ANNEX XIV: APPENDIX A

HISTORICAL REPORT REVIEW

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Tables

Abbreviations

Abbreviation	Definition
--	not recorded
AEMP	Aquatic Effects Monitoring Program
BCMOE	British Columbia Ministry of the Environment
BHP Billiton	BHP Billiton Canada Inc. including subsidiary BHP Billiton Diamonds Inc.
BSA	baseline study area
CPUE	catch-per-unit-effort
CRI	Canadian Rivers Institute
DAR	Developer's Assessment Report
DDMI	Diavik Diamond Mines Inc.
DF	diffuser
Diavik Mine	Diavik Diamond Mine
EA	Environmental Assessment
e.g.,	for example
EIR	Environmental Impact Report
EIS	Environmental Impact Statement
Ekati Mine	Ekati Diamond Mine
et al.	and more than one additional author
F	female
FF	far-field
FF1	Far Field 1
FF2	Far Field 2
Golder	Golder Associates Ltd.
GSI	gonadosomatic index
i.e.,	that is
LSI	liversomatic index
M	male
n	number of samples
n/a	not available
NF	near-field
NWT	Northwest Territories
SD	standard deviation
SE	standard error
sp.	species
TK	Traditional Knowledge
USEPA	United States Environmental Protection Agency

Units of Measure

Unit	Definition
%	percent
%F	% female
µg/g	micrograms per gram
µg/L	micrograms per litre
cm	centimetre
dw	dry weight
g	gram
kg/ha	kilograms per hectare
km	kilometre
m^2	square metre
mg/kg	milligrams per kilogram
mg/L	milligrams per litre
mm	millimetre
ppm	parts per million
ww	wet weight

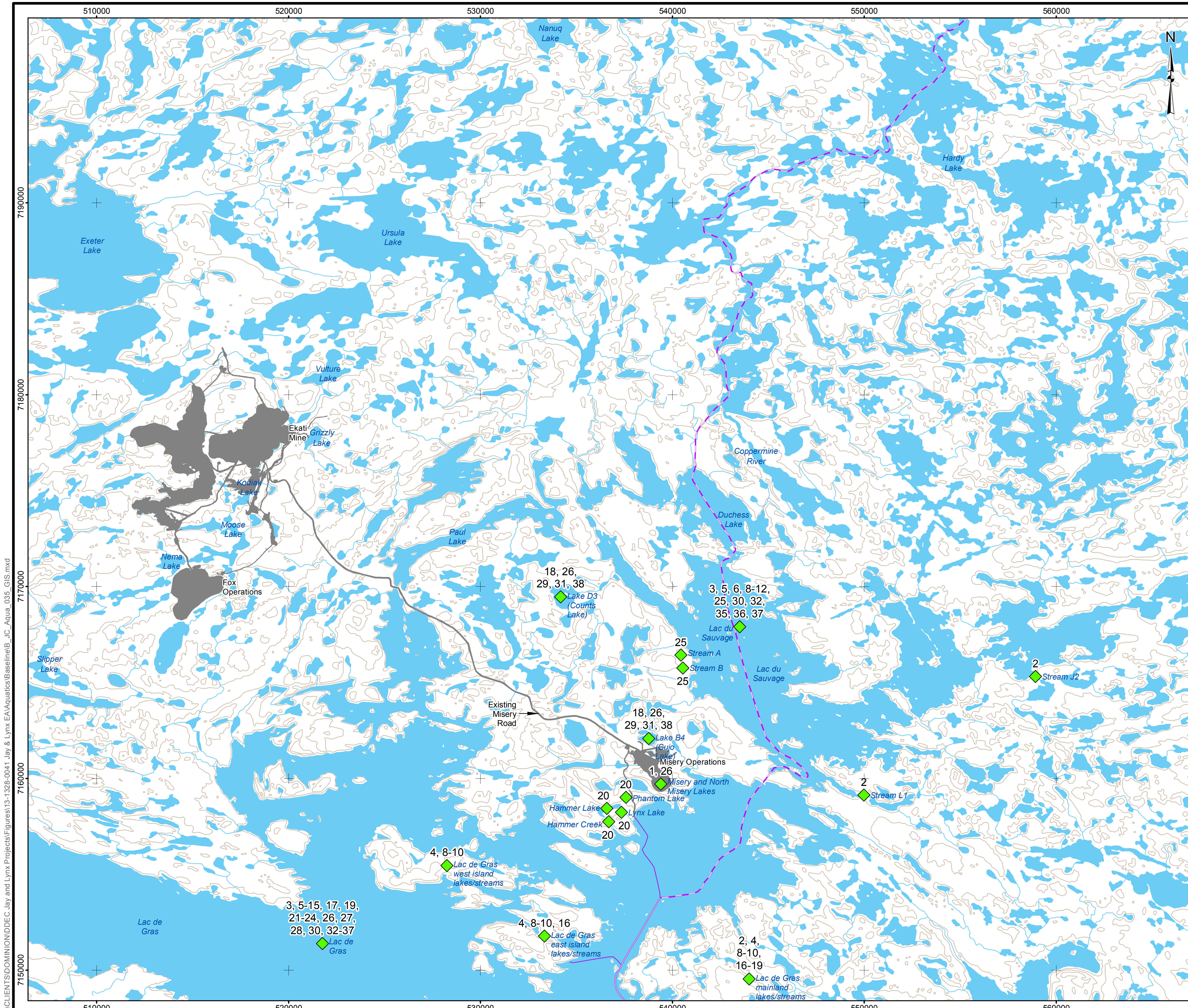
A1 SOURCES

Historical reports were reviewed as part of the Fish and Fish Habitat Baseline for the proposed Project to summarize existing information in the Fish and Fish Habitat baseline study area (BSA). The Historical Report Review presents study results and general conclusions of reports related to BHP Billiton Diamonds Inc. (BHP Billiton) (Ekati Diamond Mine [Ekati Mine]) and Diavik Diamond Mines Inc. (DDMI) mining activities within and surrounding Lac du Sauvage and Lac de Gras (Fish and Fish Habitat Baseline Section 2.0). Particular focus was on studies performed in close proximity to Lac du Sauvage, as this waterbody and immediate surrounding waterbodies are of greatest relevance to a future assessment of the proposed Project. A total of 38 documents were reviewed and included in the Historical Report Review. The oldest report included in this Historical Report Review was completed in 1995 and the most recent report in 2013. Several of the more recent reports included pertinent fish tissue chemistry, species abundance, and distribution and general life history data, some of which were consolidated into a master dataset for analyses (2006 to 2013; Developer's Assessment Report [DAR] Section 3.0).

Seven of the reports included in this Historical Report Review pertained primarily to Ekati Mine activities and the remaining 31 were associated primarily with Diavik Diamond Mine (Diavik Mine) activities (DAR Section 2.0). The reports were organized by primary relevance to either Ekati Mine or Diavik Mine activities, with a general description of each report. The following sub-headings provide a description of the relevant fish and fish habitat material provided in the reports (i.e., species abundance and distribution, life history, habitat use and availability, fish health, and fish tissue chemistry).

Waterbodies listed in the previously completed reports and included in this summary were Lac du Sauvage, Lac de Gras, Lynx Lake, Hammer Lake (previously referred to as Fisher Lake), Phantom Lake, Misery and North Misery Lakes, Lake D3 (Counts), Lake B4 (Cujo), lakes of the east and west islands of Lac de Gras, and several lakes on the eastern mainland of Lac de Gras, as well as several local streams in the Lac de Gras and Lac du Sauvage watersheds (Map A1-1). In addition to these waterbodies, the fish tissue chemistry section (Section A6) included Vulture, Kodiak, Moose, Nema, and Slipper Lakes in the Koala Watershed, as well as Nanuq Lake (a reference lake); these waterbodies are part of the Ekati Mine Aquatic Effects Monitoring Program (AEMP) and lie outside the BSA, providing supplemental information on regional trends.

Lakes and streams in the BSA were typically referred to by their BSA names for understanding the waterbody position in the watershed, and where appropriate, with historical names in parentheses. For example, Cujo Lake was referred to as Lake D3 (Cujo) because it is located above D2 and D1 lakes in the D sub-basin of Lac du Sauvage. New names were not created for lakes and streams in small sub-basins of Lac de Gras (e.g., Hammer Lake, Misery Lake) within the BSA.



LEGEND

- EKATI MINE FOOTPRINT
- WINTER ROAD
- TIBBITT TO CONTWOYTO WINTER ROAD
- NORTHERN PORTION OF TIBBITT TO CONTWOYTO WINTER ROAD
- ELEVATION CONTOUR (20 m INTERVAL)
- WATERCOURSE
- WATERBODY
- GENERAL HISTORICAL REPORT LOCATION

REPORT NUMBER	REPORT CITATION
1	BHP 1995
2	Golder 1997a
3	Golder 1997b
4	Golder 1997c
5	Golder 1997d
6	Golder 1997e
7	Golder 1997f
8	CEAA 1998
9	DDMI 1998a
10	DDMI 1998b
11	Golder 1998a
12	Golder 1998b
13	Jacques Whitford 2001
14	Dillion 20002a
15	Dillion 20002b
16	Golder 2002
17	Jacques Whitford 2002
18	Rescan 2002
19	DDMI 2003
20	Rescan 2003
21	DDMI 2004
22	Gray et al. 2005
23	CRI 2006
24	DDMI 2006
25	Rescan 2007
26	Thistle and Tonn 2007
27	DDMI 2008
28	Golder 2008
29	Rescan 2008
30	Golder 2009
31	Rescan 2009
32	Rio Tinto 2009
33	Golder 2010
34	Rio Tinto 2010
35	Rio Tinto 2011
36	Golder 2012
37	Rio Tinto 2012
38	ERM Rescan 2013

REFERENCE

CANVEC © NATURAL RESOURCES CANADA, 2012
NATURAL RESOURCES CANADA, CENTRE FOR TOPOGRAPHIC INFORMATION, 2012
DATUM: NAD83 PROJECTION: UTM ZONE 12N

DOCUMENT

FISH AND FISH HABITAT BASELINE REPORT

4 0 4
SCALE 1:200,000 KILOMETRES

PROJECT
DOMINION DIAMOND
JAY PROJECT
NORTHWEST TERRITORIES, CANADA

TITLE
GENERAL LOCATIONS OF SOURCES OF FISH AND FISH HABITAT INFORMATION PROVIDED IN THE HISTORICAL REPORTS

Golder Associates

PROJECT	13-1328-0041		FILE No. B_JC_Aqua_035_GIS
DESIGN	JV	26/03/14	SCALE AS SHOWN REV 0
GIS	JG	11/09/14	MAP A1-1
CHECK	CG	11/09/14	
REVIEW	SM	11/09/14	

A1.1 Ekati Mine

BHP (Broken Hill Proprietary Company). 1995. Environmental Impact Statement (EIS) for the Ekati Diamond Mine. Volume II: Environmental Setting – Parts 3 – 4, and Appendix II – B. Broken Hill Proprietary Company, Yellowknife, NWT, Canada. July 1995.

The earliest report included in this Historical Report Review is the 1995 *Environmental Impact Statement (EIS) for the Ekati Diamond Mine*, which assessed potential environmental effects of the Ekati Mine. Findings were based on the results of field studies conducted from 1993 to 1994. The report assessed impacts to aquatic species and habitats in several potentially impacted waterbodies, including Misery Lake, a tributary of Lac de Gras near the BSA.

Rescan (Rescan Environmental Services Ltd.). 2003. Ekati Diamond Mine: 2002 Lynx Area Aquatic Baseline Report. Prepared for BHP Billiton Diamonds Inc., Yellowknife, NWT, Canada.

The *2002 Lynx Area Aquatic Baseline Report* presented baseline environmental conditions in anticipation of potential mining activities within the Lynx Lake area. It included a wide range of information on fish communities and habitat in Lynx Lake, Phantom Lake, Hammer Lake (referred to as Fisher Lake in the report), and Hammer Creek (referred to as Stream C), tributaries of Lac de Gras near the BSA.

Rescan (Rescan Environmental Services Ltd.). 2007. Ekati Diamond Mine: 2006 Jay Pipe Aquatic Baseline. Prepared for BHP Billiton Diamonds Inc., Yellowknife, NWT, Canada.

This report summarized baseline conditions of the aquatic environment near the proposed Jay kimberlite pipe development. It contained information from various fish habitat and biological inventories for Lac du Sauvage and two, unnamed ephemeral streams (referred to as Streams A and B in report) within Jay Fish and Fish Habitat BSA.

Rescan (Rescan Environmental Services Ltd.). 2002. 2002 Aquatic Effects Monitoring Program (AEMP) Technical Report; and Appendix 1: Data Report. Prepared for BHP Billiton Diamonds Inc., Yellowknife, NWT, Canada. December 2002.

Rescan (Rescan Environmental Services Ltd.). 2008. 2007 Aquatic Effects Monitoring Program (AEMP) Technical Report; Summary Report; and Appendix B: Data Report. Prepared for BHP Billiton Diamonds Inc., Yellowknife, NWT, Canada. April 2008.

ERM Rescan (ERM Rescan Environmental Services Ltd.). 2013. 2012 Aquatic Effects Monitoring Program (AEMP) Summary Report; Part 1: Evaluation of Effects; Part 2: Data Report; and Part 3: Statistical Report. Prepared for BHP Billiton Diamonds Inc., Yellowknife, NWT, Canada. March 2013.

As part of an ongoing aquatic effects monitoring program (AEMP) in relation to Ekati Mine operations, the 2002, 2007, and 2012 Ekati Mine AEMP reports provided information on fish in the Koala watershed, King-Cujo watershed, and reference lakes, including lakes within the BSA: Lake D3 (referred to as Counts Lake in the report) and Lake B4 (referred to as Cujo Lake in the report). The AEMP reports from fish assessment years (2002, 2007, and 2012) included raw data and summaries of the findings from the most recent sampling efforts, as well as evaluations of environmental effects through comparison with previous records. A wide range of life history and habitat assessments were included. Prior baseline information collected from 1994 was also used in the evaluations of effects in the AEMP reports.

Rescan (Rescan Environmental Services Ltd.). 2009. Ekati Diamond Mine Environmental Impact Report (EIR). Prepared for BHP Billiton Diamonds Inc., Yellowknife, NWT, Canada. April 2009.

The Ekati Mine 2009 Environmental Impact Report (EIR) summarized aquatic effects, comparing monitoring program findings from the 2007 Ekati AEMP (Rescan 2008) with the predictions of the 1995 EIS for the Ekati Mine (BHP 1995). The 2012 Ekati Mine EIR was not included in this Historical Report Review because the results were based on 2007 or earlier fish and fish habitat data, which were already included in the 2009 EIR, and the summaries did not pertain to the BSA.

A1.2 Diavik Mine

Golder (Golder Associates Ltd.). 1997a. Technical Memorandum 7-2, Spring Stream Habitat and Arctic Grayling Spawning Survey. 1996 Environmental Baseline Program. Submitted to Diavik Diamond Mines Inc., NWT, Canada. January 1997. Doc No.TM7-2.

This memorandum described the results of a fish habitat survey performed in June 1996 on 34 streams around Lac de Gras and Lac du Sauvage. The main objective was to characterize stream habitats and determine the extent to which fish use streams in the area of the proposed Diavik Mine footprint in Lac de Gras, compared to other areas of Lac de Gras and Lac du Sauvage. Two reference area streams (L1 and J2, referred to as FSR1 and FSR2 in the report, respectively), tributaries of Lac du Sauvage, were within the BSA. Survey results of tributary streams of Lac de Gras were also provided in the report.

Golder (Golder Associates Ltd.). 1997b. Technical Memorandum 12-2, Shoal Habitat Survey, Lac de Gras and Lac du Sauvage, Summer 1996. Environmental Baseline Program. Submitted to Diavik Diamond Mines Inc., NWT, Canada. Doc No. TM12-2.

The results presented in this memorandum described a shoal habitat survey conducted in 1996 for Lac de Gras and Lac du Sauvage. Objectives were to estimate the quality and quantity of shoal habitats in the two lakes, with emphasis on areas near the proposed Diavik Mine in Lac de Gras, and to estimate the relative importance of potentially affected habitats for Lake Trout, Cisco and Round Whitefish.

Golder (Golder Associates Ltd.). 1997c. Technical Memorandum 13-3, Inland Lake Survey Report. 1996 Environmental Baseline Program. Submitted to Diavik Diamond Mines Inc., NWT, Canada. February 1997. Doc No. TM13-3.

The objectives of the summer and fall 1996 survey detailed in this memorandum were to determine the size and makeup of fish populations of inland lakes within the proposed Diavik Mine footprint. It also aimed to identify the quantity and quality of habitat available to fish in those lakes. Thirty-three lakes were surveyed on the east and west islands of Lac de Gras, and on a small part of the mainland within the proposed mine footprint.

Golder (Golder Associates Ltd.). 1997d. Technical Memorandum 14-2, Intensive Shoreline Habitat Survey. 1996 Environmental Baseline Program. Submitted to Diavik Diamond Mines, Inc., NWT, Canada. January 1997. Doc No. TM14-2.

