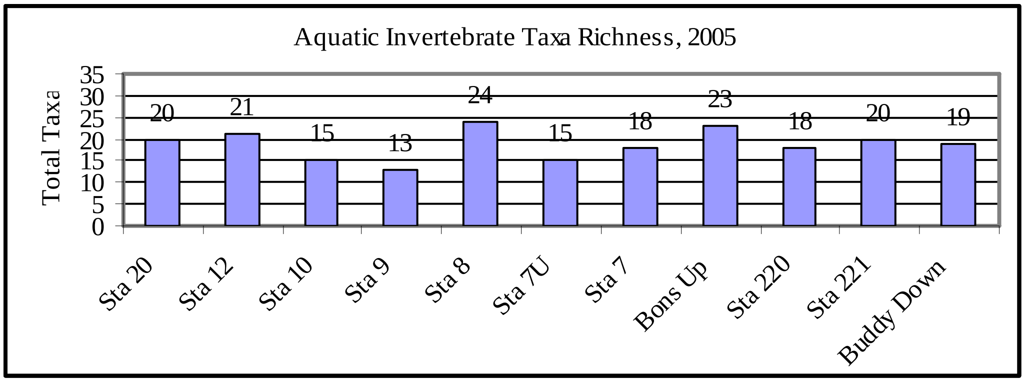

Figure 34. Aquatic Invertebrate Taxa Richness, at NPDES sample sites and in the Bons and Buddy Creek drainages.

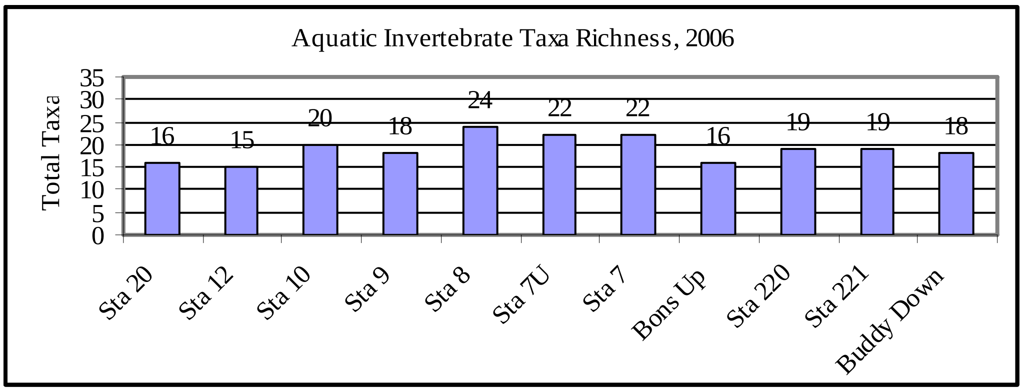

Figure 35. Aquatic Invertebrate Taxa Richness, at NPDES sample sites and in the Bons and Buddy Creek drainages.

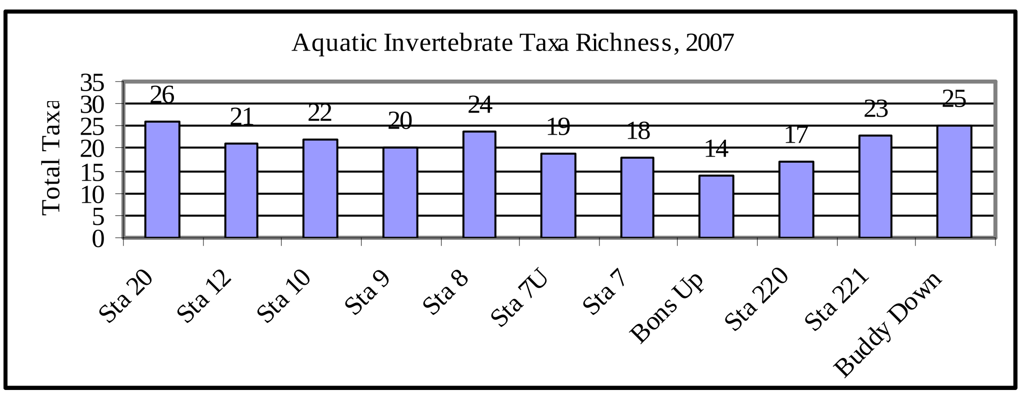

Figure 36. Aquatic Invertebrate Taxa Richness, at NPDES sample sites and in the Bons and Buddy Creek drainages.

Metals Concentrations in Juvenile Dolly Varden

Although not required by the NPDES Permit or ADEC Certification, we have conducted sampling to determine whole body concentrations of selected metals in juvenile Dolly Varden. The purposes of this sample effort are: (1) to determine if differences exist among 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, 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. 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 variability associated with fish being collected, we kept samples limited to juvenile Dolly Varden from 90 to 140 mm (basically 2 and 3 year old fish), and collected all samples in August after fish have spent time rearing in the sample stream. Fish larger than 140 mm are excluded because they could be resident fish and may be much older than fish from 90 to 140 mm.

We collected our first sample of juvenile Dolly Varden for whole body metals analyses in 1993, and in 1998 began a more systematic sampling effort that focused on 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, there are years where numbers of fish are low and the desired sample size is not achieved.

Differences in Cd, Pb, and Zn concentrations in whole body juvenile Dolly Varden were noted, with higher concentrations found in fish collected in Mainstem Red Dog Creek (Figures 37, 38, and 39) (Appendix 5). In 2005, concentrations of Cd, Pb, and Zn as determined by whole body analyses were consistently higher in fish from Mainstem Red Dog Creek than fish from either Buddy or Anxiety Ridge creeks (Appendix 6 – Statistical Analyses). Whole body concentrations of Cd, Pb, and Zn from fish captured in Buddy and Anxiety Ridge creeks were similar in 2005.

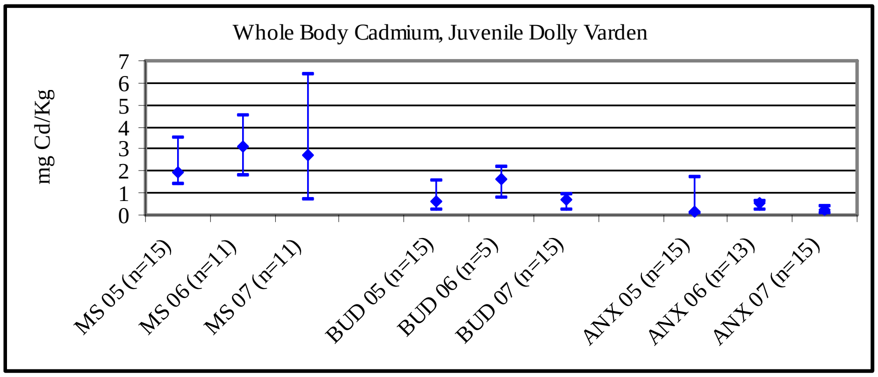

Figure 37. Whole body Cd concentrations (dry weight) in juvenile Dolly Varden from Mainstem Red Dog (MS), Buddy (BUD) and Anxiety (ANX) Ridge creeks (2005, 2006, and 2007).

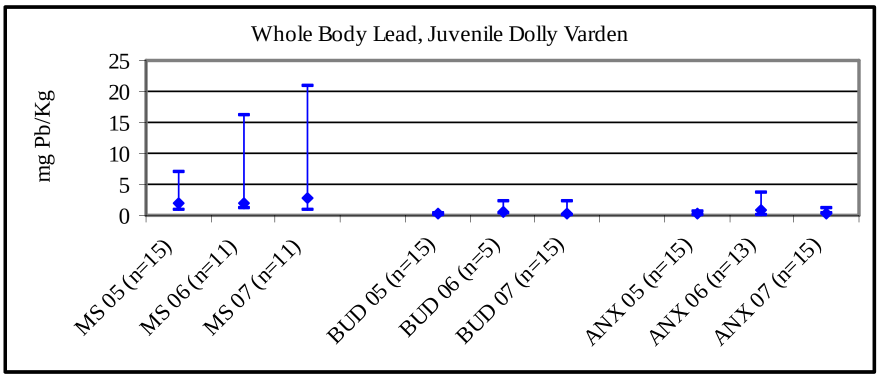

Figure 38. Whole body Pb concentrations (dry weight) in juvenile Dolly Varden from Mainstem Red Dog (MS), Buddy (BUD) and Anxiety (ANX) Ridge creeks (2005, 2006, and 2007).

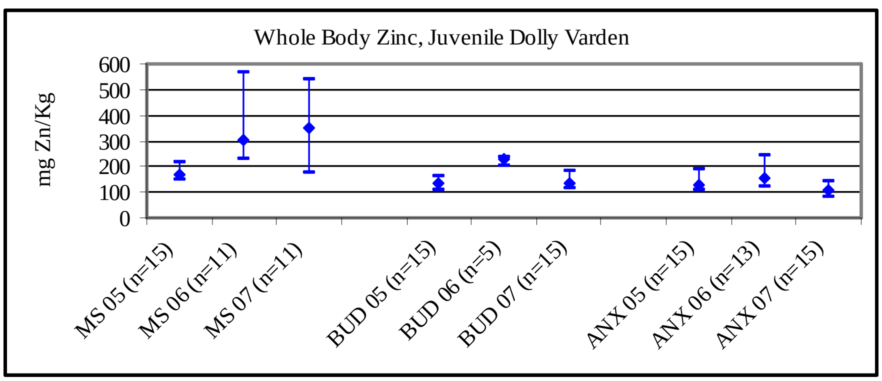

Figure 39. Whole body Zn concentrations (dry weight) in juvenile Dolly Varden from Mainstem Red Dog (MS), Buddy (BUD) and Anxiety (ANX) Ridge creeks (2005, 2006, and 2007).

In 2006, Cd, Pb, and Zn concentrations found in fish from Mainstem Red Dog Creek were higher than concentrations in fish found in Anxiety Ridge Creek, but similar to concentrations in fish found in Buddy Creek. Pairwise comparisons indicate that in every case, Mainstem Red Dog Creek fish had higher concentrations than Anxiety Ridge Creek fish and that fish from Buddy Creek had whole body concentrations somewhere in between. In 2007, as noted in the water quality section of this report, Cd, Pb, and Zn concentrations were highest in Mainstem Red Dog Creek compared with Buddy Creek. Water quality data for these sample years from Anxiety Ridge Creek are not available.

Our second objective was to determine if changes in tissue metals concentrations were occurring over time. In Mainstem Red Dog Creek, we have seen no obvious pattern of change in cadmium concentrations from 1998 through 2007 (Figure 40). Linear regression analysis provided no support for a trend in Cd concentrations in fish over time with a resulting non-significant regression (Appendix 6 - Statistical Analyses).

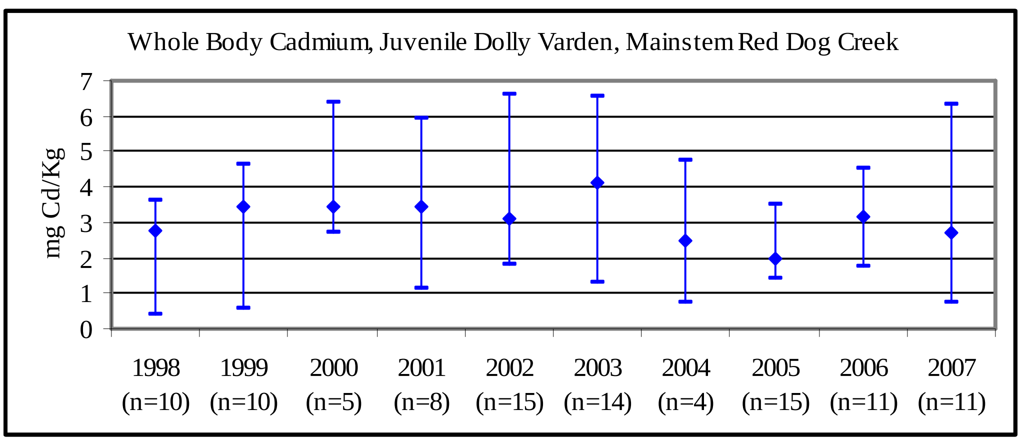

Figure 40. Whole body Cd concentrations (median, maximum, and minimum dry weight) in juvenile Dolly Varden from Mainstem Red Dog Creek.

Pb concentrations in juvenile Dolly Varden from Mainstem Red Dog Creek also do not show a trend with time (Figure 41). The median Pb values may have decreased slightly over the last 10 years. However, linear regression analysis of Pb concentrations in fish from Mainstem Red Dog Creek collected from 1998 to 2007 provides no support for a relationship with time (Appendix 6 - Statistical Analyses).

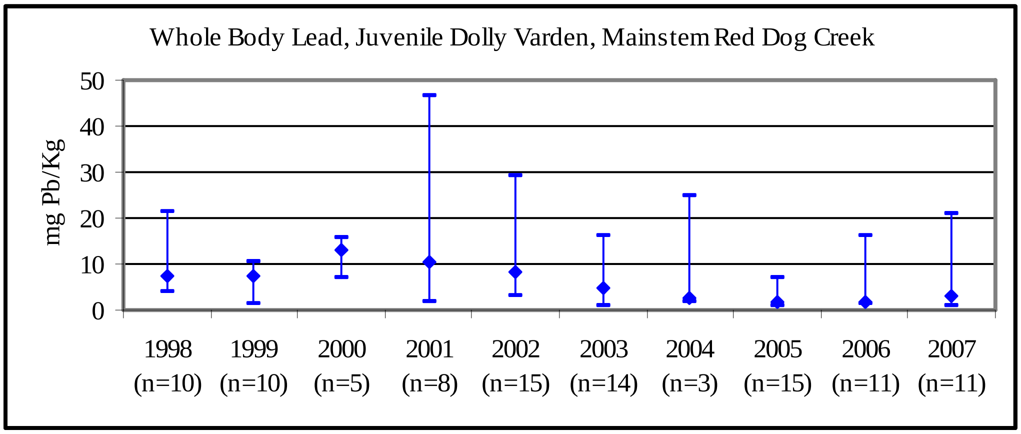

Figure 41. Whole body Pb concentrations (median, maximum, and minimum dry weight) in juvenile Dolly Varden from Mainstem Red Dog Creek.

Juvenile Dolly Varden collected in Mainstem Red Dog Creek were analyzed for Zn in 2001 through 2007 (Figure 42). There is a slight increase in Zn concentrations in the last two sample events (2006 and 2007). Regression analysis of Zn concentrations from juveniles collected over the 7 year sampling period indicates a significant increasing trend with time; however, the resultant adjusted R-squared of 0.088 suggests that time explains little of the variation observed in Zn concentrations found in sampled fish (Appendix 6 - Statistical Analyses).

The analysis appears to be influenced by the high Zn concentrations found in fish in 2006 and 2007, indicating it is likely a response to something that happened in 2006 (or late 2005) that is influencing the analysis.

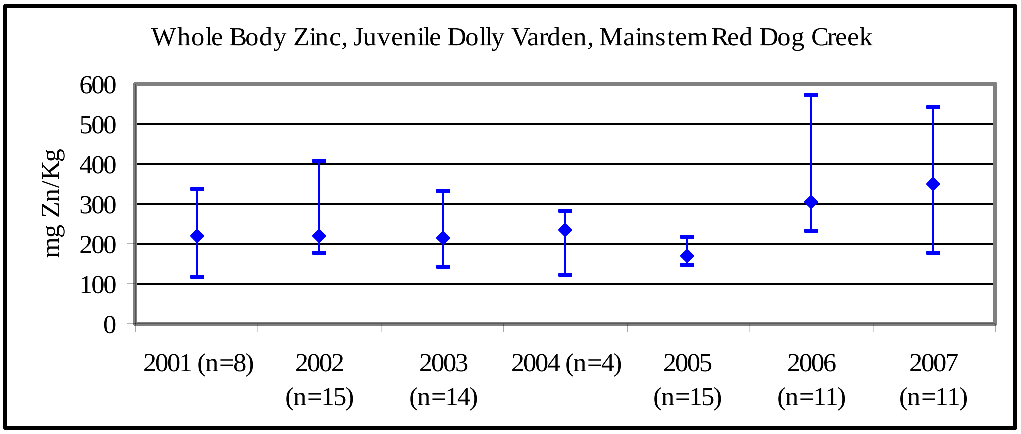

Figure 42. Whole body Zn concentrations (median, maximum, and minimum dry weight) in juvenile Dolly Varden from Mainstem Red Dog Creek.

Based on our results to date, we believe that the whole body concentrations of selected metals in juvenile Dolly Varden do reflect differences among sample sites. At Red Dog, trends with time are uncommon; rather we see what appear to be discrete events that affect metals concentrations in fish for a time period proximate to the event.

Metals Concentrations in Adult Dolly Varden

Since 1990, we have sampled adult Dolly Varden from the Wulik River at 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. In 2004, 2005, 2006, and 2007, 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 six fish, except in fall 2002 when only five fish were caught.

The purpose of sampling adult Dolly Varden for metals concentrations is to monitor long-term condition of fish over the life of the mine, to identify changes in metals that may be related to mining activities, and to provide a data base for use by other professionals. 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 vary with exposure to freshwater and marine environments. Fish collected in spring after overwintering in the freshwaters of the Wulik River likely reflect freshwater conditions, whereas fish collected in early fall generally have just returned from spending the summer in the marine environment. None of the analytes we measure concentrate in muscle tissue, but they do concentrate in other tissues, as listed below:

- Al concentrates in gill tissue (Figure 43);
- Cd concentrates in kidney tissue (Figure 44);
- Cu concentrates in liver tissue (Figure 45);
- Pb concentrates in gill tissue (Figure 46);
- Se concentrates in kidney and ovarian tissue (Figure 47);
- Zn concentrates in ovarian tissue (Figure 48); and
- Hg concentrates in kidney tissue (Figure 49).

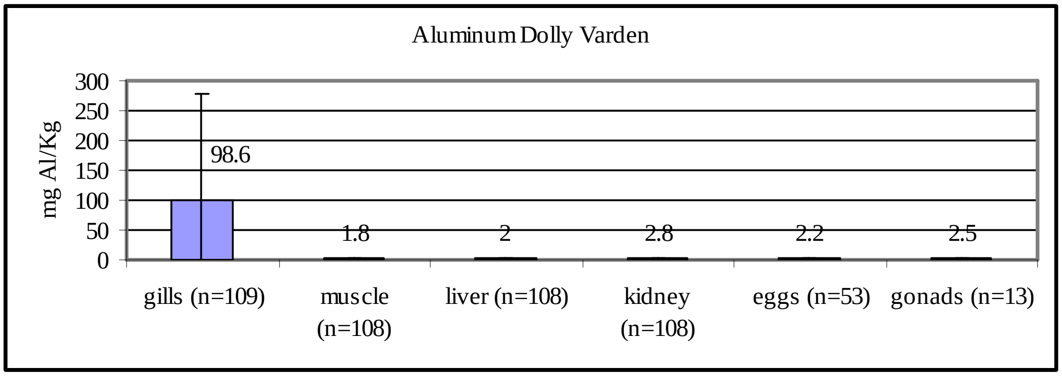

Figure 43. Average Al (mg/Kg dry weight) concentrations in adult Dolly Varden tissues (1999 to 2007), plus and minus one standard deviation.

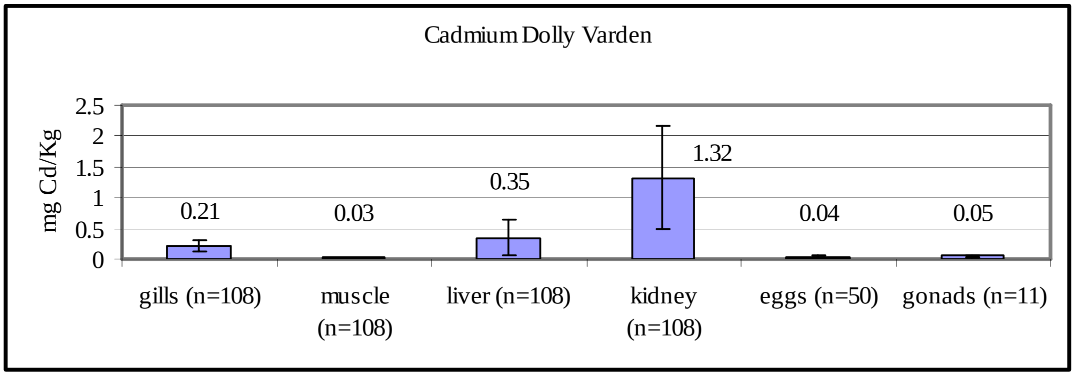

Figure 44. Average Cd (mg/Kg dry weight) concentrations in adult Dolly Varden tissues (1999 to 2007), plus and minus one standard deviation.

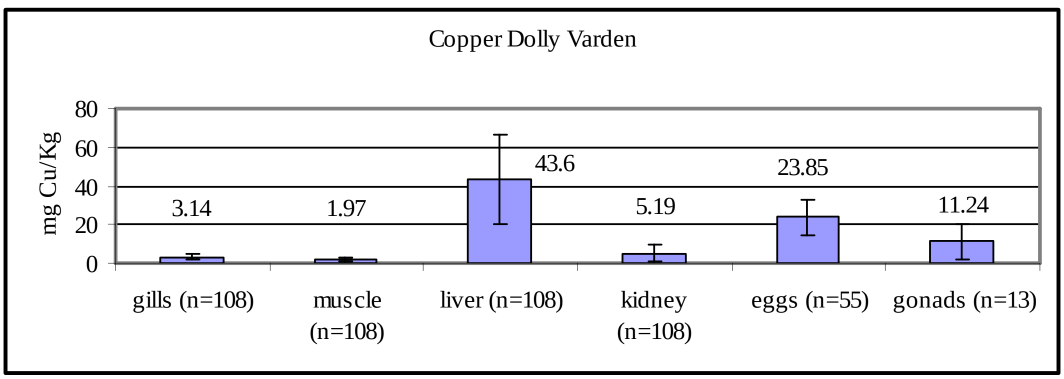

Figure 45. Average Cu (mg/Kg dry weight) concentrations in adult Dolly Varden tissues (1999 to 2007), plus and minus one standard deviation.

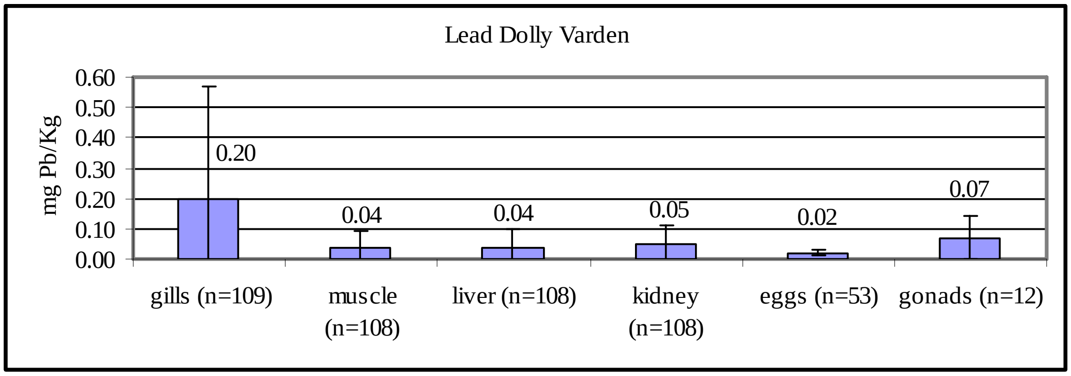

Figure 46. Average Pb (mg/Kg dry weight) concentrations in adult Dolly Varden tissues (1999 to 2007), plus and minus one standard deviation.

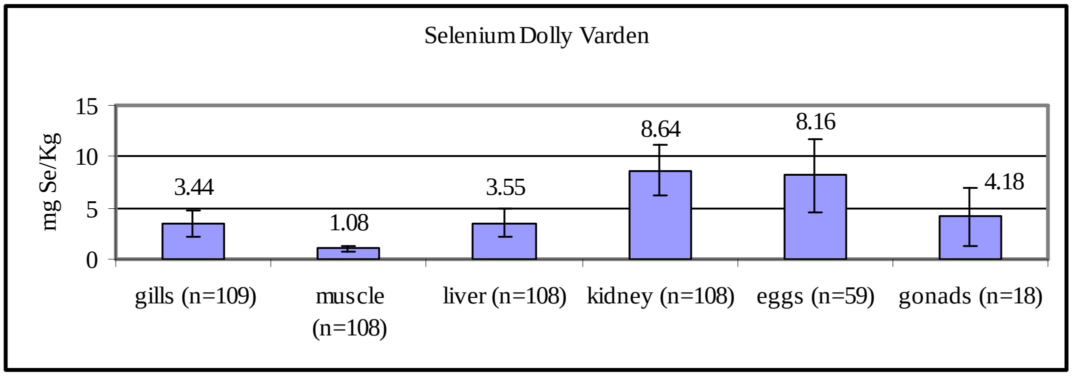

Figure 47. Average Se (mg/Kg dry weight) concentrations in adult Dolly Varden tissues (1999 to 2007), plus and minus one standard deviation.

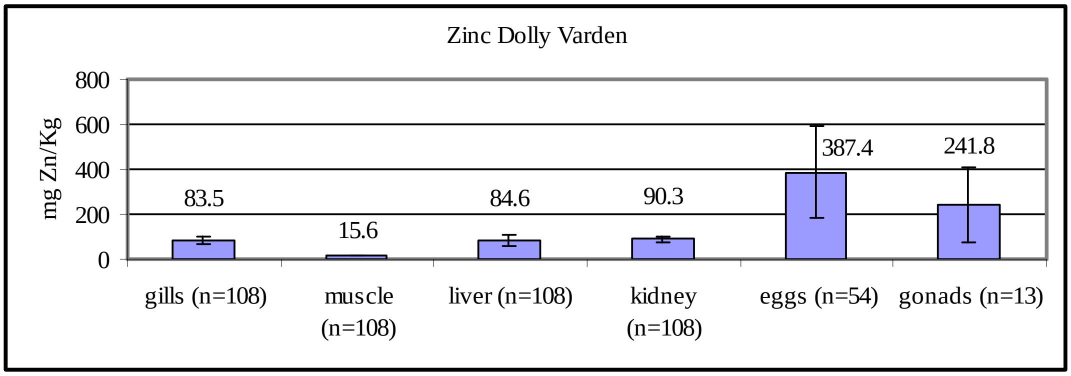

Figure 48. Average Zn (mg/Kg dry weight) concentrations in adult Dolly Varden tissues (1999 to 2007), plus and minus one standard deviation.

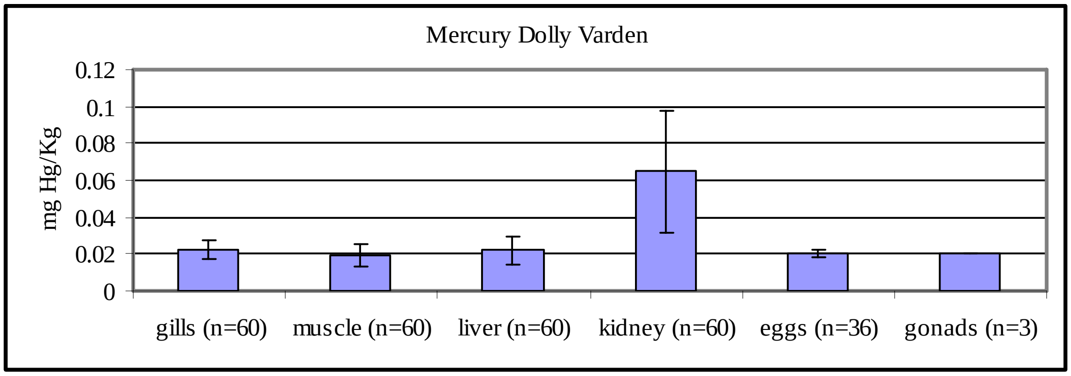

Figure 49. Average Hg (mg/Kg dry weight) concentrations in adult Dolly Varden tissues (2003 to 2007), plus and minus one standard deviation.