Technical Memorandum 14-2 summarized the findings of a 1996 survey to characterize the shoreline fisheries habitat in the area of the proposed Diavik Mine footprint in Lac de Gras. Additionally, the report made comparisons to shoreline habitat availability in areas of Lac de Gras and Lac du Sauvage that lie outside of the mine footprint, as described in Golder (1997e).

Golder (Golder Associates Ltd.). 1997e. Technical Memorandum 15-2, Extensive Shoreline Habitat Survey. 1996 Environmental Baseline Program. Submitted to Diavik Diamond Mines, Inc., NWT, Canada. January 1997. Doc No. TM15-2.

As a companion report to Technical Memorandum 14-2 (Golder 1997d), this memorandum described aquatic shoreline habitat of Lac de Gras and Lac du Sauvage, which lie outside of the potential mine footprint. Approximately 7,000 kilometres (km) of shoreline in Lac de Gras and 300 km in Lac du Sauvage were included in this survey.

Golder (Golder Associates Ltd.). 1997f. Technical Memorandum 17-2, Fall Lake Trout Spawning Survey. 1996 Environmental Baseline Program. Submitted to Diavik Diamond Mines Inc., NWT, Canada. April 1997. Doc No. TM17-2.

This memorandum summarized a 1996 survey of fall spawning habitat and use of habitat by Lake Trout in Lac de Gras. The primary focus was on areas in the immediate vicinity of the proposed Diavik Mine, but other areas of Lac de Gras outside the potential mine footprint were also investigated. In addition to habitat observations, the report also provided population, distribution, and life history information on Lake Trout captured during the survey.

Golder (Golder Associates Ltd.). 1997g. Technical Memorandum 20-2: Spring/Summer Fish Population and Fish Health Report. 1996 Environmental Baseline Program. Submitted to Diavik Diamond Mines Inc., NWT, Canada. May 1997. Doc No. TM20-2.

This report detailed the results of a spring and summer monitoring program to establish baseline fish population and health information before diamond mine activity at Lac de Gras. Fish surveys were conducted in the spring and summer of 1996 in the immediate vicinity of the proposed mine development, as well as in Lac du Sauvage (mostly in the southern portion), which was used as a reference lake. Various fish health, population, habitat, and life history assessments were included in this study.

Golder (Golder Associates Ltd.). 1997h. Technical Memorandum 20 - Addendum: Lac de Gras Fish Health Survey - Metallothionein Results. 1996 Environmental Baseline Program. Submitted to Diavik Diamond Mines Inc., NWT, Canada. May 1998. Doc No. TM20AD-1.

This memorandum presented analytical results for the protein metallothionein analyses of Lake Trout and Round Whitefish livers and kidneys during the 1996 Environmental Baseline Program. Tissue samples were collected from fish in Lac de Gras, a lake potentially impacted by future mine activities, and Lac du Sauvage, an unimpacted upstream lake.

CEA Agency (Canadian Environmental Assessment Agency). 1998. The Canadian Environmental Assessment Act, Comprehensive Study Report, Diavik Diamonds Project.

Following the submission of the DDMI Environmental Assessment (EA; DDMI 1998b) for development of the Diavik Mine at Lac de Gras, the Canadian Federal Government prepared this report to summarize the EA and present reviews and comments of various groups. The Diavik Diamonds Project was reviewed at the comprehensive study level by responsible authorities (Department of Indian Affairs and Northern Development, the Department of Fisheries and Oceans, and the Department of Natural Resources Canada), with input from various other governmental, community, and non-governmental organizations. Comments related to the fish sections of the EA dealt primarily with concerns over proposed recreational angling, sediment dispersion and deposition, impacts to fish habitat, and blasting. No new fish-related information not already provided in the 1998 EA was included in this report, and thus, no further summary of this report was provided in this Historical Report Review.

DDMI (Diavik Diamond Mines Inc.). 1998a. Diavik Diamonds Project Environmental Assessment – Environmental Effects Report on Fish and Water Quality. Diavik CD-ROM series, second edition. Diavik Diamond Mines Inc., NWT, Canada. September 1998.

The *Environmental Effects Report on Fish and Water Quality* was completed as one of six environmental effects reports for DDMI's Environmental Assessment Submission for its proposed mine at Lac de Gras. The purpose of the report was to provide an assessment of potential effects of the proposed mine on the aquatic environment in Lac de Gras. Of particular relevance to this historical fisheries report compilation were summaries of fish populations and fish habitat in Lac de Gras, and in 33 small lakes and 39 streams on the east mainland and east and west islands. The data came from baseline studies carried out in 1996 (Golder 1997a,b,c,d,e,f,g,h), which are described individually in this Historical Report Review. The report provides conclusions about potential effects of various project-related activities on water quality, fish populations, and fish habitat conditions.

DDMI (Diavik Diamond Mines Inc.). 1998b. Integrated Environmental and Socio-Economic Baseline Report. Diavik Diamond Mines Inc., NWT, Canada.

This report included a detailed summary of the baseline program initiated by DDMI to collect information about the natural and socio-economic environment in the area of the proposed Diavik Mine. Summaries of the findings from aquatic studies conducted as part of the Environmental Baseline Program from 1994 to 1996 were included. These studies pertained to fish and fish habitat in Lac de Gras, Lac du Sauvage, inland lakes on east island and west island of Lac de Gras, and in the lakes on the mainland east of the proposed Diavik Mine. Fisheries surveys for streams draining into these lakes were also included in these studies, and are summarized in this report.

Jacques Whitford (Jacques Whitford Environment Limited). 2001. Diavik Diamond Mines Inc. North Inlet Fish Salvage Project (July-August 2001). Final Report. Prepared for Diavik Diamonds Inc., NWT, Canada. November 2001.

This report provided details of efforts to salvage fish isolated in the North Inlet of Lac de Gras by a DDMI dike. Fish salvage operations were conducted in July and August 2001. Species abundance and life history information for fish captured in the inlet were included in this Historical Report Review. Overall, 37 percent (%) of fish salvaged survived, including 100% for Burbot, 69% for Lake Trout, 50% for Round

Whitefish, and 24% for Cisco. As much as 90% of fish were estimated to have been removed from the inlet with the salvage and fish-out operations.

Dillon (Dillon Consulting Ltd.). 2002a. Lake Trout Habitat Utilization Study, 2001. Technical Report – Final. Prepared for Diavik Diamond Mines Inc., NWT, Canada. November 2002.

This report described a 2000 to 2001 study of habitat use by Lake Trout in Lac de Gras. Angling and gill netting were used to capture fish, hydroacoustic sounding equipment was used to count fish, and radio-acoustic telemetry was used to track movements of 25 Lake Trout. The primary aims of the study were to gain a better understanding of habitat use in Lac de Gras, particularly near the A154 dike, and to develop and implement a standardized shoal habitat utilization survey in this area. Basic biological information was also collected for captured fish, with more detailed assessments of fish mortalities.

Dillon (Dillon Consulting Ltd.). 2002b. Slimy Sculpin Baseline Metals Study. Technical Report – Final. Prepared for Diavik Diamond Mines Inc., NWT, Canada. January 2002. Doc No. 00-8103.

This technical report described a 2000 to 2001 study of baseline metals in Slimy Sculpin inhabiting areas associated with the proposed A154/A418 dikes in Lac de Gras. Nineteen Slimy Sculpin (3 in 2000 and 16 in 2001) were captured in this study, and the results of metals and metallothionein analyses were presented in the report. There was minimal life history and catch data for the captured Slimy Sculpin in the report and appendices; therefore, these data were not reported in this Historical Report Review.

Golder (Golder Associates Ltd.). 2002. Draft Report on Inland Lakes Fish-Out Study Results, July 2000. Draft for Review. Prepared for Diavik Diamond Mines Inc., NWT, Canada. Revised March 2002.

As part of DDMI's Lac de Gras mine development, four inland lakes on the east island of Lac de Gras were dewatered. This report presented the results of a fish-out study conducted during July and August 2000 on each lake prior to dewatering. Fish population information was provided for these lakes, with additional post-dewatering habitat information for Lake E10. The report concluded with a discussion on absolute density of fish in small Arctic lakes, conventional fish sampling techniques as estimators of population size in small Arctic lakes, the ability to completely fish out a lake, and physical habitat characteristics.

Jacques (Jacques Whitford Environment Limited). 2002. Diavik Diamond Mines Inc. Dike A154 Fish Salvage Project (July-August 2002). Final Report. Prepared for Diavik Diamonds Inc., NWT, Canada. November 2002.

The results of a project to salvage fish isolated within Dike A154, part of the infrastructure of the Diavik Mine in Lac de Gras, were provided in this report. Fish were captured in July and August 2002 with gill nets, trap nets, minnow traps, and by angling. Species abundance and life history information for the captured fish were provided. The overall survivorship rate using all capture methods was 50%. Highest survival rates were from trap net catches (98.5%) and lowest from gill net catches (30.2%). Fish capture and recovery method recommendations were also made for future salvage efforts.

DDMI (Diavik Diamond Mines Inc.). 2003. Fish Palatability and Texture Study. Diavik Diamond Mines Inc., NWT, Canada. December 2003.

This report provided the results of a fish palatability and texture study conducted in 2002 and 2003 with community members at the Lac de Gras Diavik Mine site. No concerns about fish condition or quality were noted in the study, and thus, specific details were not available for this Historical Report Review. Raw data on the basic biology of individual fish, and results of texture and palatability analysis were included in the report’s appendices.

DDMI (Diavik Diamond Mines Inc.). 2004. 2003 Water Intake Report. Diavik Diamond Mines Inc., NWT, Canada. August 2004.

Results of a monitoring program on the effects of the mining operation water intake in Lac de Gras during the summer of 2003 were summarized in this report. It primarily included details of fish presence and abundance around the intake structure. Additionally, fish tissue, scale and bones were identified in samples from the intake pipe/pump backwash to assess direct fish mortality resulting from water intake. A lack of fish tissue, scales, or bones suggested the effectiveness of the screen and intake velocities in preventing uptake of fish during normal and high flow scenarios.

Gray M, Munkittrick K, Palace V, Baron C. 2005. Assessment of Slimy Sculpin (*Cottus cognatus*) collected from East Island, Lac de Gras, NWT. Technical report prepared for Fisheries and Oceans and Diavik Diamond Mines Inc., NWT, Canada.

This report was a joint effort between members of the Canadian Rivers Institute, the Department of Zoology at the University of Manitoba, and Fisheries and Oceans Canada. It presented the findings of a 2004 project to assess tissue metal concentrations of Slimy Sculpin near a DDMI dike (A154) and reference areas in Lac de Gras. The report also provided limited population and life history information for Slimy Sculpin.

CRI (Canadian Rivers Institute). 2006. Fish Health and Fish Population Assessment, Lac de Gras: Summer 2005. Technical Report. Prepared for Diavik Diamond Mines Inc., NWT, Canada. July 2006.

The findings of a 2005 fish population and fish health index assessment for Lac de Gras were provided in this report. It included information on size, growth, reproductive performance, parasites, and contaminant levels of fish near Diavik mining operations.

DDMI (Diavik Diamond Mines Inc.). 2006. Historical Information Review - Aquatic Environment. Diavik Diamond Mines Inc., NWT, Canada. May 2006.

This report presented historical data used in the revision of the 2001 to 2005 AEMP design. It contained raw data from baseline studies and construction/operations monitoring programs, and a description of how these data were evaluated for use in the AEMP. A final post-evaluation dataset of raw aquatics data was also included. Baseline fish data used in revising the AEMP were from Gray et al. (2005).

Thistle ME, Tonn WM. 2007. Patterns and relationships in fish composition and habitat in Barrenlands Lakes. Prepared for Bruce Hanna, Department of Fisheries and Oceans, Fish Habitat Management – Western Arctic Area by the Department of Biological Sciences, University of Alberta, Edmonton, AB. March 25, 2007.

The purpose of this study was to examine fish-habitat relationships in Arctic lakes using previously gathered data, primarily to support more effective habitat management decisions. Three objectives were considered: 1) to quantify fish production and productivity of lower trophic levels in Barrenlands lakes, 2) to examine patterns and relationships between fish habitat and fish communities, and 3) to assess the suitability of fish population sampling methods and to provide recommendations for future baseline fisheries study methodologies. Of particular relevance to the Jay Fish and Fish Habitat Baseline Study was information on fish and fish habitat for several lakes in the BSA. These included Lac de Gras, Lake D3 (Counts), Lake B4 (Cujo), Misery and North Misery Lake, and the North Inlet of Lac de Gras. However, location-specific data were limited, as the report ultimately provided overall summaries of fisheries resources in Barrenlands lakes based on compiled data from prior studies. General conclusions were that standardizing fishing gear and set times before fishing is the best way to compare or integrate fish production estimates, and that further organization, evaluation, and analysis of data are needed to better assess species composition, distribution, and relationships to environmental characteristics of Barrenlands lakes.

DDMI (Diavik Diamond Mines Inc.). 2008. Diavik Diamond Mine Shoal Habitat Utilization Report. Diavik Diamond Mines Inc., NWT, Canada. July 2008.

The *Diavik Diamond Mine Shoal Habitat Utilization Report* summarized the results of shoal habitat utilization surveys conducted in 2004, 2005, and 2006. The objective was to determine levels of shoal habitat use of Lake Trout near the A154 dike and a proposed A418 dike in Lac de Gras. These surveys were performed with hydroacoustic sounding equipment, and subsequent angling to ground truth the hydroacoustic data and gain additional habitat and life history information. This report also included the findings from a Lake Trout habitat utilization survey conducted with hydroacoustic sounding equipment throughout Lac de Gras in 2000 and 2001 (Dillon 2002a). The 2001 survey also used radio telemetry to track habitat use of tagged fish, and subsequent angling and gill netting provided additional detail on habitat use.

Golder (Golder Associates Ltd.). 2008. Fish Report In Support of the 2007 AEMP Annual Report for the Diavik Diamond Mine, NWT. Prepared for Diavik Diamond Mines Inc., NWT, Canada. April 2008. Doc. No. RPT-616 Ver. 0.

This report provided results of a 2007 survey on fish population health in Lac de Gras. Slimy Sculpin were the focal species of the survey, and therefore, sampling occurred within the littoral zone of Lac de Gras in habitat dominated by gravel or cobble substrate where Slimy Sculpin usually occur. Fish were captured by backpack electrofishing. Fish surveys were conducted at four locations: a near-field (NF) and far-field (FF) site (in relation to distance from a DDMI effluent diffuser), and two reference sites.

Golder (Golder Associates Ltd.). 2009. Metals in Lake Trout Report In Support of the 2008 AEMP Annual Report for the Diavik Diamond Mine Inc., NWT. Prepared for Diavik Diamond Mines Inc., NWT, Canada. April 2009. Doc No. RPT-841 Ver. 0 Rev. 1.

This study was completed in response to results from an earlier 2007 study (Golder 2008) that revealed elevated mercury concentrations in Slimy Sculpin populations exposed to mining effects. This was considered an early warning indicator of potential effects to Lake Trout tissue quality, and thus a survey to assess mercury concentrations was conducted in 2008 in Lac de Gras and Lac du Sauvage. This report presented the results of the survey and investigated possible trends in mercury concentrations over time by analyzing additional data from earlier studies. While the focus of the report was on Lake Trout tissue chemistry, limited abundance, life history, and fish health information was also included.

Rio Tinto. 2009. Diavik Diamond Mine Aquatic Effects Monitoring Program, 2008 Annual Report. Prepared for Diavik Diamond Mines Inc., NWT, Canada. April 2009.

The fish section of the 2008 AEMP report was a summary of the 2008 study of metals in Lac de Gras and Lac du Sauvage Lake Trout described in Golder (2009). It also made comparisons between the 2008 results versus results of Lake Trout fish tissue analyses from 1996 and 2005, and detailed fisheries authorizations and other special effects studies related to fish in Lac de Gras.

Golder (Golder Associates Ltd.). 2010. Fish Report in Support of the 2010 AEMP Annual Report for the Diavik Diamond Mine, NWT. Prepared for Diavik Diamond Mines Inc., NWT, Canada. March 21, 2011. Doc No. RPT-1032 Ver. 0.

The DDMI 2010 AEMP Fish Report presented the results of a 2010 fish survey in Lac de Gras to assess effects of DDMI effluent. As with the 2007 AEMP fish report (Golder 2008), this study targeted Slimy Sculpin, and thus, sampling took place within the specific littoral zone sites of Lac de Gras. Fish were captured by backpack electrofishing in shallow areas and by baited minnow traps in deeper water. Results indicated low-level effects of exposure to the Diavik Mine on fish population health, and low- and moderate-level effects on fish usability.

Rio Tinto. 2010. Diavik Diamond Mine Community-Based Monitoring (CBM) Camp Report – Fish Palatability 2009. Prepared for Diavik Diamond Mines Inc., NWT, Canada. March 31, 2010.

This report summarized a study of the palatability of Lake Trout from Lac de Gras. Local Aboriginal community groups participated in this assessment of the quality (taste, texture, and general condition or health) of four Lake Trout to test for adverse effects of mining activities in Lac de Gras. The consensus was that fish were okay to eat at the time of the study. Limited life history, fish tissue chemistry, and catch data for Lake Trout were available in this report, and because of low sample sizes, only the fish tissue chemistry results were presented in this Historical Report Review.

Rio Tinto. 2011. 2007 to 2010 AEMP Summary Report. Prepared for Diavik Diamond Mines, Inc., NWT, Canada. July 2011.

A summary of four AEMP annual reports (2007 to 2011) for the Diavik Mine was provided in this report. Included were trends in life history characteristics, health, and tissue chemistry of Slimy Sculpin and Lake Trout in Lac de Gras and Lac du Sauvage. Potential mine-related effects were identified based on these trends.

Golder (Golder Associates Ltd.). 2012. Mercury in Lake Trout Report in Support of the 2011 AEMP Annual Report for the Diavik Diamond Mine, NWT. Prepared for Diavik Diamond Mines Inc., NWT, Canada. March 2012. Doc No. RPT-1126 Ver. 0.

This report was produced in response to a previous study in 2007 (Golder 2008) that revealed higher mercury concentrations in Slimy Sculpin populations exposed to mining effects. This finding was considered an early warning indicator of potential effects to Lake Trout tissue quality, and thus, surveys to assess mercury concentrations in Lake Trout were conducted in 2008 and 2011 in Lac de Gras and Lac du Sauvage. The results of the 2011 survey were presented in this report. In addition to details on mercury levels in Lake Trout, it also included life history and species abundance information for other species caught during the survey.

Rio Tinto. 2012. Diavik Diamond Mine Aquatic Effects Monitoring Program, 2011 Annual Report. Prepared for Diavik Diamond Mines Inc., NWT, Canada. March 2012.

The 2011 AEMP included an overview of the 2011 Mercury in Lake Trout Report for the Diavik Mine (Golder 2012). Overall, Lake Trout tissue analyses from 1996, 2005, 2008, and 2011 indicated an increase in mercury concentrations since 1996, resulting in a low-level effect classification for Lake Trout usability. This increase was observed in Lac de Gras, where the Diavik Mine is located, as well as Lac du Sauvage, and therefore, it was concluded that the increase in mercury in Lac de Gras could not be attributed to mine effects. Details of the 2011 Mercury in Lake Trout Report were provided under a separate heading (Golder 2012) in this Historical Report Review.

A2 SPECIES ABUNDANCE AND DISTRIBUTION

A2.1 Ekati Mine

BHP 1995

The Ekati Diamond Mine EIS assessed fish presence in numerous streams and lakes through a combination of minnow trapping, gill netting, and backpack electrofishing. Misery Lake, a 13.7 ha tributary lake of Lac de Gras close to the BSA, contained only Lake Trout. The index gillnetting (1.5 and 2.0 inch stretched-mesh gillnets set perpendicular from shore) catch-per-unit-effort (CPUE) was considered low for this waterbody at 47 fish/100 metres (m)/24 hours, with an estimated population size of 91.

Rescan 2002

The report evaluated results from the 2002 monitoring program and identified potential effects of the Ekati Mine on the aquatic environment in the Koala and King-Cujo watersheds. The study included evaluation of effects to Round Whitefish and Lake Trout populations in Koala and King-Cujo watersheds, and two external reference lakes. Within the Jay Fish and Fish Habitat BSA, the report included information for Lake D3 (Counts) and Lake B4 (Cujo). Results did not indicate any major changes in fish communities as a result of the mine. Furthermore, there were no effects attributed to the mine on the Round Whitefish or Lake Trout populations in Lake B4 (Cujo).

Rescan 2003

Community composition, population estimates, and CPUE values from gillnetting (3.8 centimetre [cm] mesh) in Lynx Lake, Hammer Lake (referred to as Fisher Lake in the report) and Phantom Lake were reported for the 2002 Lynx Area Aquatic Baseline Report. Total CPUE was much higher in Hammer than Lynx and Phantom lakes, but CPUE for Lake Trout was highest in Lynx Lake.

In Lynx Lake, the mean CPUE for Lake Trout was 12.32 fish/100 square metres (m^2) of net/24 hours and 49.44 for Lake Whitefish, with a combined mean total CPUE of 61.80 fish. The population of Lake Whitefish was estimated to be between 1,460 and 2,020, with a minimum estimate of 880 (110 standard deviation [SD]). Lake Trout were estimated to make up 16% to 20% of the population in Lynx Lake with a minimum of 220 individuals.

As with Lynx Lake, only Lake Trout and Lake Whitefish were caught in Hammer Lake. The CPUE values in Hammer Lake were 4.01 for Lake Trout and 226.6 for Lake Whitefish. Based on these results, the population of Lake Whitefish was estimated to be between 1,290 and 3,000 individuals. Only 2% of the catch was Lake Trout and, therefore, the study reported that if Lake Trout comprised only 2% of the fish population of Hammer Lake, the estimated minimum population was 34 (10 SD) Lake Trout. Unlike Lynx and Hammer lakes, only Lake Chub were captured in Phantom Lake, with a relatively low CPUE of 22.79 fish/100 m^2 of net/ 24 hours. No population estimate was made for Lake Chub in Phantom Lake.

Population estimates and CPUE values were as expected, based on the trophic levels in Lynx Lake and Hammer Lake. However, a greater number of Lake Trout was expected in Hammer Lake than was observed given the relatively high population of Lake Whitefish available as prey. Thus, since food was not a limiting factor, there may have been another, unidentified, limiting factor for Lake Trout in Hammer Lake, such as spawning shoals.

Rescan 2007

The 2006 Jay Pipe Aquatic Baseline Report included CPUE and community composition data for Lac du Sauvage. Lake Trout, Lake Whitefish, and Round Whitefish were caught in gill nets, and Burbot and Slimy Sculpin were caught using minnow traps. Based on gill net catch data, species composition for Lac du Sauvage was estimated to be 59% Lake Trout, 29% Lake Whitefish, and 12% Round Whitefish. Combined (all fish) gill net CPUE was 32 fish/100 m^2/24 hours (6.7 standard error [SE]), while minnow trap CPUE was only 0.03 fish/100 m^2/24 hours (0.03 SE), with only Burbot captured in minnow traps.

Rescan 2008

The 2007 Ekati AEMP summary and data reports contained species composition (relative abundance) and CPUE data for Lake D3 (Counts) and Lake B4 (Cujo). A combination of gill nets, minnow traps, and backpack electrofishing was used for fish sampling in the AEMP Study Area. In Lake D3 (Counts) and Lake B4 (Cujo), the two waterbodies in the report within the BSA, fishing success was limited to gill netting and only Round Whitefish and Lake Trout were captured. The mean combined (both species) gill net CPUE (using 111 m^2 of 3.8 cm mesh net) in Lake D3 (Counts) was 1.37 fish/100 m^2/24 hours (0.11 SE) and relative species abundance was 66% Round Whitefish and 34% Lake Trout. In Lake B4 (Cujo), the mean combined CPUE was slightly lower at 1.19 fish/100 m^2/24 hours (0.07 SE), and the relative species abundance was 64% Round Whitefish and 36% Lake Trout.

Temporal changes in fish population biology were reported since baseline years and 2002. One trend was a decline in the abundance of Round Whitefish and Lake Trout in the majority of Koala watershed lakes, Lake B4 (Cujo), and Ekati AEMP reference lakes. However, this was likely a result of historical sampling mortality since the decline was observed in both reference and potentially impacted lakes. A regional climatic effect could not be excluded as a possible influence.

Rescan 2009

Comparisons between the results of Ekati environmental monitoring activities and the predictions of the 1995 EIS (BHP 1995) were made in this report. In the majority of the Koala watershed and reference lakes, including Lake D3 (Counts), as well as in Lake B4 (Cujo) in the King-Cujo watershed, CPUE of Lake Trout and Round Whitefish declined from baseline years through 2002. The report concluded that this decline was likely a result of historic sampling mortality; current mortality rates are assumed to be much lower as methods (catch limits) have changed to reduce sampling mortality. Furthermore, while a regional climactic effect had not been ruled out as an explanation, it was determined not to be a result of a mine effect because the decline in CPUE was observed in potentially impacted lakes as well as in reference lakes.

ERM Rescan 2013

The 2012 Ekati AEMP summary and data reports contained species composition (relative abundance) and CPUE data for Lake D3 (Counts) and Lake B4 (Cujo). Using gill netting and backpack electrofishing, Arctic Grayling, Round Whitefish, Slimy Sculpin, and Lake Trout were captured in Lake B4 (Cujo), and Round Whitefish, Slimy Sculpin, Lake Trout, and Burbot in Lake D3 (Counts).

In Lake D3 (Counts), mean gillnetting (using 111.57 m^2 of 3.81 millimetre [mm] mesh net) CPUEs were 0.98 (0.50 SE) fish/100 m^2/24 hours for Lake Trout and 3.60 (0.90 SE) for Round Whitefish, with a combined gill netting CPUE of 4.54 (1.10 SE). The species composition from gill netting was 22% Lake Trout and 78% Round Whitefish. In Lake D3 (Counts), the backpack electrofishing CPUE for Arctic Grayling was 0.06 fish/100 seconds, 0.03 for Lake Trout and 0.25 for slimly Sculpin, with a combined CPUE of 0.34.

In Lake B4 (Cujo), gill netting mean CPUEs were 0.22 (0.22 SE) fish/100m^2/24 hours for Arctic Grayling, 3.31 (1.05 SE) for Lake Trout, and 2.46 (0.77 SE) for Round Whitefish. The combined (all species) mean CPUE for Lake B4 (Cujo) by gill netting was 5.98 (1.31 SE) and species composition was 2% Arctic Grayling, 48% Round Whitefish, and 50% Lake Trout. Backpack electrofishing CPUE (number of fish per second) for Lake B4 (Cujo) was 0.06 for Arctic Grayling, 0.03 for Lake Trout, and 0.25 for Slimy Sculpin, with a combined CPUE of 0.20.

A decrease in CPUE for Lake Trout was identified in Lake D3 (Counts) since previous years, but the report stated that this may have been a result of mortality from previous sampling efforts and not mine effects. There was no clear temporal trend in CPUE values for Round Whitefish or Slimy Sculpin in Lake D3 (Counts). No trends in CPUE were identified in Lake B4 (Cujo).

A2.2 Diavik Mine

Golder 1997a

This report included observations of Arctic Grayling spawning in two streams in the BSA. In both streams, L1 (referred to as Stream FSR1 in the report) and J2 (referred to as Stream FSR2 in the report), adult Arctic Grayling were present. A relatively high density of spawning adults was observed in Stream L1 and a moderate density in Stream J2.

Golder 1997c

Summaries of fisheries resources in each of 33 surveyed inland lakes in the proposed mine footprint area on the east and west islands of Lac de Gras, as well as on the eastern mainland were included in this report. The report provided information on species presence in each of the lakes, as determined by use of various capture methods in each lake, including gill netting, beach seining, and angling.

Each lake was then ranked as having low or high fisheries importance. Low ranked lakes were those with maximum depth at or below 4 m or having no direct connection to Lac de Gras, lakes with no resident fish or only a few stunted fish, and lakes with a direct connection to Lac de Gras that do not provide spawning or foraging habitat for any fish species. Moderate ranked lakes had transient Lake Trout or Arctic Grayling populations and resident populations of Longnose Sucker, Round Whitefish, Cisco, or Lake Whitefish. Lakes ranked as having high fisheries importance had resident adult Arctic Grayling or Lake Trout populations and a connection to Lac de Gras that provides spawning or foraging habitat for Arctic Grayling.

Seven fish species were identified in the small lakes surveyed. Fish were recorded in 21 of 33 lakes (64% occurrence) and only 11 lakes (33% occurrence) contained Lake Trout. Similarly, only 12 lakes of those surveyed were identified as high fisheries importance. Those with high value fish habitat had resident Lake Trout or Arctic Grayling populations and a passable connection to Lac de Gras, which provides spawning and foraging habitat for Arctic Grayling. Additional details on age class (fry, juvenile, or adult) for some species were provided in the report.

Golder 1997f

The report presents Lake Trout data captured by gill netting and angling in Lac de Gras from a survey of fall spawning areas within and outside of the proposed Diavik Mine footprint. Fish presence was also assessed with sounding and video surveys and direct observations by field crews. Catch per unit effort was similar between the intensive (within potential mine footprint) and extensive (outside footprint) study areas. Spawning fish preferred open-water shoals bordered by deep waters in Lac de Gras. Further detailed catch records for Lake Trout and other species in Lac de Gras were provided in the report.

Golder 1997g

Lake Trout, Round Whitefish, Cisco, Arctic Grayling, Burbot, and Longnose Sucker were captured in Lac de Gras, and Lake Trout, Round Whitefish, Cisco, Arctic Grayling, and Lake Whitefish were captured in Lac du Sauvage in 1996 spring and summer fish surveys. Fish were captured primarily by gill netting, with some angling to supplement Lake Trout sample sizes. Limited trap netting was also done in the spring sampling program with low capture efficiency.

Abundance estimates were based on the summer versus spring sampling program. CPUEs in the spring were elevated because of capture methods targeting pre-spawn staging pools. Summer gill net CPUE indicated a slightly greater abundance of fish in Lac du Sauvage (1.9 fish/100 m/hour, 2.0 SD) than Lac de Gras (1.1, 3.8 SD). In Lac de Gras, the mean summer gill net CPUE for Longnose Sucker was 0.01 (0.09 SD), 0.27 (3.27 SD) for Arctic Grayling, 0.32 (1.54 SD) for Cisco, 0.39 (0.83 SD) for Lake Trout, 0.10 (0.59 SD) for Round Whitefish, and less than 0.01 (0.01 SD) for Burbot. Summer gill net CPUE in Lac du Sauvage for Cisco was 0.19 (0.62 SD), 1.07 (1.34 SD) for Lake Trout, 0.35 (0.71 SD) for Round Whitefish, and 0.37 (1.09 SD) for Lake Whitefish. In Lac de Gras, Lake Whitefish were only captured in the narrows between Lac de Gras and Lac du Sauvage.

DDMI 1998a

Fish species abundance and distribution data used in this report came from previous DDMI baseline reports (Golder 1997a,b,c,d,e,f). This information is summarized in this Historical Report Review under the individual baseline reports headings. General conclusions on abundance and distribution based on these previous studies included the following:

- Lac de Gras supports slow-growing, coldwater fish.
- Dominant fish species in Lac de Gras include Lake Trout, Cisco, and Round Whitefish.
- The Lac de Gras fish population is not exploited and represents the accumulation of many years of slow growth.
- Seven fish species were identified in the small lakes surveyed.

- Fish species were identified in streams only on the mainland.

DDMI 1998b

This report summarized previous environmental baseline studies (Golder 1997a,b,c,d,e,f, 1998; Acres and Bryant 1996) from 1995 and 1996 of fish and fish habitat in Lac de Gras, Lac du Sauvage, inland lakes on the east and west island of Lac de Gras, and in lakes on the mainland near the proposed Diavik Mine. Surveys were also conducted on streams draining into these lakes. Fish were captured with gill nets, trap nets, and seine nets in the 1995 survey, and gill nets, fyke nets, and angling in 1996. Overall, gill netting was the most efficient capture method. Based on gill net CPUE, Lake Trout, Round Whitefish, and Cisco were the most abundant species in the Lac de Gras intensive study area (area within the proposed mine footprint). Arctic Grayling, Lake Whitefish, Longnose Sucker, and Burbot were also caught by gill nets in Lac de Gras. Slimy Sculpin and Burbot were also present, but captured by other methods. In Lac du Sauvage, the most abundant fish species caught by gill net were Lake Trout, followed by Lake Whitefish and Round Whitefish. Cisco were also caught in Lac du Sauvage.

Longnose Sucker, Lake Trout, Round Whitefish, Lake Whitefish, Cisco, and Lake Chub were captured in the lakes on the east island of Lac de Gras. Lake Trout were found most frequently, being captured in 5 of the 11 lakes surveyed on the east island. One of the six lakes surveyed on the west island of Lac de Gras contained Lake Trout and Round Whitefish, one contained only Longnose Sucker, and one contained only Lake Trout. Lakes surveyed on the east mainland contained Longnose Sucker, Lake Trout, Round Whitefish, Lake Chub, and Arctic Grayling. Lake Trout were found most frequently, captured in 5 of the 16 mainland lakes, followed by Arctic Grayling in 4 of the lakes.

Jacques Whitford 2001

Species abundance and population information for fish salvaged in the North Inlet of Lac de Gras in July and August 2001 were detailed in this report. In total, 1,961 fish were captured in the inlet using primarily gill nets, but also char traps and minnow traps. Cisco was the dominant species, followed by Round Whitefish, Lake Trout, Burbot, and Arctic Grayling.