Included in Appendix 7 are graphs 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. Median Al concentrations in gill tissue are highly variable within samples and among spring and fall sample events. No real pattern or trend appears to exist for Al in gill tissue. Median Cd concentrations in Dolly Varden kidney tissue, both spring and fall, are lower than baseline data. Over the last four years, Cd concentrations have been stable and lower than those reported previously. Median Cu concentrations in liver tissue of Dolly Varden 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. Median Se concentrations in ovarian tissue consistently are higher in fall-caught fish. Zn concentrations (median) in ovarian tissue have remained fairly consistent during the sample period. Generally, Zn concentrations are higher in fall-caught fish. Generally, the concentration of Hg in all tissues, except kidney, are at or below the detection limit of 0.02 mg/Kg.

Dolly Varden, Overwintering

An aerial survey to estimate the number of overwintering Dolly Varden in the Wulik River was flown October 5, 2007 (DeCicco 2007). Aerial survey conditions were ideal (clear, calm winds) with the exception of a short section above Sivu where floating slush ice was present. As in 2006, DeCicco observed only a couple of schools of small Dolly Varden (1st year migrants, 250 to 325 mm long). DeCicco reported 99,311 Dolly Varden in the survey area from Kivalina Lagoon to upstream of the mouth of Ikalukrok Creek.

The number of Dolly Varden estimated in fall in the Wulik River varies annually (Figure 50, Appendix 8 and 9). Surveys conducted through fall 2007, suggest that over 90% of the Dolly Varden are seen downstream of the mouth of Ikalukrok Creek. Only in 2004 is the percentage of fish below Ikalukrok Creek less than 90% and as DeCicco (2004) stated, conditions for aerial observations in the lower river in fall 2004 were poor due to overcast skies.

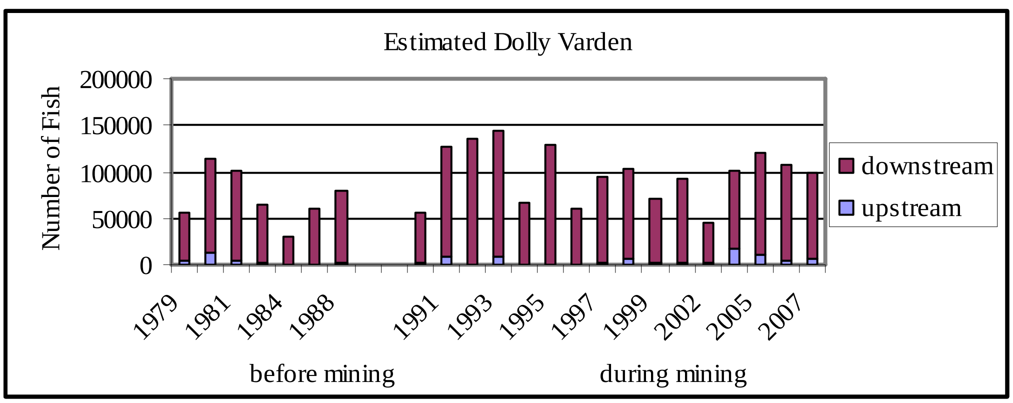

Figure 50. Estimated count of Dolly Varden in the Wulik River in fall just prior to freezeup.

Chum Salmon, Spawning

ADNR conducts annual aerial surveys to assess the distribution of adult chum salmon in Ikalukrok Creek from its confluence with Wulik River upstream to Dudd Creek (Table 4, Appendix 9). In fall 2007, we flew one helicopter (R44) survey along Ikalukrok Creek. Survey conditions were good with clear skies, scattered clouds, and a downriver wind. Each observer made a separate count with the estimated number of chum salmon being 1,408 and 1,998 (Ott and Townsend 2007). We also observed 8 chinook salmon and about 100 adult Dolly Varden. All salmon were seen downstream of Station 160. Twenty-eight dead, spawned out chum salmon were recorded. Our estimate should be viewed as the minimum number present. Adult chinook salmon were not observed in a slough (N67.56.45 W163.24.91) of Ikalukrok Creek where 56 spawners were seen in fall 2004.

Counts of chum salmon in Ikalukrok Creek after mine development in 1990 and 1991 were lower than reported in baseline studies. Surveys began again in 1995, with the highest count of chum salmon made in fall 2006. Large returns of chum salmon in recent years, including 2007, are good indications that the population has recovered from the low counts made in 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 1990b
August 1986	1,985	DeCicco 1990b
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

Dolly Varden Juveniles

Limited pre-mining juvenile Dolly Varden distribution and use data are available for streams in the Red Dog Mine area. However, Anxiety Ridge Creek was identified as the most productive stream system in the project area by Houghton and Hilgert (1983). Only one Dolly Varden was found in the headwaters of North Fork Red Dog Creek and that fish was presumed to be a resident (Houghton and Hilgert 1983). Surveys along Mainstem Red Dog Creek reported either a few fish or an absence of fish, and in some cases mortalities were noted 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 vicinity of the Red Dog Mine 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 10), with 10 minnow traps per sample reach and a fishing effort of about 24 hr twice each summer.

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 sample gear for juvenile Dolly Varden because they are very effective for this species and age classes, the gear is suitable for all sample sites (i.e., large to small streams), the effort is uniform across sample sites, variability due to sampler is reduced, and there is virtually no mortality to the fish. Juvenile Dolly Varden generally are the most numerous fish species present and are distributed the most widely in all the drainages being sampled. Our objectives are to assess seasonal patterns of use, to qualitatively assess numbers of fish using streams over time, and to sample juvenile Dolly Varden for whole body metal analyses from selected streams.

Relative abundance of juvenile Dolly Varden varies considerably among sample years (Figure 51), although the relative catches among some sample sites (e.g., Anxiety Ridge and Buddy Creeks) follow similar patterns. Natural environmental conditions such as duration of breakup, patterns and magnitudes of rainfall events, ambient air temperatures, and strength of the age 1 cohort fish affect distribution of juveniles and relative abundance.

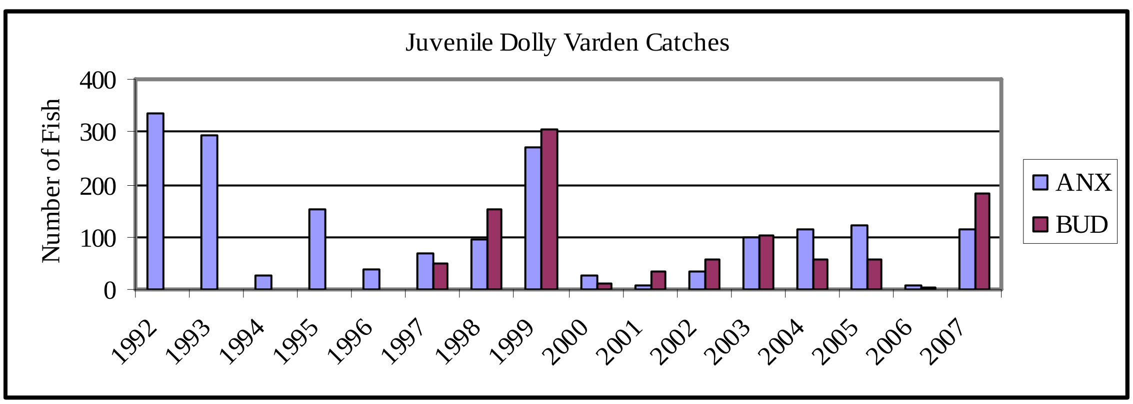

Figure 51. Catch of juvenile Dolly Varden in Anxiety Ridge (ANX) and Buddy (BUD) creeks in late July to late August of each year.

Abundance of juvenile Dolly Varden is higher in the upper reaches of streams by August. The sample reach at the mouth of Dudd Creek almost always had lower catches than in Anxiety Ridge Creek located in the upper part of the drainage.

Peak use occurs from late July to mid-August. The onset of freeze-up determines when fish leave these rearing habitats for overwintering areas. Catches of juvenile Dolly Varden in the early 1990s, when sampling occurred from spring to fall, were very low in spring, peaked in the fall, and then decreased as freezeup approached. Abundance of juvenile Dolly Varden also is highly variable among streams with catches consistently higher in Anxiety Ridge and Buddy creeks than in North Fork Red Dog or Mainstem Red Dog creeks (Figure 52 and Appendix 11).

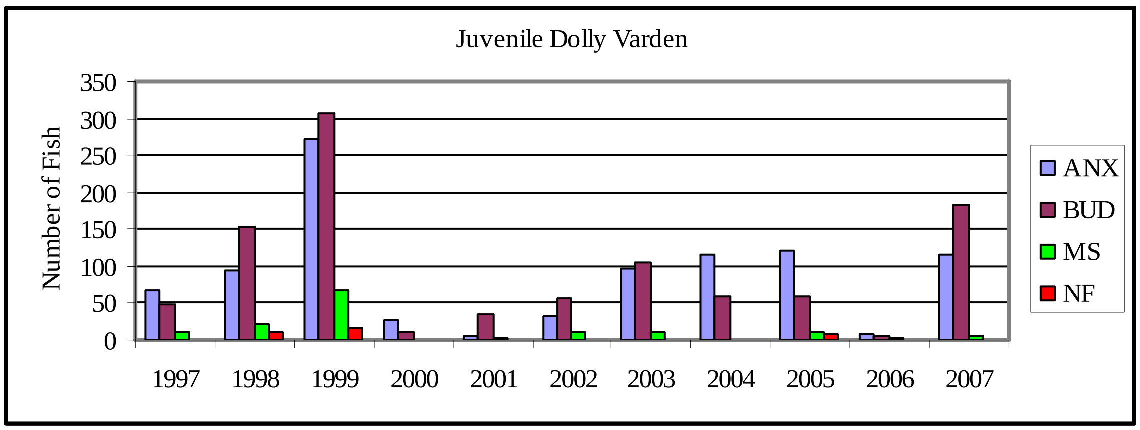

Figure 52. Catch of juvenile Dolly Varden in Anxiety Ridge (ANX), Buddy (BUD), Mainstem Red Dog (MS), and North Fork Red Dog (NF) creeks in late July to late August of each year.

The length frequency distribution of juvenile Dolly Varden, especially the presence of fry, indicates successful reproduction and survival. Dolly Varden less than 60 mm in late July and early August probably are age 0 (Houghton and Hilgert 1983, DeCicco 1985). Age 0 fish 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).

Generally, when high catches of age 1 fish occur in our sample reaches, particularly in consecutive years, catches in the following year are high. Our catch in 2007 in mid-August for the 10 sample reaches was 415 fish. This is the third highest catch seen in 11 years (Figure 53).

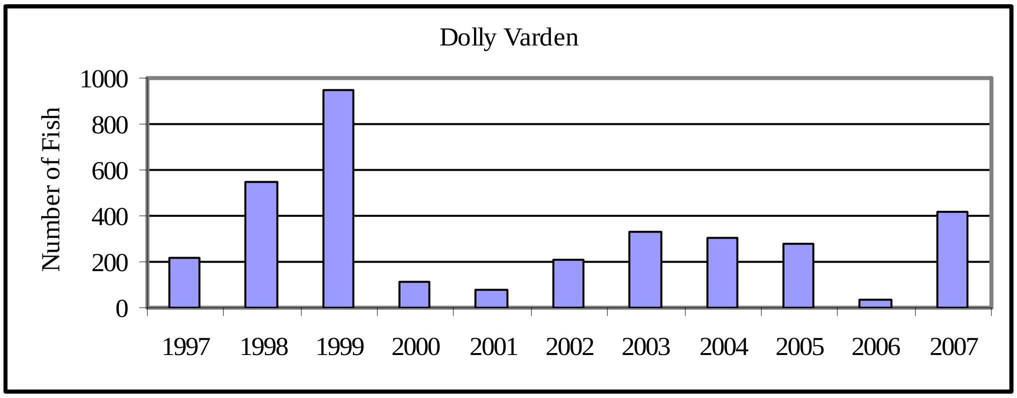

Figure 53. Catch of juvenile Dolly Varden in minnow traps fished in late-July or early August (10 sample sites, 10 minnow traps per site).

Our fall 2007 catches included a large number of Dolly Varden less than 70 mm and most of these fish probably are age 1 (Figure 54). These small Dolly Varden were common in Buddy Creek, but not in the other sample areas, including Anxiety Ridge Creek (Figures 54 and 55).

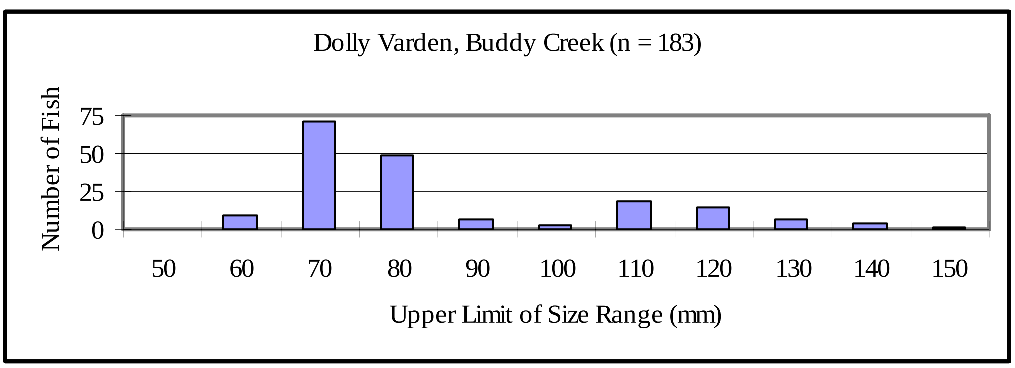

Figure 54. Length frequency distribution of Dolly Varden caught in minnow traps fished in mid-August, 2007, in Buddy Creek.

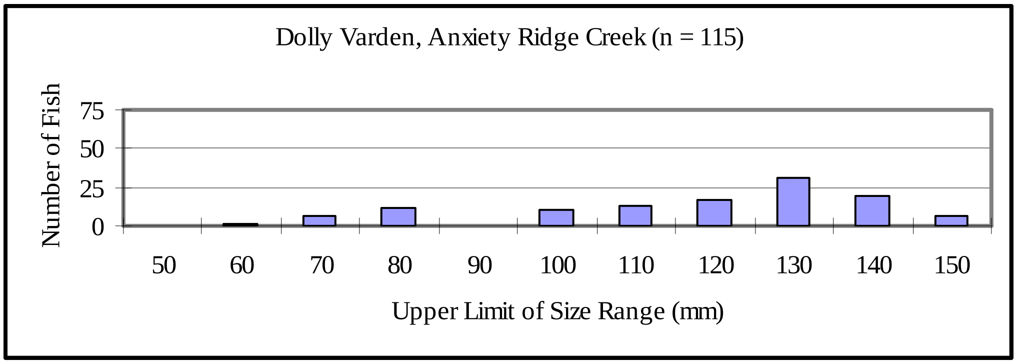

Figure 55. Length frequency distribution of Dolly Varden caught in minnow traps fished in mid-August, 2007, in Anxiety Ridge Creek.

In most summers, there are about 30 to 50 adult Dolly Varden spawners at the mouth of Dudd Creek in early July. Spawning areas in Dudd Creek immediately below the confluence of Anxiety and Buddy creeks have been documented. Adult spawners also have been seen in Buddy Creek.

Most of the juvenile Dolly Varden captured at various sample sites are from anadromous parents; however, there is a component of the population that are resident fish. Mature adults, primarily males, have been captured in minnow traps in Anxiety Ridge Creek during fall sampling.

Each spring (2000 through 2007), we capture resident Dolly Varden moving upstream with the Arctic grayling in fyke nets. In spring 2007, we caught 21 Dolly Varden, most of which were presumed to be resident fish (i.e., larger than smolts, obvious parr marks, and distinct orange/pink dots) (Figure 56). It is unknown whether this consistent change in fish use is related to water quality improvements in Mainstem Red Dog Creek or simply due to increased sampling effort and the use of fyke nets.

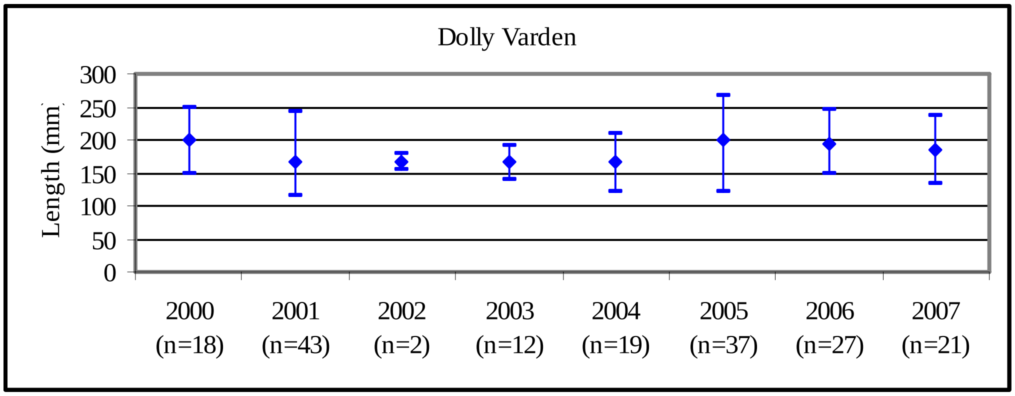

Figure 56. Dolly Varden caught in fyke nets fished in North Fork Red Dog Creek in spring during the Arctic grayling spawning run.

Juvenile Dolly Varden sampling in both upper and lower Mainstem Red Dog Creek has occurred each year since 1997. Sampling is conducted twice each summer with catches almost always being higher in the later sample period. Catches of juvenile Dolly Varden in Mainstem Red Dog Creek were highest in 1998 and 1999, but have been low every year since 2000 (Figure 57). The total catch at the 10 sample sites also was highest in 1998 and 1999.

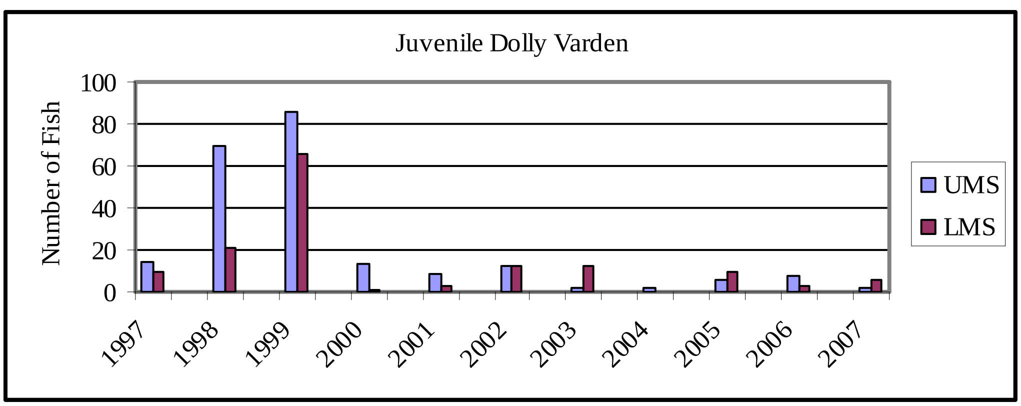

Figure 57. Catches of juvenile Dolly Varden in upper Mainstem Red Dog (UMS) and lower Mainstem Red Dog (LMS) creeks, 1997 to 2007.

Arctic Grayling

Before mine development, Arctic grayling adults migrated through Mainstem Red Dog Creek in spring when discharge was high and metals concentrations low (Ward and Olsen 1980, EVS and Ott Water Engineer 1983, and Houghton and Hilgert 1983). Arctic grayling moved through Mainstem Red Dog Creek to spawn in North Fork Red Dog Creek, but none of the reports indicated that spawning occurred 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. Very few, if any, juvenile Arctic grayling were found rearing in North Fork Red Dog Creek and mortalities of fry were reported in Mainstem Red Dog Creek (EVS Consultants Ltd and Ott Water Engineers 1983, Ward and Olson 1980). Since 1994, we have consistently documented Arctic grayling use (migration, spawning, and rearing) of Mainstem Red Dog Creek (Appendix 12).

Arctic Grayling Spawning

Water temperature is the most likely factor determining spawning time, emergence of fry, first year growth, and survival of fry. 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 completed in Mainstem Red Dog Creek.

Discharge volume and quality from the water treatment system at Red Dog are regulated to meet permit conditions (NPDES Permit AK-003865-2, dated August 28, 1998 as modified on August 22, 2003). TDS concentrations are limited to 500 mg/L at Station 151 (Station 10) during Arctic grayling spawning. Upon completion of spawning in Mainstem Red Dog Creek, TDS concentrations are not to exceed 1,500 mg/L for the remainder of the discharge 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 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).

However, due to third party appeals, the conditions of the original NPDES Permit are still in effect and in spring 2007, TCAK regulated the waste water discharge in such a manner at to maintain the TDS concentrations at or below 500 mg/L until Arctic grayling spawning was completed in Mainstem Red Dog Creek. TDS concentrations as required by permit condition did not exceed 1,500 mg/L for the remainder of the summer season (Figure 58).

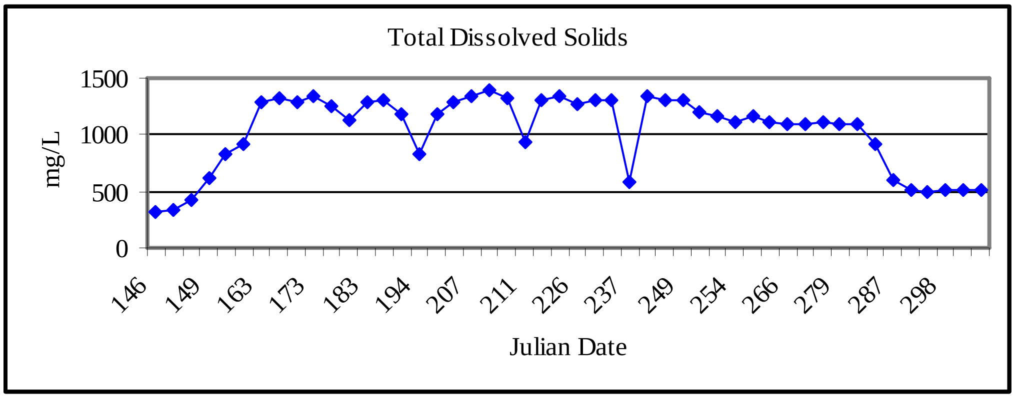

Figure 58. TDS concentrations at Station 151 during 2007. Station 151 is located immediately below the mixing zone in upper Mainstem Red Dog Creek just downstream of its confluence with North Fork Red Dog Creek.

A fyke net was set in North Fork Red Dog Creek on May 30 along the south bank, and on May 31, a large fyke net/weir combination was deployed in North Fork Red Dog Creek (Morris and Jacobs 2007) (Figure 59). These fyke nets capture fish moving upstream to spawn and rear, as well as fish that have spawned in Mainstem Red Dog Creek and are migrating upstream into North Fork Red Dog Creek. The fyke nets provide catch data that help characterize the spawning run of Arctic grayling in Mainstem Red Dog Creek. Both nets were checked twice daily until the evening of June 3 when the nets were pulled.

Figure 59. Fyke nets/weir combination in North Fork Red Dog Creek in May/June 2007.

Fyke net catches on May 31 indicated that the spawning migration of adult Arctic grayling was underway and that some spawning already was occurring in Mainstem Red Dog Creek. Upwards of 20% of adult females captured were spent or partially spent, including one female caught by angling at the mouth of North Fork Red Dog Creek. The ratio of males to females was nearly 1:1 and no immature Arctic grayling were present in the catch. Based on the increase of spent females observed in net catches on June 2, we walked Mainstem Red Dog Creek from its confluence with North Fork Red Dog Creek about 1.6 km to the 4th downstream bend. Active spawning was observed at the 4th downstream bend and fish were not receptive to wet or dry flies. Water temperatures between Station 151 and Station 10 peaked between 7.8°C and 8.9°C on June 2. By the morning of June 3, the numbers of adult fish captured at the net sites had decreased dramatically and nearly 70% of the few adult females captured were spent.

The catch was nearly 80% juvenile Arctic grayling. Based on the June 3 morning catch, we flew to the confluence of Mainstem Red Dog and Ikalukrok creeks. Several adult males were observed fighting and displaying; however, one female was observed at the confluence with Ikalukrok Creek. The female was feeding and was captured by angling. The fish was a spawned-out female. We proceeded upstream from the mouth about 0.7 km to the second bend in the creek. In this vicinity, numerous adult-sized fish, typically in groups of 3 to 6, were observed moving downstream through pools and riffles. At the pool near the mid section of the bend, all female Arctic grayling observed were actively feeding and were easily caught by angling. Only one female was brought close enough for inspection to assess condition; the female appeared spawned-out. In contrast to observations on June 2, no spawning was observed and all females seen were feeding on June 3. All fish observed were moving downstream and many were moving rapidly. Additionally, several fish were observed feeding in the large pool by Station 151 on June 3. A summary of female spawning condition from May 31 to June 3 is presented in Figure 60.

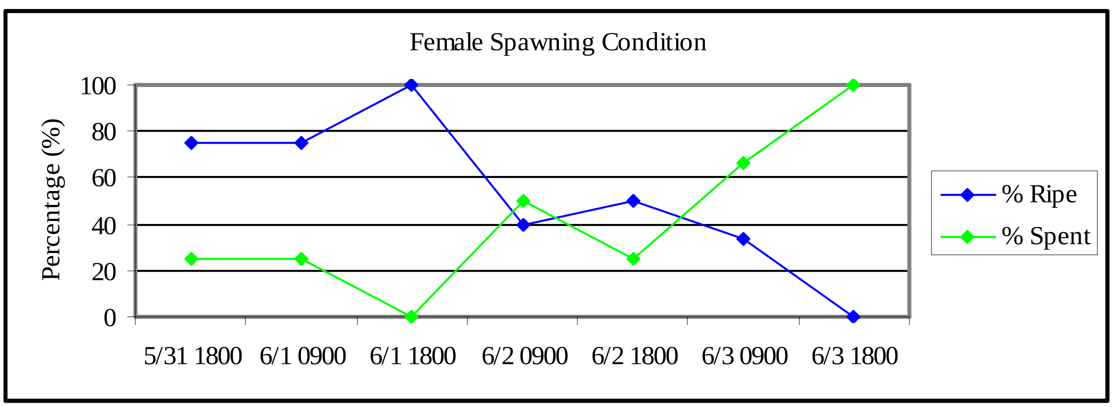

Figure 60. Twice daily adult female Arctic grayling spawning condition summary, North Fork Red Dog Creek, May/June, 2007. (Note, x-axis is the month, day and time the net was worked).

Fyke net catches on the evening of June 3 consisted of 90% immature Arctic grayling; all female Arctic grayling captured (only 2 fish) were spent/spawned-out. The shift in catch composition from adults to juveniles is typical of the end of spawning season catches observed in the Red Dog Creek system in prior years (Figure 61).

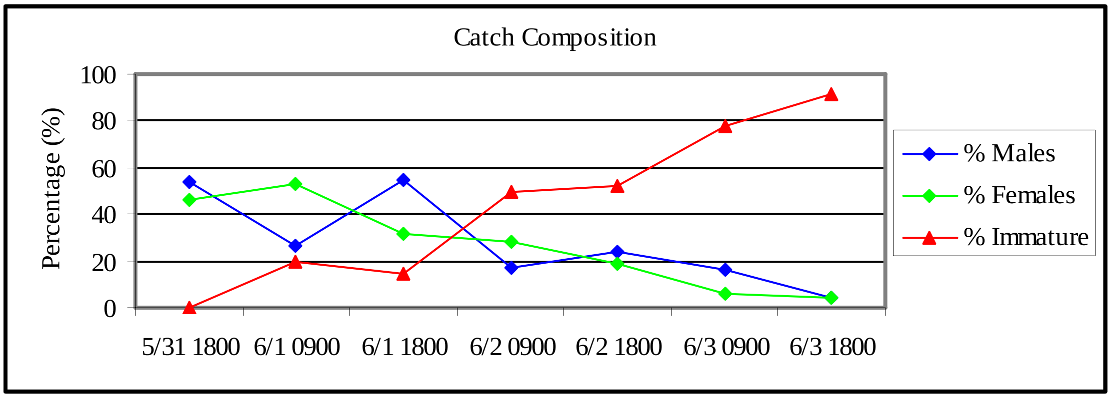

Figure 61. Twice daily Arctic grayling catch composition, North Fork Red Dog Creek, May/June, 2007. (Note, x-axis is the month, day and time the net was worked).

Water temperatures warmed quickly in spring 2007, reached at least 3°C on May 26, and peaked above 4°C for the next 8 consecutive days (Figure 62). Spawning by Arctic grayling was deemed substantially complete by 1300 hours on June 3, 2007.

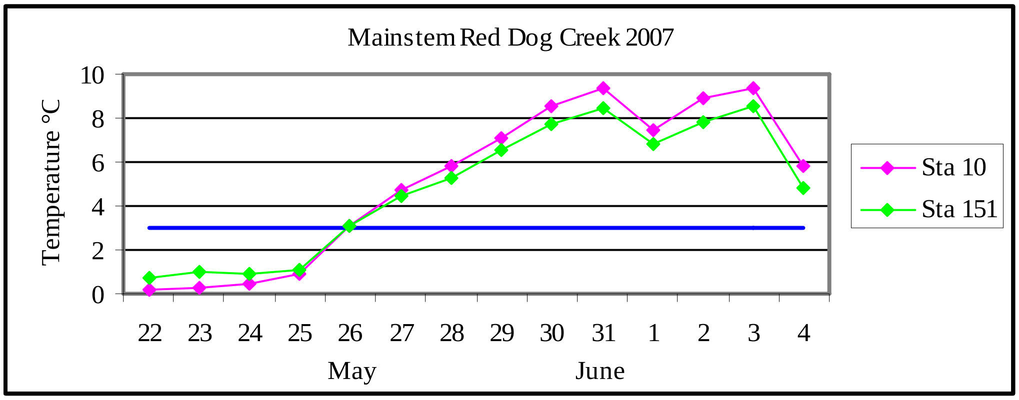

Figure 62. Water temperatures in Mainstem Red Dog Creek during spring 2007. Stations 10 and 151 are both located in Mainstem Red Dog Creek.

A summary of Arctic grayling spawning in Mainstem Red Dog Creek from spring 2001 to 2007 is presented in Table 6. The earliest spawning has been judged to be substantially complete was on May 31, 2004. The latest spawning was judged to be substantially complete was June 15 in both 2001 and 2006.

Table 6. Summary of Arctic grayling spawning in Mainstem Red Dog Creek from 2001 to 2007.

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

[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.

Arctic Grayling Mark/Recapture

In spring 2007, we caught 239 Arctic grayling in North Fork Red Dog and Mainstem Red Dog creeks. Most of these fish were caught in fyke nets fished in North Fork Red Dog Creek. A total of 120 mature fish ranging in fork length from 261 to 447 mm were captured. Mature female Arctic grayling averaged 358 mm fork length (n = 59) while males averaged 366 mm long (n = 61) (Figure 63). In comparison, we caught 130 adult Arctic grayling in Bons Creek just upstream from Bons Pond. These fish, originally transplanted from North Fork Red Dog Creek, now constitute a self-sustaining population in Bons Pond and are maturing at a much smaller size (Figure 64).

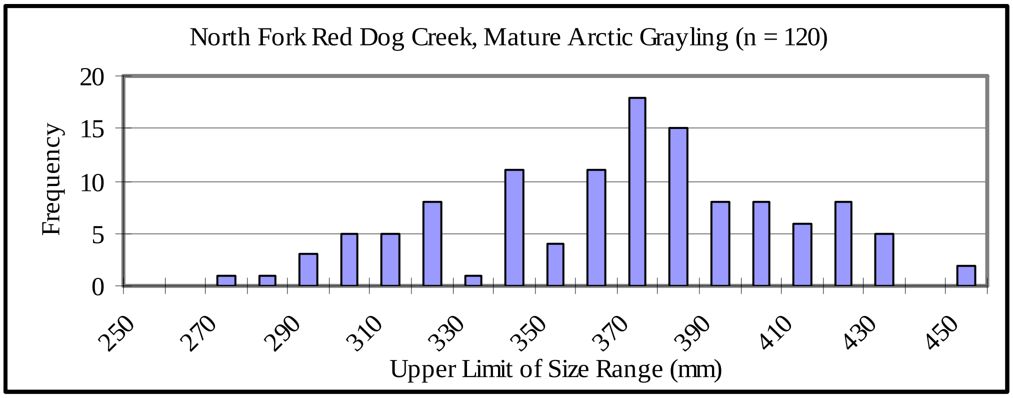

Figure 63. Length frequency distribution of mature male and female Arctic grayling captured in North Fork Red Dog Creek drainage, May/June, 2007.

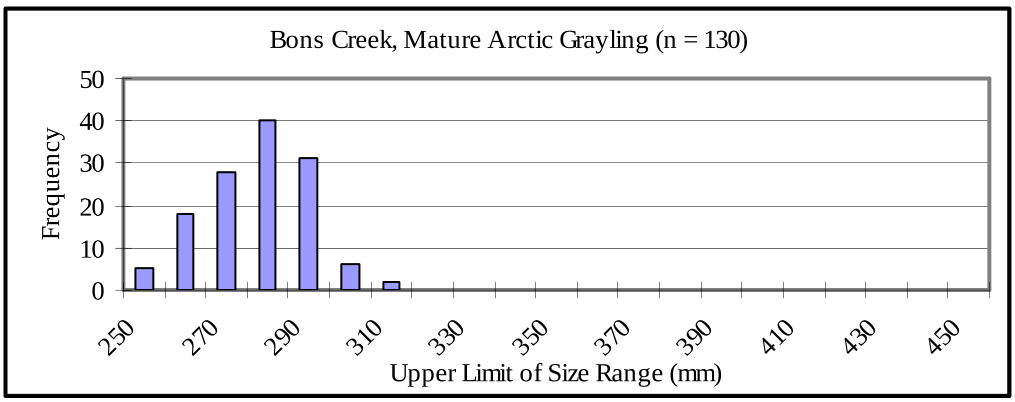

Figure 64. Length frequency distribution of mature male and female Arctic grayling captured in Bons Creek, May/June 2007.

Immature Arctic grayling captured in North Fork Red Dog Creek ranged from 107 to 315 mm fork length (n = 119). Comparison of length frequency distributions between mature and immature fish indicates that maturation occurs at lengths as low as 260 mm, but typically does not occur until fish reached between 300 and 320 mm in fork length.

The length frequency distribution of immature Arctic grayling in the Red Dog Creek drainage is a bimodal distribution showing two strong age classes (Figure 65). The strength and spread of the larger size class, ranging roughly between 260 and 300 mm suggests that a strong recruitment to the spawning Arctic grayling population will occur in the next one to two years depending on summer feeding and wintering conditions.

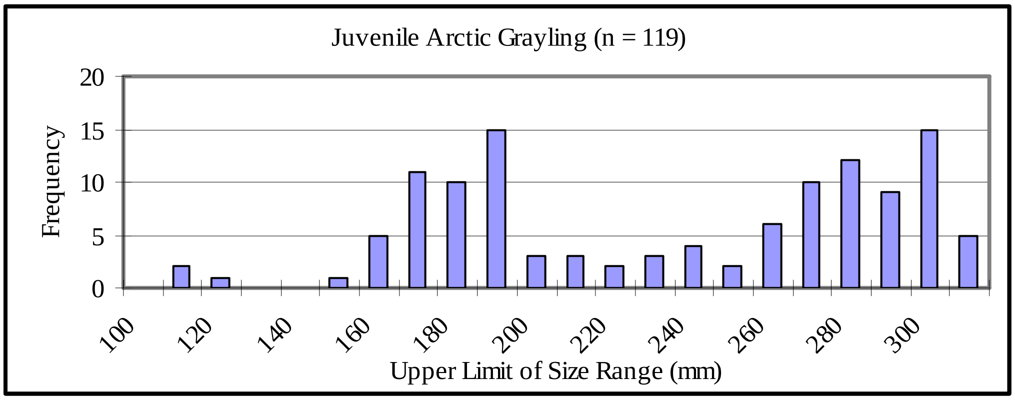

Figure 65. Length frequency distribution of immature Arctic grayling captured in North Fork Red Dog Creek drainage, May/June, 2007.

In spring 2007, 41 of the Arctic grayling caught had been marked previously; most of these fish were originally tagged in North Fork Red Dog Creek (Table 7). Seven of the recaptured fish were originally marked in Bons Pond (Table 7). The Bons Pond Arctic grayling population is the result of a fish transplant made in 1994 and 1995 (Ott and Townsend 2003). Fish that leave Bons Pond travel downstream over a waterfall that is impassable to upstream movement of fish. These fish probably continue to move downstream to overwintering habitats in lower Ikalukrok Creek or the Wulik River and then return to North Fork Red Dog Creek as a component of the spring spawning population. Recruitment of fish from Bons Pond to the North Fork Red Dog Creek population is occurring and based on 2007 catch data, is substantial (17% of the recaptured fish were from Bons Pond). Length frequency distributions for Arctic grayling caught in spring 2000 through 2007 are presented in Appendix 13.

Table 7. Arctic grayling recaptures in spring 2007 in North Fork Red Dog Creek.

Tag Number	Color	Gear Type	Length (mm)	Sex	Date Captured	Site Captured	Recapture Date	Recapture Site	Length (mm)
1745	White	Fyke Net	238	Female	7/20/1995	North Fork	7/13/1996	North Fork	272
							7/13/1999	North Fork	348
							5/31/2007	North Fork	382
13083	Green	Fyke Net	322	Female	7/9/2000	North Fork	5/31/2007	North Fork	374
13094	Green	Fyke Net	357	Female	7/10/2000	North Fork	6/2/2002	North Fork	361
							6/2/2007	North Fork	371
13124	Green	Fyke Net	406	Male	7/11/2000	North Fork	6/1/2002	North Fork	408
							5/31/2007	North Fork	420
13297	Green	Fyke Net	372	Male	6/2/2002	North Fork	5/31/2007	North Fork	396
9334	Orange	Fyke Net	298	Female	6/15/2003	North Fork	5/31/2007	North Fork	361
9714	Orange	Fyke Net	222	Male	6/16/2003	North Fork	6/1/2007	North Fork	365
9790	Orange	Fyke Net	301	Male	6/16/2003	North Fork	5/29/2004	North Fork	327
							6/3/2007	North Fork	392
15610	White	Fyke Net	328	Female	5/29/2004	North Fork	6/2/2007	North Fork	376
15617	White	Fyke Net	396	Male	5/29/2004	North Fork	6/1/2005	North Fork	403
							5/31/2007	North Fork	411
14073	White	Fyke Net	253	Female	5/30/2004	North Fork	6/1/2007	North Fork	340
15641	White	Fyke Net	301	Female	5/31/2004	North Fork	6/4/2005	North Fork	333
							6/1/2007	North Fork	355
15642	White	Fyke Net	324	Female	5/31/2004	North Fork	6/1/2007	North Fork	378
15645	White	Fyke Net	329	Male	5/31/2004	North Fork	6/2/2007	North Fork	389
15736	White	Fyke Net	323	Male	7/10/2004	North Fork	6/1/2007	North Fork	354
15738	White	Fyke Net	325	Female	7/13/2004	North Fork	6/1/2007	North Fork	351
15793	White	Fyke Net	365	Female	6/1/2005	North Fork	5/31/2007	North Fork	384
15805	White	Fyke Net	363	Male	6/2/2005	North Fork	5/31/2007	North Fork	378
15807	White	Fyke Net	440	Male	6/2/2005	North Fork	5/31/2007	North Fork	430
15802	White	Fyke Net	314	Female	6/2/2005	North Fork	6/2/2007	North Fork	336
15872	White	Fyke Net	314	Male	6/3/2005	North Fork	6/3/2007	North Fork	364
15874	White	Fyke Net	394	Male	6/3/2005	North Fork	6/14/2006	North Fork	406
15861	White	Fyke Net	295	Female	6/4/2005	North Fork	6/3/2007	North Fork	332
15855	White	Fyke Net	334	Male	6/4/2005	North Fork	5/31/2007	North Fork	368
15862	White	Fyke Net	376	Male	6/4/2005	North Fork	6/1/2007	North Fork	380
15851	White	Fyke Net	275	Male	6/4/2005	North Fork	6/1/2007	North Fork	333
15521	White	Fyke Net	229	Female	6/5/2005	North Fork	6/3/2007	North Fork	365
15879	White	Fyke Net	301	Male	6/5/2005	North Fork	6/1/2007	North Fork	365
15894	White	Fyke Net	321	Male	6/5/2005	North Fork	6/1/2007	North Fork	361
17610	Gray	Angling	380	Male	8/2/2005	rk Ikalukrok	5/31/2007	North Fork	395

Table 7. Arctic grayling recaptures in spring 2007 in North Fork Red Dog Creek (concluded).

Tag Number	Color	Gear Type	Length (mm)	Sex	Date Captured	Site Captured	Recapture Date	Recapture Site	Length (mm)
17815	Gray	Fyke Net	379	Female	6/14/2006	North Fork	5/31/2007	North Fork	380
17821	Gray	Fyke Net	410	Female	6/14/2006	North Fork	6/1/2007	North Fork	410
17873	Gray	Fyke Net	332	Female	6/15/2006	North Fork	5/31/2007	North Fork	339
17892	Gray	Fyke Net	269	Immature	6/16/2006	North Fork	6/1/2007	North Fork	289
These Fish Listed Below Were Tagged in Bons Pond									
9186	Orange	Fyke Net	222	Male	6/13/2003	Bons Pond	6/3/2007	North Fork	351
9746	Orange	Fyke Net	201	Immature	6/16/2003	Bons Pond	6/1/2007	North Fork	305
14117	White	Fyke Net	221	Immature	6/1/2004	Bons Pond	6/3/2007	North Fork	280
14730	White	Fyke Net	233	Male	6/7/2004	Bons Pond	8/20/2004	Bons Pond	257
							6/2/2007	North Fork	315
14818	White	Fyke Net	230	Female	6/8/2004	Bons Pond	6/2/2007	North Fork	290
15939	White	Fyke Net	264	Male	5/29/2005	Bons Pond	6/1/2007	North Fork	336
16059	White	Fyke Net	247	Immature	8/2/2005	Bons Pond	6/3/2007	North Fork	279

Arctic Grayling Fry

Since 1992, we have observed adult and fry Arctic grayling in North Fork Red Dog Creek. We have visual observations of active spawning in North Fork Red Dog Creek and have captured fry (12 to 15 mm long) in drift nets at Station 10 in Mainstem Red Dog Creek and at Station 12 in North Fork Red Dog Creek. We also conduct visual surveys along North Fork Red Dog in July to assess spawning success (Table 8). From 2000 through 2006, we had not seen large numbers of fry in North Fork Red Dog Creek, but in 2007, fry were numerous (Table 8). Fry also were numerous in Mainstem Red Dog Creek along the stream margins near Station 10.

Table 8. Relative abundance of Arctic grayling fry in North Fork Red Dog Creek (1992 to 2007).

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
2006	low	Spawning partially abandoned due to cold water temperatures, no fry observed in early August, July surveys not possible due to high water
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

Slimy Sculpin

Houghton and Hilgert (1983) found slimy sculpin in Ikalukrok 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 and in Anxiety Ridge Creek. Catches of slimy sculpin generally have been the highest in Ikalukrok Creek near Dudd Creek. The total catch of slimy sculpin for all sample reaches, except Evaingiknuk Creek, is presented in Figure 66. Catches were low in 2006 due in part to reduced sampling effort in July because of high water. Trends in total numbers indicate an increasing presence of slimy sculpin from 1996 through 1999, with a decrease from 2000 to 2002, and then an increasing trend through 2005.

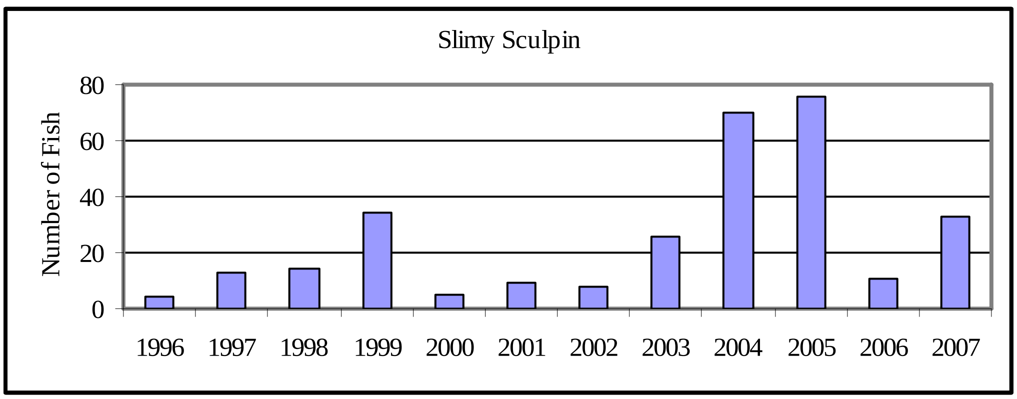

Figure 66. Slimy sculpin caught in Ikalukrok, Red Dog, Buddy, and Anxiety Ridge creeks, 1996 to 2006. Nine sites with ten buckets/site fished for about 24 hr twice each summer (early July and mid-August).

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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 (concluded)

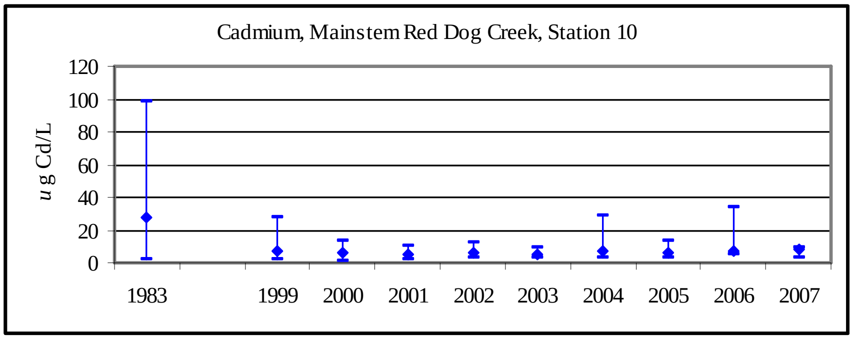
2007

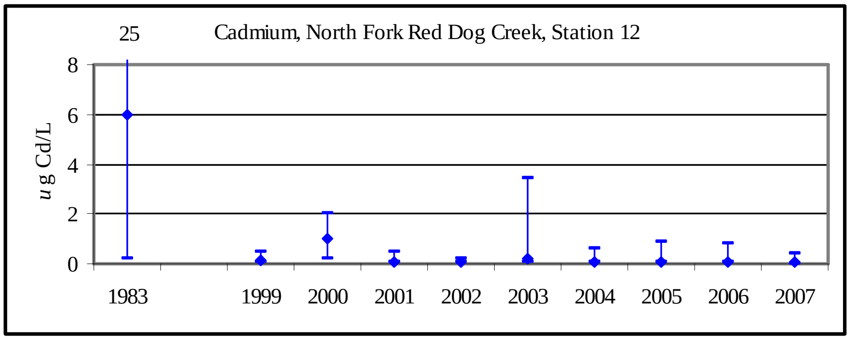
●Our two estimates for adult chum salmon in Ikalukrok Creek (downstream of Station 160) were 1,408 and 1,998 along with about 100 adult Dolly Varden and 8 chinook salmon

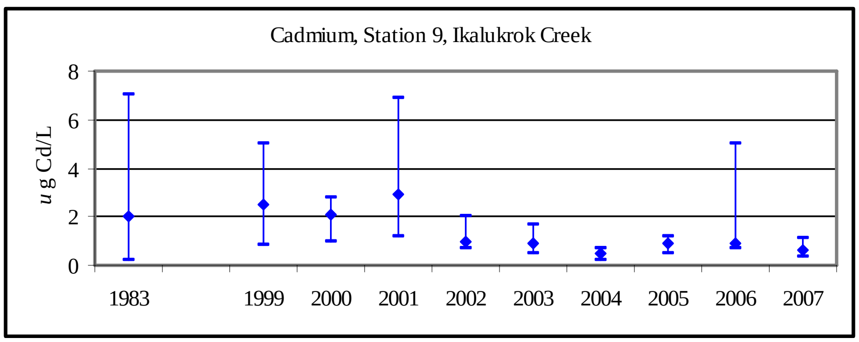
●Work on a Supplemental EIS for the Aqqaluk Extension project began with a draft scoping document in August, public meetings in early October, and draft alternatives scoping in December

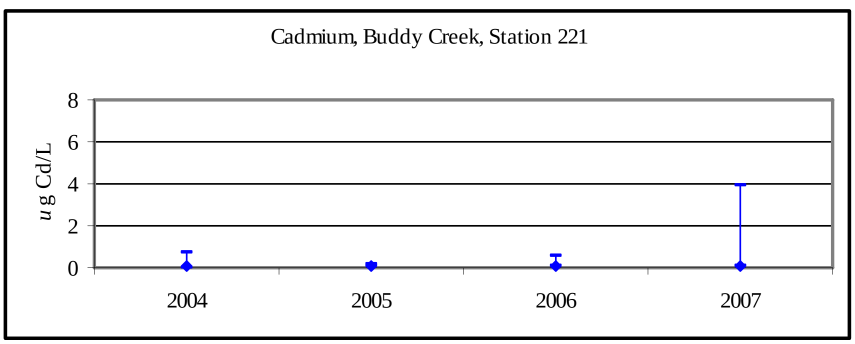
●TCAK continued to make improvements to the mine's clean water bypass system. In October, galvanized culvert was installed replacing sections of HDPE lined ditch in Middle Fork Red Dog Creek upstream of Shelly Creek and continued upstream to the Rachel Creek confluence. In addition, the section of HDPE lined ditch in Connie Creek was converted to culvert as well

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

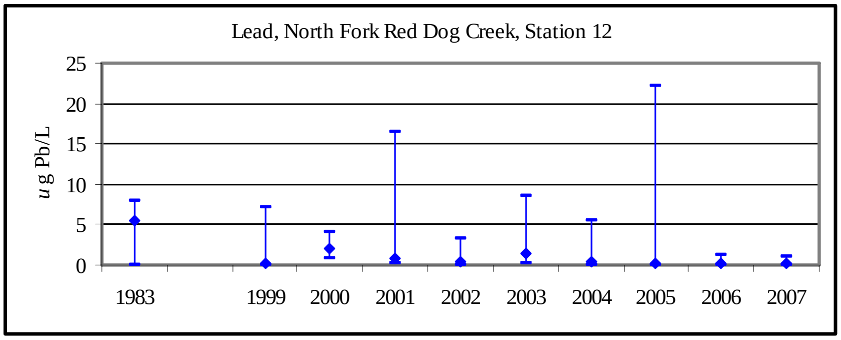


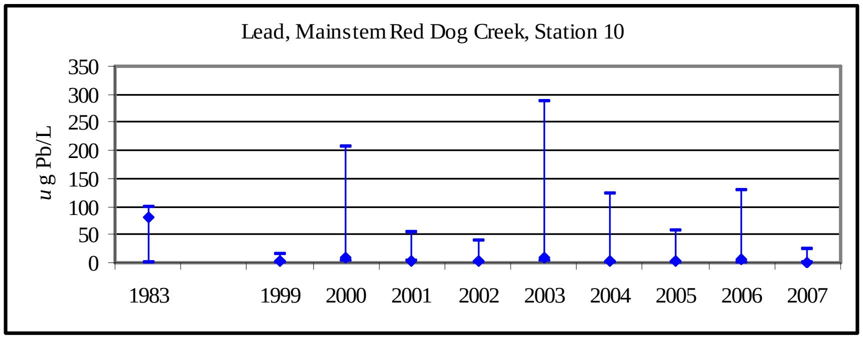


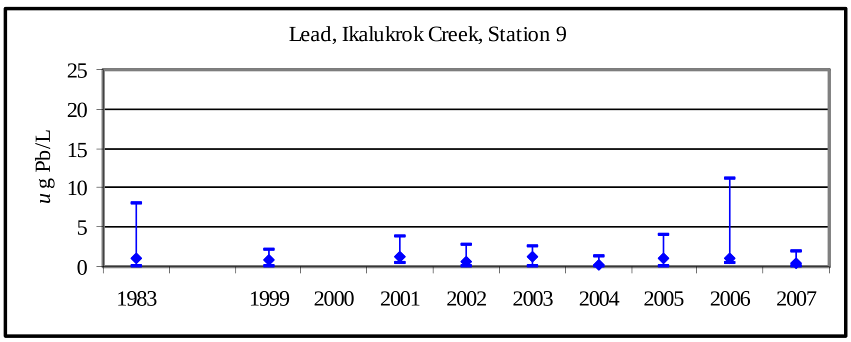


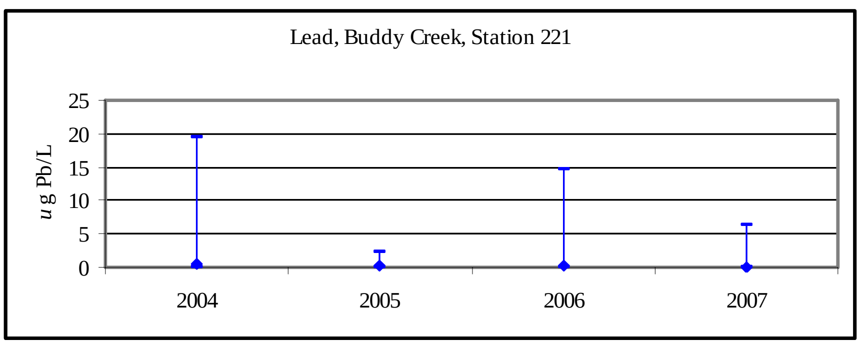


Appendix 2 (continued)