Golder 2002

The objectives of the fish-out study were to catch and remove all fish from four lakes on the east and west islands of Lac de Gras within the planned Diavik Mine footprint. A catch level of zero fish in 24 hours of continuous fishing, or only recapture of marked fish, would indicate success. This was accomplished in Lake E7 and Lake E10, but not in Lake E3 and Lake E8 where a plateau of 0.1 fish caught per hour was reached. Fish were captured by a combination of minnow traps, seine nets, and gill nets. Catch rates varied over time and did not decline linearly. Total fish catch was as follows:

- Lake E3: 3 Burbot, 3,218 Lake Chub, 6 Ninespine Stickleback, and 12 Slimy Sculpin were captured;
- Lake E7: 1 Burbot, 785 Lake Chub, 326 Longnose Sucker, 2 Ninespine Stickleback, and 10 Slimy Sculpin were captured;
- Lake E8: 5 Burbot, 212 Lake Chub, and 323 Longnose Sucker were captured; and,
- Lake E10: 7 Arctic Grayling, 3 Burbot, 15 Cisco, 9 Lake Trout, 63 Lake Whitefish, 1 Longnose Sucker, 7 Ninespine Stickleback, 73 Round Whitefish, and 4 Slimy Sculpin captured.

Observed fish density by weight was greatest in Lake E7 with a biomass of 23.4 kilograms per hectare (kg/ha), followed by Lake E8 with 15.8 kg/ha, Lake E10 with 12.2 kg/ha, and Lake E3 with 7.3 kg/ha.

Using mark-recapture and fishing effort data, the Petersen Estimate was used to estimate population sizes in Lakes E3, E7, and E8. The estimated population size of Lake Chub in Lake E3 was 5,951. An estimated 1,357 Longnose Suckers and Lake Chub occurred in Lake E7, and 550 Longnose Suckers and Lake Chub in Lake E8.

Jacques Whitford 2002

Species abundance information based on fish salvaged in the Dike A154 area of Lac de Gras in July and August 2002 were provided in this report. In total, 5,049 fish were removed from the Dike A154 study area. Cisco were the most abundant species, followed by Round Whitefish, Lake Trout, Burbot, Slimy Sculpin, and lastly Arctic Grayling. Relative abundance of species was similar to that of the North Inlet Fish Salvage Project conducted in in Lac de Gras in 2001 (Jacques Whitford 2001). The report stated that there was no evidence to suggest that fish taken from either the North Inlet or the Dike A154 study area were representative of the overall fish community of Lac de Gras.

DDMI 2004

This report detailed fish presence and abundance around the Diavik Mine intake structure in Lac de Gras in July and August 2003. Fish presence was determined by traversing five transects surrounding the water intake pipe with a custom drag net. Transects were approximately 400 m long and positioned two metres apart. July fish monitoring resulted in the capture of nine fish ranging from 2.0 to 2.5 cm fork length. No fish were captured in August.

Gray et al. 2005

Fish were captured by backpack electrofisher and minnow traps at three sites along the shoreline of the east island of Lac de Gras (one site near Diavik Mine dike (A154) and two reference sites). Only one Slimy Sculpin, one Round Whitefish, and one Burbot were captured in over 1,600 hours of minnow trapping. Electrofishing efforts resulted in 207 Slimy Sculpin, 15 Burbot, 2 Lake Trout, and 1 Ninespine Stickleback.

CRI 2006

A total of six fish species were captured with gill nets and trap nets at three locations in Lac de Gras. The most abundant species caught was Lake Trout (106), followed by Round Whitefish (27), Cisco (4), Lake Whitefish (2), along with 1 Burbot and 1 Longnose Sucker. Most fish were caught in gill nets, and the gill net CPUE (number fish per hour soak time using 125-m-long gangs consisting of 25-m-long panels of 2.5 cm, 5.1 cm, 7.6 cm, 10.2 cm, and 12.7 cm mesh sizes) for Lake Trout ranged from 0.42 to 0.52 fish per hour soak time at the three sites.

DDMI 2006

This report provided limited information on the abundance and distribution of Slimy Sculpin in Lac de Gras based on data from Gray et al. (2005). Distribution of Slimy Sculpin was patchy. Most fish were found in shallow water with small cobble substrate, and were generally not found along the new rock substrate at the A154 dike.

Thistle and Tonn 2007

This report included a broad summary of fish community-habitat interactions based on 1994 to 2003 data from 57 lakes in the Barrenlands. The report suggested that fish assemblages in these lakes may converge to a single community type of four core component species: Arctic Grayling, Burbot, Lake Trout, and Round Whitefish.

- Information relevant to the Jay Fish and Fish Habitat Baseline Study was limited to species presence and richness in Lake D3 (Counts), Lake B4 (Cujo), Lac de Gras, Misery Lake, N. Misery Lake, and North Inlet of Lac de Gras. Based on the data records used for this report, lakes were described as follows:
- Lake D3 (Counts) contained Lake Trout and Round Whitefish.
- Lake B4 (Cujo) contained Arctic Grayling, Lake Trout, and Round Whitefish.
- Lac de Gras contained Cisco, Lake Trout, and Round Whitefish.
- Misery Lake contained only Lake Trout.
- North Misery Lake was fishless.
- The North Inlet of Lac de Gras contained Arctic Grayling, Burbot, Cisco, Lake Trout, and Round Whitefish.

Golder 2008

The target species in this fish survey was Slimy Sculpin, but juvenile Lake Trout, juvenile Burbot, Ninespine Stickleback, juvenile Round Whitefish, and Arctic Grayling were also captured in Lac de Gras. Fish were captured by backpack electrofishing in shallow areas with boulder and cobble substrate, with a combined CPUE for all fish between 0.67 and 1.59 fish/100 seconds. The CPUE values were from 0.60 to 1.56 for Slimy Sculpin, from 0.01 to 0.07 for Lake Trout, 0.13 for Burbot, less than 0.04 for Ninespine Stickleback, and less than 0.01 for Round Whitefish and Arctic Grayling. There was no evidence to suggest an effect of effluent on catch rates.

Golder 2009

Catch-per-unit-effort (CPUE) values were provided in this report for Lake Trout captured in Lac de Gras and Lac du Sauvage as part of a tissue chemistry analysis for metals study. Only angling was used to capture fish. A single Northern Pike in Lac du Sauvage was the only non-target species caught, with the remaining catch being Lake Trout. In Lac de Gras, the CPUE (fish/angler-hour) ranged from 0.67 and 2.02. The cumulative CPUE was 1.21 with a total of 25 Lake Trout captured. In Lac du Sauvage, CPUE ranged from 0.42 to 1.50, with a cumulative CPUE of 0.67 and 23 Lake Trout captured.

Golder 2010

As with the 2007 AEMP fish report, the focal species of the DDMI 2010 AEMP Fish Report was Slimy Sculpin, but Lake Trout, Burbot, Ninespine Stickleback, Round Whitefish, and Lake Chub were also captured at Lac de Gras sampling locations. Fish were captured at the same survey locations as in 2007. Backpack electrofishing CPUE (number of fish/100 seconds) values at the four survey locations ranged from 0.833 to 1.147 for all species combined (number of samples [n] = 321 fish). The CPUE values were from 0.581 to 1.147 for Slimy Sculpin, from 0.049 to 0.109 for Lake Trout, from 0.006 to 0.037 for Burbot, less than 0.129 for Ninespine Stickleback, less than 0.010 for Round Whitefish, and less than 0.009 for Lake Chub. There was no evidence of decreased Slimy Sculpin catch rates in exposure areas.

Golder 2012

Gill net and angling CPUEs were presented for Lake Trout captured in Lac du Sauvage and Lac de Gras in this report. In addition to Lake Trout, Round Whitefish and Lake Whitefish were also captured by angling. Only Lake Trout were caught by gill netting. The three gill netting sampling effort CPUEs (number of fish/hour of fishing effort) ranged from 2.47 to 6.67 for both lakes combined. Angling CPUE (number of fish/angler-hour) for Lake Trout ranged from 1.13 to 4.00 in Lac de Gras, with a total CPUE of 10.21 based on 59 fish captured. In Lac du Sauvage, angling CPUE for Lake Trout ranged from 0.15 to 2.00 with a total CPUE of 6.71 based on 58 fish captured. Additional detail was available as raw data in the report's appendices.

A3 LIFE HISTORY

A3.1 Ekati Diamond Mine

BHP 1995

The 1995 Ekati Mine EIS reported a mean fork length of Lake Trout in Misery Lake of 339 mm (178 SD, n = 54) and mean weight of 437 grams (g) (212 SD, n = 52), with a mean condition factor by fin ray age of 1.035. Mean age of Lake Trout in Misery Lake was estimated to be 10.9 years (n = 66 fish), based on fin ray and otolith age measurements. The growth rates of Lake Trout in Misery Lake were considered slower than that in most lakes in the BHP study area, as well as Northwest Territories (NWT) lakes outside of the study area. The diet of Lake Trout in Misery Lake consisted primarily of trichoptera, hemiptera, and diptera.

Rescan 2002

Basic life history information was provided for Round Whitefish and Lake Trout in the Koala watershed, King-Cujo watershed and reference lakes, including Lake B4 (Cujo) and Lake D3 (Counts) in the Jay Fish and Fish Habitat BSA.

In 2002, Round Whitefish in Lake D3 (Counts) had a mean fork length of 317 mm (4 SE), a mean weight of 368 g (12 SE), and a mean condition factor of 1.13 (0.010 SE), all of which were slightly greater than in 1997 baseline results. Mean age was approximately eight years (0.4 SE), slightly lower than in 1997. The diet composition of Round Whitefish appeared to have substantially changed since 1997, primarily with an increase in cladocera and mollusca, and decrease in diptera, by weight.

Lake Trout in Lake D3 (Counts) in 2002 had a mean fork length of 460 mm (22 SE), a mean weight of 1,271 g (233 SE), a mean condition factor of 1.07 (0.02 SE), and a mean age of 17 years (1.4 SE). Again, weight, length, and age were all greater than in 1997 baseline results. As with Round Whitefish, the diet composition of Lake Trout had also changed substantially since 1997, primarily with an increase in copepoda and cladocera, and decrease in fish, by weight.

In Lake B4 (Cujo), Round Whitefish in 2002 had a mean fork length of 291 mm (5 SE), a mean weight of 310 g (22 SE), and a mean condition factor of 1.09 (0.011 SE), all of which were slightly less than in 1997 baseline results. Mean age was approximately eight years (0.7 SE), slightly lower than in 1997.

Lake Trout in Lake B4 (Cujo) in 2002 had a mean fork length of 460 mm (44 SE), a mean weight of 1,330 g (501 SE), a mean condition factor of 1.1 (0.04 SE), and a mean age of 21 years (3.8 SE). Weight, length, and age were all greater than in 1997 baseline results.

The report concluded that changes in Round Whitefish and Lake Trout life history characteristics were related to natural variations, and that no changes were a result of mine effects.

Rescan 2003

The 2002 Lynx Area Aquatic Baseline Report included data on fork length, weight, condition, age, sex, maturity, reproductive status, and diet (stomach contents) for Lake Chub in Phantom Lake, and Lake Trout and Lake Whitefish in Lynx Lake and Hammer Lake (referred to as Fisher Lake in the report).

In Lynx Lake, the most abundant Lake Trout were small adult fish, which was considered to be similar to other northern lakes. Most Lake Trout were between 18 and 23 years of age. Condition factor was relatively uniform among all size-classes.

Lake Whitefish in Lynx Lake were dominated by young mature fish of 270 mm to 309 mm, followed by older, larger fish in the 350 mm to 369 mm size range. Age of Lake Whitefish was highly variable, but young mature fish (five to six years old) were the most abundant age class, as expected. Results also indicated that Lake Whitefish within age cohorts display divergence in growth rates, particularly with more variation in weights. Condition factor of Lake Whitefish was relatively uniform for size classes. Sex ratio of both species was close to one to one.

Stomach content analysis of Lake Trout from Lynx Lake revealed hemipterans to be the most abundant organisms by number, being 43% of total items consumed, and 37% of overall diet mass. Forty-two percent of the diet by weight was teleosts, but they accounted for less than 1% of total food items consumed. Molluscs and dipterans were also abundant in Lake Trout stomachs, comprising 26% and 18% food items, respectively. They accounted for 13% and 3% of the total mass of the diet, respectively. Lake Whitefish stomachs contents were dominated by cladocerans, which comprised approximately 79% of all items, but only 27% of the overall mass. By weight, molluscs made up over 35% of their diet, but only 3% of total food items. Diets of both species were similar to that reported in other northern Canadian populations.

In Hammer Lake, Lake Trout sample size (n = 2) was too low to make comparisons of morphology with other lakes. Size classes of Lake Whitefish were relatively evenly distributed for Lake Whitefish in Hammer Lake, with young mature fish being the most abundant size class. The age of Lake Whitefish was highly variable, but young mature fish were the most abundant. Weight was highly variable within and among year-classes for Lake Whitefish, particularly in younger mature fish. Condition of Lake Whitefish was relatively uniform for size-classes. The condition factor was lower than in Lynx Lake, but not significantly so, and was similar to other lake fish populations in the Lac de Gras watershed. The sex ratio of Lake Whitefish was close to one to one.

Stomach content analysis revealed trichopterans to be the most abundant organisms by number in Hammer Lake, but less than 1% of the overall diet weight, with teleosts accounting for 99.9% of the diet by weight. For Lake Whitefish, cladocerans were the most abundant organisms (96%), but accounted for only 22% of total mass. Dipterans made up only 2% of total organisms, but 18% of the diet by weight. Trichopterans and molluscs were also prominent in stomachs making up 13% and 11% by weight, respectively.

Rescan 2007

The 2006 Jay Pipe Aquatic Baseline Report included a wide range of biological data for Lake Trout, Lake Whitefish, Round Whitefish, and Burbot in Lac du Sauvage, captured by gill netting and minnow trapping, as shown in Table 3.1-1. Mean lengths of Lake Trout were close to that observed in baseline surveys in 1996 (Acres and Bryant 1996). Weight-length relationships suggested that juveniles and adult fish of all species in Lac du Sauvage experienced similar growth conditions.

For all species in Lac du Sauvage, sex ratios were skewed towards males. Maturity analysis for Lake Trout, suggested that reproduction may not occur annually in Lac du Sauvage. This may indicate inadequate energy reserves, which is the typical explanation for cold water systems (Martin 1966). Mean age and age distribution in Lac du Sauvage was consistent with previous assessments (Acres and Bryant 1996).

Stomach content analysis of Lake Whitefish demonstrated a pelagic diet dominated by cladocera, by both weight and number of items. Round Whitefish diet was indicative of their benthic nature, being dominated by trichopterans by both weight and number. Stomach contents of Lake Trout in Lac du Sauvage showed a diet abundant in fish (74% by weight of total stomach contents).

Table 3.1-1 Select Life History Characteristics of Fish in Lac du Sauvage, 2006

	Fork Length (mm)			Weight (g)			Age (years)			Sex Ratio		% Mature	Relative Fecundity[a]		
Species	n	Mean	SE	n	Mean	SE	n	Mean	SE	n	%F	%	n	Mean	SE
Burbot	3	63	0.9	3	4	1	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Lake Trout	36	564	14.8	36	2,119	168	18	15	1	5	40	79	5	4.5	0.81
Lake Whitefish	23	459	11.6	23	1,307	98	14	13	0.6	7	45	100	7	40	5.96
Round Whitefish	11	319	16.2	11	366	55	3	9	1.3	2	33	100	2	9.9	0.01

Source: Rescan (2007).
a) Relative fecundity = eggs/g body weight.
n/a = not available; n = sample size; SE = standard error; mm = millimetre; g = grams; % = percent; %F = percent female.

Rescan 2008

The 2007 Ekati AEMP report included various biological measurements for all fish sampled including fork length, weight, condition, growth, sex, age, maturity, reproductive status, liver weight, gonadosomatic index (GSI), liver somatic index (LSI), diet, gonad weight, ovary weight, and eggs (Table 3.1-2).

Based on stomach content analysis (only including details on items which accounted for 1% or more of the diet by weight), in Lake D3 (Counts), Round Whitefish diet by weight was dominated by cladocera (96%), followed by mollusca (3%), and trichoptera (1%). The diet by weight of Lake Trout in Lake D3 (Counts) was also dominated by cladocera (95%), followed by diptera (3%), fish (1%), and copepoda (1%). In Lake B4 (Cujo), Round Whitefish diet was dominated by cladocera (97%), mollusca (2%), and diptera (1%). Lake Trout diet in Lake B4 (Cujo) was dominated by diptera (52%), followed by cladocera (22%), mollusca (22%), and hemiptera (4%).

The report also summarized changes in aquatic conditions, including fish biology, since baseline years and 2002. One change was an increase in average length, weight, age, and growth rate of Lake Trout in the Koala watershed and Lac de Gras. In Lake B4 (Cujo), Round Whitefish and Lake Trout average length and weight, as well as growth rate in Lake Trout, also increased. In both cases, this was likely a result of increased growth and less competition for food resources because of sampling mortality from previous studies (i.e., fewer adult fish in lake).

Table 3.1-2 Select Life History Characteristics of Fish in Lake D3 (Counts) and Lake B4 (Cujo), 2007

		Fork Length (mm)			Weight (g)			Age (years)			Sex Ratio	% Mature
Lake	Species	n	Mean	SE	n	Mean	SE	n	Mean	SE	m:f	%
Lake D3 (Counts)	Round Whitefish	31	326	6	31	394	22	40	10	1	4.2	92
	Lake Trout	18	444	26	18	1,035	218	21	15	1	4	60
	Slimy Sculpin	30	52	1.8	30	1.3	0.1	--	--	--	--	--
Lake B4 (Cujo)	Round Whitefish	29	341	10	17	509	57	51	9	1	0.7	100
	Lake Trout	24	507	39	13	2,883	955	29	14	2	0.3	75
	Slimy Sculpin	30	61	3.3	9	1.8	0.3	--	--	--	--	--

Source: Rescan (2008).