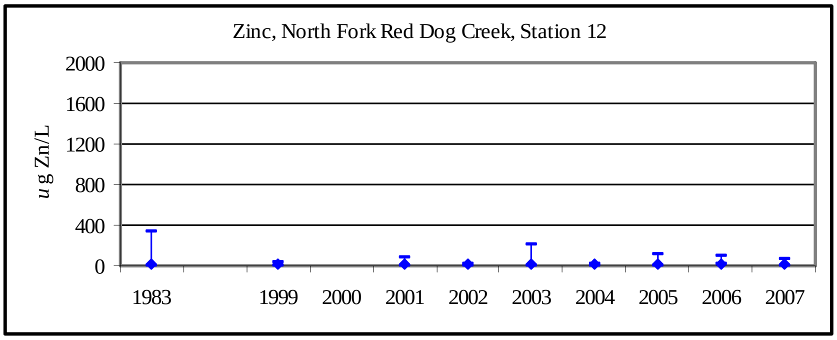


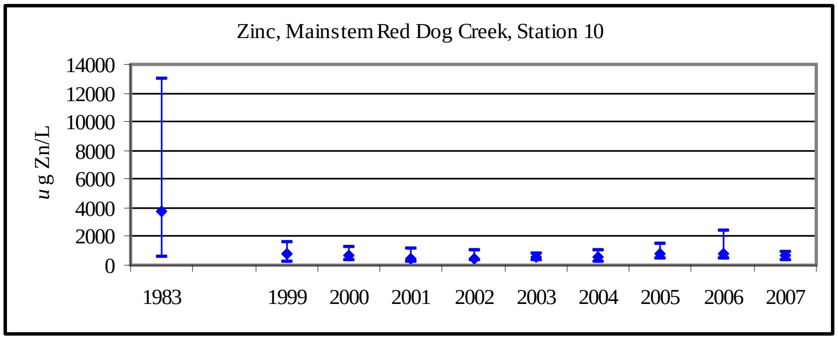


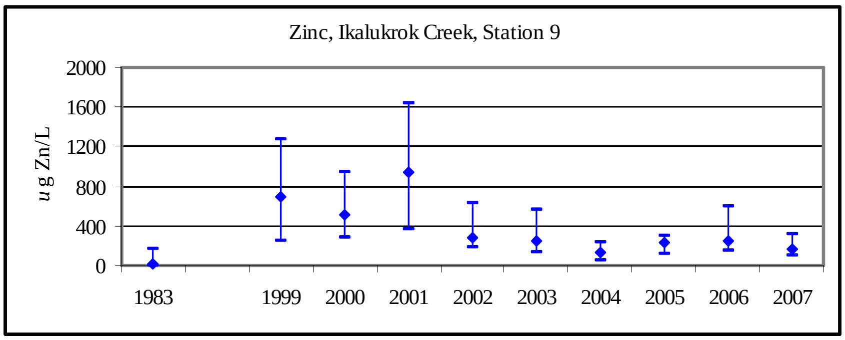


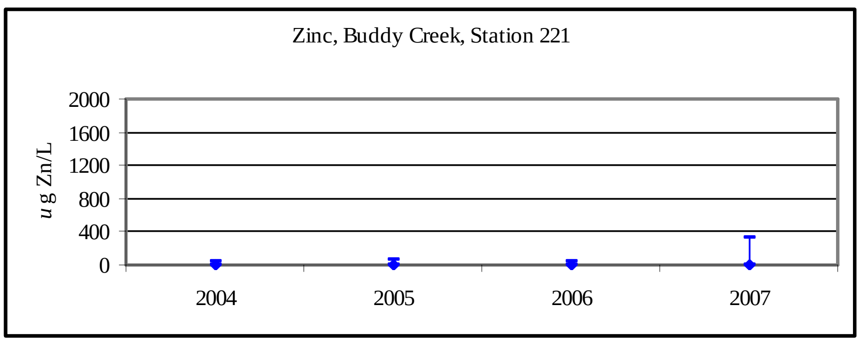


Appendix 2 (concluded)









Appendix 3. Chlorophyll Samples

Red Dog 2007 Periphyton Analysis Results - NPDES and Bons Creek Baseline												
	Note- no significant difference between Phaeo corrected Chl a and Chl a											
								Phaeo Corrected				
		Station	Date	Date	Vial	**Chl a**	**Below Method**	**Chl a**	**664/665**	Chl b	Chl c	
Daily	Site/Project	Number	Collected	Analyzed	Chl a	**mg/m2**	**Detection Limit**	**mg/m2**	**Ratio**	mg/m2	mg/m2	**Notes**
Vial #							**(0.06 Vial Chl a)**					
							OR					
							Above Linear Check					
							(6.96 Vial Chl a)					
1	BLANK	BLANK		11/14/07	0.00		**Below Detection**			0.00	0.00	
2	NPDES	STA 7	July 2007	11/14/07	0.31	**1.24**		1.28	1.80	0.00	0.10	
3	NPDES	STA 7	July 2007	11/14/07	0.33	**1.32**		1.39	1.81	0.00	0.05	
4	NPDES	STA 7	July 2007	11/14/07	0.57	**2.29**		2.24	1.72	0.00	0.06	
5	NPDES	STA 7	July 2007	11/14/07	0.33	**1.32**		1.39	1.81	0.00	0.05	
6	NPDES	STA 7	July 2007	11/14/07	0.61	**2.43**		2.46	1.77	0.00	0.04	
7	NPDES	STA 7	July 2007	11/14/07	0.44	**1.77**		1.71	1.70	0.17	0.03	
8	NPDES	STA 7	July 2007	11/14/07	0.10	**0.41**		0.53	2.25	0.04	0.04	
9	NPDES	STA 7	July 2007	11/14/07	0.46	**1.83**		1.92	1.82	0.00	0.12	
10	NPDES	STA 7	July 2007	11/14/07	0.64	**2.55**		2.56	1.75	0.11	0.09	
11	NPDES	STA 7	July 2007	11/14/07	0.38	**1.51**		1.60	1.83	0.00	0.09	
12	NPDES	STA 10	July 2007	11/14/07	0.05	**0.18**	**Below Detection**			0.00	0.04	
13	NPDES	STA 10	July 2007	11/14/07	0.07	**0.27**		0.21	1.50	0.03	0.00	
14	NPDES	STA 10	July 2007	11/14/07	0.05	**0.18**	**Below Detection**			0.00	0.04	
15	NPDES	STA 10	July 2007	11/14/07	0.08	**0.32**		0.32	1.75	0.00	0.09	
16	NPDES	STA 10	July 2007	11/14/07	0.07	**0.28**		0.32	2.00	0.00	0.03	
17	NPDES	STA 10	July 2007	11/14/07	0.06	**0.23**	**Below Detection**			0.00	0.03	
18	NPDES	STA 10	July 2007	11/14/07	0.07	**0.27**		0.21	1.50	0.02	0.10	
19	NPDES	STA 10	July 2007	11/14/07	0.16	**0.63**		0.64	1.75	0.08	0.05	
20	NPDES	STA 10	July 2007	11/14/07	0.07	**0.28**		0.32	2.00	0.00	0.03	
21	NPDES	STA 10	July 2007	11/14/07	0.08	**0.32**		0.32	1.75	0.01	0.00	
22	NPDES	STA 12	July 2007	11/14/07	0.98	**3.91**		3.84	1.71	0.69	0.18	
23	NPDES	STA 12	July 2007	11/14/07	1.77	**7.06**		6.73	1.68	0.63	0.61	
24	NPDES	STA 12	July 2007	11/14/07	0.29	**1.14**		1.17	1.79	0.00	0.01	
25	NPDES	STA 12	July 2007	11/14/07	2.69	**10.78**		10.47	1.70	0.97	0.72	
26	NPDES	STA 12	July 2007	11/14/07	0.40	**1.59**		1.71	1.84	0.09	0.12	
27	NPDES	STA 12	July 2007	11/14/07	0.42	**1.68**		1.71	1.76	0.13	0.07	
28	NPDES	STA 12	July 2007	11/14/07	4.00	**15.99**		15.81	1.72	1.59	0.23	
29	NPDES	STA 12	July 2007	11/14/07	0.33	**1.32**		1.28	1.71	0.07	0.02	
30	NPDES	STA 12	July 2007	11/14/07	3.89	**15.55**		15.27	1.72	1.32	0.29	
31	NPDES	STA 12	July 2007	11/14/07	0.25	**1.00**		1.07	1.83	0.07	0.03	
32	BLANK	BLANK		11/14/07	0.00		**Below Detection**			0.00	0.00	
28	DOUBLE	STA 12	July 2007	11/14/07	3.99	**15.98**		15.59	1.71	1.66	0.30	
1	BLANK	BLANK		11/15/07	0.00		**Below Detection**			0.00	0.00	
2	NPDES	STA 20	July 2007	11/15/07	0.02	**0.09**	**Below Detection**			0.00	0.00	
3	NPDES	STA 20	July 2007	11/15/07	0.11	**0.46**		0.43	1.67	0.02	0.00	
4	NPDES	STA 20	July 2007	11/15/07	0.01	**0.05**	**Below Detection**			0.00	0.00	
5	NPDES	STA 20	July 2007	11/15/07	0.01	**0.05**	**Below Detection**			0.00	0.00	
6	NPDES	STA 20	July 2007	11/15/07	0.04	**0.14**	**Below Detection**			0.00	0.00	
7	NPDES	STA 20	July 2007	11/15/07	0.05	**0.18**	**Below Detection**			0.00	0.04	
8	NPDES	STA 20	July 2007	11/15/07	0.02	**0.09**	**Below Detection**			0.03	0.05	
9	NPDES	STA 20	July 2007	11/15/07	0.02	**0.09**	**Below Detection**			0.04	0.00	
10	NPDES	STA 20	July 2007	11/15/07	0.02	**0.09**	**Below Detection**			0.03	0.05	
11	NPDES	STA 20	July 2007	11/15/07	0.09	**0.37**		0.43	2.00	0.00	0.00	

Appendix 3 (continued)

Red Dog 2007 Periphyton Analysis Results - NPDES and Bons Creek Baseline												
	Note- no significant difference between Phaeo corrected Chl a and Chl a											
								Phaeo Corrected				
		Station	Date	Date	Vial	**Chl a**	**Below Method**	**Chl a**	**664/665**	Chl b	Chl c	
Daily	Site/Project	Number	Collected	Analyzed	Chl a	**mg/m2**	**Detection Limit**	**mg/m2**	**Ratio**	mg/m2	mg/m2	**Notes**
Vial #							**(0.06 Vial Chl a)**					
							OR					
							Above Linear Check					
							(6.96 Vial Chl a)					
12	NPDES	STA 9	July 2007	11/15/07	0.70	**2.79**		2.88	1.79	0.00	0.19	
13	NPDES	STA 9	July 2007	11/15/07	0.53	**2.10**		2.14	1.77	0.00	0.11	
14	NPDES	STA 9	July 2007	11/15/07	1.30	**5.22**		5.13	1.73	0.00	0.32	
15	NPDES	STA 9	July 2007	11/15/07	0.61	**2.42**		2.35	1.71	0.00	0.20	
16	NPDES	STA 9	July 2007	11/15/07	0.51	**2.06**		2.14	1.80	0.00	0.12	
17	NPDES	STA 9	July 2007	11/15/07	0.72	**2.88**		2.88	1.75	0.00	0.17	
18	NPDES	STA 9	July 2007	11/15/07	0.38	**1.50**		1.60	1.83	0.06	0.06	
19	NPDES	STA 9	July 2007	11/15/07	0.62	**2.46**		2.46	1.74	0.00	0.16	
20	NPDES	STA 9	July 2007	11/15/07	0.59	**2.38**		2.24	1.68	0.00	0.21	
21	NPDES	STA 9	July 2007	11/15/07	0.46	**1.83**		1.82	1.74	0.00	0.08	
22	NPDES	IK us Dudd	July 2007	11/15/07	0.22	**0.87**		0.96	1.90	0.00	0.11	
23	NPDES	IK us Dudd	July 2007	11/15/07	0.26	**1.05**		1.07	1.77	0.05	0.03	
24	NPDES	IK us Dudd	July 2007	11/15/07	0.15	**0.59**		0.64	1.86	0.03	0.00	
25	NPDES	IK us Dudd	July 2007	11/15/07	0.22	**0.86**		0.96	1.90	0.05	0.08	
26	NPDES	IK us Dudd	July 2007	11/15/07	0.24	**0.96**		0.96	1.75	0.01	0.07	
27	NPDES	IK us Dudd	July 2007	11/15/07	0.27	**1.09**		0.96	1.60	0.03	0.02	
28	NPDES	IK us Dudd	July 2007	11/15/07	0.31	**1.23**		1.28	1.80	0.03	0.07	
29	NPDES	IK us Dudd	July 2007	11/15/07	0.25	**1.00**		1.17	2.00	0.06	0.13	
30	NPDES	IK us Dudd	July 2007	11/15/07	0.69	**2.78**		2.67	1.69	0.07	0.12	
31	NPDES	IK us Dudd	July 2007	11/15/07	0.24	**0.96**		0.96	1.75	0.01	0.07	
32	BLANK	BLANK		11/15/07	0.00		**Below Detection**			0.00	0.00	
16	DOUBLE	STA 9	July 2007	11/15/07	0.51	**2.06**		2.14	1.80	0.00	0.22	
1	BLANK			11/16/07	0.00		**Below Detection**			0.00	0.00	
2	NPDES	STA 8	July 2007	11/16/07	1.03	**4.12**		4.06	1.73	0.00	0.17	
3	NPDES	STA 8	July 2007	11/16/07	1.74	**6.95**		6.94	1.75	0.00	0.42	
4	NPDES	STA 8	July 2007	11/16/07	0.77	**3.06**		3.10	1.76	0.00	0.18	
5	NPDES	STA 8	July 2007	11/16/07	0.89	**3.57**		3.52	1.73	0.00	0.24	
6	NPDES	STA 8	July 2007	11/16/07	0.58	**2.33**		2.35	1.76	0.00	0.21	
7	NPDES	STA 8	July 2007	11/16/07	0.72	**2.88**		2.88	1.75	0.00	0.34	
8	NPDES	STA 8	July 2007	11/16/07	0.86	**3.43**		3.20	1.67	0.00	0.17	
9	NPDES	STA 8	July 2007	11/16/07	0.78	**3.11**		2.99	1.70	0.00	0.27	
10	NPDES	STA 8	July 2007	11/16/07	0.49	**1.97**		1.92	1.72	0.00	0.16	
11	NPDES	STA 8	July 2007	11/16/07	0.81	**3.24**		3.31	1.78	0.00	0.22	
12	Bons Baselin	Buddy blw F	July 2007	11/16/07	0.66	**2.63**		2.56	1.71	0.13	0.24	
13	Bons Baselin	Buddy blw F	July 2007	11/16/07	1.21	**4.86**		4.70	1.69	0.88	0.09	
14	Bons Baselin	Buddy blw F	July 2007	11/16/07	3.78	**15.10**		14.95	1.73	0.00	0.58	
15	Bons Baselin	Buddy blw F	July 2007	11/16/07	0.92	**3.66**		3.74	1.76	0.43	0.18	
16	Bons Baselin	Buddy blw F	July 2007	11/16/07	0.17	**0.67**		0.64	1.67	0.15	0.01	
17	Bons Baselin	Buddy blw F	July 2007	11/16/07	0.26	**1.04**		1.07	1.77	0.12	0.09	
18	Bons Baselin	Buddy blw F	July 2007	11/16/07	0.96	**3.82**		3.74	1.70	0.75	0.10	
19	Bons Baselin	Buddy blw F	July 2007	11/16/07	0.52	**2.08**		2.03	1.70	0.24	0.19	
20	Bons Baselin	Buddy blw F	July 2007	11/16/07	1.67	**6.70**		6.73	1.73	1.32	0.18	
21	Bons Baselin	Buddy blw F	July 2007	11/16/07	0.68	**2.74**		2.67	1.71	0.00	0.26	

Appendix 3 (concluded)

Daily Vial #	Site/Project	Station Number	Date Collected	Date Analyzed	Vial Chl a	**Chl a mg/m2**	**Below Method Detection Limit (0.06 Vial Chl a) OR Above Linear Check (6.96 Vial Chl a)**	**Phaeo Corrected Chl a mg/m2**	**Phaeo Corrected 664/665 Ratio**	Chl b mg/m2	Chl c mg/m2	**Notes**
Red Dog 2007 Periphyton Analysis Results - NPDES and Bons Creek Baseline												
	Note- no significant difference between Phaeo corrected Chl a and Chl a											
22	Bons Baselin	Lower Bons	July 2007	11/16/07	1.03	**4.11**		4.06	1.73	0.00	0.50	
23	Bons Baselin	Lower Bons	July 2007	11/16/07	2.37	**9.49**		9.40	1.73	0.58	0.62	
24	Bons Baselin	Lower Bons	July 2007	11/16/07	0.25	**1.00**		1.07	1.83	0.06	0.13	
25	Bons Baselin	Lower Bons	July 2007	11/16/07	1.25	**5.00**		4.91	1.72	0.16	0.32	
26	Bons Baselin	Lower Bons	July 2007	11/16/07	0.94	**3.76**		3.63	1.69	0.38	0.16	
27	Bons Baselin	Lower Bons	July 2007	11/16/07	1.89	**7.58**		7.37	1.71	0.00	0.34	
28	Bons Baselin	Lower Bons	July 2007	11/16/07	0.36	**1.46**		1.39	1.68	0.00	0.10	
29	Bons Baselin	Lower Bons	July 2007	11/16/07	0.73	**2.91**		2.88	1.73	0.12	0.53	
30	Bons Baselin	Lower Bons	July 2007	11/16/07	0.67	**2.69**		2.67	1.74	0.03	0.17	
31	Bons Baselin	Lower Bons	July 2007	11/16/07	0.67	**2.69**		2.67	1.74	0.04	0.07	
32	BLANK	BLANK			0.00		**Below Detection**			0.00	0.00	
3	DOUBLE	STA 8	July 2007	11/16/07	1.73	**6.90**		6.94	1.76	0.00	0.42	
33	BLANK	BLANK			0.00		**Below Detection**			0.00	0.00	
34	Bons Baselin	STA 221	July 2007	11/16/07	2.58	**10.32**		10.25	1.74	0.00	0.72	
35	Bons Baselin	STA 221	July 2007	11/16/07	0.89	**3.56**		3.52	1.73	0.01	0.18	
36	Bons Baselin	STA 221	July 2007	11/16/07	0.49	**1.96**		1.92	1.72	0.00	0.13	
37	Bons Baselin	STA 221	July 2007	11/16/07	1.93	**7.73**		7.58	1.70	1.54	0.15	
38	Bons Baselin	STA 221	July 2007	11/16/07	1.29	**5.15**		5.13	1.74	0.00	0.53	
39	Bons Baselin	STA 221	July 2007	11/16/07	1.62	**6.50**		6.51	1.74	0.29	0.55	
40	Bons Baselin	STA 221	July 2007	11/16/07	2.25	**8.99**		8.86	1.72	0.54	0.23	
41	Bons Baselin	STA 221	July 2007	11/16/07	0.97	**3.88**		3.84	1.73	0.00	0.30	
42	Bons Baselin	STA 221	July 2007	11/16/07	1.37	**5.49**		5.23	1.67	0.89	0.83	
43	Bons Baselin	STA 221	July 2007	11/16/07	0.73	**2.92**		2.99	1.78	0.00	0.20	
44	Bons Baselin	STA 220	July 2007	11/16/07	0.68	**2.73**		2.78	1.76	0.09	0.13	
45	Bons Baselin	STA 220	July 2007	11/16/07	1.56	**6.24**		6.09	1.71	0.12	0.32	
46	Bons Baselin	STA 220	July 2007	11/16/07	1.98	**7.91**		7.26	1.63	1.62	0.06	
47	Bons Baselin	STA 220	July 2007	11/16/07	4.07	**16.26**		15.38	1.67	1.47	0.85	
48	Bons Baselin	STA 220	July 2007	11/16/07	5.17	**20.67**		19.86	1.69	0.48	0.77	
49	Bons Baselin	STA 220	July 2007	11/16/07	2.49	**9.97**		8.54	1.56	2.05	0.00	
50	Bons Baselin	STA 220	July 2007	11/16/07	0.48	**1.90**		1.71	1.62	0.18	0.08	
51	Bons Baselin	STA 220	July 2007	11/16/07	1.56	**6.23**		6.30	1.76	0.29	0.26	
52	Bons Baselin	STA 220	July 2007	11/16/07	1.58	**6.30**		5.87	1.65	0.50	0.16	
53	Bons Baselin	STA 220	July 2007	11/16/07	2.89	**11.57**		10.04	1.58	2.05	0.24	
54	BLANK	BLANK		11/16/07	0.00		**Below Detection**			0.00	0.00	
45	DOUBLE	STA 220	July 2007	11/16/07	1.56	**6.24**		6.19	1.73	0.12	0.32	

Appendix 4. Aquatic Invertebrate Drift Samples

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

Appendix 4 (continued)

North Fork Red Dog Creek, Station 12, Drift Samples Invertebrates									
Date:	1999	2000	2001	2002	2003	2004	2005	2006	2007
Total aquatic taxa	13	13	18	16	26	20	21	15	21
Tot. Ephemeroptera	67	14	20	170	194	38	198	882	163
Tot. Plecoptera	23	94	117	40	64	5	5	19	11
Tot. Trichoptera	4	6	6	0	4	0	0	0	1
Total Aq. Diptera	700	314	1134	116	716	27	333	755	641
Misc.Aq.sp	30	69	226	43	188	17	39	32	135
% Ephemeroptera	8%	3%	1%	46%	16%	44%	34%	52%	17%
% Plecoptera	3%	19%	8%	11%	6%	5%	1%	1%	1%
% Trichoptera	1%	1%	0%	0%	0%	0%	0%	0%	0%
% Aq. Diptera	85%	63%	75%	31%	62%	31%	58%	45%	67%
% other	4%	14%	15%	12%	16%	19%	7%	2%	14%
% EPT	11%	23%	9%	57%	23%	50%	35%	53%	18%
% Chironomidae	54%	36%	57%	22%	27%	25%	36%	14%	61%
% Dominant Aquatic Taxon	45%	32%	43%	46%	35%	48%	34%	44%	36%
Volume of water (m^3)	559	221	747	226	672	672	380	368	297
average water/net	112	44	149	45	134	134	76	74	59
StDev of water volume	80	12	54	23	37	64	54	10	24
Estimated total inverts/m^3 water	9.23	11.8	10.2	13.5	9.3	0.9	12.4	23.6	18.3
Estimated aquatic inverts/m^3 water	7.4	11.2	10	8.1	8.7	0.6	7.6	23	16
average inv/m^3	14.2	11.5	10.2	15.0	10	0.8	16.3	23.5	19.9
average aq. Invertebrates/m^3 water	11.4	10.85	10.02	9.09	9.44	0.63	11.83	22.83	17.51
Stdev of aq. Inv. Den.	8.3	5.74	1.47	5.27	5.17	0.21	9.41	3.90	6.62
Total aquatic invertebrates	4120	2486	7509	1839	5827	435	2875	8442	4750
Total. terrestrial invertebrates	1044	129	117	1211	426	159	1833	248	670
Total invertebrates	5164	2615	7626	3050	6254	594	4708	8691	5420
% Sample aquatic	80%	95%	98%	60%	93%	73%	61%	97%	88%
% Sample terrestrial	20%	5%	2%	40%	7%	27%	39%	3%	12%
Average # aquatic inverts / net	824	497	1502	368	1165	87	575	1688	950
stdev aq inv/net	138	352	545	161	409	60	278	448	265
Average # terr. inverts / net	209	26	23	242	85	32	367	50	134
Average # inverts / net	1033	523	1525	610	1251	119	942	1738	1084
stdev inv/net	274	339	560	188	434	97	587	447	308
Total Larval Arctic Grayling/site	1	3	1	0	0	0	0	0	9
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

Appendix 4 (continued)

Mainstem Red Dog Creek, Station 10, Drift Samples Invertebrates									
	1999	2000	2001	2002	2003	2004	2005	2006	2007
Total aquatic taxa	11	7	19	12	21	17	15	20	22
Tot. Ephemeroptera	2	0	6	14	313	24	54	77	56
Tot. Plecoptera	35	16	34	30	292	16	36	45	144
Tot. Trichoptera	0	1	3	0	1	0	7	0	1
Total Aq. Diptera	182	20	676	129	438	37	396	87	558
Misc.Aq.sp	3	2	82	8	58	9	82	73	141
% Ephemeroptera	1%	1%	1%	8%	28%	28%	9%	27%	6%
% Plecoptera	16%	41%	4%	17%	27%	18%	6%	16%	16%
% Trichoptera	0%	3%	0%	0%	0%	0%	1%	0%	0%
% Aq. Diptera	82%	52%	84%	71%	40%	43%	69%	31%	62%
% other	1%	4%	10%	4%	5%	11%	14%	26%	16%
% EPT	17%	44%	5%	25%	55%	47%	17%	43%	22%
% Chironomidae	69%	25%	79%	62%	24%	39%	36%	22%	60%
% Dominant Aquatic Taxon	61%	42%	64%	52%	29%	30%	33%	23%	42%
Volume of water (m3)	869	356	1323	255	688	1239	665	417	422
average water/net	174	71	265	51	138	248	133	83	84
StDev of water volume	122	27	56	15	39	54	65	13	20
Estimated total inverts/m3 water	1.44	0.6	3.1	3.8	8.2	0.5	7.5	4.8	13.5
Estimated aquatic inverts/m3 water	1.3	0.5	3	3.6	8	0.3	4.3	3.4	10.7
average inv/m3	1.9	0.7	3.2	4.2	8.6	0.5	8.2	5	14
average aq. inverts/m3 water	1.8	0.59	3.12	4.01	8.38	0.35	4.58	3.51	11.06
Stdev of aq. Inv. Den.	1.3	0.33	0.77	2.07	1.91	0.04	1.55	1.39	2.30
Total aquatic invertebrates	1111	192	4003	910	5503	427	2875	1410	4497
Total. terrestrial invertebrates	136	21	121	49	121	173	2119	609	1218
Total invertebrates	1247	213	4123	959	5624	600	4993	2018	5715
% Sample aquatic	89%	90%	97%	95%	98%	71%	58%	70%	79%
% Sample terrestrial	11%	10%	3%	5%	2%	29%	42%	30%	21%
Average # aquatic inverts / net	222	38	801	182	1101	85	575	282	899
stdev aq inv/net	126	25	182	47	152	16	311	66	83
Average # terr. inverts / net	27	4	24	10	24	35	424	122	244
Average # inverts / net	249	43	825	192	1125	120	999	404	1143
stdev inv/net	153	27	171	51	152	25	529	69	111
Total Larval Arctic Grayling/site	5	5	0	2	1	0	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

Appendix 4 (continued)

Ikalukrok Creek, Station 9, Drift Samples Invertebrates	1999	2000	2001	2002	2003	2004	2005	2006	2007
Total aquatic taxa	8	9	15	13	21	16	13	18	20
Tot. Ephemeroptera	11	63	267	213	138	208	571	67	225
Tot. Plecoptera	17	13	159	24	54	30	189	57	98
Tot. Trichoptera	0	0	0	0	0	0	1	0	1
Total Aq. Diptera	10	58	1252	285	485	196	185	56	217
Misc.Aq.sp	9	8	56	5	23	23	23	25	24
% Ephemeroptera	24%	44%	15%	40%	19%	45%	59%	33%	40%
% Plecoptera	36%	9%	9%	5%	8%	7%	19%	28%	17%
% Trichoptera	0%	0%	0%	0%	0%	0%	0%	0%	0%
% Aq. Diptera	22%	41%	72%	54%	70%	43%	19%	27%	39%
% other	19%	6%	3%	1%	3%	5%	2%	12%	4%
% EPT	60%	54%	25%	45%	27%	52%	79%	60%	57%
% Chironomidae	21%	39%	69%	52%	65%	25%	15%	18%	35%
% Dominant Aquatic Taxon	32%	45%	65%	44%	57%	36%	37%	24%	35%
Volume of water (m^3)	260	478	833	575	450	2772	555	352	382
average water/net	52	96	167	115	90	554	111	70	76
StDev of water volume	25	16	106	29	23	161	12	16	23
Estimated total inverts/m^3 water	1.5	1.6	10.7	4.9	8.7	1.4	11.4	3.8	9.0
Estimated aquatic inverts/m^3 water	0.9	1.5	10.4	4.6	7.8	0.8	8.7	2.9	7.4
average inv/m^3	1.6	1.6	12	5	8.9	1.4	11.4	3.9	9.5
average aq inverts/m^3 water	1	1.47	11.7	4.71	7.94	0.85	8.68	2.95	7.91
Stdev of aq. inv. Den.	0.6	0.28	4.58	0.82	1.04	0.11	1.74	1.18	2.45
Total aquatic invertebrates	232	714	8668	2635	3497	2288	4848	1028	2822
Total. terrestrial invertebrates	159	66	220	168	403	1507	1482	325	606
Total invertebrates	391	780	8888	2803	3900	3795	6330	1353	3427
% Sample aquatic	59%	92%	98%	94%	90%	60%	77%	76%	82%
% Sample terrestrial	41%	8%	2%	6%	10%	40%	23%	24%	18%
Average # aquatic inverts / net	46	143	1734	527	699	458	970	206	564
stdev aq inv/net	26	46	822	102	115	90	255	81	120
Average # terr. inverts / net	32	13	44	34	81	301	296	65	121
Average # inverts / net	78	156	1778	561	780	759	1266	271	685
stdev inv/net	51	50	849	99	110	158	296	94	173
Total Larval Arctic Grayling/site	1	1	0	0	0	0	0	0	0
Total Larval Slimy Sculpin/site	0	0	0	0	0	1	0	0	0
Total Larval Dolly Varden/site	0	0	0	0	0	0	0	0	0

Appendix 4 (continued)

Ikalukrok Creek, Station 8, Drift Samples Invertebrates									
Year Sampled	1999	2000	2001	2002	2003	2004	2005	2006	2007
Total Aquatic Taxa	12	10	23	13	24	17	24	24	24
Tot. Ephemeroptera	2	4	157	35	204	53	356	22	159
Tot. Plecoptera	7	4	106	19	92	16	164	110	76
Tot. Trichoptera	0	0	1	0	0	0	2	0	0
Total Aq. Diptera	27	16	458	87	907	47	313	66	185
Misc. Aq. Sp.	1	1	55	2	77	10	41	20	29
% Ephemeroptera	5%	16%	20%	24%	16%	42%	41%	10%	35%
% Plecoptera	19%	17%	14%	13%	7%	12%	19%	50%	17%
% Tricoptera	1%	2%	0%	0%	0%	0%	0%	0%	0%
% Aq. Diptera	73%	63%	59%	61%	71%	38%	36%	30%	41%
% Other	3%	2%	7%	1%	6%	8%	5%	9%	6%
% EPT	24%	35%	34%	38%	23%	55%	60%	60%	52%
% Chironomidae	60%	51%	54%	56%	65%	30%	30%	21%	38%
% Dominant Aquatic Taxon	56%	34%	42%	41%	44%	27%	28%	47%	30%
Volume of Water (m^3)	273	371	1207	547	646	1391	706	428	281
average water/net	55	74	241	109	129	278	141	86	56
StDev of water volume	27	56	71	34	40	35	66	20	18
Estimated total inverts/m^3 water	0.84	0.42	3.3	1.4	11.2	0.63	8.13	3.9	11.16
Estimated aquatic inverts/m^3 water	0.7	0.35	3.2	1.3	9.9	0.45	6.21	2.54	7.99
average inv/m^3	1.1	0.56	3.6	1.4	11.1	0.64	8.9	4.06	12.09
average aq inverts/m^3 water	0.9	0.46	3.46	1.32	9.78	0.45	6.65	2.66	8.57
StDev of aq. Inv. Density	0.7	0.21	1.27	0.28	1.25	0.1	1.41	0.94	2.75
Total aquatic invertebrates	183	128	3883	715	6398	625	4382	1089	2248
Total terrestrial invertebrates	46	27	113	33	823	257	1355	582	892
Total invertebrates	229	155	3996	748	7221	882	5736	1671	3140
% sample aquatic	80%	83%	97%	96%	89%	71%	76%	65%	72%
% sample terrestrial	20%	17%	3%	4%	11%	29%	24%	35%	28%
Average # aquatic inverts/net	37	26	777	143	1280	125	876	218	450
StDev aq inverts/net	14	7	181	45	461	21	231	60	104
Average # terr. inverts/net	9	5	23	7	165	51	271	116	178
Average # inverts/net	46	31	799	150	1444	176	1147	334	628
StDev inverts/net	17	10	173	49	511	40	245	78	133
Total Larval Arctic Grayling/site	0	1	0	1	0	0	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

Appendix 4 (continued)

Ikalukrok Creek, Station 7U (upstream of Dudd Creek), Drift Samples Invertebrates									
Year Sampled	1999	2000	2001	2002	2003	2004	2005	2006	2007
Total aquatic taxa	14	17	19	19	16	21	15	22	19
Tot. Ephemeroptera	4	0	269	9	27	45	175	35	106
Tot. Plecoptera	66	74	75	20	26	38	15	31	21
Tot. Trichoptera	1	0	1	0	0	1	2	0	4
Total Aq. Diptera	149	269	249	199	775	210	696	215	754
Misc.Aq.sp	23	24	52	18	67	26	25	44	156
% Ephemeroptera	2%	0%	42%	4%	3%	14%	19%	11%	10%
% Plecoptera	27%	20%	12%	8%	3%	12%	2%	9%	2%
% Trichoptera	0%	0%	0%	0%	0%	0%	0%	0%	0%
% Aq. Diptera	61%	73%	39%	81%	87%	66%	76%	66%	72%
% other	9%	7%	8%	7%	8%	8%	3%	13%	15%
% EPT	29%	20%	53%	12%	6%	26%	21%	20%	13%
% Chironomidae	59%	53%	33%	30%	20%	49%	40%	40%	62%
% Dominant Aquatic Taxon	51%	48%	42%	50%	66%	30%	36%	30%	37%
Volume of water (m^3)	966	255	1069	698	824	2644	945	560	402
average water/net	193	51	214	140	165	529	189	112	80
StDev of water volume	103	14	37	21	45	264	54	47	20
Estimated total inverts/m^3 water	1.95	9.7	3.3	2.3	5.7	1	6.9	3.9	16.4
Estimated aquatic inverts/m^3 water	1.3	7.2	3	1.8	5.4	0.6	4.8	2.9	12.9
average inv/m^3	2.8	10.6	3.2	2.4	6	1.1	7.1	4.1	17.6
average aq inverts/m^3 water	1.8	7.45	3	1.79	5.75	0.66	4.74	2.99	13.87
StDev of aq. Inv. Density	1.9	1.57	0.35	0.3	1.61	0.22	0.92	0.7	5.03
Total aquatic invertebrates	1210	1840	3229	1231	4475	1600	4564	1621	5206
Total. terrestrial invertebrates	673	640	245	403	212	938	1994	578	1394
Total invertebrates	1883	2480	3474	1634	4687	2538	6558	2199	6600
% Sample aquatic	64%	74%	93%	75%	96%	63%	70%	74%	79%
% Sample terrestrial	36%	26%	7%	25%	4%	37%	30%	26%	21%
Average # aquatic inverts / net	242	368	646	246	895	320	913	324	1041
stdev aq inv/net	168	79	154	30	130	120	407	125	150
Average # terr. inverts / net	135	128	49	81	42	188	399	116	279
Average # inverts / net	377	496	695	327	937	508	1312	440	1320
stdev inv/net	241	48	168	42	140	125	424	159	250
Total Larval Arctic Grayling/site	0	3	0	3	1	0	0	0	1
Total Larval Slimy Sculpin/site	0	0	0	0	0	0	1	3	0
Total Larval Dolly Varden/site	0	0	0	0	0	0	0	0	0

Appendix 4 (continued)

Ikalukrok Creek below Dudd Creek Station 7									
Year Sampled	1999	2000	2001	2002	2003	2004	2005	2006	2007
Total aquatic taxa	10	12	18	9	18	24	18	22	18
Tot. Ephemeroptera	1	4	138	12	59	23	152	114	126
Tot. Plecoptera	9	102	43	12	37	8	4	29	21
Tot. Trichoptera	0	1	1	0	1	2	0	2	1
Total Aq. Diptera	38	319	262	111	1054	95	529	323	1356
Misc.Aq.sp	3	105	22	2	36	44	8	83	187
% Ephemeroptera	1%	1%	30%	8%	5%	13%	22%	21%	7%
% Plecoptera	17%	19%	9%	8%	3%	4%	1%	5%	1%
% Trichoptera	0%	0%	0%	0%	0%	1%	0%	0%	0%
% Aq. Diptera	75%	60%	56%	81%	89%	55%	76%	59%	80%
% other	7%	20%	5%	1%	3%	26%	1%	15%	11%
% EPT	18%	20%	39%	17%	8%	19%	22%	26%	9%
% Chironomidae	66%	39%	51%	36%	22%	43%	59%	43%	68%
% Dominant Aquatic Taxon	63%	39%	46%	46%	67%	31%	38%	27%	58%
Volume of water (m^3)	190	513	617	359	866	1182	303	617	502
average water/net	38	103	123	72	173	236	61	123	100
StDev of water volume	23	54	40	23	19	114	14	35	33
Estimated total inverts/m^3 water	1.8	5.7	3.9	2.2	7.2	1	15.3	5.2	23.1
Estimated aquatic inverts/m^3 water	1.3	5.17	3.8	1.9	6.9	0.73	11.4	4.47	16.86
average inv/m^3	2.5	6.03	4.1	2.3	7.3	0.99	15.36	5.57	26.09
average aq inverts/m^3 water	1.7	5.35	4	1.95	6.95	0.75	11.43	4.88	18.8
StDev of aq. Inv. Density	1	1.32	0.99	0.77	1.51	0.12	3.39	1.97	7.63
Total aquatic invertebrates	253	2657	2335	684	5940	857	3465	2759	8455
Total. terrestrial invertebrates	90	291	54	114	291	279	1181	428	3112
Total invertebrates	343	2948	2389	798	6232	1136	4646	3187	11567
% Sample aquatic	74%	90%	98%	86%	95%	75%	75%	87%	73%
% Sample terrestrial	26%	10%	2%	14%	5%	25%	25%	13%	27%
Average # aquatic inverts / net	51	531	467	137	1188	171	693	552	1691
stdev aq inv/net	27	309	64	56	167	63	292	111	209
Average # terr. inverts / net	18	58	11	23	58	56	236	86	622
Average # inverts / net	69	590	478	160	1246	227	929	637	2313
stdev inv/net	29	328	66	53	167	84	352	130	276
Total Larval Arctic Grayling/site	0	2	0	14	1	0	0	0	0
Total Larval Slimy Sculpin/site	0	0	0	0	1	0	0	1	0
Total Larval Dolly Varden/site	0	0	0	0	0	7	0	0	0

Appendix 5. Juvenile Dolly Varden Whole Body Metal Concentrations

Juvenile Dolly Varden, Mainstem Red Dog Creek (Stations 10 and 151 areas)												
						Method	200.80	200.8	7471A	7740.0	200.8	
						analyte	Cd	Pb	Hg	Se	Zn	
Sample		Date	Fish	Length	Weight		total	total	total	total	total	%
Number	Stream	Collected	Spp	(mm)	(g)	MRL	0.05	0.02	0.02	1.0	0.5	Solids
080798MSDVJ1	Red Dog	8/7/1998	DV	132		Juvenile	1.97	5.04		6.46		25.5
080798MSDVJ2	Red Dog	8/7/1998	DV	145		Juvenile	3.62	15.00		7.27		26.8
080798MSDVJ3	Red Dog	8/7/1998	DV	124		Juvenile	3.62	16.20		6.40		23.8
080798MSDVJ4	Red Dog	8/7/1998	DV	124		Juvenile	3.04	10.60		5.23		23.7
080798MSDVJ5	Red Dog	8/7/1998	DV	110		Juvenile	3.07	6.97		5.73		24.3
080798MSDVJ6	Red Dog	8/7/1998	DV	130		Juvenile	1.89	4.17		7.29		24.1
080798MSDVJ7	Red Dog	8/7/1998	DV	143		Juvenile	0.42	3.95		6.88		25.6
080798MSDVJ8	Red Dog	8/7/1998	DV	130		Juvenile	2.54	21.20		8.68		23.3
080798MSDVJ9	Red Dog	8/7/1998	DV	132		Juvenile	3.08	6.48		7.26		23.3
080798MSDVJ10	Red Dog	8/7/1998	DV	132		Juvenile	1.04	7.97		7.62		24.2
081299MSDVJ01	Red Dog	8/10/1999	DV	140		Juvenile	4.62	8.91		6.89		23.9
081299MSDVJ02	Red Dog	8/10/1999	DV	121		Juvenile	3.90	8.78		7.13		22.6
081299MSDVJ03	Red Dog	8/10/1999	DV	125		Juvenile	3.75	8.68		8.90		22.2
081299MSDVJ04	Red Dog	8/10/1999	DV	127		Juvenile	4.14	3.11		7.26		24.1
081299MSDVJ05	Red Dog	8/10/1999	DV	130		Juvenile	3.19	4.97		6.87		20.8
081299MSDVJ06	Red Dog	8/10/1999	DV	134		Juvenile	1.28	3.18		7.30		24.1
081299MSDVJ07	Red Dog	8/10/1999	DV	139		Juvenile	3.84	6.52		8.89		22.8
081299MSDVJ08	Red Dog	8/10/1999	DV	145		Juvenile	3.17	10.40		6.30		23.3
081299MSDVJ09	Red Dog	8/10/1999	DV	143		Juvenile	0.54	1.09		5.66		26.0
081299MSDVJ10	Red Dog	8/10/1999	DV	120		Juvenile	2.47	9.94		4.24		23.2
072800MSDVJ01	Red Dog	7/28/2000	DV	131	17.9	Juvenile	2.69	6.80		6.8		22.5
072800MSDVJ02	Red Dog	7/28/2000	DV	117	12.3	Juvenile	3.45	13.0		10.8		25.1
072800MSDVJ03	Red Dog	7/28/2000	DV	140	21.8	Juvenile	4.75	9.75		9.1		22.7
072800MSDVJ04	Red Dog	7/28/2000	DV	110	11.2	Juvenile	2.91	13.4		12.5		24.6
072800MSDVJ05	Red Dog	7/28/2000	DV	125	16	Juvenile	6.40	15.8		8.9		20.9
080501MSRDDVJ01	Red Dog	7/31/2001	DV	92	6.93	Juvenile	5.92	46.6		12.3	333	22.0
080501MSRDDVJ02	Red Dog	7/31/2001	DV	133	16.11	Juvenile	3.88	16.8		7.6	244	20.8
080501MSRDDVJ03	Red Dog	7/31/2001	DV	94	6.22	Juvenile	3.42	25.0		15.2	327	24.9
080501MSRDDVJ04	Red Dog	7/31/2001	DV	132	15.98	Juvenile	1.15	1.95		6.7	117	21.4
080501MSRDDVJ05	Red Dog	7/31/2001	DV	134	21.74	Juvenile	3.83	9.79		14.4	210	22.8
080501MSRDDVJ06	Red Dog	7/31/2001	DV	117	12.7	Juvenile	2.78	4.43		10.5	226	20.7
080501MSRDDVJ07	Red Dog	7/31/2001	DV	106	9.69	Juvenile	2.80	5.62		11.1	210	21.5
080501MSRDDVJ08	Red Dog	7/31/2001	DV	106	9.3	Juvenile	3.52	11.4		13.1	188	23.2
081002MSRDDV01	Red Dog	7/28/2002	DV	112	13.99	Juvenile	6.63	20.7		9.4	271	23.8
081002MSRDDV02	Red Dog	7/28/2002	DV	100	11.75	Juvenile	5.62	8.89		13	276	25.1
081002MSRDDV03	Red Dog	7/28/2002	DV	127	20.25	Juvenile	6.16	14.6		16.1	404	25.4
081002MSRDDV04	Red Dog	7/28/2002	DV	128	20.53	Juvenile	6.17	29.2		12.7	402	23.6
081002MSRDDV05	Red Dog	7/28/2002	DV	90	6.22	Juvenile	1.83	6.77		6.6	195	22.9
081002MSRDDV06	Red Dog	7/28/2002	DV	106	10.88	Juvenile	3.39	9.33		13	230	25.1
081002MSRDDV07	Red Dog	7/28/2002	DV	104	10.93	Juvenile	4.82	8.39		17.2	314	24.9
081002MSRDDV08	Red Dog	7/28/2002	DV	98	8.74	Juvenile	3.13	6.42		17	210	24.2
081002MSRDDV09	Red Dog	7/28/2002	DV	119	16.71	Juvenile	2.82	5		14.2	205	26.1
081002MSRDDV10	Red Dog	7/28/2002	DV	95	9.04	Juvenile	3.65	16.9		9.2	218	23.4
081002MSRDDV11	Red Dog	7/29/2002	DV	134	23.22	Juvenile	3.05	8.4		9.8	219	24.7
081002MSRDDV12	Red Dog	7/29/2002	DV	116	13.21	Juvenile	2.31	5.26		8.7	180	20.5
081002MSRDDV13	Red Dog	7/29/2002	DV	99	9.67	Juvenile	2.64	3.02		11.2	218	25.3
081002MSRDDV14	Red Dog	7/29/2002	DV	100	10.6	Juvenile	3.11	8.12		13.3	221	24
081002MSRDDV15	Red Dog	7/29/2002	DV	96	8.36	Juvenile	2.04	10.1		8.2	177	24

Appendix 5 (continued)

Juvenile Dolly Varden, Mainstem Red Dog Creek (Stations 10 and 151 areas)													
						Method	200.80	200.8		7471A	7740.0	200.8	
						analyte	Cd	Pb		Hg	Se	Zn	
Sample		Date	Fish	Length	Weight		total	total		total	total	total	%
Number	Stream	Collected	Spp	(mm)	(g)	MRL	0.05	0.02		0.02	1.0	0.5	Solids
080803MSDVJ01	Red Dog	8/8/2003	DV	150	30	Juvenile	4.98	10.7			11.8	233	25.4
080803MSDVJ02	Red Dog	8/8/2003	DV	128	16.7	Juvenile	5.48	8.4			11.5	208	24.5
081003MSDVJ03	Red Dog	8/10/2003	DV	112	13.5	Juvenile	6.56	15.2			10.1	271	23.2
081003MSDVJ04	Red Dog	8/10/2003	DV	111	13.6	Juvenile	3.86	2.42			10.0	220	25.2
081003MSDVJ05	Red Dog	8/10/2003	DV	119	15.5	Juvenile	3.41	1.72			10.1	166	24.2
081003MSDVJ06	Red Dog	8/10/2003	DV	108	12	Juvenile	2.82	3.41			10.0	197	23
081003MSDVJ07	Red Dog	8/10/2003	DV	106	11.3	Juvenile	5.92	9.26			10.4	331	23.3
081003MSDVJ08	Red Dog	8/10/2003	DV	108	11.2	Juvenile	4.65	4.51			11.0	212	24.6
081003MSDVJ09	Red Dog	8/10/2003	DV	112	12.3	Juvenile	2.96	4.66			8.5	185	24.6
081003MSDVJ10	Red Dog	8/10/2003	DV	118	16.3	Juvenile	5.15	16.3			12.7	258	24.3
081003MSDVJ11	Red Dog	8/10/2003	DV	111	11.9	Juvenile	4.37	12.7			9.6	234	24.7
081003MSDVJ12	Red Dog	8/10/2003	DV	109	11.6	Juvenile	1.29	1.87			10.1	153	24.7
081003MSDVJ13	Red Dog	8/10/2003	DV	106	15.5	Juvenile	1.86	0.97			8.2	140	24.9
081003MSDVJ14	Red Dog	8/10/2003	DV	110	12.8	Juvenile	3.53	4.42			13.7	249	25.5
082004MSDVJ01	Red Dog	8/20/2004	DV	91	6.5	Juvenile	4.72	24.7		0.06	5.7	265	20.1
082004MSDVJ02	Red Dog	8/20/2004	DV	110	10.7	Juvenile	1.23	2.4		0.03	3.9	208	21.9
082704MSDVJ03	Red Dog	8/27/2004	DV	128	18.1	Juvenile	0.76	1.63	<	0.02	3.2	120	26.2
082704MSDVJ04	Red Dog	8/27/2004	DV	116	11.8	Juvenile	3.74	147		0.04	6.8	282	22.2
072805MSRDDVJ01	Red Dog	7/28/2005	DV	109	11.52	Juvenile	3.48	3.05		0.03	10.8	167	24.1
072805MSRDDVJ02	Red Dog	7/28/2005	DV	111	11.79	Juvenile	2.5	2.06		0.02	9.7	173	24.3
072805MSRDDVJ03	Red Dog	7/28/2005	DV	123	16.36	Juvenile	1.48	2.72		0.03	8.5	176	24.3
072805MSRDDVJ04	Red Dog	7/28/2005	DV	131	19	Juvenile	1.4	2.13		0.04	9.8	159	22.3
072805MSRDDVJ05	Red Dog	7/28/2005	DV	116	15.75	Juvenile	1.66	1.63		0.03	7.8	190	24.1
072805MSRDDVJ06	Red Dog	7/28/2005	DV	103	10.96	Juvenile	2.87	7.03		0.04	7.7	214	23
072905MSRDDVJ07	Red Dog	7/29/2005	DV	122	15.89	Juvenile	1.67	1.91		0.03	10.2	147	24.2
072905MSRDDVJ08	Red Dog	7/29/2005	DV	107	12.47	Juvenile	2.11	0.95		0.03	9.2	166	24.6
072905MSRDDVJ09	Red Dog	7/29/2005	DV	119	15.9	Juvenile	3.27	1.93		0.03	9.6	171	21.7
072905MSRDDVJ10	Red Dog	7/29/2005	DV	109	13.15	Juvenile	1.71	1.62		0.04	8.7	199	23.8
072905MSRDDVJ11	Red Dog	7/29/2005	DV	136	22.93	Juvenile	2.09	1.73		0.02	9.5	163	25.6
072905MSRDDVJ12	Red Dog	7/29/2005	DV	107	11.31	Juvenile	1.6	2.19		0.03	4.6	202	22.8
072905MSRDDVJ13	Red Dog	7/29/2005	DV	114	13.03	Juvenile	2.74	0.78		0.02	8.8	145	22.7
072905MSRDDVJ14	Red Dog	7/29/2005	DV	106	10.9	Juvenile	1.96	1.72		0.04	7.6	181	23.2
072905MSRDDVJ15	Red Dog	7/29/2005	DV	113	14.66	Juvenile	1.87	1.05		0.03	8.7	164	24
081106MSRDDVJ01	Red Dog	8/11/2006	DV	109	11.94	Juvenile	3.15	1.84		0.04	5.7	288	23.1
081106MSRDDVJ02	Red Dog	8/11/2006	DV	110	14.47	Juvenile	3	5.49		0.04	6.9	349	24.5
081106MSRDDVJ03	Red Dog	8/11/2006	DV	108	11.77	Juvenile	2.8	1.15		0.04	6.2	284	24.4
081206MSRDDVJ04	Red Dog	8/12/2006	DV	94	8.33	Juvenile	4.52	12		0.06	6.3	569	20
081206MSRDDVJ05	Red Dog	8/12/2006	DV	112	13.17	Juvenile	3.35	3.99		0.04	8	305	24.1
081206MSRDDVJ06	Red Dog	8/12/2006	DV	110	13.27	Juvenile	3.68	4.81		0.03	6.6	229	23.4
081206MSRDDVJ07	Red Dog	8/12/2006	DV	112	13.14	Juvenile	2.18	1.28		0.04	7.4	260	22
081206MSRDDVJ08	Red Dog	8/12/2006	DV	108	11.03	Juvenile	2.28	1.31		0.03	6.7	317	22.2
081206MSRDDVJ09	Red Dog	8/12/2006	DV	127	18.64	Juvenile	1.77	1.53		0.05	7.4	294	22
081206MSRDDVJ10	Red Dog	8/12/2006	DV	95	8.65	Juvenile	3.76	1.24		0.03	7.4	513	22.4
081206MSRDDVJ11	Red Dog	8/12/2006	DV	102	9.75	Juvenile	3.17	16		0.02	6.4	529	21.6
081007MSRDDVJ01	Red Dog	8/10/2007	DV	124	15.67	Juvenile	5.88	13.3		0.03	7.4	540	24.8
081007MSRDDVJ02	Red Dog	8/10/2007	DV	110	11.81	Juvenile	5.58	2.89		0.03	6.2	463	24.2
081007MSRDDVJ03	Red Dog	8/10/2007	DV	123	15.89	Juvenile	4.89	0.93		0.04	4.4	192	26.7
081007MSRDDVJ04	Red Dog	8/10/2007	DV	78	4.42	Juvenile	1.06	0.87		0.04	2.6	239	27.1
081007MSRDDVJ05	Red Dog	8/10/2007	DV	120	14.32	Juvenile	2.71	3		0.04	5.5	220	23.8
081107MSRDDVJ06	Red Dog	8/11/2007	DV	78	4.3	Juvenile	6.35	3.26		0.03	6.8	359	25.3
081207MSRDDVJ07	Red Dog	8/12/2007	DV	119	15.25	Juvenile	5.43	20.9		0.06	4.9	497	24
081207MSRDDVJ08	Red Dog	8/12/2007	DV	107	11.83	Juvenile	1.88	6.32	<	0.02	3.3	351	26.1
081307MSRDDVJ09	Red Dog	8/12/2007	DV	63	2	Juvenile	1.19	2.75	<	0.18	3.5	250	21.3
081307MSRDDVJ10	Red Dog	8/12/2007	DV	65	2.31	Juvenile	0.72	1.24	<	0.02	2.9	176	22.2
081307MSRDDVJ11	Red Dog	8/12/2007	DV	65	2.36	Juvenile	1.83	1.7	<	0.02	4.5	366	21.4

Appendix 5 (continued)