-- = not recorded; n = sample size; SE = standard error; mm = millimetre; g = gram; % = percent; m = male; f = female.

Rescan 2009

The Ekati Mine 2009 EIR summarized several findings based on comparisons between the AEMPs and baseline studies. With relevance to the Jay Fish and Fish Habitat BSA, specifically Lake D3 (Counts) and Lake B4 (Cujo), the average length, weight, and growth rate of Lake Trout increased relative to baseline findings. Length and weight of Round Whitefish also increased in Lake B4 (Cujo), and age of Round Whitefish increased in Lake D3 (Counts). However, the report concluded that this was most likely the result of growth release from the survivors of sampling mortality in previous surveys (i.e., growth increased because of less competition of food resources).

ERM Rescan 2013

The 2012 AEMP provided biological measures for fish collected, including Round Whitefish, Lake Trout, Slimy Sculpin, Arctic Grayling, and Burbot in Lake D3 (Counts) and Lake B4 (Cujo), as shown in Table 3.1-3. In Lake B4 (Cujo), a trend toward consistently higher weight of Slimy Sculpin over time was identified, suggesting that fish growth had not been stunted as a result of mine operations. The condition of Lake Trout had also increased over time in Lake B4 (Cujo) and decreased in Ekati AEMP reference lakes, further supporting this conclusion. No other changes or effects were identified for life history characteristics of fish in Lake B4 (Cujo). In Lake D3 (Counts), no major trends over time in fish life history characteristics were identified.

Table 3.1-3 Select Life History Characteristics of Fish in Lake D3 (Counts) and Lake B4 (Cujo), 2012

Lake	Species	Fork Length (mm)			Weight (g)		Age (years)		Sex Ratio
		n	Mean	SD	Mean	SD	Mean	SD	m:f
Lake D3 (Counts)	Round Whitefish	23	327	43	428	168	11	4.3	1.3
	Lake Trout	9	325	142	506	349	9	3.4	--
	Burbot	3	51	5	1.2	0.5	--	--	--
	Slimy Sculpin	31	65	12	2.5	1.5	3	0.9	0.4
Lake B4 (Cujo)	Round Whitefish	21	344	63	501	223	11	4.3	1.6
	Lake Trout	25	410	163	996	1059	10	4.7	0
	Arctic Grayling	7	104	117	87.7	226	--	--	--
	Slimy Sculpin	25	64	10	2.6	1.2	3	1.1	0.1

Source: ERM Rescan (2013).

-- = not recorded; n = sample size; SD = standard deviation; mm = millimetre; g = gram; m = male; f = female.

Stomach contents of Round Whitefish and Slimy Sculpin from Lake D3 (Counts) and Lake B4 (Cujo) were also analyzed. In Lake D3 (Counts), Round Whitefish diet by weight (including only items accounting for 1% or more of the contents) was dominated by crustacea–brachiopoda (93%), followed by diptera–chironomidae (5%), and gastropoda (1%). The dominant dietary item by weight in Lake D3 (Counts) for Slimy Sculpin was diptera–chironomidae (99%). Diets appeared to be relatively similar in Lake B4 (Cujo). The dominant item by weight in the diet of Round Whitefish was crustacea–brachiopoda (54%), followed by diptera–chironomidae (39%), gastropoda (5%), and bivalvia (2%). Slimy Sculpin diet in Lake B4 (Cujo) was dominated by diptera–chironomidae (57%), followed by crustacea–brachiopoda (35%) and diptera (6%). In lakes of the King-Cujo and Koala watersheds, and reference lakes, changes observed in the taxonomic composition of zooplankton and lake benthos communities did not appear to have an effect on fish prey choice, with dominant prey items having generally remained consistent over time.

The 2012 AEMP also made comparisons between 2012 data and data from previous years. For fish length, the study identified no overall spatial patterns in length distributions in monitored versus reference lakes, suggesting no relationship between changes in length distributions and mining activities. By comparing 2012 results with previous years, an increase in the mean fork length of Round Whitefish was detected in Lake D3 (Counts).

Weight was found to differ for all species within and among all lakes over the years, and no clear temporal or spatial pattern was evident to suggest a relationship to mining activities. In Lake D3 (Counts), however, Round Whitefish were found to have greater mean weights compared to previous years (as noted for fish length).

An overall trend in decreased body condition over time (since the start of Ekati Mine operations) was identified for Lake Trout, but this trend occurred in both reference and monitored lakes, providing no causal support for effects of mining activities. No temporal or spatial patterns in Round Whitefish or Slimy Sculpin body conditions were identified to suggest mine effects.

Up until 2007, a shift to older Lake Trout was apparent, but data from 2012 showed the return of a strong young cohort, similar to that seen in baseline surveys of the 1990s. The trend was observed in both reference and monitored lakes, and no spatial patterns were identified, suggesting no relationship to mining activities. No trends in age for Round Whitefish or Slimy Sculpin were observed. Overall growth rate results showed a shift to lower growth rates over time for Lake Trout in monitored and reference lakes, but results of analyses suggested these changes were unrelated to mining activity.

For all other life history variables analyzed in the 2012 AEMP, while variations were identified, no overall clear, consistent spatial or temporal patterns were found to suggest effects of mining activities. However, in some cases, sample sizes were low, giving insufficient data for comparisons to previous years.

A3.2 Diavik Mine

Golder 1997f

Limited life history information on Lake Trout captured in Lac de Gras was provided in this report. Captured male Lake Trout were most often ripe (able to release spawning products by touch), while females were most often green (preparing to spawn that year). Lake Trout spawned at dusk or during the night between September 3 and 13, 1996, in Lac de Gras. Additional detail on individual fish morphology and age was available in report appendices.

Golder 1997g

This report included summaries of life history information for fish captured in spring and summer 1996 sampling programs in Lac de Gras and Lac du Sauvage. Details of age, length, weight, and condition values for Lake Trout, Cisco, Arctic Grayling, and Round Whitefish were provided (DAR Section 2.2.3, Table 2.2-1), with summaries of trends and comparisons within and between the two lakes. Lake Trout were found to have the widest ranging and most evenly distributed ages. Most of the male Lake Trout in Lac de Gras were younger than male Lake Trout in Lac du Sauvage. Female Lake Trout were on average younger than male Lake Trout in both systems. On average, Lake Trout were older than other species, and had the widest range of age classes in both lakes.

Energy allocation endpoints were assessed by comparing growth rate, condition, and reproduction of species between the two lakes. Growth curves were relatively similar for Lake Trout and Arctic Grayling between the two lakes, but indicated slower growth of Round Whitefish in Lac du Sauvage, particularly males. In Lac du Sauvage, Round Whitefish appeared to have greater mean lengths per age class for both sexes when compared to Lac de Gras. Lake Trout, in contrast, appeared to have greater mean lengths per age class in Lac de Gras. There was no major difference in condition factor between lakes for all species except Cisco, which had lower condition in Lac de Gras.

No major differences in LSIs (liver-somatic indices) between lakes for males or females of any species were identified. Females generally had larger LSIs than males for Lake Trout, Cisco, and Round Whitefish, possibly due to added weight of vitellogenin in female livers. Ripe, gravid, and spent maturity classes were the most commonly seen in Arctic Grayling from both lakes, but this is likely due to sampling during spring spawning time.

The most common maturity class of both sexes of Round Whitefish was green (sexually mature, spawned in previous season and developing gonads for the coming season) in both lakes. Green was also the most common stage observed in female Cisco from both lakes, but a higher proportion of males were maturing in Lac du Sauvage than in Lac de Gras. In both lakes, a large proportion of female Lake Trout were immature or resting, with a greater percentage of resting females in Lac de Gras. For male Lake Trout, green and immature stages were most common in both lakes. Maturity classes were more variable for fish selected for a detailed fish health study.

Additional characteristics, including age to maturity, GSI, fecundity and egg diameter, and histological determination of maturity, were assessed for select sacrificed fish, and comparisons between lakes and between species were made. Arctic Grayling in both lakes reached sexual maturity at 5 years of age. In Lac du Sauvage, it appeared male Round Whitefish reach sexual maturity (8 years) earlier than females (9 years), while the reverse was true in Lac de Gras (males 11 years and females maturing at 6 years, and all females sexually mature by 10 years). Male Cisco sexually matured one year earlier in Lac de Gras (5 years) than in Lac du Sauvage (6 years). Female Cisco in both lakes reached sexual maturity at 5 years. Male Lake Trout matured earlier in Lac de Gras (first mature at 8 years) than in Lac du Sauvage (10 years), but all fish reached sexual maturity at an older age in Lac de Gras (17 years in Lac de Gras, 11 years in Lac du Sauvage). Female Lake Trout first matured at 7 years in Lac de Gras and were all sexually mature at age 12, whereas in Lac du Sauvage, females first matured at 4 years and total sexually maturity was reached at age 11.

Gonad weights and GSIs were higher for male Arctic Grayling in Lac de Gras than Lac du Sauvage, but this may be a reflection of later sampling in the spawning season in Lac du Sauvage resulting in partially spent males. In both lakes, a small sample size made it difficult to compare female gonad weights and GSIs. In Lac de Gras, both male and female Round Whitefish had smaller gonads than in Lac du Sauvage, but only more so for females. Male and female Cisco also had smaller GSIs in Lac de Gras, but only more so for males. No significant differences in GSI were observed in male or female Lake Trout.

Fecundity was higher in Round Whitefish and Lake Trout from Lac de Gras, but egg diameter did not differ between the lakes. No site differences were identified in the fecundity or egg diameter of Cisco. Arctic Grayling sample sizes were too small for comparisons, and the report did not include a comparison for Lake Trout.

Histopathological examinations of mature gonads were used to confirm maturity classifications made in the field. Since they were captured during the spawning run, all Arctic Grayling were classified as ready to spawn. One-third of analyzed Lake Trout (males and females combined) from Lac de Gras were classified as in resting condition, and the remainder classified in the developing gonads stage. Only one Lake Trout selected for analysis from Lac du Sauvage was resting, and all others were developing gonads. Round Whitefish and Cisco were found to be in developing gonads stage in Lac de Gras. In Lac du Sauvage, no Round Whitefish were found to be in resting condition, but one individual did have non-functional gonads. Eight of the nine Cisco from Lac du Sauvage were in the developing gonad stage, with only one in resting condition.

DDMI 1998b

This report summarized previous findings of environmental baseline studies (Golder 1997a,b,c,d,e,f, 1998). Life history information included summaries of age, size and condition, diet, disease, body burden, state of maturity, and spawning habitat of Lake Trout, Round Whitefish, Cisco, and Arctic Grayling in Lac de Gras and Lac du Sauvage.

Lake Trout had the widest range of ages of the four species captured, with no clear difference between Lac de Gras and Lac du Sauvage. Average lengths of adult Lake Trout were similar in Lac de Gras and Lac du Sauvage. Condition factors indicated healthy fish in both lakes. Stomach content analyses indicated a diet composed of fish and insects, caddisfly larvae, and dipteran adults the most common in the summer, with more zooplankton and dipterans in the fall.

Jacques Whitford 2001

Limited life history information for fish salvaged in the North Inlet of Lac de Gras in July and August 2001 was available in this report. In total, 1,961 fish were captured, most of which were adult and juvenile Cisco and Round Whitefish, and juvenile Lake Trout. The respective mean fork length (mm) and weight (g) of fish captured by gill net (salvage and fish-out) was: 229.4 mm and 148.8 g for Cisco; 273.0 mm and 264.1 g for Round Whitefish; 241.4 mm and 250.1 g for Lake Trout; 333.5 mm and 528.2 g for Burbot; and the one Arctic Grayling caught was 355 mm long and weighed 550 g. More detailed life history information for individual fish including sex and maturity was provided in the report.

Jacques Whitford 2002

Limited life history information for fish salvaged in Dike A154 area of Lac de Gras in July and August 2002 was available in this report. In total, 5,049 fish were captured. The respective mean fork length (mm) and weight (g) of fish captured by gill netting (one-hour and overnight sets) was: 198.7 mm and 124.7 g for Cisco; 199.3 mm and 136.2 g for Round Whitefish; 229.7 mm and 201.1 g for Lake Trout; 271.3 mm and 245.6 g for Burbot; and the one Arctic Grayling caught was 278 mm long and weighed 250 g. Additional life history data including sex and maturity of individual fish were provided in the report.

While relative abundance was similar to that of the 2001 North Inlet Fish Salvage Project, mean fork length and weight were lower for fish taken in this study. However, this is likely of little significance, as larger fish may have migrated away from dike construction and activity, as they were able to move freely in and out of the dike area. The report points out that there is no evidence to suggest that fish taken from either the North Inlet or the Dike A154 Study Area are representative of the overall fish community of Lac de Gras. More detailed life history data, including raw data for individual fish were included in the report's appendices.

Gray et al. 2005

Only information on life history characteristics of Slimy Sculpin was provided in this report. Based on 20 fish from a site near the DDMI dike in Lac de Gras and 20 fish from a reference site, mean length and weight of Slimy Sculpin was 61.2 mm (1.5 SE) and 2.07 g (0.16 SE), and 65.8 mm (1.9 SE) and 2.68 g (0.23 SE), respectively. There were no statistically significant differences between sites for length, condition factor, or adjusted condition factor, but reference site Slimy Sculpin were significantly heavier than dike site Slimy Sculpin. Additionally, it was noted that Slimy Sculpin stomachs from the reference site were full of caddisflies.

CRI 2006

This report provided detailed life history information for Lake Trout (81 individuals) and Round Whitefish (25 individuals) in Lac de Gras. The mean age of Lake Trout from three sample sites in Lac de Gras ranged from 17 to 22 years with no significant difference between the sites. There were 1.6 females to every one male captured, and the proportion of pre-spawning fish was greater for males (0.55) than for females (0.18). Twenty-six percent of Lake Trout were immature, 42% resting, and 32% pre-spawners. No difference in mature Lake Trout size-at-age among sites was found, suggesting no significant difference in growth rates. No significant difference in condition of adult males or females, or in stomach contents between sites was identified. Liver weights of pre-spawning males and females were also not significantly different between sites, but resting females at the diffuser area did have smaller livers than those at one of the more distant sites. No significant differences in gonad weight or fecundity of male or female Lake Trout were found between sites.

The mean age of Round Whitefish was 6 to 10 years at the three sites, with no clear difference between sites. Approximately 2.6 females were captured for every one male. Twenty-eight percent of fish captured were immature, 4% resting, and 64% pre-spawners. As with Lake Trout, there were no significant differences in growth rates between sites, and condition, liver weight, stomach weight, and fecundity did not appear to be significantly different for pre-spawning females between sites; however, conclusive statements were limited by low sample sizes.

DDMI 2006

Limited life history information for Slimy Sculpin from Lac de Gras was available in this report, as a summary of the results were in Gray et al. (2005). A strong yearling age-class was found at the A154 dike area and a reference location (REF1), indicating successful reproduction at both sites. There was no statistically significant difference in length between the two sites, but Slimy Sculpin from REF1 were significantly heavier than Slimy Sculpin from the A154 area. This difference may have been an indication of an increased food supply at REF1.

Thistle and Tonn 2007

Life history information in this report that is relevant to the Jay Fish and Fish Habitat BSA was limited to figures of frequency by fork length and weight for Round Whitefish, Lake Trout, and Burbot in North Inlet, and Lake Trout in Misery Lake. The life history figures were not summarized in this Historical Report Review.

Golder 2008

In the 2007 AEMP fish report, life history data were limited to Slimy Sculpin from Lac de Gras. Slimy Sculpin in the two mine exposure locations tended to be larger and older than Slimy Sculpin in the reference sites. It was unclear why age differed between sites; the report suggested that it may have been a result of lack of precision in fish ageing, rather than a mine-related effect. However, the increased body size was indicative of increased resource availability. No clear evidence of resource availability for fish was provided in the report and it was suggested that it may be related to a mine effect, natural variation, or proximity of sites to Lac du Sauvage, which may be more productive than Lac de Gras. Juvenile Slimy Sculpin from one of the exposure sites had the greatest condition factor, potentially related to a more diverse diet, as more benthic and pelagic prey items were found in stomachs of fish from this area, compared to fish with stomach contents more dominated by planktonic organisms in one of the reference areas. Differences in relative liver sizes between sites were observed, but there was no clear pattern to suggest a mine-related effect.

In the exposure site nearest the effluent source, male Slimy Sculpin had relatively small gonads. Because sampling occurred well before spawning time, the report did not make inferences from these data about implications related to mine effects or to gonadosomatic index (GSI) during the post-spawning period.

Golder 2009

Limited Lake Trout life history information was provided in this report for fish collected in Lac de Gras and Lac du Sauvage for tissue chemistry analysis. In Lac de Gras, the mean length of Lake Trout captured in 2008 for this study was 601 mm (138 SD, n = 25). The mean length of Lake Trout from Lac du Sauvage was 649 (68 SD, n = 23). Additional raw biological data on individual fish were available in the appendices, but not summarized in this Historical Report Review.