Juvenile Dolly Varden, Buddy Creek, downstream of falls below the haul road												
						Method	200.80	200.8	7471A	7740.0	200.8	
						analyte	Cd	Pb	Hg	Se	Zn	
Sample		Date	Fish	Length	Weight		total	total	total	total	total	%
Number	Stream	Collected	Spp	(mm)	(g)	MRL	0.05	0.02	0.02	1.0	0.5	Solids
080302BUDVJ01	Buddy Creek	7/29/2002	DV	108	13.38	Juvenile	0.5	0.4		7.8	110	25.2
080302BUDVJ02	Buddy Creek	7/29/2002	DV	100	9.93	Juvenile	0.56	0.41		7.9	122	24.7
080302BUDVJ03	Buddy Creek	7/29/2002	DV	99	9.6	Juvenile	0.7	0.19		5.9	152	22.8
080302BUDVJ04	Buddy Creek	7/29/2002	DV	100	10.14	Juvenile	0.6	0.19		7.5	127	22.8
080302BUDVJ05	Buddy Creek	7/29/2002	DV	104	12.83	Juvenile	0.95	0.71		8.4	150	24.7
080302BUDVJ06	Buddy Creek	7/29/2002	DV	102	11.59	Juvenile	0.74	0.55		6.3	121	27.7
080302BUDVJ07	Buddy Creek	7/29/2002	DV	117	15.07	Juvenile	0.39	0.37		5.9	141	22.9
080302BUDVJ08	Buddy Creek	7/29/2002	DV	106	10.78	Juvenile	0.43	0.25		7	128	24.5
080302BUDVJ09	Buddy Creek	7/29/2002	DV	110	13.26	Juvenile	0.93	0.23		7.1	132	25
080302BUDVJ10	Buddy Creek	7/29/2002	DV	110	13.75	Juvenile	0.28	0.16		7.1	117	24.8
080302BUDVJ11	Buddy Creek	7/29/2002	DV	112	14.48	Juvenile	0.31	0.65		8.8	120	31.1
080302BUDVJ12	Buddy Creek	7/29/2002	DV	136	23.85	Juvenile	0.24	0.35		6.8	125	26.3
080302BUDVJ13	Buddy Creek	7/29/2002	DV	112	13.8	Juvenile	0.44	0.23		7.8	103	26.4
080302BUDVJ14	Buddy Creek	7/29/2002	DV	144	28.25	Juvenile	0.39	0.39		6.6	123	24.4
080302BUDVJ15	Buddy Creek	7/29/2002	DV	144	28.6	Juvenile	0.29	0.35		8.1	117	24.5
080903BUDVJ01	Buddy Creek	8/9/2003	DV	108	12.3	Juvenile	0.72	1.18		8.4	160	23.7
080903BUDVJ02	Buddy Creek	8/9/2003	DV	118	15.4	Juvenile	0.50	1.44		6.0	130	25.9
080903BUDVJ03	Buddy Creek	8/9/2003	DV	122	18.5	Juvenile	0.54	0.49		6.1	125	25.1
080903BUDVJ04	Buddy Creek	8/9/2003	DV	106	11.8	Juvenile	0.77	0.44		6.8	138	25.4
080903BUDVJ05	Buddy Creek	8/9/2003	DV	134	20.7	Juvenile	0.57	0.52		7.6	125	22.5
080903BUDVJ06	Buddy Creek	8/9/2003	DV	118	14	Juvenile	0.39	1.37		7.0	130	24.6
080903BUDVJ07	Buddy Creek	8/9/2003	DV	120	15.1	Juvenile	0.77	0.6		7.1	138	25.3
080903BUDVJ08	Buddy Creek	8/9/2003	DV	102	8.8	Juvenile	1.75	0.58		6.7	165	26.1
080903BUDVJ09	Buddy Creek	8/9/2003	DV	102	8.8	Juvenile	0.35	0.18		8.5	122	24.9
080903BUDVJ10	Buddy Creek	8/9/2003	DV	109	11.2	Juvenile	0.42	0.41		6.9	118	24.9
080903BUDVJ11	Buddy Creek	8/9/2003	DV	104	9.9	Juvenile	0.62	0.46		6.9	143	25
080903BUDVJ12	Buddy Creek	8/9/2003	DV	115	15	Juvenile	0.43	0.17		7.1	130	26.3
080903BUDVJ13	Buddy Creek	8/9/2003	DV	90	5.4	Juvenile	0.48	0.53		5.0	180	24.6
080903BUDVJ14	Buddy Creek	8/9/2003	DV	110	11	Juvenile	1.12	0.59		6.6	154	26.8
080903BUDVJ15	Buddy Creek	8/9/2003	DV	102	9.7	Juvenile	0.94	0.46		5.5	167	26.9
082404BUDVJ01	Buddy Creek	8/24/2004	DV	130	18.7	Juvenile	0.47	0.34	0.03	5.7	120	24.2
082404BUDVJ02	Buddy Creek	8/24/2004	DV	118	13.9	Juvenile	0.6	0.31	0.04	6.3	129	22.1
082404BUDVJ03	Buddy Creek	8/24/2004	DV	107	10.1	Juvenile	0.22	0.29	0.04	4.9	116	22.3
082404BUDVJ04	Buddy Creek	8/24/2004	DV	103	8.9	Juvenile	0.26	0.19	0.04	3.9	172	23.3
082404BUDVJ05	Buddy Creek	8/24/2004	DV	124	16.1	Juvenile	0.24	0.11	0.03	5.9	163	24.9
082404BUDVJ06	Buddy Creek	8/24/2004	DV	96	6.7	Juvenile	0.35	0.17	0.04	3.7	111	22.2
082404BUDVJ07	Buddy Creek	8/24/2004	DV	116	14.7	Juvenile	0.14	0.18	0.03	4.8	93.4	26.0
082404BUDVJ08	Buddy Creek	8/24/2004	DV	96	7.2	Juvenile	0.1	0.06	0.05	2.6	92.6	21.0
082404BUDVJ09	Buddy Creek	8/24/2004	DV	101	10.1	Juvenile	0.26	4.52	0.04	4.2	122	22.5
082404BUDVJ10	Buddy Creek	8/24/2004	DV	116	14.7	Juvenile	0.17	0.12	0.02	5.8	110	23.8
082404BUDVJ11	Buddy Creek	8/24/2004	DV	100	9.3	Juvenile	0.22	0.11	0.04	4.5	116	22.1
082404BUDVJ12	Buddy Creek	8/24/2004	DV	120	15.5	Juvenile	0.24	0.14	0.03	6.3	129	23.6
082404BUDVJ13	Buddy Creek	8/24/2004	DV	108	11.7	Juvenile	0.28	0.1	0.03	5.2	204	22.0
082404BUDVJ14	Buddy Creek	8/24/2004	DV	140	25.4	Juvenile	0.36	0.11	0.03	5.8	128	25.6
082404BUDVJ15	Buddy Creek	8/24/2004	DV	135	21.1	Juvenile	0.47	0.1	0.02	7.2	123	23.9

Appendix 5 (continued)

Juvenile Dolly Varden, Buddy Creek, downstream of falls below the haul road																	
						Method		200.80		200.8		7471A		7740.0		200.8	
						analyte		Cd		Pb		Hg		Se		Zn	
Sample		Date	Fish	Length	Weight			total		total		total		total		total	%
Number	Stream	Collected	Spp	(mm)	(g)	MRL		0.05		0.02		0.02		1.0		0.5	Solids
072905BUDVJ01	Buddy Creek	7/29/2005	DV	104	10.91	Juvenile		1.53		0.18		0.03		8		149	24.4
072905BUDVJ02	Buddy Creek	7/29/2005	DV	106	12	Juvenile		0.5		0.1		0.02		6.9		134	24.3
072905BUDVJ03	Buddy Creek	7/29/2005	DV	115	14.17	Juvenile		1.37		0.16		0.03		6.8		132	24
072905BUDVJ04	Buddy Creek	7/29/2005	DV	102	9.86	Juvenile		0.6		0.1		0.03		7.4		141	25.9
072905BUDVJ05	Buddy Creek	7/29/2005	DV	110	11.92	Juvenile		0.41		0.15		0.02		5.6		114	24.4
072905BUDVJ06	Buddy Creek	7/29/2005	DV	134	18.55	Juvenile		0.2		0.1		0.03		7		131	24.4
072905BUDVJ07	Buddy Creek	7/29/2005	DV	105	10.61	Juvenile		0.58		0.09		0.02		6.4		145	23
072905BUDVJ08	Buddy Creek	7/29/2005	DV	120	16.02	Juvenile		0.26		0.1		0.02		5.7		110	25
072905BUDVJ09	Buddy Creek	7/29/2005	DV	102	10.07	Juvenile		0.87		0.17		0.03		7.1		137	23.1
072905BUDVJ10	Buddy Creek	7/29/2005	DV	101	9.7	Juvenile		1.23		0.13		0.04		5.9		159	22.9
072905BUDVJ11	Buddy Creek	7/29/2005	DV	125	17.42	Juvenile		0.58		0.28		0.04		5.9		106	25.8
072905BUDVJ12	Buddy Creek	7/29/2005	DV	114	12.1	Juvenile		0.61		0.14		0.03		7.4		144	21.1
072905BUDVJ13	Buddy Creek	7/29/2005	DV	105	9.44	Juvenile		0.77		0.19	<	0.02		5.8		135	21
072905BUDVJ14	Buddy Creek	7/29/2005	DV	103	9.02	Juvenile		0.45		0.14		0.02		5.6		131	22.6
072905BUDVJ15	Buddy Creek	7/29/2005	DV	105	11.2	Juvenile		0.62		0.13		0.03		7.2		123	24.6
081506BUDVJ01	Buddy Creek	8/15/2006	DV	93	7.32	Juvenile		1.69		0.38		0.08		5.2		227	19.8
081506BUDVJ02	Buddy Creek	8/15/2006	DV	98	9.72	Juvenile		1.64		0.47		0.04		6.3		215	23.6
081506BUDVJ03	Buddy Creek	8/15/2006	DV	82	5.84	Juvenile		2.18		1.36		0.05		5.2		230	23.8
081506BUDVJ04	Buddy Creek	8/15/2006	DV	95	8.76	Juvenile		0.81		0.38		0.04		5.4		236	24.2
081506BUDVJ05	Buddy Creek	8/15/2006	DV	92	8.53	Juvenile		1.07		2.27		0.03		6.2		205	22.6
081107BUDVJ01	Buddy	8/11/2007	DV	114	12.85	Juvenile		0.77		0.66		0.04		4.8		142	27.2
081107BUDVJ02	Buddy	8/11/2007	DV	118	14.01	Juvenile		0.27		0.11		0.04		4.8		113	25.7
081107BUDVJ03	Buddy	8/11/2007	DV	121	15.94	Juvenile		0.44		0.21		0.04		4.7		129	26.1
081107BUDVJ04	Buddy	8/11/2007	DV	104	9.89	Juvenile		0.69		0.14		0.05		4.1		125	25.2
081107BUDVJ05	Buddy	8/11/2007	DV	103	10.22	Juvenile		0.80		0.12		0.04		4		154	24.9
081107BUDVJ06	Buddy	8/11/2007	DV	131	18.92	Juvenile		0.74		2.19		0.02		3.6		181	24.8
081107BUDVJ07	Buddy	8/11/2007	DV	112	13.06	Juvenile		0.57		0.66		0.04		4.7		137	26.4
081107BUDVJ08	Buddy	8/11/2007	DV	115	12.65	Juvenile		0.8		0.11		0.04		4.9		146	25.1
081107BUDVJ09	Buddy	8/11/2007	DV	112	12.37	Juvenile		0.76		0.42		0.05		5.7		130	25.2
081107BUDVJ10	Buddy	8/11/2007	DV	135	20.43	Juvenile		0.43		0.19		0.06		3.7		116	24.9
081107BUDVJ11	Buddy	8/11/2007	DV	111	11.43	Juvenile		0.94		0.1		0.03		4.7		132	25.8
081107BUDVJ12	Buddy	8/11/2007	DV	131	18.77	Juvenile		0.28		0.23		0.06		5.6		129	24.3
081107BUDVJ13	Buddy	8/11/2007	DV	105	10.34	Juvenile		0.35		1.02		0.1		4.5		133	24.7
081107BUDVJ14	Buddy	8/11/2007	DV	109	11.18	Juvenile		0.47		2.23		0.03		4		134	26
081107BUDVJ15	Buddy	8/11/2007	DV	93	7.37	Juvenile		0.67		0.26		0.04		3.7		126	23.9

Appendix 5 (continued)

Juvenile Dolly Varden, Anxiety Ridge Creek, at Haul Road																	
						Method		200.8		200.8		7471A		7740		200.8	
						analyte		Cd		Pb		Hg		Se		Zn	
Sample		Date	Fish	Length	Weight			total		total		total		total		total	%
Number	Stream	Collected	Spp	(mm)	(g)	MRL		0.05		0.02		0.02		1		0.5	Solids
082593ARDVJ1	Anxiety	8/25/1993	DV	131	20	Juvenile		0.26		1.52							22.3
082593ARDVJ2	Anxiety	8/25/1993	DV	136	21	Juvenile		0.24		2.12							24.4
082593ARDVJ3	Anxiety	8/25/1993	DV	122	17	Juvenile		0.28		2.51							24.4
082593ARDVJ4	Anxiety	8/25/1993	DV	124	19	Juvenile		0.24		1.52							24.3
082593ARDVJ5	Anxiety	8/25/1993	DV	126	18	Juvenile		0.2		0.69							24.9
082593ARDVJ6	Anxiety	8/25/1993	DV	122	16	Juvenile		0.24		2.6							23.3
081098AXDVJ01	Anxiety	8/10/1998	DV	120		Juvenile		0.14		1.03				2.9			24
081098AXDVJ02	Anxiety	8/10/1998	DV	120		Juvenile		0.1		0.72				2.5			21.6
081098AXDVJ03	Anxiety	8/10/1998	DV	118		Juvenile		0.18		1.33				5.2			21.3
081098AXDVJ04	Anxiety	8/10/1998	DV	133		Juvenile		0.21		1.45				2.8			23.2
081098AXDVJ05	Anxiety	8/10/1998	DV	142		Juvenile		0.15		1.77				3.1			22.7
081098AXDVJ06	Anxiety	8/10/1998	DV	126		Juvenile		0.16		0.62				3			21.9
081098AXDVJ07	Anxiety	8/10/1998	DV	140		Juvenile		0.11		0.17				5.1			23.9
081098AXDVJ08	Anxiety	8/10/1998	DV	128		Juvenile		0.11		1.07				3.5			22.1
081098AXDVJ09	Anxiety	8/10/1998	DV	132		Juvenile		0.15		0.41				3.6			18.6
081098AXDVJ10	Anxiety	8/10/1998	DV	111		Juvenile		0.13		1.15				4.3			22.4
081299AXDVJ01	Anxiety	8/12/1999	DV	125		Juvenile		0.22		0.42				5.6			23.2
081299AXDVJ02	Anxiety	8/12/1999	DV	134		Juvenile		0.39		0.51				5.9			23
081299AXDVJ03	Anxiety	8/12/1999	DV	135		Juvenile		0.18		0.48				4.6			23.3
081299AXDVJ04	Anxiety	8/12/1999	DV	131		Juvenile		0.37		1.2				4.2			22.9
081299AXDVJ05	Anxiety	8/12/1999	DV	137		Juvenile		0.13		0.27				4			17.6
081299AXDVJ06	Anxiety	8/12/1999	DV	130		Juvenile		0.26		0.36				4.3			22.2
081299AXDVJ07	Anxiety	8/12/1999	DV	123		Juvenile		0.34		1.1				5.2			20.4
081299AXDVJ08	Anxiety	8/12/1999	DV	127		Juvenile		0.14		0.43				4.9			23.4
081299AXDVJ09	Anxiety	8/12/1999	DV	123		Juvenile		0.23		0.68				4.5			21.9
081299AXDVJ10	Anxiety	8/12/1999	DV	126		Juvenile		0.27		0.56				5.5			25
080100AXDV01	Anxiety	8/1/2000	DV	125	16.1	Juvenile		0.21		1.36				3.4			21.9
080100AXDV02	Anxiety	8/1/2000	DV	117	12.4	Juvenile		0.31		2.86				5.4			21.4
080100AXDV03	Anxiety	8/1/2000	DV	124	14.2	Juvenile		0.31		2.09				3.9			19.8
080100AXDV04	Anxiety	8/1/2000	DV	133	21.9	Juvenile		0.11		2.3				3.9			25.2
080100AXDV05	Anxiety	8/1/2000	DV	134	18.7	Juvenile		0.27		1.2				4.1			24.3
073105AXDVJ01	Anxiety	7/31/2005	DV	118	15.05	Juvenile		0.45		0.42		0.04		3.8		126	23.8
073105AXDVJ02	Anxiety	7/31/2005	DV	135	21.32	Juvenile		0.13		0.14		0.05		3.7		107	23.4
073105AXDVJ03	Anxiety	7/31/2005	DV	102	9.25	Juvenile		0.26		0.22		0.05		7.2		135	22.1
073105AXDVJ04	Anxiety	7/31/2005	DV	114	13.41	Juvenile		0.17		0.15		0.06		5		117	22.1
073105AXDVJ05	Anxiety	7/31/2005	DV	121	16.7	Juvenile		0.11		0.17		0.06		4.1		129	22.7
073105AXDVJ06	Anxiety	7/31/2005	DV	101	8.91	Juvenile		0.27		0.2		0.06		5.3		124	21.1
073105AXDVJ07	Anxiety	7/31/2005	DV	119	14.76	Juvenile		0.1		0.06		0.07		4.6		106	22.4
073105AXDVJ08	Anxiety	7/31/2005	DV	110	11.91	Juvenile		0.12		0.24		0.05		4.2		107	23
073105AXDVJ09	Anxiety	7/31/2005	DV	109	11.62	Juvenile		0.14		0.1		0.06		5.2		114	23.2
073105AXDVJ10	Anxiety	7/31/2005	DV	123	15.22	Juvenile		0.61		0.17		0.04		6		157	20.6
073105AXDVJ11	Anxiety	7/31/2005	DV	114	13.02	Juvenile		1.75		0.23	<	0.02		7.6		175	22.9
073105AXDVJ12	Anxiety	7/31/2005	DV	113	11.67	Juvenile		0.19		0.26		0.08		5.7		188	21.1
073105AXDVJ13	Anxiety	7/31/2005	DV	105	10.96	Juvenile		0.35		0.13		0.03		4.9		137	23
073105AXDVJ14	Anxiety	7/31/2005	DV	108	10.94	Juvenile		0.28		0.27		0.07		5.1		168	21.8
073105AXDVJ15	Anxiety	7/31/2005	DV	102	8.47	Juvenile		0.13		0.13		0.05		4.2		144	20.8

Appendix 5 (concluded)

Juvenile Dolly Varden, Anxiety Ridge Creek, at Haul Road													
						Method	200.8	200.8	7471A		7740	200.8	
						analyte	Cd	Pb	Hg		Se	Zn	
Sample		Date	Fish	Length	Weight		total	total	total		total	total	%
Number	Stream	Collected	Spp	(mm)	(g)	MRL	0.05	0.02	0.02		1	0.5	Solids
081406AXDVJ01	Anxiety	8/14/2006	DV	120	16.69	Juvenile	0.57	0.78	0.1		3.9	158	23.1
081406AXDVJ02	Anxiety	8/14/2006	DV	112	13.87	Juvenile	0.27	0.44	0.08		3.8	120	24.9
081406AXDVJ03	Anxiety	8/14/2006	DV	92	7.91	Juvenile	0.65	1.03	0.09	<	1	164	23.2
081406AXDVJ04	Anxiety	8/14/2006	DV	87	6.39	Juvenile	0.33	0.44	0.09		6.1	169	23.7
081406AXDVJ05	Anxiety	8/14/2006	DV	109	12.42	Juvenile	0.54	1.25	0.09		4.1	141	23.7
081406AXDVJ06	Anxiety	8/14/2006	DV	90	7.22	Juvenile	0.32	1.36	0.09		3.7	245	23.2
081406AXDVJ07	Anxiety	8/14/2006	DV	93	8.38	Juvenile	0.57	0.11	0.07		4.4	157	25
081406AXDVJ08	Anxiety	8/14/2006	DV	103	10.84	Juvenile	0.56	1.3	0.1		2.9	147	22.8
081406AXDVJ09	Anxiety	8/14/2006	DV	116	15.94	Juvenile	0.49	1.04	0.15		4.7	129	22.9
081406AXDVJ10	Anxiety	8/14/2006	DV	90	7.67	Juvenile	0.31	0.45	0.05		3.2	142	24
081406AXDVJ11	Anxiety	8/14/2006	DV	93	8.73	Juvenile	0.48	3.69	0.07		5.9	171	25
081406AXDVJ12	Anxiety	8/14/2006	DV	123	19.77	Juvenile	0.64	0.95	0.12		3.7	155	24.9
081406AXDVJ13	Anxiety	8/14/2006	DV	84	6.29	Juvenile	0.62	0.92	0.08		4	144	24.3
081007AXDVJ01	Anxiety Ridge	8/10/2007	DV	113	12.48	Juvenile	0.25	0.25	0.14		4.4	133	23
081007AXDVJ02	Anxiety Ridge	8/10/2007	DV	93	7.7	Juvenile	0.32	0.22	0.07		3.1	93.9	27.3
081007AXDVJ03	Anxiety Ridge	8/10/2007	DV	128	18.42	Juvenile	0.25	0.2	0.09		4.6	102	24.1
081007AXDVJ04	Anxiety Ridge	8/10/2007	DV	132	21.02	Juvenile	0.29	0.27	0.1		3.6	99.4	26.4
081007AXDVJ05	Anxiety Ridge	8/10/2007	DV	125	15.85	Juvenile	0.18	0.14	0.07		4	114	24.1
081007AXDVJ06	Anxiety Ridge	8/10/2007	DV	128	18.64	Juvenile	0.22	0.16	0.05		3.6	141	24.1
081007AXDVJ07	Anxiety Ridge	8/10/2007	DV	126	16.43	Juvenile	0.09	0.15	0.07		1.3	101	26.5
081007AXDVJ08	Anxiety Ridge	8/10/2007	DV	128	17.58	Juvenile	0.21	0.38	0.05		3.5	106	23.5
081007AXDVJ09	Anxiety Ridge	8/10/2007	DV	100	10.27	Juvenile	0.21	0.52	0.05		3.4	107	26.7
081007AXDVJ10	Anxiety Ridge	8/10/2007	DV	104	10.22	Juvenile	0.38	1.07	0.05		3.2	114	26.3
081007AXDVJ11	Anxiety Ridge	8/10/2007	DV	96	8.23	Juvenile	0.26	0.77	0.08		3.8	89.8	28.5
081007AXDVJ12	Anxiety Ridge	8/10/2007	DV	103	10.15	Juvenile	0.19	0.32	0.08		3.4	119	25.4
081007AXDVJ13	Anxiety Ridge	8/10/2007	DV	129	18.73	Juvenile	0.13	0.84	0.09		3.2	113	25.3
081007AXDVJ14	Anxiety Ridge	8/10/2007	DV	102	9.33	Juvenile	0.19	0.14	0.08		3.7	78.8	27.9
081007AXDVJ15	Anxiety Ridge	8/10/2007	DV	129	19.29	Juvenile	0.17	0.2	0.08		3.4	97.2	24.7

Appendix 6. Dolly Varden Juveniles, Statistical Analyses

Between Site Comparisons of Juvenile Dolly Varden Whole Body Cd, Pb and Zn Concentrations from Mainstem Red Dog Creek, Anxiety Ridge Creek and Buddy Creek by Year (2005, 2006, 2007)

<u>2005</u>

Kruskal-Wallis One-Way Nonparametric AOV for Cd by Site, 2005.

Site	Mean Rank	Sample Size
Anxiety	10.7	15
Buddy	20.8	15
Mainstem	37.5	15
Total	23.0	45

Kruskal-Wallis Statistic 31.7730
P-Value, Using Chi-Squared Approximation 0.0000

Parametric AOV Applied to Ranks

Source	DF	SS	MS	F	P
Between	2	5479.03	2739.52	54.57	0.0000
Within	42	2108.47	50.20		
Total	44	7587.50			

Total number of values that were tied 10
Max. diff. allowed between ties 0.00001

Cases Included 45 Missing Cases 0

Kruskal-Wallis All-Pairwise Comparisons Test of Cd by Site, 2005.

Site	Mean	Homogeneous Groups
Mainstem	37.467	A
Buddy	20.833	B
Anxiety	10.700	B

Alpha 0.05
Critical Z Value 2.394 Critical Value for Comparison 11.481
There are 2 groups (A and B) in which the means
are not significantly different from one another.

Appendix 6 (continued)

Kruskal-Wallis One-Way Nonparametric AOV for Pb by Site, 2005.

Site	Mean Rank	Sample Size
Anxiety	18.3	15
Buddy	12.7	15
Mainstem	38.0	15
Total	23.0	45

Kruskal-Wallis Statistic 30.7904
P-Value, Using Chi-Squared Approximation 0.0000

Parametric AOV Applied to Ranks

Source	DF	SS	MS	F	P
Between	2	5297.70	2648.85	48.95	0.0000
Within	42	2272.80	54.11		
Total	44	7570.50			

Total number of values that were tied 17
Max. diff. allowed between ties 0.00001

Kruskal-Wallis All-Pairwise Comparisons Test of Pb by Site, 2005

Site	Mean	Homogeneous Groups
Mainstem	38.000	A
Anxiety	18.300	B
Buddy	12.700	B

Alpha 0.05
Critical Z Value 2.394 Critical Value for Comparison 11.481
There are 2 groups (A and B) in which the means
are not significantly different from one another.

Appendix 6 (continued)

Kruskal-Wallis One-Way Nonparametric AOV for Zn by Site, 2005.

Site	Mean Rank	Sample Size
Anxiety	17.2	15
Buddy	16.1	15
Mainstem	35.7	15
Total	23.0	45

Kruskal-Wallis Statistic 21.2104
P-Value, Using Chi-Squared Approximation 0.0000

Parametric AOV Applied to Ranks

Source	DF	SS	MS	F	P
Between	2	3656.63	1828.32	19.54	0.0000
Within	42	3928.87	93.54		
Total	44	7585.50			

Total number of values that were tied 18
Max. diff. allowed between ties 0.00001

Cases Included 45 Missing Cases 0

Kruskal-Wallis All-Pairwise Comparisons Test of Zn by Site, 2005

Site	Mean	Homogeneous Groups
Mainstem	35.733	A
Anxiety	17.167	B
Buddy	16.100	B

Alpha 0.05
Critical Z Value 2.394 Critical Value for Comparison 11.481
There are 2 groups (A and B) in which the means
are not significantly different from one another.

2006

Kruskal-Wallis One-Way Nonparametric AOV for Cd by Site, 2006.

Site	Mean Rank	Sample Size
Anxiety	7.0	13
Buddy	16.3	5
Mainstem	23.9	11
Total	15.0	29

Appendix 6 (continued)

Kruskal-Wallis Statistic	23.5241
P-Value, Using Chi-Squared Approximation	0.0000

Parametric AOV Applied to Ranks

Source	DF	SS	MS	F	P
Between	2	1704.65	852.327	68.32	0.0000
Within	26	324.35	12.475		
Total	28	2029.00			

Total number of values that were tied 4
Max. diff. allowed between ties 0.00001

Cases Included 29 Missing Cases 0

Kruskal-Wallis All-Pairwise Comparisons Test of Cd by Site, 2006.

Site	Mean	Homogeneous Groups
Mainstem	23.864	A
Buddy	16.300	AB
Anxiety	7.0000	B

Alpha 0.05
Critical Z Value 2.394 Critical Value for Comparison 8.3508 TO 10.994
There are 2 groups (A and B) in which the means
are not significantly different from one another.