Golder 2010

Life history data were limited to Slimy Sculpin in the DDMI 2010 AEMP Fish Report. As with the 2007 study, this study also identified an enrichment effect at the exposure areas with a tendency towards larger fish, particularly for males, and adults, with juveniles slightly smaller in exposure areas. Enrichment effects in exposure areas were also identified in benthic invertebrates and plankton communities suggesting more resource availability to fish in exposure areas. Slimy Sculpin in the exposure areas also had a greater condition factor and LSI than those from reference sites. This finding may reflect more abundant food resources because no clear difference in diet composition between areas was found. In addition to being smaller in exposure areas, juvenile (age-1) fish had lower fat content and LSI values.

Temperature data suggested that fish in the FF1 (Far Field 1) area may have been exposed to warmer water earlier in the season, which may have resulted in increased growth rate of juveniles. However, the smaller adult fish in the non-exposure areas suggested that adult fish growth was not positively influenced by the warmer temperatures.

Rio Tinto 2011

Based on the results of surveys in 2007 and 2010, Slimy Sculpin showed a general pattern of response to mine exposure areas of Lac de Gras, with increased size, size-at-age, and condition factor in adult fish in 2010. The size (length and weight) of Slimy Sculpin in the exposure area was within the normal range, but adult males were near the top of the range. These larger males also had greater condition factors in 2010, suggesting a response to nutrient enrichment in the exposure area. However, the condition factors of female fish were similar in 2007 and 2010, and juvenile fish actually had lower condition factors in 2010, with no statistical difference between exposure and non-exposure areas. A slight decline in condition for the entire population at one of the exposure sites (NF) may have been related to seasonal differences, especially for juveniles. The LSI for female Slimy Sculpin in the exposure area was greater in 2010 than in 2007, which may reflect excess energy storage as a response to a nutrient-enriched environment.

Golder 2012

A limited amount of life history information for Lake Trout captured in Lac de Gras and Lac du Sauvage for fish tissue chemistry analyses was available in this report. Mean fork length, total body weight, and condition of Lake Trout from Lac de Gras was 634 mm (91 SD), 2,627 g (915 SD), and 1.02 (0.18 SD), respectively. In Lac du Sauvage, the mean fork length, total body weight, and condition of Lake Trout was 643 mm (113 SD), 2,460 g (942 SD), and 0.90 (0.16 SD), respectively. The mean age of Lake Trout was 15 years (4 SD) in both lakes.

Golder (2012) also included mean total body weights, ages, and condition factors for the fish captured in the 2008 metals in lake trout study (Golder 2009). The mean total body weight for Lake Trout in Lac de Gras was 2,513 g (1,382 SD) and in Lac du Sauvage was 3,026 g (920 SD). The mean condition factor for Lake Trout in Lac de Gras was 1.06 (0.16 SD) and in Lac du Sauvage was 1.08 (0.11 SD). Mean age of Lake Trout in Lac de Gras was 17 years (7 SD) and 19 years (7 SD) in Lac du Sauvage. Overall, Lake Trout were, on average, larger, older, and of a slightly higher condition in Lac du Sauvage than Lac du Gras.

A4 HABITAT USE AND AVAILABILITY

A4.1 Ekati Mine

BHP 1995

A habitat assessment for Misery Lake was conducted as part of the 1995 EIS, which produced a map showing the substrate types present in the lake. The map indicated optimal Lake Trout spawning habitat in the western and southern portions of the lake.

Rescan 2003

The 2002 Lynx Area Aquatic Baseline Report included details about littoral zone habitat availability in Lynx Lake, Phantom Lake, and Hammer Lake (referred to as Fisher Lake in the report). The report concluded that all three lakes appeared to contain adequate substrate to support Lake Trout, but the lack of deep water and overwintering habitat prevented Phantom Lake from sustaining large-bodied species. Minimal cobble substrate in Hammer Lake provided only limited spawning habitat for Lake Trout. Suitable spawning, rearing, and overwintering habitat for Lake Whitefish was identified in all three lakes. A habitat survey was also conducted for one stream, Hammer Creek (referred to as Stream C in the report), which flows from Hammer Lake to Lac de Gras. This was the only stream identified in the Lynx study area with a defined channel open for more than a few metres. Based on substrate, stream morphology, and flow, only marginal fish habitat was identified, possibly providing rearing and/or spawning habitat at both ends of the watercourse. However, at the time of the survey, no fish were present.

Rescan 2007

Information, including maps, on habitat availability for Lake Trout, Lake Whitefish, Round Whitefish, and Burbot in Lac du Sauvage was provided in the 2006 Jay Pipe Aquatic Baseline Report. Habitat data were collected by a littoral zone shoreline walk and quadrant surveys, and video shoreline shoal assessments. Through comparisons of fish habitat requirements with data collected on substrate, vegetation, and cover, the report concluded that the Jay Pipe area of Lac du Sauvage provides habitat potentially used by the following life stages and species:

- all life stages of Round Whitefish;
- spawning, young-of-year, and juvenile rearing habitat for Lake Trout;
- spawning, young-of-year, and juvenile rearing habitat for Burbot; and,
- spawning, juvenile, and adult habitat for Lake Whitefish.

The report also presented detailed habitat surveys of two small, ephemeral streams between the B and C sub-basins of Lac du Sauvage. At the time of the surveys, water levels were low and both streams were non-fish bearing.

A4.2 Diavik Mine

Golder 1997a

This report included summaries of habitat types in two streams in the Jay Fish and Fish Habitat BSA, tributaries of Lac du Sauvage. Stream L1 had 30% “R1” habitat (lowest quality, deepest run habitat), 35% “R2” (moderate quality/depth run habitat), 20% “R3” (highest quality/depth run habitat) 5% “R4” (similar to R3, but channel braided through thick willows), and 10% “P1” (highest quality pool habitat). One hundred percent of habitat in Stream J2 was identified as “R4.” Two “P1” pools (low-quality pool habitat) and two “P2” pools (moderate-quality pool habitat) were identified in Stream L1. No pools were identified in Stream J2.

Golder 1997b

This memorandum included summaries and maps of habitat-use and availability in Lac de Gras and Lac du Sauvage. Particular focus was on shoal habitat available for spawning Lake Trout and other dominant fish species. A total of 181 shoals (160 in Lac de Gras and 21 in Lac du Sauvage) were identified with a bathymetric survey using echo-sounding equipment. The substratum composition of each shoal was then assessed using underwater video equipment, and subsequently mapped according to quality of spawning habitat. The study identified a higher occurrence of potential spawning habitat in shallow areas in Lac de Gras compared to those in Lac du Sauvage. In Lac de Gras, approximately 52%, 61%, and 30% of shoals displayed characteristics to support Lake Trout, Cisco, and Round Whitefish spawning activity, respectively.

In Lac du Sauvage, approximately 43% of the shoals may provide spawning habitat for Lake Trout and Cisco, and only 10% for Round Whitefish. Shoal habitat ranked as “fair” for Lake Trout and Cisco was the most frequently encountered shoal habitat in Lac de Gras, while in Lac du Sauvage “unsuitable” habitat was the most commonly encountered shoal habitat. Habitat considered “unsuitable” for Round Whitefish spawning was most common in Lac de Gras and Lac du Sauvage.

The report estimated 12.5 million m^2 of Lake Trout spawning habitat (“good” and “fair” quality) in the Lac de Gras intensively sampled area (near the proposed mine footprint) and 58 million m^2 in the extensively sampled area. In contrast, an estimated 18 million m^2 of Lake Trout spawning habitat was present in Lac du Sauvage. Much of this habitat was identified as non-attached shoals and shoals extending from small islands. A larger proportion of shoal habitat in Lac du Sauvage was shoreline-attached shoals, at least partially as a result of narrow features of Lac du Sauvage (DAR Section 3.2, Maps 3.2-1, 3.2-2, and 3.2-3).

Golder 1997c

Shoreline habitat and bathymetry descriptions were provided for 33 inland lakes within the proposed Diavik Mine footprint on the east and west island of Lac de Gras and on the mainland. The lakes were also ranked by relative importance in terms of fish habitat. Those with “high” value fish habitat had both resident Lake Trout or Arctic Grayling populations and a passable connection to Lac de Gras that provides spawning and foraging habitat for Arctic Grayling. “Moderate” value habitat was identified for lakes with transient Lake Trout or Arctic Grayling populations, and with resident populations of Longnose Sucker, Round Whitefish, Lake Whitefish, or Cisco. Lakes with “low” value fish habitat included lakes with a maximum depth below 4 m, with no direct connections to Lac de Gras, no resident fish or only a few stunted fish, and a connection to Lac de Gras that does not provide spawning and foraging habitat for Arctic Grayling or any other species of fish. Twelve lakes were determined to have “high” value habitat, eight “moderate” value, and 13 “low” value fish habitat. Shoreline habitat maps and bathymetric contour maps are provided in the report’s appendices.

Golder 1997d

The report summarizes a survey of small-scale shoreline details while conducting a slow boat cruise along the intensive area (area in vicinity of the proposed Diavik Mine) shoreline in Lac de Gras. The resulting maps detailed habitat types (five), based on substrate composition. The habitat types were classified as follows:

- Type 1: boulder ledge at shoreline; drop-off composed of boulders leading into sand and boulder patches;
- Type 2: gravel ledge at shoreline, shifting to cobble, then boulders; drop-off composed of boulders leading to mixed sand and boulders;
- Type 3: bedrock outcrops surrounded by boulder and cobble leading to a mixture of large boulders and sand;
- Type 4: mixture of boulders and sand (4a. boulders dominant over sand; 4b. sand dominant over boulder); and,
- Type 5: mixture of boulder, cobble, and gravel; elevated gravel mounts alternate through the other substrates in linear, winding fashion.

Note: “Inundated vegetation,” “sand,” and “unclassified” (islands or shoreline areas not mapped) areas were also included in the data summary.

The intensive survey area in Lac de Gras was dominated by boulder shorelines, with bedrock habitat second. Within the intensive area of Lac de Gras, the top four habitat types consisted of 68.1% (Type 1), 24.6% (Type 3), 3.2% (Type 4b), and 3.1% (Type 2) of the habitat in the area.

Golder 1997e

This habitat survey was performed by mapping habitat types (five types based on substrate composition) in the extensive areas of Lac de Gras and Lac du Sauvage, using video evidence taken from a helicopter. These maps were then verified by on-the-ground habitat surveys along 125 shoreline transects selected by the fisheries discipline leader. Habitat type availability was then calculated for the extensive survey area.

As in the intensive area, the extensive area was dominated by Type 1 shorelines, with Type 3 bedrock shorelines second, and Type 4b shorelines ranked third. The rank order was similar for the intensive and extensive areas, based on shoreline ranking by habitat type. However, the shoreline habitat in Lac du Sauvage was more evenly distributed among the dominant types than in the rest of the extensive area. A greater percentage of total shoreline habitats were sandy substrate habitat (Types 4a and 4b) in Lac du Sauvage shorelines than in Lac de Gras. In Lac du Sauvage, habitat Type 1 was the most abundant shoreline habitat (61.33 km, 30.5% of shoreline), followed by Type 3 (41.99 km, 20.9% of shoreline), Type 4b (39.72 km, 19.7% of shoreline), Type 4a (27.46 km, 13.7% of shoreline), Type 5 (10.63 km, 5.3% of shoreline), and lastly Type 2 (1.66 km, 0.8% of shoreline). Additionally, sand accounted for 11.93 km (5.9%) of shoreline and 6.40 km (3.2% of shoreline) was unclassified. Additional shoal habitat detail for Lac de Gras intensive and extensive areas was available in the report.

Golder 1997f

Lake Trout observed in this survey showed a preference for open-water shoals bordered by deep waters in Lac de Gras. Shorelines were infrequently used, even if many spawning habitat requirements were met. The most common areas of spawning activity were also relatively shallow and composed primarily of large coarse substrate with many interstitial spaces. These habitats also tended to be on relatively steep slopes and in areas of high wind and wave action, which resulted in substrate free of silt. The report concluded that spawning habitat is not limited for Lake Trout populations within the intensive and extensive survey areas of Lac de Gras.

DDMI 1998a

Only habitat data previously reported in previous environmental baseline reports (Golder 1997a,b,c,d,e,f, g,h) were included in this report. The report summarized general habitat conditions, and habitat suitability and availability for the fish species present in Lac de Gras, Lac du Sauvage, inland lakes on east island and west island of Lac de Gras, and in the lakes on the mainland east of the proposed Diavik Mine. Surveys were also conducted on streams draining into these lakes.

Lac de Gras was described as having a very uneven bottom, and a prevalence of shallow shoals dominated by large boulders to cobble to gravel. Many shoals had steep rocky sides down to a depth of 6 to 8 m before changing to silt. Shoals in Lac du Sauvage were generally not as deep or as numerous. Lac de Gras had more potential spawning habitat (good to fair-quality shoals) compared to Lac du Sauvage for Lake Trout, Cisco, and Round Whitefish.

The shoreline habitat of inland lakes was predominantly large boulders, with sporadic cobble and sandy beaches. The slope varied from fairly flat to vertical bedrock walls. Based on species presence and habitat requirements, 12 of the 33 inland lakes surveyed were determined to be of high fisheries importance (8 on east mainland, 2 on west island, and 1 on east island). Eight lakes were of moderate importance (5 on east island, 2 on east mainland, 1 on west island), and 13 were given a low ranking (5 on east island, 5 on east mainland and 3 on west island).

Streams were dominated by run habitat. In the intensive study area, streams ranged in size from ephemeral in the east island to large on the east mainland. Streams in the mainland intensive and extensive study areas had similar habitat characteristics and size.

DDMI 1998b

Fish species data used in this report came from previous baseline reports completed as technical memoranda by Golder for DDMI (previously summarized; Golder 1997a,b,c,d,e,f, g,h). The report gave general summary statements about habitat in Lac de Gras, small islands, and streams based on these previous studies, including:

- Sheltered rearing habitat is not abundant and may be limited.
- Migration between small lakes is limited.
- Limited use of streams for migration is expected due to physical barriers.
- None of the streams on the east island provide spawning or rearing habitat.

Dillon 2002a

This report covered several distinct Lake Trout habitat survey components in Lac de Gras. The first components were a series of telemetry surveys conducted over the course of a year to determine spawning, feeding, and overwintering habitats of Lake Trout. The report indicated that Lake Trout were observed moving considerable distances throughout the year (e.g., from Lac de Gras-Lac du Sauvage narrows to the inlet north of the Lac de Gras west island). The report also concluded that the shoal habitat near A154 was unlikely to be a critical/limiting habitat component for Lake Trout spawning, as fish likely utilized other shoal habitat widespread throughout the lake. Fish continued to use shoal habitats near the A154 dike during construction activity despite increased noise and potential changes to water quality. The variability in shoal utilization and the migratory nature of Lake Trout was further illustrated in this study by fish numbers ranging from 0 to 90 in individual transect surveys.

The narrows connecting Lac de Gras to Lac du Sauvage was identified as a highly productive and important area for fish. As a result of bathymetry and flow characteristics, open water remains in the narrows year-round. The open water, combined with the substrate types present, provides for above average spawning, rearing, and forage habitats. In 2001, at least one tagged Lake Trout was located in the immediate vicinity of the narrows by every telemetry survey.

The second component of the study was a series of shoal habitat utilization surveys using hydroacoustic equipment. The study concluded that Lac de Gras fish continued to utilize shoal habitats directly adjacent to the A154 dike, notable variation in fish numbers during individual transect surveys were indicative of variability in shoal utilization and the migratory nature of Lake Trout, and fish were more prevalent in shallow water shoal habitats in the early morning.

Golder 2002

Summaries of earlier baseline habitat surveys for Lakes E3, E7, and E8, as well as a summary of a pre- and post-dewatering habitat surveys in Lake E10 were presented in this report. The baseline surveys were summarized above with Golder (1997c). Lake E10 was an 8.2 hectare inland lake with average depth of 1.4 m and a maximum depth of 7.8 m. It had a mostly flat lakebed with a deep, terraced basin, as well as a shallower basin at the east end. After dewatering, substrate surveys revealed a lake composed largely of shallow margins with mostly fractured boulder and coble substrate (60% of total area). Interstitial spaces were filled with organic material and limited aquatic and emergent vegetation grew on the substrate, which likely provided food sources for fish and spawning habitat for small-bodied fish, such as Ninespine Stickleback. Two areas with small and large gravel were observed on the east shore, covering less than 1% of the total area of the lake. These relatively small areas of gravel may have provided spawning habitat for spring spawning species such as Longnose Sucker and Lake Chub. The north shore of the lake had steeply sloped bedrock substrate and limited fractured bedrock hanging over substrate that may have provided overhead cover for fish. Overall, a positive correlation between maximum lake depth and the number of species was identified.

DDMI 2008

Using hydroacoustic and radio telemetry surveys, plus subsequent angling and gill netting, the studies summarized in this report identified shoal habitat use, primarily of Lake Trout, throughout Lac de Gras from 2000 to 2006. The report showed that there is notable variability in shoal utilization of Lake Trout along the perimeter of the lake. The report also concluded that fish continue to use shoal habitat near the A154 dike, even during construction periods, despite increased noise levels and potential changes to water quality.

A5 FISH HEALTH (DISEASE, PARASITES, AND ABNORMALITIES)

A5.1 Ekati Mine

Rescan 2008

Deformities, erosions, tumors, lesions (DELT), and parasites were assessed in fish communities of the King-Cujo watershed and reference lakes in 2007, including Lake D3 (Counts) and Lake B4 (Cujo) in the Jay Fish and Fish Habitat BSA. In the King-Cujo watershed and Ekati AEMP reference lakes, Round Whitefish and Lake Trout were generally healthy looking; no tumors or fin erosions were found on both species, and very few internal or external lesions or deformities were observed. No parasites were identified in Round Whitefish, but Lake Trout from all lakes contained cysts. This finding was considered a result of natural variability. A greater incidence of infection of Slimy Sculpin by the parasite *Ligula intestinalis* was recorded in Lake B4 (Cujo) and other potentially affected lakes than in reference lakes. It is unclear if this was a result of cumulative mine effects or natural variability. Further details on the pathology of each species in each lake were also available in the report.

ERM Rescan 2013

In 2012, fish biologists and Aboriginal community groups identified deformities, erosions, tumors, and lesions and parasites in fish in Koala watershed, King-Cujo watershed, and reference lakes. This included Lake Trout, Round Whitefish, and Slimy Sculpin from Lake D3 (Counts) and Lake B4 (Cujo) within the Jay Fish and Fish Habitat BSA. To look for possible indications of mine-related effects, comparisons were made between lakes and to earlier data from 2007.

Overall, very few deformities were observed in Lake Trout and Round Whitefish. However, for both species, eroded fins were observed more often than in 2007, but this was not considered a mine-related effect because fin erosions were observed in all lakes (including reference lakes). In 2007, 14.3% of Slimy Sculpin captured in Lake D3 (Counts) had parasite infections. The rate of infection was slightly lower in 2012 at 12.9%. Parasitism of Slimy Sculpin differed significantly between lakes, and a visual trend of prevalence with proximity to the mine site was noted. The report was unable to confirm a mine effect because no baseline data were available for Slimy Sculpin. Additional details on the pathology of each species in each lake were available in the report.

A5.2 Diavik Mine

Golder 1997g

The section on disease in the report includes summaries of gross external pathology, histopathology, and parasitic infections for fish captured in Lac de Gras and Lac du Sauvage. A complete report of histopathological examinations was provided in the report’s appendices.

External Abnormalities

External abnormalities were observed in less than 25% of fish examined in both lakes. In Lac du Sauvage, 12% of Arctic Grayling had parasites and 6% had fin damage; 4% also had a small incidence of growths and 2% had gill damage. In Lac de Gras, inflamed anus/urogenital opening was the most commonly observed external abnormality observed in Arctic Grayling (7%), followed by fin damage, and parasites (both 2%).

The most common external abnormality in Round Whitefish in Lac du Sauvage was fin haemorrhaging and lesions/wounds (6%), followed by fin damage/erosion, inflamed anus/urogenital opening, and opercle shortening (all 2%). A smaller range of external abnormalities was observed in Lac de Gras Round Whitefish. Nine percent had fin damage/erosion, and 2% had fin haemorrhaging or inflamed anus/urogenital opening.

Lake Trout in Lac du Sauvage had fin damage/erosion, inflamed anus/urogenital opening, and parasites at 6%, 5%, and 1%, respectively. Four percent of fish also had emaciated body form, opercle shortening, or cloudy eyes. The same abnormalities were observed in Lac de Gras, at 2%, 3%, and 1%, respectively. Lesions/wounds, growths, and missing fins totalled only 3%.

Cisco had the least external abnormalities of all species in either lake. No abnormalities were observed on Cisco in Lac du Sauvage, and fin damage and opercle shortening was only found on 2% and 1%, respectively.

Histopathology

No morphological signs of toxicity were identified, but a baseline incidence of disease was recorded; this was usually attributed to background disease, including parasitic or bacterial disease. In Lac du Sauvage, 100% of Lake Trout had incidence of heart disease, compared to 93% in Lac de Gras. One hundred percent of Round Whitefish in Lac du Sauvage also had heart disease, twice that of Lac de Gras. A small number of Cisco and Arctic Grayling from both lakes also had heart disease.

Cisco had the highest incidence of histopathological alterations of the gills in both lakes. One hundred percent of Cisco in Lac du Sauvage and 96% in Lac de Gras had histopathological alterations of the gills. Incidence in Round Whitefish was 79% in Lac du Sauvage and 66% in Lac de Gras.

Incidence of liver pathology was observed in Lake Trout in both Lac du Sauvage (81%) and Lac de Gras (67%). Muscle alterations were observed in 13% of Lake Trout in Lac du Sauvage, and 9% of Cisco in Lac de Gras. Kidney alterations were only observed in Lac du Sauvage Round Whitefish (26%) and Lac de Gras Arctic Grayling (1%).

Parasitic Infections

Twenty-six parasite samples were analyzed for taxonomic identification and details were provided in the report's appendices. Overall, all species captured in Lac de Gras and Lac du Sauvage had incidences of a variety of parasites.

Jacques Whitford 2001

Observations were made of abnormalities in Cisco, Round Whitefish, and Lake Trout salvaged in the North Inlet of Lac de Gras as part of this project. Evidence of abnormalities assessed included parasites, tumors, or otherwise abnormal organs. The only abnormality noted was the presence of cestode parasite (*Diphyllobothrium* sp.) cysts in 31% of Lake Trout, 18% of Cisco, and 1% of Round Whitefish. This parasite was common in other fish in the NWT and did not indicate poor health of North Inlet fish. Detailed raw data for each fish captured, including basic biology and observed abnormalities were provided in the report's appendices.

Golder 2002

Parasite occurrence was recorded for fish collected during a fish-out study of four inland lakes on the east island of Lac de Gras in 2000. Tapeworms were the most common parasites observed in the body cavity of fish in three of the lakes. Fish in Lake E3 had the greatest incidence of tapeworms, followed by Lakes E7 and E8. Gonads of Lake Chub and Longnose Sucker were in many cases degenerated by the presence of a tapeworm in the body.

CRI 2006

Parasite observations for Lake Trout and Round Whitefish collected in Lac de Gras in 2005 were summarized in this report. A greater incidence of different types of parasites was seen in Lake Trout than in Cisco or Round Whitefish. The highest number of parasites affecting individual Lake Trout was observed in the reference site close to the narrows that joins Lac de Gras to Lac du Sauvage. No mine-related effect of an increased incidence on any of the health parameters measured in this study was detected. Round Whitefish had a lower incidence of different types of parasites than Lake Trout or Cisco.

Golder 2008

Pathological assessment of Slimy Sculpin in Lac de Gras, including observation of parasites and external abnormalities were included in this report. *Ligula intestinalis* was the only internal parasite species observed. Infection rates were highest in the exposure areas (near the Diavik Mine diffuser), but severity of infection was low with fish generally hosting only one parasite. No external parasites were observed.

External abnormalities were only observed on five fish, including body abnormalities, haemorrhaging of the thymus, protruding eye, skin aberrations, and fin erosion. Internal abnormalities were also observed in some fish, with a slightly higher incidence in fish from the FF1 (Far Field 1) reference area. The FF2 (Far Field 2) exposure area had the least incidence. Liver abnormalities were recorded at all four study areas. Females from the NF exposure area had the highest overall rate of abnormalities (over 33%). This may have suggested increased stress, but males from the same area had the lowest frequency of pathology among the populations. Furthermore, the same abnormalities were seen in all areas, and fish from all study areas appeared healthy. It was noted that the observation of fatty livers in the NF fish may also indicate exposure to nutrient-enriched habitats.

Golder 2009

Internal and external observations of Lake Trout pathology were made on fish collected in Lac de Gras and Lac du Sauvage for assessment of mercury concentrations. Raw data on individual fish abnormalities and parasite infection were provided in the report appendices, but no summary was provided. However, based on a brief review of the data, no external body deformities were observed on Lake Trout in Lac de Gras or Lac du Sauvage, and parasite infestations appeared to be relatively common in both lakes.

Golder 2010

The 2010 AEMP included pathological assessments of Slimy Sculpin in Lac de Gras from mine exposure areas and reference areas. Pathologies were more frequent amongst Slimy Sculpin in the NF exposure area including both the occurrence and severity of parasitic infections. This result may suggest that the population is under increased stress, but each of the abnormalities recorded were present in more than one population. All fish also appeared healthy. The observation of fatty livers in the NF fish may have also indicated exposure to nutrient-enriched habitats. Additional details on internal and external abnormalities, and parasitic loads were included in the report.

Rio Tinto 2011

Differences in the incidence of infection of parasitic *Ligula intestinalis* in adult Slimy Sculpin from the different exposure areas of Lac de Gras between 2007 and 2010 were generally small. However, juvenile fish from all study areas of Lac de Gras (reference and exposure areas) and females from one of the reference areas in Lac de Gras had higher levels of infection in 2010.

In 2010, increased incidences of internal and external abnormalities were observed in Slimy Sculpin in Lac de Gras. Pale or fatty livers were the most common abnormality observed in 2010 and incidence was greater in fish from the exposure area, likely a result of nutrient enrichment in the exposure area. A more frequent occurrence of pathologies, including occurrence and severity of parasitic infection, in the NF exposure area may be an indicator of stress in the population. Differences among areas were not observed in 2007, and thus, the pathological differences observed in 2010 may have represented natural population or habitat differences. The report stated that continued monitoring would likely be required to establish possible mine-related effects on fish pathology.

A6 FISH TISSUE CHEMISTRY

A6.1 Ekati Mine

BHP 1995

As part of baseline descriptions for a future mining development, BHP collected specimens of common species from each of 12 study lakes from June to October 1994 for trace metal analyses to document natural background levels. A total of 145 fish were submitted for analysis (63 Lake Trout, 56 Round Whitefish, 23 Arctic Grayling, 1 Longnose Sucker, 1 Lake Chub, and 1 Burbot). Results were compared to CCREM (1993) guidelines which included: a maximum allowable level of mercury in muscle tissue of fish sold in Canada for human consumption of 0.5 milligrams per kilogram (mg/kg) (0.5 parts per million [ppm]) wet weight; and a recommended guideline of 0.2 ppm total mercury when fish constitutes a major subsistence food.

Of the 12 lakes sampled, five had mean mercury values in muscle tissue greater than 0.2 ppm. Only one of the fish analyzed, a 15-year-old Lake Trout from Nema Lake, had a mercury value that exceeded the 0.5 ppm guideline (0.529 ppm). Most trace metals were higher in liver tissue than in edible muscle tissue. Trace metal concentrations in fish tissue from the 1994 study were similar with fish captured in 1993, and fish from other unpolluted waters in the NWT (McKee et al. 1989).

Rescan 2002

The report evaluated results from the 2002 monitoring program and identified effects that the Ekati Mine may have on the aquatic environment for waterbodies in the Koala and King-Cujo watersheds, including Lake B4 (Cujo) and Lake D3 (Counts) in the Jay BSA. Fish communities were sampled from five lakes in the Koala watershed (Vulture, Kodiak, Moose, Nema, and Slipper Lakes), Lake B4 in the King-Cujo watershed, and two external reference lakes in other watersheds (Nanuq Lake and Lake D3). Although Lakes B4 and D3 were the only Lake in this study within the Jay BSA, the other lakes provide for a regional comparison of results.

For Round Whitefish samples, liver concentrations of cadmium, copper, and zinc did not vary substantially among lakes. Average liver cadmium concentrations ranged from 0.06 and 0.10 mg/kg wet weight (ww) for Nanuq Lake and Lake D3 (Counts), respectively. Average liver copper concentrations ranged from 2.4 to 2.7 mg/kg ww, and average zinc concentrations ranged from 23.0 and 26.4 mg/kg ww. Average Round Whitefish liver mercury concentrations were more variable among lakes with the lowest concentration in Nanuq Lake (0.04 mg/kg ww) and the highest concentration in Slipper Lake (0.22 mg/kg ww). Similarly, mercury concentrations in muscle tissue were lowest, on average, in Nanuq Lake (0.03 mg/kg ww) and highest, on average, in Slipper Lake (0.13 mg/kg ww). None of the Round Whitefish tissue samples had mercury concentrations above Health Canada's guideline for human consumption of 0.5 mg/kg ww.

The metal concentrations in Lake Trout livers and muscle were higher than those in Round Whitefish, possibly reflecting their differences in age, size, and trophic position. Liver cadmium concentrations of Lake Trout, on average, ranged from 0.16 to 0.66 mg/kg ww with the lowest average in Lake B4 (Cujo) and the highest in Kodiak Lake. Average liver copper concentrations ranged from 8.4 mg/kg ww in Lake B4 (Cujo) to 20.6 mg/kg in Nanuq Lake. Average liver zinc concentrations ranged from 20.6 to 44.1 mg/kg ww for Lake B4 (Cujo) and Kodiak lakes, respectively. Average liver mercury concentrations ranged from 0.08 mg/kg ww in Vulture Lake to 0.54 mg/kg ww in Slipper Lake, whereas muscle mercury concentrations ranged from 0.07 to 40 mg/kg for the same two lakes. A small number of samples (seven liver and five muscle samples) from very large Lake Trout (greater than 440 mm long) from Kodiak, Moose, Nema, and Slipper lakes exceeded Health Canada's guideline. This result was expected because mercury concentrations above the guideline can be observed in large fish from pristine lakes (though biomagnification mechanisms).

Rescan 2003

Baseline aquatic studies were performed during the 2002 open water season within the Lynx Study Area, as part of a potential mining development. Specimens included those of Lake Trout and Lake Whitefish captured in Lynx Lake and Hammer Lake (referred to as Fisher Lake in the report). Lake Chub was the only species recorded in Phantom Lake and was not assessed for fish tissue chemistry. Tissues were analyzed for the presence of 26 metals. Guideline values were based on Canadian Council of Ministers of the Environment (CCME 1999) and Health Canada (2002) guidelines. Mercury, arsenic, and lead were the only metals with Health Canada (2002) guidelines.

Metal concentrations were generally higher in liver samples than muscle samples from Lake Trout and Lake Whitefish. Arsenic and lead levels were well below recommended guidelines (0.0035 milligrams per litre [mg/L] and 0.005 mg/L, respectively) in all fish tissue sampled. However, Health Canada (2002) mercury guidelines of 0.5 mg/kg, of total mercury in muscle, were exceeded in fish tissue samples collected in Lynx Lake. Lake Trout captured in Lynx Lake in excess of 417 mm and/or 708 g had naturally occurring mercury concentrations in muscle tissue that were over Health Canada's recommended guideline. Mercury concentrations in Lake Whitefish muscle tissue, however, were below the suggested guideline in both lakes.

When examining liver mercury concentrations, both lakes showed levels exceeding recommended guidelines. It was estimated that liver mercury exceeded the Health Canada (2002) guideline for Lake Whitefish longer than 316 mm in Hammer Lake and 447 mm in Lynx Lake. Thus, it was concluded that Hammer Lake may have higher background levels of mercury, versus Lynx Lake.

Rescan 2007

Aquatic baseline data were collected in 2006 near the proposed Jay kimberlite pipe development in Lac du Sauvage. Fish were sampled in Lac du Sauvage and Ursula Lake in August and September 2006, and a subset of individuals were sacrificed for dorsal myomere (muscle) samples and liver samples for determination of metal body burden. Note that Ursula Lake is not within the Jay Fish and Fish Habitat BSA, but in this example provided a reference for a regional comparison as part of the Historical Report Review.

Eight of the 25 metals measured in the muscle and liver tissues of Lake Trout, Lake Whitefish, and Round Whitefish had 90% or more of their values below the minimum detection limit in either the muscle or liver tissue. Notable differences in concentrations between the two study lakes included lead levels with Lac du Sauvage tissues containing almost twice the lead-load in Ursula Lake tissues. Aluminum levels were also substantially higher in tissues from Lac du Sauvage versus Ursula Lake.

Mercury guidelines of 0.5 ppm, according to the edible tissue content guidelines of the Canadian Food Inspection Agency, were exceeded in five Lake Trout liver samples in Lac du Sauvage. The Canadian Food Inspection Agency guidelines for lead (0.5 ppm) were exceeded in four Lake Trout muscle samples, one Lake Trout liver sample, two Round Whitefish muscle samples, and one Round Whitefish liver sample from Lac du Sauvage, and were exceeded in one Lake Trout muscle sample from Ursula Lake. Arsenic was not exceeded in any sample (maximum Canadian Food Inspection Agency guideline = 3.5 ppm).

Rescan 2008

The report summarized results from monitoring activities as specified in the Ekati Diamond Mine: Aquatic Effects Monitoring Program Plan for 2007 to 2009 (Rescan 2006). Appendix B comprised the Evaluation of Effects part of the annual report. For the fish tissue chemistry component of the AEMP plan, samples from six lakes in the Koala watershed, one lake in the King-Cujo watershed, and two external reference lakes were collected between mid-August and early September 2007. Lakes sampled within the Koala watershed included Vulture Lake, an internal reference lake, and Kodiak, Leslie, Moose, Nema, and Slipper lakes. Fish were also captured at Lake B4 (Cujo), located within the King-Cujo watershed, and Nanuq Lake and Lake D3 (Counts) (external reference lakes situated in other watersheds). With the exception of Lake B4 (Cujo) and Lake D3 (Counts), most of the lakes discussed in this report lie outside the Jay Fish and Fish Habitat Baseline Area.