Kruskal-Wallis One-Way Nonparametric AOV for Pb by Site, 2006.

Site	Mean Rank	Sample Size
Anxiety	10.9	13
Buddy	10.9	5
Mainstem	21.7	11
Total	15.0	29

Kruskal-Wallis Statistic	11.0708
P-Value, Using Chi-Squared Approximation	0.0039

Parametric AOV Applied to Ranks

Source	DF	SS	MS	F	P
Between	2	802.04	401.021	8.50	0.0014
Within	26	1226.46	47.171		
Total	28	2028.50			

Total number of values that were tied 6
Max. diff. allowed between ties 0.00001

Cases Included 29 Missing Cases 0

Appendix 6 (continued)

Kruskal-Wallis All-Pairwise Comparisons Test of Pb by Site, 2006.

Site	Mean	Homogeneous Groups
Mainstem	21.727	A
Buddy	10.900	AB
Anxiety	10.885	B

Alpha 0.05
Critical Z Value 2.394 Critical Value for Comparison 8.3508 TO 10.994
There are 2 groups (A and B) in which the means are not significantly different from one another.

Kruskal-Wallis One-Way Nonparametric AOV for Zn by Site, 2006.

Site	Mean Rank	Sample Size
Anxiety	7.5	13
Buddy	15.4	5
Mainstem	23.7	11
Total	15.0	29

Kruskal-Wallis Statistic 21.7571
P-Value, Using Chi-Squared Approximation 0.0000

Parametric AOV Applied to Ranks

Source	DF	SS	MS	F	P
Between	2	1577.39	788.694	45.31	0.0000
Within	26	452.61	17.408		
Total	28	2030.00			

Total number of values that were tied 0
Max. diff. allowed between ties 0.00001

Cases Included 29 Missing Cases 0

Kruskal-Wallis All-Pairwise Comparisons Test of Zn by Site, 2006.

Site	Mean	Homogeneous Groups
Mainstem	23.727	A
Buddy	15.400	AB
Anxiety	7.4615	B

Alpha 0.05
Critical Z Value 2.394 Critical Value for Comparison 8.3508 TO 10.994
There are 2 groups (A and B) in which the means are not significantly different from one another.

Appendix 6 (continued)

2007

Kruskal-Wallis One-Way Nonparametric AOV for Cd by Site, 2007.

Site	Mean Rank	Sample Size
Anxiety	8.5	15
Buddy	22.9	15
Mainstem	35.5	11
Total	21.0	41

Kruskal-Wallis Statistic	32.8380
P-Value, Using Chi-Squared Approximation	0.0000

Parametric AOV Applied to Ranks

Source	DF	SS	MS	F	P
Between	2	4710.61	2355.30	87.12	0.0000
Within	38	1027.39	27.04		
Total	40	5738.00			

Total number of values that were tied 8
Max. diff. allowed between ties 0.00001

Cases Included 41 Missing Cases 0

Kruskal-Wallis All-Pairwise Comparisons Test of Cd by Site, 2007.

Site	Mean	Homogeneous Groups
Mainstem	35.455	A
Buddy	22.933	B
Anxiety	8.4667	C

Alpha 0.05
Critical Z Value 2.394 Critical Value for Comparison 10.472 TO 11.384
All 3 means are significantly different from one another.

Appendix 6 (continued)

Kruskal-Wallis One-Way Nonparametric AOV for Pb by Site, 2007.

Site	Mean Rank	Sample Size
Anxiety	16.1	15
Buddy	15.7	15
Mainstem	34.9	11
Total	21.0	41

Kruskal-Wallis Statistic	20.2913
P-Value, Using Chi-Squared Approximation	0.0000

Parametric AOV Applied to Ranks

Source	DF	SS	MS	F	P
Between	2	2910.02	1455.01	19.56	0.0000
Within	38	2826.48	74.38		
Total	40	5736.50			

Total number of values that were tied 9
Max. diff. allowed between ties 0.00001

Cases Included 41 Missing Cases 0

Kruskal-Wallis All-Pairwise Comparisons Test of Pb by Site, 2007.

Site	Mean	Homogeneous Groups
Mainstem	34.909	A
Anxiety	16.133	B
Buddy	15.667	B

Alpha 0.05
Critical Z Value 2.394 Critical Value for Comparison 10.472 TO 11.384
There are 2 groups (A and B) in which the means
are not significantly different from one another.

Appendix 6 (continued)

Kruskal-Wallis One-Way Nonparametric AOV for Zn by Site, 2007.

Site	Mean Rank	Sample Size
Anxiety	9.6	15
Buddy	21.5	15
Mainstem	35.9	11
Total	21.0	41

Kruskal-Wallis Statistic 30.6571
P-Value, Using Chi-Squared Approximation 0.0000

Parametric AOV Applied to Ranks

Source	DF	SS	MS	F	P
Between	2	4397.76	2198.88	62.34	0.0000
Within	38	1340.24	35.27		
Total	40	5738.00			

Total number of values that were tied 8
Max. diff. allowed between ties 0.00001

Cases Included 41 Missing Cases 0

Statistix 9.0 Main Anx Bud juves 2007, 3/7/2008, 12:53:43 PM

Kruskal-Wallis All-Pairwise Comparisons Test of Zn by Site, 2007.

Site	Mean	Homogeneous Groups
Mainstem	35.909	A
Buddy	21.467	B
Anxiety	9.6000	C

Alpha 0.05
Critical Z Value 2.394 Critical Value for Comparison 10.472 TO 11.384
All 3 means are significantly different from one another.

Appendix 6 (continued)

Between Year Comparisons of Juvenile Dolly Varden Whole Body Cd, Pb and Zn Concentrations from Mainstem Red Dog Creek (2005, 2006, 2007)

Kruskal-Wallis One-Way Nonparametric AOV for Cd by Year, Mainstem Red Dog Creek

Year	Mean Rank	Sample Size
2005	14.3	15
2006	23.9	11
2007	20.5	11
Total	19.0	37

Kruskal-Wallis Statistic 5.2492
P-Value, Using Chi-Squared Approximation 0.0725

Parametric AOV Applied to Ranks

Source	DF	SS	MS	F	P
Between	2	615.03	307.515	2.90	0.0686
Within	34	3602.97	105.970		
Total	36	4218.00			

Total number of values that were tied 0
Max. diff. allowed between ties 0.00001

Cases Included 37 Missing Cases 0

Kruskal-Wallis All-Pairwise Comparisons Test of Cd by Year, Mainstem Red Dog Creek

Year	Mean	Homogeneous Groups
2006	23.909	A
2007	20.455	A
2005	14.333	A

Alpha 0.05
Critical Z Value 2.394 Critical Value for Comparison 10.286 TO 11.049
There are no significant pairwise differences among the means.

Kruskal-Wallis One-Way Nonparametric AOV for Pb by Year, Mainstem Red Dog Creek

Year	Mean Rank	Sample Size
2005	16.6	15
2006	20.0	11
2007	21.2	11
Total	19.0	37

Appendix 6 (continued)

Kruskal-Wallis Statistic	1.3059
P-Value, Using Chi-Squared Approximation	0.5205

Parametric AOV Applied to Ranks

Source	**DF**	**SS**	**MS**	**F**	**P**
Between	2	152.99	76.495	0.64	0.5336
Within	34	4064.51	119.544		
Total	36	4217.50			

Total number of values that were tied   2
Max. diff. allowed between ties   0.00001

Cases Included 37   Missing Cases 0

Kruskal-Wallis All-Pairwise Comparisons Test of Pb by Year, Mainstem Red Dog Creek

Year	**Mean**	**Homogeneous Groups**
2007	21.227	A
2006	20.045	A
2005	16.600	A

Alpha   0.05
Critical Z Value 2.394   Critical Value for Comparison 10.286 TO 11.049
There are no significant pairwise differences among the means.

Kruskal-Wallis One-Way Nonparametric AOV for Zn by Year, Mainstem Red Dog Creek

Year	**Mean Rank**	**Sample Size**
2005	8.6	15
2006	27.3	11
2007	25.0	11
Total	19.0	37

Kruskal-Wallis Statistic	23.6926
P-Value, Using Chi-Squared Approximation	0.0000

Parametric AOV Applied to Ranks

Source	**DF**	**SS**	**MS**	**F**	**P**
Between	2	2775.66	1387.83	32.73	0.0000
Within	34	1441.84	42.41		
Total	36	4217.50			

Total number of values that were tied   2
Max. diff. allowed between ties   0.00001

Cases Included 37   Missing Cases 0

Appendix 6 (continued)

Statistix 9.0 Main Anx Bud juves 2007, 2/25/2008, 12:35:16 PM

Kruskal-Wallis All-Pairwise Comparisons Test of Zn by Year, Mainstem Red Dog Creek

Year	Mean	Homogeneous Groups
2006	27.273	A
2007	24.955	A
2005	8.5667	B

Alpha 0.05
Critical Z Value 2.394 Critical Value for Comparison 10.286 TO 11.049
There are 2 groups (A and B) in which the means are not significantly different from one another.

Kruskal-Wallis One-Way Nonparametric AOV for Cd by Year, Anxiety Ridge Creek.

Year	Mean Rank	Sample Size
2005	17.5	15
2006	33.9	13
2007	16.2	15
Total	22.0	43

Kruskal-Wallis Statistic 16.9044
P-Value, Using Chi-Squared Approximation 0.0002

Parametric AOV Applied to Ranks

Source	DF	SS	MS	F	P
Between	2	2662.24	1331.12	13.47	0.0000
Within	40	3952.26	98.81		
Total	42	6614.50			

Total number of values that were tied 20
Max. diff. allowed between ties 0.00001

Cases Included 43 Missing Cases 0

Appendix 6 (continued)

Kruskal-Wallis All-Pairwise Comparisons Test of Cd by Year, Anxiety Ridge Creek.

Year	Mean	Homogeneous Groups
2006	33.923	A
2005	17.500	B
2007	16.167	B

Alpha 0.05
Critical Z Value 2.394 Critical Value for Comparison 10.976 TO 11.391
There are 2 groups (A and B) in which the means are not significantly different from one another.

Kruskal-Wallis One-Way Nonparametric AOV for Pb by Year, Anxiety Ridge Creek.

Year	Mean Rank	Sample Size
2005	13.2	15
2006	33.5	13
2007	20.9	15
Total	22.0	43

Kruskal-Wallis Statistic 18.3894
P-Value, Using Chi-Squared Approximation 0.0001

Parametric AOV Applied to Ranks

Source	DF	SS	MS	F	P
Between	2	2896.34	1448.17	15.58	0.0000
Within	40	3718.66	92.97		
Total	42	6615.00			

Total number of values that were tied 18
Max. diff. allowed between ties 0.00001

Cases Included 43 Missing Cases 0

Kruskal-Wallis All-Pairwise Comparisons Test of Pb by Year, Anxiety Ridge Creek.

Year	Mean	Homogeneous Groups
2006	33.462	A
2007	20.900	B
2005	13.167	B

Alpha 0.05
Critical Z Value 2.394 Critical Value for Comparison 10.976 TO 11.391
There are 2 groups (A and B) in which the means are not significantly different from one another.

Appendix 6 (continued)

Kruskal-Wallis One-Way Nonparametric AOV for Zn by Year, Anxiety Ridge Creek.

Year	Mean Rank	Sample Size
2005	24.2	15
2006	32.5	13
2007	10.7	15
Total	22.0	43

Kruskal-Wallis Statistic 21.8589
P-Value, Using Chi-Squared Approximation 0.0000

Parametric AOV Applied to Ranks

Source	DF	SS	MS	F	P
Between	2	3443.04	1721.52	21.71	0.0000
Within	40	3172.46	79.31		
Total	42	6615.50			

Total number of values that were tied 16
Max. diff. allowed between ties 0.00001

Cases Included 43 Missing Cases 0

Kruskal-Wallis All-Pairwise Comparisons Test of Zn by Year, Anxiety Ridge Creek.

Year	Mean	Homogeneous Groups
2006	32.538	A
2005	24.200	A
2007	10.667	B

Alpha 0.05
Critical Z Value 2.394 Critical Value for Comparison 10.976 TO 11.391
There are 2 groups (A and B) in which the means are not significantly different from one another.

Kruskal-Wallis One-Way Nonparametric AOV for Cd by Year, Buddy Creek.

Year	Mean Rank	Sample Size
2005	16.4	15
2006	31.4	5
2007	15.1	15
Total	18.0	35

Kruskal-Wallis Statistic 10.1068
P-Value, Using Chi-Squared Approximation 0.0064

Appendix 6 (continued)

Parametric AOV Applied to Ranks

Source	DF	SS	MS	F	P
Between	2	1060.77	530.383	6.77	0.0035
Within	32	2507.73	78.367		
Total	34	3568.50			

Total number of values that were tied 6
Max. diff. allowed between ties 0.00001

Cases Included 35 Missing Cases 0

Kruskal-Wallis All-Pairwise Comparisons Test of Cd by Year, Buddy Creek.

Year	Mean	Homogeneous Groups
2006	31.400	A
2005	16.433	B
2007	15.100	B

Alpha 0.05
Critical Z Value 2.394 Critical Value for Comparison 8.9575 TO 12.668
There are 2 groups (A and B) in which the means
are not significantly different from one another.

Kruskal-Wallis One-Way Nonparametric AOV for Pb by Year, Buddy creek.

Year	Mean Rank	Sample Size
2005	11.6	15
2006	29.2	5
2007	20.7	15
Total	18.0	35

Kruskal-Wallis Statistic 12.9800
P-Value, Using Chi-Squared Approximation 0.0015

Parametric AOV Applied to Ranks

Source	DF	SS	MS	F	P
Between	2	1357.37	678.683	9.88	0.0005
Within	32	2198.13	68.692		
Total	34	3555.50			

Total number of values that were tied 18
Max. diff. allowed between ties 0.00001

Cases Included 35 Missing Cases 0

Appendix 6 (continued)

Kruskal-Wallis All-Pairwise Comparisons Test of Pb by Year, Buddy Creek.

Year	Mean	Homogeneous Groups
2006	29.200	A
2007	20.700	A
2005	11.567	B

Alpha 0.05
Critical Z Value 2.394 Critical Value for Comparison 8.9575 TO 12.668
There are 2 groups (A and B) in which the means are not significantly different from one another.

Kruskal-Wallis One-Way Nonparametric AOV for Zn by Year, Buddy Creek.

Year	Mean Rank	Sample Size
2005	15.8	15
2006	33.0	5
2007	15.2	15
Total	18.0	35

Kruskal-Wallis Statistic 12.5291
P-Value, Using Chi-Squared Approximation 0.0019

Parametric AOV Applied to Ranks

Source	DF	SS	MS	F	P
Between	2	1314.63	657.317	9.34	0.0006
Within	32	2252.87	70.402		
Total	34	3567.50			

Total number of values that were tied 10
Max. diff. allowed between ties 0.00001

Cases Included 35 Missing Cases 0

Kruskal-Wallis All-Pairwise Comparisons Test of Zn by Year, Buddy Creek.

Year	Mean	Homogeneous Groups
2006	33.000	A
2005	15.767	B
2007	15.233	B

Alpha 0.05
Critical Z Value 2.394 Critical Value for Comparison 8.9575 TO 12.668
There are 2 groups (A and B) in which the means are not significantly different from one another.

Appendix 6 (continued)

Linear Regression Analysis of Juvenile Dolly Varden Whole Body Cd, Pb and Zn Concentrations over Time– Mainstem Red Dog Creek, 1998-2007 (Zn, 2001-2007).

Least Squares Linear Regression of Cd, Mainstem Red Dog Creek, 1998-2007.

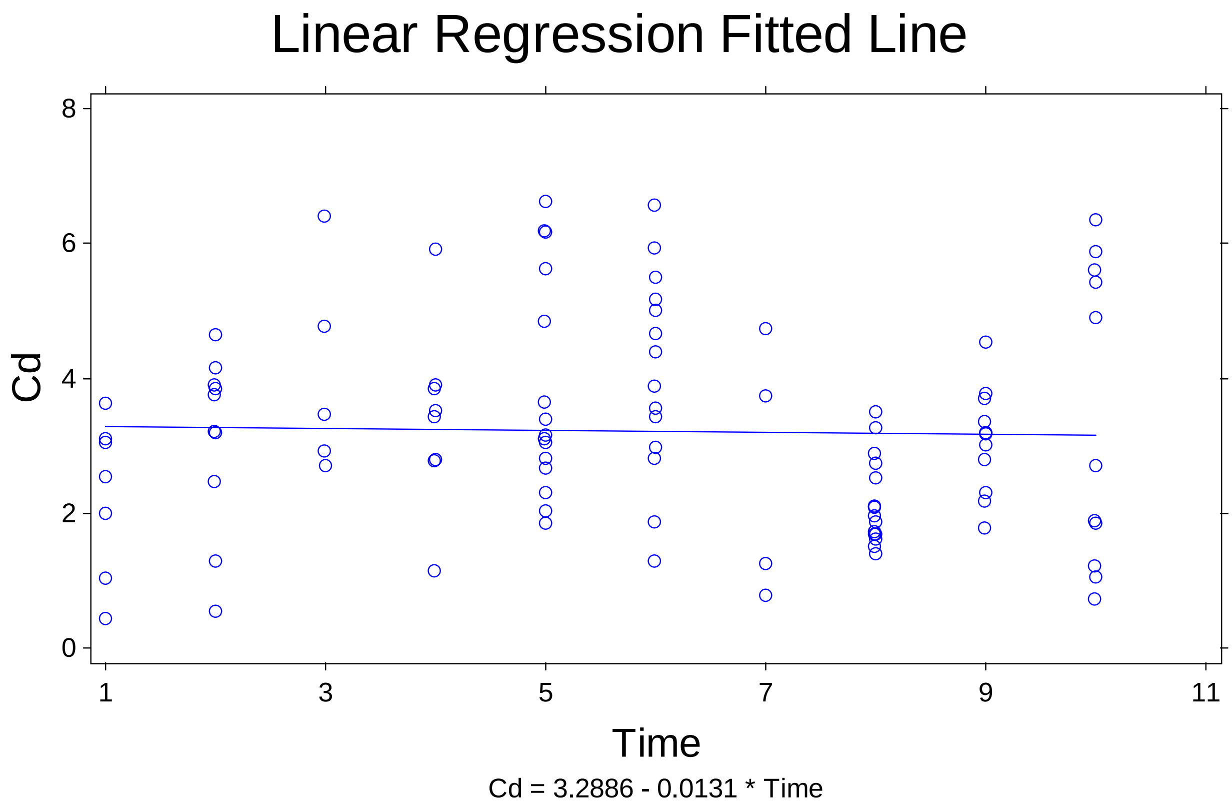
Predictor Variables	Coefficient	Std Error	T	P
Constant	3.28862	0.33635	9.78	0.0000
Time	-0.01313	0.05237	-0.25	0.8025

R-Squared	0.0006	Resid. Mean Square (MSE)	2.28969
Adjusted R-Squared	-0.0093	Standard Deviation	1.51317
AICc	89.550		
PRESS	240.56		

Source	DF	SS	MS	F	P
Regression	1	0.144	0.14399	0.06	0.8025
Residual	101	231.259	2.28969		
Total	102	231.403			
Lack of Fit	8	44.289	5.53619	2.75	0.0090
Pure Error	93	186.970	2.01043		

Cases Included 103   Missing Cases 0

Appendix 6 (continued)



NOTE – Time in years, year 1 = 1998

Least Squares Linear Regression of Pb, Mainstem Red Dog Creek, 1998-2007.

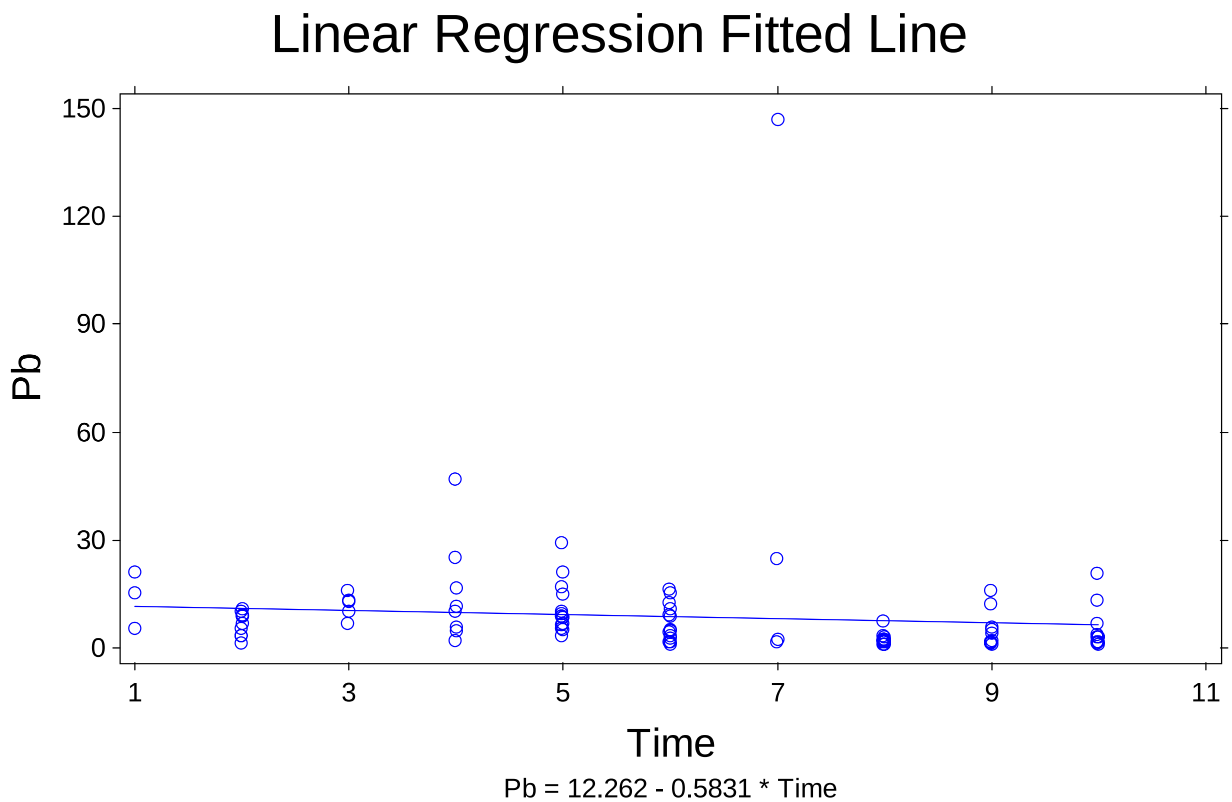
Predictor Variables	Coefficient	Std Error	T	P
Constant	12.2616	3.45210	3.55	0.0006
Time	-0.58310	0.53748	-1.08	0.2806

R-Squared	0.0115	Resid. Mean Square (MSE)	241.195
Adjusted R-Squared	0.0017	Standard Deviation	15.5305
AICc	569.24		
PRESS	24995		

Source	DF	SS	MS	F	P
Regression	1	283.9	283.878	1.18	0.2806
Residual	101	24360.7	241.195		
Total	102	24644.6			
Lack of Fit	8	6186.5	773.308	3.96	0.0005
Pure Error	93	18174.3	195.422		

Cases Included 103 Missing Cases 0

Appendix 6 (continued)



NOTE – Time in years, year 1 = 1998

Least Squares Linear Regression of Zn, Mainstem Red Dog Creek, 2001-2007.

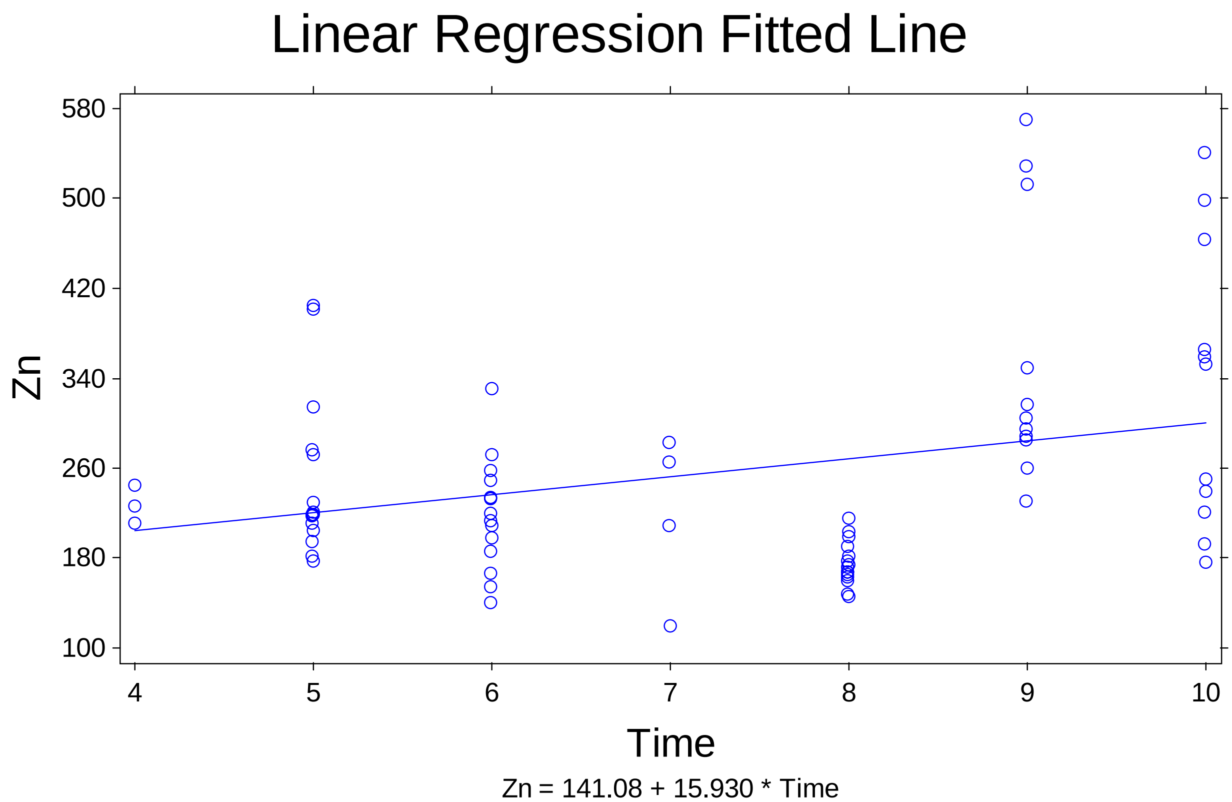
Predictor Variables	Coefficient	Std Error	T	P
Constant	141.079	40.1378	3.51	0.0007
Time	15.9303	5.50006	2.90	0.0049

R-Squared	0.0994	Resid. Mean Square (MSE)	9194.65
Adjusted R-Squared	0.0876	Standard Deviation	95.8887
AICc	716.16		
PRESS	739844		

Source	DF	SS	MS	F	P
Regression	1	77135	77134.6	8.39	0.0049
Residual	76	698793	9194.6		
Total	77	775928			
Lack of Fit	5	230518	46103.5	6.99	0.0000
Pure Error	71	468276	6595.4		

Cases Included 78   Missing Cases 25

Appendix 6 (continued)

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NOTE – Time in years, year 4 = 2001  (2001 = first year fish analyzed
for Zn)
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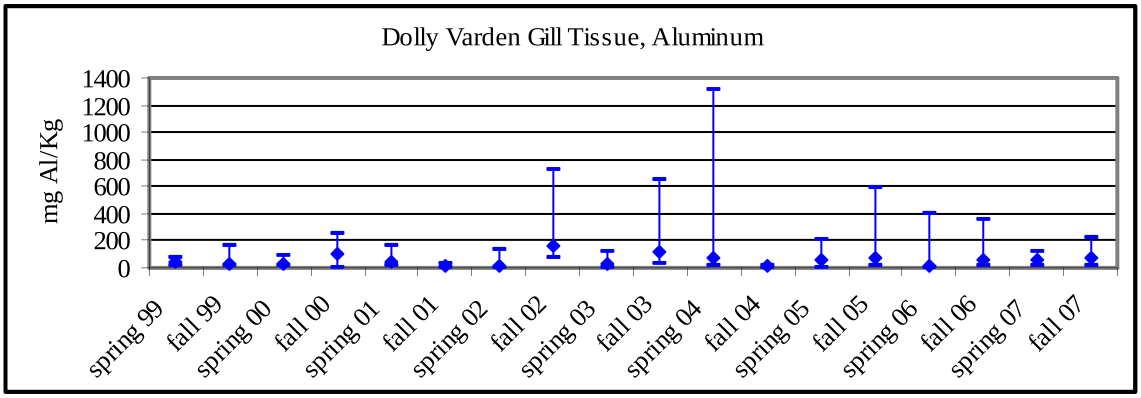
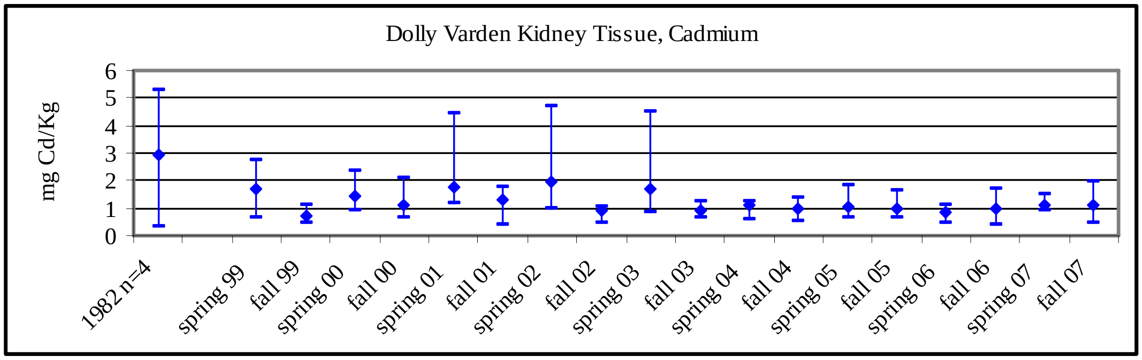
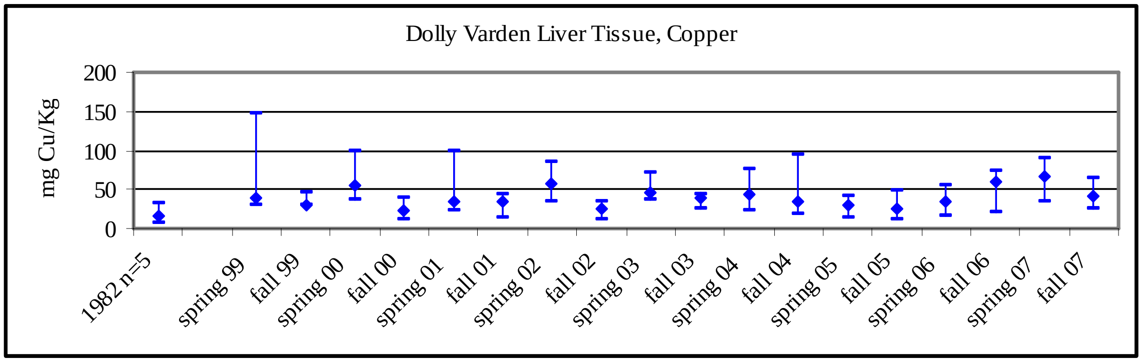
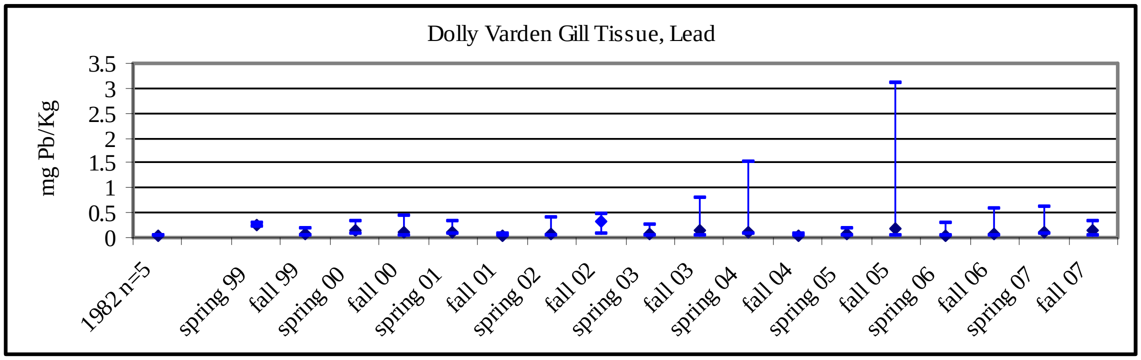
Appendix 7. Dolly Varden Adults, Metals Graphs

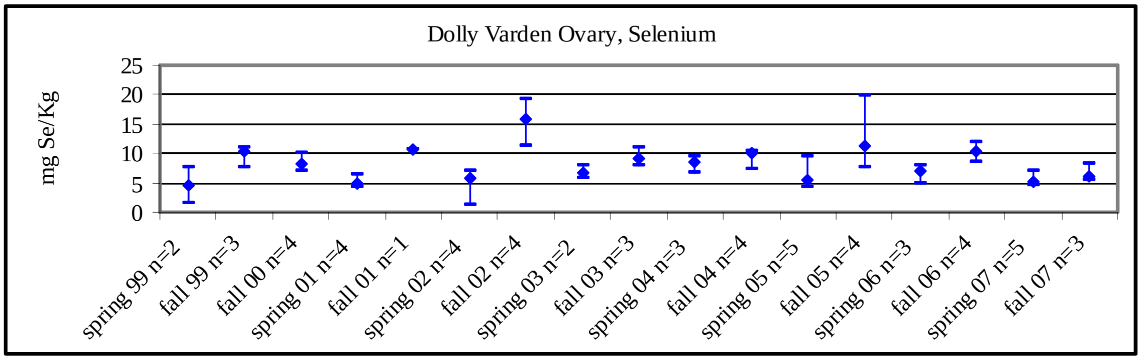


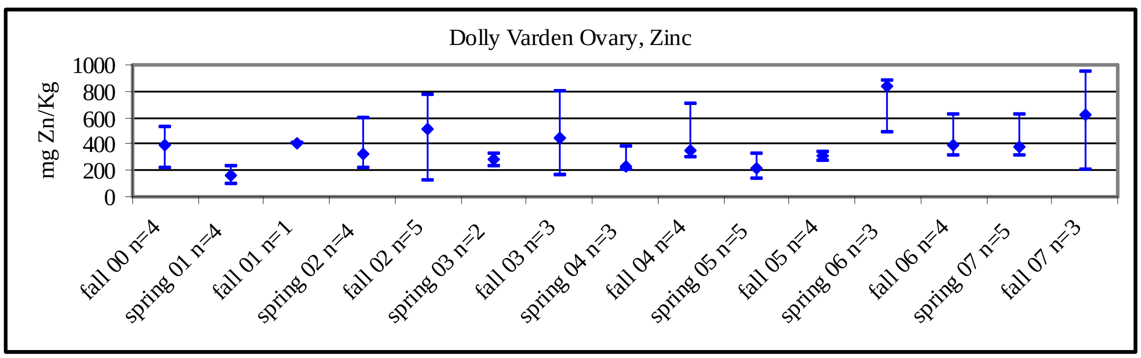




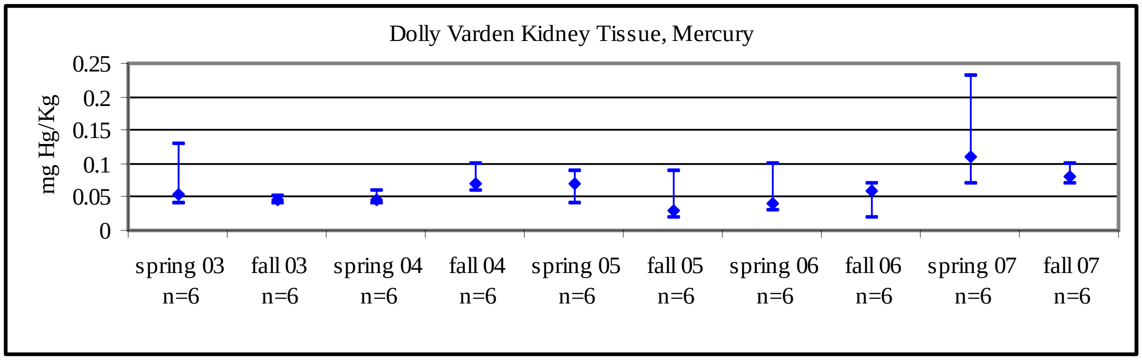
Appendix 7 (continued)







Appendix 7 (concluded)

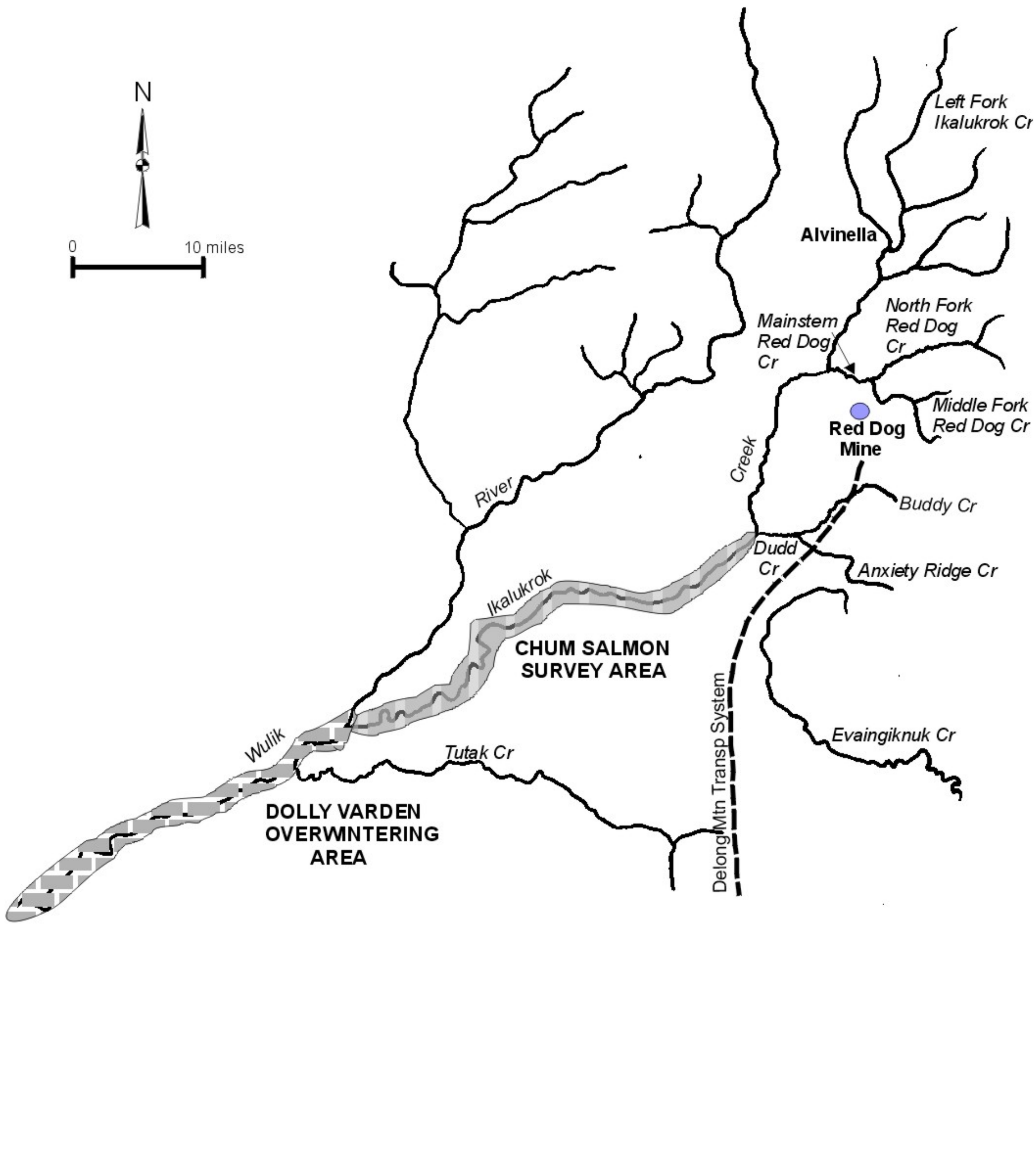


Appendix 8. Dolly Varden Aerial Surveys

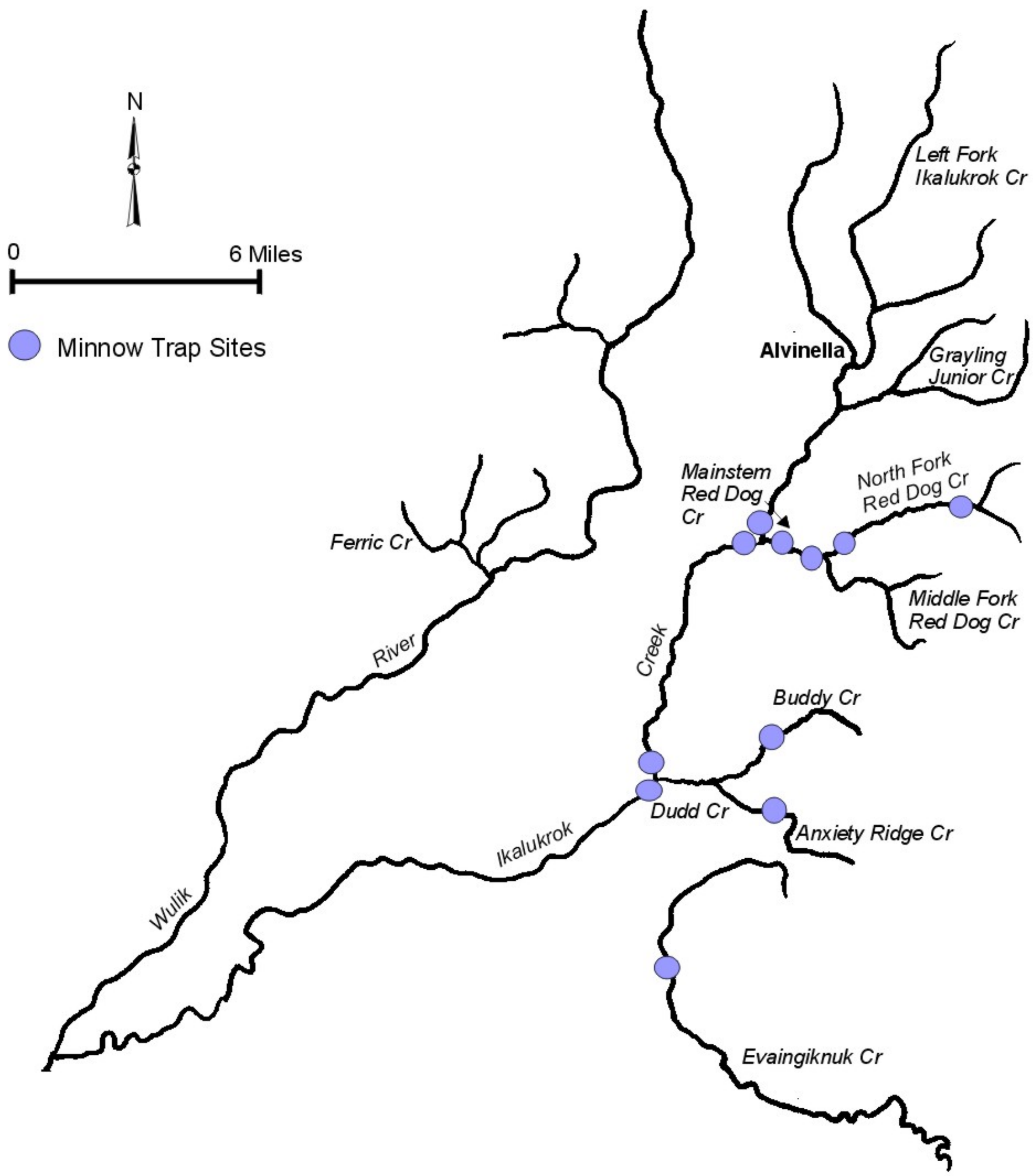
Estimated number of overwintering Dolly Varden in the Wulik River before freezeup. Surveys conducted by ADF&G (DeCicco 1989, 1991-1999, 2001-2002, and 2004-2007.

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
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 9. Dolly Varden and Chum Salmon Survey Areas



Appendix 10. Juvenile Dolly Varden Sampling Sites



Appendix 11. 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
Evaingiknuk (Noatak Tributary)	54	27	38	2	7	20	64	71	29	4	67
Anxiety Ridge	68	94	271	27	6	33	98	116	121	8	115
Buddy	48	154	306	11	34	57	104	59	59	5	183
North Fork Red Dog Creek (Sta 12)	0	12	17	1	1	1	0	1	8	0	1
Mainstem (below North Fork)	14	70	86	13	9	12	2	2	6	8	2
Mainstem (Station 10)	10	21	66	1	3	12	12	0	10	3	6
Ikalukrok Creek (below Dudd)	13	51	55	31	6	17	17	27	36	2	25
Ikalukrok Creek (above Dudd)	3	53	37	14	0	22	27	11	6	0	4
Ikalukrok Creek (below Mainstem)	4	19	28	6	11	15	3	2	0	0	5
Ikalukrok Creek (above Mainstem)	3	44	41	5	2	18	3	12	0	5	7
Total Catch Dolly Varden	217	545	945	111	79	207	330	301	275	35	415

Appendix 12. Arctic Grayling, Mainstem Red Dog Creek

Observations and catches of Arctic grayling in Mainstem Red Dog Creek below confluence of North Fork 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 12 (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

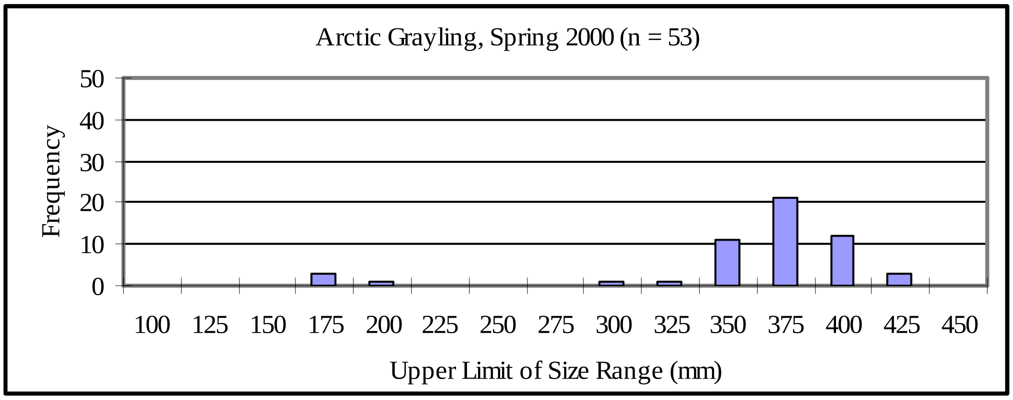
Appendix 12 (concluded)

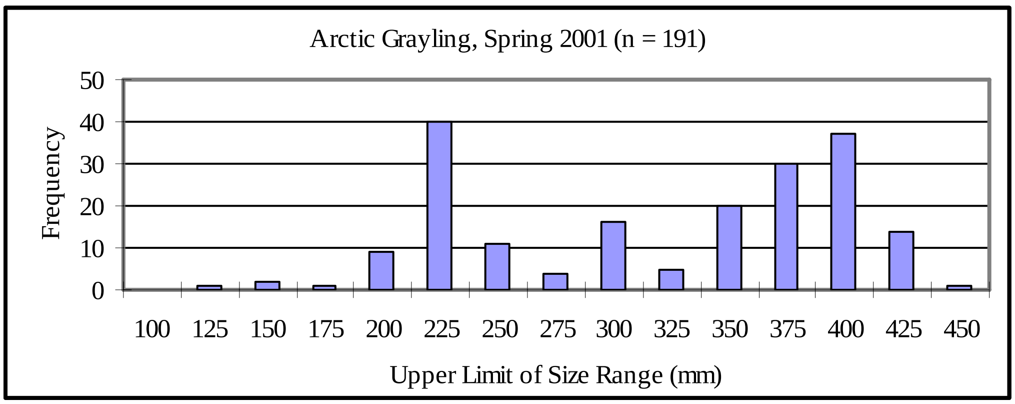
6/5/05 – aerial, observed 30 adult Arctic grayling, only two sets paired
6/25 and 26/05 – Houghton reported catching about 60 fish in Mainstem between mouth and North Fork Red Dog Creek
7/4/05 – visual, 8 adults and fry (about 70) observed near Station 10
7/28/05 – visual, small numbers of fry in backwaters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

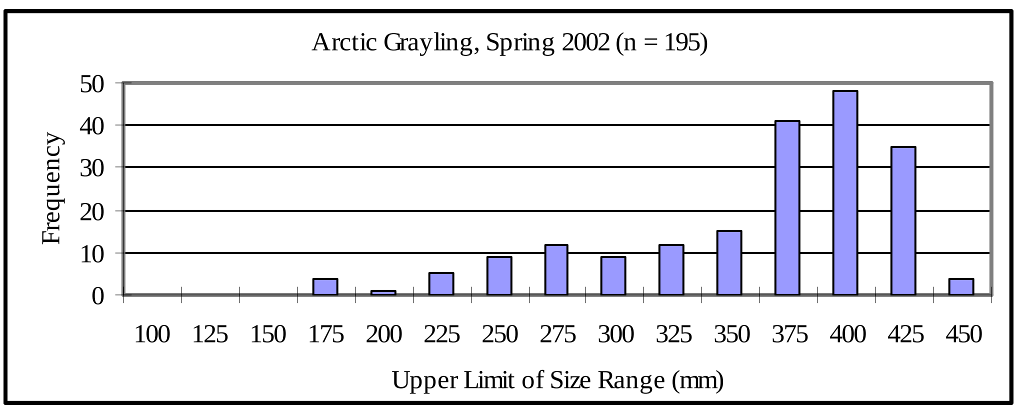
6/13/06 – visual, five adult Arctic grayling seen in Mainstem near Station 10
6/16/06 – angling, caught 8 Arctic grayling (260 – 355 mm long) in Mainstem just below mouth of North Fork

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)

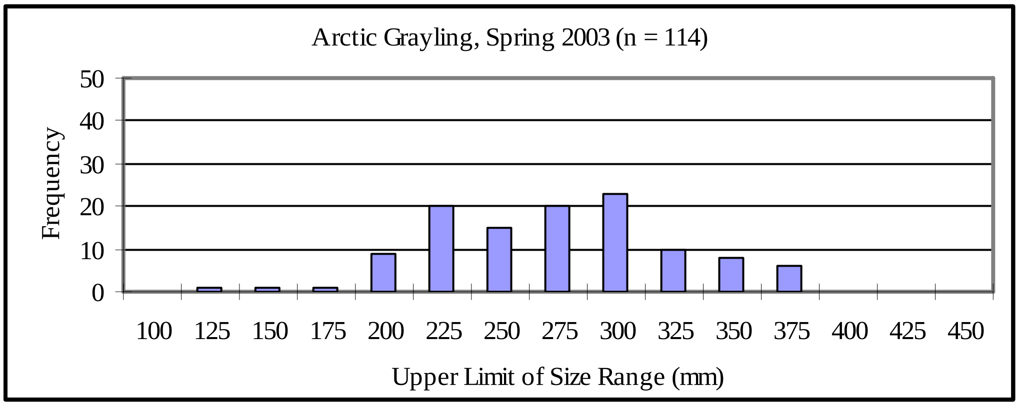
Appendix 13. Arctic Grayling Length Frequency

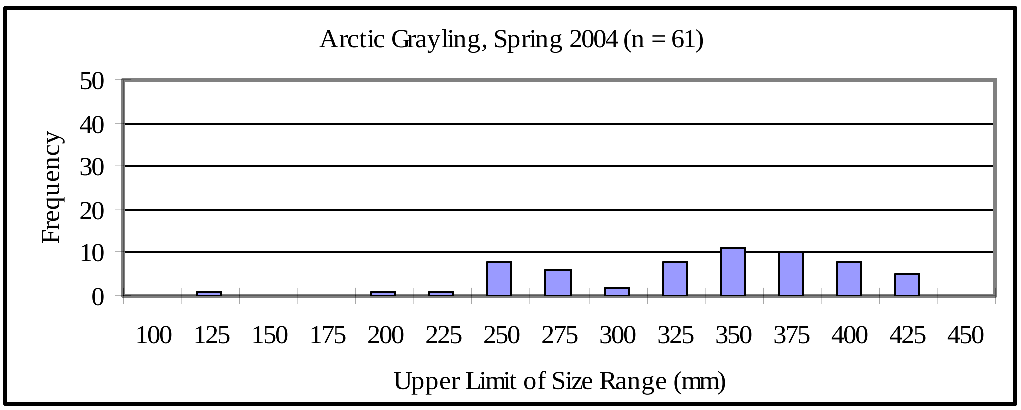


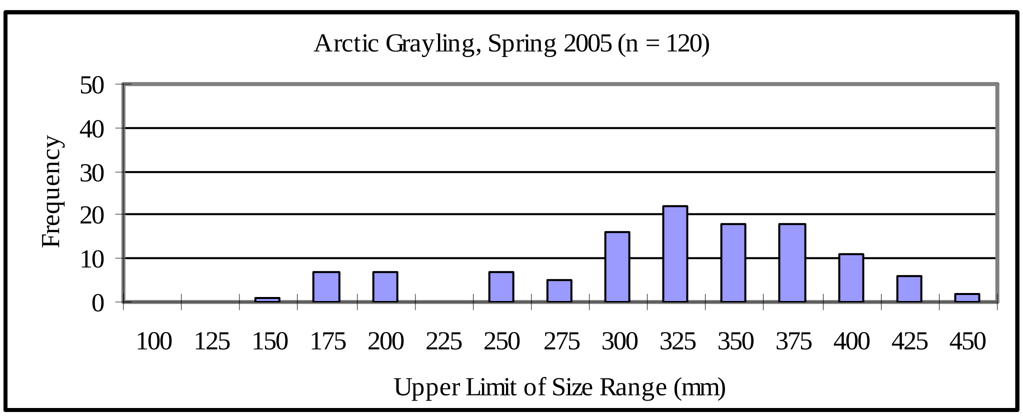




Appendix 13 (continued)







Appendix 13 (concluded)