Liver and myomere samples from sacrificed Round Whitefish, Lake Trout, and Slimy Sculpin were analyzed for the suite of total metals (25 metal parameters). In the 2002 AEMP, cadmium, copper, mercury, and zinc concentrations in Round Whitefish and Lake Trout were evaluated. In the 2007 AEMP, the list of parameters was expanded to include the analysis of aluminum, arsenic, antimony, barium, cadmium, copper, mercury, molybdenum, nickel, strontium, and zinc in fish tissues. The list was expanded because the 2006 AEMP showed that, for example, arsenic, molybdenum, and nickel concentrations in water were above background. Furthermore, antimony, barium, and strontium concentrations in water increased from 2002 to 2006.

Key findings for Koala watershed and Lac de Gras area were that concentrations of several metals in Round Whitefish liver (barium, mercury, molybdenum, and strontium) and myomere (aluminum, barium, mercury, molybdenum, and strontium), and in Lake Trout liver (arsenic, mercury, and molybdenum) and myomere (barium and mercury), were higher in 2007 versus levels recorded during baseline years. Most increases appear to be due to natural variation. For Slimy Sculpin, metal concentrations in whole-body samples were greater in potentially affected lakes compared to reference lakes. However, it was concluded that trends are confounded by differences in metal concentrations between parasite-infected sculpin and non-parasitized sculpin, as well as by the absence of historical metal concentrations for Slimy Sculpin.

Key findings for King-Cujo watershed and Lac du Sauvage area included temporal increases in concentrations of a few metals in Round Whitefish liver (mercury, strontium, and zinc), but not in Lake Trout liver or muscle myomere when compared to baseline conditions or to reference lakes. Differences were attributed to both mine-related activities and natural variation.

To address issues associated with palatability of fish, muscle and liver tissues were also analyzed for chlorinated phenols, and bile was tested for hydrocarbon metabolites for a subset of the Round Whitefish and Lake Trout samples. The 19 chlorinated phenolics evaluated in Round Whitefish and Lake Trout liver and muscle tissues were all below detection limits in the four lakes sampled (Nanuq Lake, Lake D3 [Counts], and Leslie and Moose lakes).

ERM Rescan 2013

The report summarized results from monitoring activities as specified in the Ekati Diamond Mine: Aquatic Effects Monitoring Program Plan for 2010-2012 (Rescan 2010). Part 1 of the annual report included the Evaluation of Effects, which provided the methods used to assess change in the aquatic environment, as well as a summary of the results of the effects analysis. Many of the lakes examined in this report lie outside the Jay Fish and Fish Habitat BSA, but were reviewed as part of a regional summary in this Historical Report Review. Fish tissues were analyzed and evaluated against the following concentration guidelines:

- Health Canada (2011) for arsenic = 3.5 mg/kg ww;
- *Canadian Food and Drug Act* (CFDA 2012) and Health Canada (2012) for mercury = 0.5 mg/kg ww; and,
- British Colombia Ministry of Environment (BCMOE 2001) for selenium = 4.0 mg/kg ww and US Environmental Protection Agency (USEPA 2004) for selenium = 7.91 mg/kg ww.

Key findings in fish community variables in 2012 for the Koala watershed and Lac de Gras were as follows:

- increased antimony concentrations in Lake Trout muscle tissue and Slimy Sculpin from Leslie, Moose, and Nema lakes;
- increased molybdenum concentrations in Lake Trout and Round Whitefish muscle tissue from Leslie, Moose (Round Whitefish only), and Nema lakes;
- increased selenium concentrations in Lake Trout muscle and Round Whitefish liver and muscle tissue from Leslie, Moose, and Nema lakes; and,
- increased ethoxyresorufin-O-deethylase activity in Round Whitefish from monitored lakes and significant correlation with ethoxyresorufin-O-deethylase activity in Slimy Sculpin and distance from the Long Lake Containment Facility.

Guidelines related to fish tissue metal concentrations exist for only three of the eight evaluated variables in the AEMP (selenium, arsenic, and mercury). For selenium, mean tissue concentrations were below British Columbia (4.0 mg/kg dry weight [dw]) and USEPA guidelines (7.91 mg/kg dw) at all lakes for all species, except Lake Trout from Leslie Lake in 2012. Selenium concentrations in Round Whitefish and Lake Trout tissue from Leslie, Moose, and Nema lakes have increased over the years but have remained constant in reference lakes. In contrast to Round Whitefish and Lake Trout tissue, selenium concentrations in Slimy Sculpin tissue decreased in 2012 from 2007 levels. The Slimy Sculpin results suggest a diet shift to sediment associated prey.

For mercury, concentrations in Lake Trout tissue were generally below the Health Canada guideline (0.5 mg/kg ww; 11 individual fish, 6 from Slipper Lake, 3 from Nema Lake, 1 from Moose Lake, 1 from Kodiak Lake), and all Round Whitefish and Slimy Sculpin tissue samples were less than the guideline value. Mercury concentrations were higher at the monitored lakes (versus reference lakes) for Lake Trout and Slimy Sculpin, although the differences were only statistically significant for Slimy Sculpin.

Arsenic concentrations in fish tissue samples were below the Health Canada guideline (3.5 mg/kg ww) at all lakes for all species; however, concentrations in Lake Trout from all lakes have increased in 2012 versus 2007. In contrast to Lake Trout, arsenic concentrations in Slimy Sculpin have decreased in 2012 when compared to that observed in 2007. Increases in Lake Trout tissue concentrations were consistent with the increased arsenic concentrations observed in water quality samples from the Long Lake Containment Facility for processed kimberlite to Slipper Lake, although sediment concentrations had not increased downstream from the Long Lake Containment Facility and increases in reference lakes were not supported by water quality data. Thus, it was suggested that these increases may not have been represented in Round Whitefish or Slimy Sculpin due to differences in feeding preferences, with Round Whitefish and Slimy Sculpin primarily feeding on more benthic invertebrates (over forage fish species).

Key findings in fish community variables observed in 2012 for the King-Cujo watershed and reference lakes were as follows:

- increased selenium concentrations in Lake Trout muscle and Round Whitefish muscle and liver tissue from Lake B4 (Cujo);
- increased uranium concentrations in Round Whitefish liver tissue and Slimy Sculpin from Lake B4 (Cujo); and,
- significant correlation with elevated ethoxyresorufin-O-deethylase activity in Slimy Sculpin and distance from haul road.

For selenium, concentrations in muscle tissue were below the USEPA (7.91 mg/kg dw) and British Columbia guidelines (4.0 mg/kg dw) at all study lakes and for all species. Selenium was higher in fish from Lake B4 (Cujo) and had increased over time for Lake Trout and Round Whitefish while remaining constant at reference lakes. Fish tissue concentrations in most of the AEMP lakes (with the exception of Leslie Lake) could be predicted according to selenium concentrations measured in sediment cores, and therefore, observed increases in sediment selenium concentrations were suggested to be used as a precursor indicator to future increases in fish tissue concentrations.

For arsenic, concentrations in tissues collected from all species were below the Health Canada guideline (3.5 mg/kg ww); levels had decreased when compared to earlier monitoring years for all species collected from Lake B4 (Cujo). Similarly, mercury concentrations in all species collected from all lakes were also below the Health Canada guideline (0.5 mg/kg ww). However, mercury concentrations were higher at Lake B4 (Cujo) for all species, and these concentrations have not changed over time.

A6.2 Diavik Mine

Golder 1997g

The 1996 baseline fish survey was designed to be consistent with the framework of Environmental Effects Monitoring by providing baseline data on several assessment endpoints. Tissue samples were analyzed to determine baseline metal content of various tissues in Arctic Grayling, Round Whitefish, Cisco, and Lake Trout from Lac de Gras and Lac du Sauvage.

For muscle tissue samples, none of the four species tested had mercury, arsenic, copper, cadmium, or lead concentrations above the consumption guidelines. Consumption guidelines for trace elements, as set out by the National Health and Medical Research Council (Reilly 1991), were as follows: arsenic = 1.0 micrograms per gram (µg/g), cadmium = 0.2 µg/g, copper = 10 µg/g, lead = 2.5 µg/g, and mercury = 0.5 µg/g.

For kidney and liver samples, only Lake Trout from Lac du Sauvage had mercury levels above 0.5 µg/g. In Arctic Grayling, cadmium levels were at consumption guideline levels (0.2 µg/g) for Lac du Sauvage fish, but double the guideline in Lac de Gras. For all other species in both lakes, cadmium levels were almost always above the consumption guidelines, especially in Lake Trout. For liver samples from Lake Trout, fish from both sites were at or above the consumption guidelines. Females from both sites were slightly above the guidelines for cadmium, whereas males were consistently 2.0 to 2.5 times over.

Golder 1997h

Metallothionein concentration (as an indicator of exposure to heavy metals) was assayed in liver and kidney from Lake Trout and Round Whitefish collected from two sampling areas: 1) Lac de Gras, an area that may be impacted in the future due to mining, and 2) Lac du Sauvage, an upstream reference area. Metallothionein samples were collected during the summer fish population and fish health study conducted from July 16 to August 19, 1997. Kidney and liver samples from Lake Trout and Round Whitefish from Lac de Gras and Lac du Sauvage were analyzed. Tissue from 12 individual fish from each species-lake-tissue combination (a total of 48 fish; 96 tissues) were submitted frozen for metallothionein analysis.

No statistical difference was found in liver metallothionein concentration for Lake Trout and Round Whitefish between Lac de Gras and Lac du Sauvage. In contrast, a significant difference was found between kidney metallothionein samples collected from Lac de Gras and samples collected from Lac du Sauvage for Lake Trout and Round Whitefish. Kidney metallothionein concentrations were particularly divergent for Lake Trout with fish from Lac de Gras having in excess of three times the concentration found in Lac du Sauvage fish. However, the metallothionein levels measured in Lac du Sauvage were actually low compared to levels in top predators measured in other Arctic lakes, whereas Lac de Gras fish were more characteristic of levels typically found. This result suggests that at the time of sampling (1996), metallothionein levels in Lac du Sauvage were depressed, rather than levels in Lac de Gras fish being induced.

Dillon 2002b

As per its Fisheries Authorization, DDMI was responsible for the collection of Slimy Sculpin from Lac de Gras, before in-lake dredging and dike construction. From this collection, samples were analyzed for baseline tissue metals and metallothionein levels.

During September 2000 and July 2001, a total of 19 Slimy Sculpin were collected for tissue analyses from the proposed drawdown areas of the A154 and A418 dikes. Visceral contents (stomach, intestine, and all other internal organs) of the sampled Slimy Sculpin were analyzed for metals and metallothionein, while the remaining carcass (i.e., muscle, skin, and fins, except the head) was analyzed for metals only. No interpretation of results or comparison against guideline values were performed in the report.

DDMI 2003

As per its Fisheries Authorization, DDMI, in cooperation with Fisheries and Oceans Canada and Aboriginal partners, performed a fish palatability and texture study for Lake Trout from Lac de Gras. Samples of Lake Trout were also sent for analysis, as part of baseline efforts to monitor fish populations and indices of fish health. The study was done in August 2002 (n = 46 fish), and then repeated in 2003 (n = 32) at the request of the Aboriginal groups.

The five groups participating in the study agreed that the taste of the fish in Lac de Gras was good during both study years. Of the fish caught, five fish were selected based on freshness (which was determined by checking their gills) for tissue sample analysis in 2002, and four fish were selected in 2003. Muscle samples were taken for tissue metal concentrations, and muscle, liver, and kidney samples were taken for metallothionein analysis. No concerns in fish quality or condition were noted. No interpretation of analytical results or comparison against guideline values were performed in this report.

Gray et al. 2005

As per its Fisheries Authorization, DDMI collected Slimy Sculpin for an assessment of metal concentrations in fish from a constructed dike and at reference sites in Lac de Gras. Slimy Sculpin were captured around East Island study locations (A154 dike, REF 1, and REF2) in August 2004. Metals analyses were conducted on homogenized body carcass tissues (i.e., predominantly muscle tissue, but excluded heads), and metallothionein analyses were conducted on pooled kidney and visceral organs.

In this study, concentrations of selected metals (cadmium, chromium, iron, nickel, arsenic, and mercury) were significantly higher in fish captured at REF1, compared with fish from the A154 dike site. Only manganese was elevated at the A154 dike site compared with REF1. All other metals analyzed showed no difference between the two sites. In the absence of other baseline metal concentration data for Slimy Sculpin in Lac de Gras, or additional reference sites, the lower levels of the other six metals (cadmium, chromium, iron, nickel, arsenic, and mercury) at the A154 dike site suggest two possible conclusions: (1) that the metals are mildly elevated at REF1 (future A21 dike site); or (2) that the metals are lower at the A154 dike site (exposure site). In the first case, the increases were minor and could be explained by effects from minor surface deposits at REF1. In the second case, the decrease at the exposure site may be due to surface deposits buried at the A154 dike site, or induction and isolation of metals from the muscle tissue is occurring in Slimy Sculpin at the A154 dike site.

Levels of metallothionein found in the sculpin visceral and kidney tissues are intermediate compared to those found in the liver and kidney of Lake Trout and Round Whitefish collected in Lac de Gras in 1997. Of particular interest is that pre-development metallothionein levels were higher in Lac de Gras Lake Trout and Round Whitefish compared to those collected in a nearby reference lake, Lac du Sauvage. For Lake Trout, the higher levels of metallothionein corresponded with lower levels of metals in fish muscle also shown in this study for Slimy Sculpin. This relationship, however, does not hold true for Round Whitefish, where metal concentrations in muscle tissue were not always lower in Lac de Gras compared to Lac du Sauvage. The report noted that questions remain related to the significance of the elevated metallothionein levels and the lack of relationship with metals in the fish tissues.

CRI 2006

The fish health and fish population assessment in Lac de Gras was conducted by the Canadian Rivers Institute (CRI) to meet requirements outlined within the Fisheries Authorization granted to DDMI in 2001. Fish were collected from each of three areas referred to as diffuser (DF), Traditional Knowledge (TK) camp, and the reference, or far-field (FF) area, ranging from approximately 0.5 km to 2 km from the diffuser to approximately 9 km northeast of the diffuser, closer to the narrows that joins Lac de Gras and Lac du Sauvage.

Whole liver, head, kidneys, and dorsal muscle tissue were sampled from each fish and analyzed for metals and trace elements, as well as metallothionein. Metal concentrations in muscle, liver, and kidney tissues and metallothionein in liver were analyzed among sampling areas using the non-parametric Kruskall-Wallis test for Lake Trout and Round Whitefish. Statistical analysis was not conducted on metals where there were only data for two sampling areas. The metallothionein in Lake Trout liver was regressed with the molar equivalents of metals (cadmium, copper, zinc, and a molar sum of the three metals) in liver tissue to investigate known relationships between certain metals and the induction of metallothionein. This analysis could not be conducted for Round Whitefish or for kidney tissues due to low sample sizes.

Key findings included few site differences for metal and other element concentrations in the muscle tissue of mature female Round Whitefish. Potassium and phosphorus were higher at the DF versus the TK and FF areas. Titanium was also higher at the DF versus the TK area, and nickel was lower at the DF versus FF area. There were no trends in any metal and other element between areas for liver tissues in female Round Whitefish. The only significant difference was lower levels of potassium at the DF versus TK area for liver samples. There were no significant differences in metallothionein levels for female Round Whitefish across the three areas. For kidney samples, there were no significant differences for any elements among the three areas for female Round Whitefish.

At the time of this study, there were no easily accessible guidelines for acceptable levels of metals in fish tissues. In the pre-development baseline report (Golder 1997a), the consumption guidelines were based on Reilly (1991) for arsenic (1.0 µg/g), cadmium (0.2 µg/g), lead (2.5 µg/g), mercury (0.5 µg/g), and copper (10 µg/g). Using these values, only copper was above the limits in Lake Trout liver tissues. The number of exceedances for samples collected from Lac de Gras was consistent across the sampling locations (DF, TK, and FF).

DDMI 2006

The goal of this report was to present historical data including baseline and construction/operations monitoring data as part of the AEMP from 2001 to 2005. No relationship was identified between metal concentration and fish size. Concentrations of most metals in Slimy Sculpin were observed to be similar to concentrations in Lake Trout collected in 1996 (Golder 1997h). As described in Gray et al. (2005), surface deposits of arsenic, cadmium, chromium, iron, mercury, and nickel may be responsible for higher tissue concentrations detected at the REF1 site compared to sites near the A154 dike. It is also possible that metals are being inducted and isolated from muscle tissue in the fish from the A154 dike area.

Golder 2008

In 2007, DDMI conducted the field component of an AEMP in Lac de Gras. As per the procedure outlined in the AEMP design, Slimy Sculpin were selected as an early warning indicator of potential effects in tissue concentrations in Lake Trout.

The fish tissue chemistry study indicated that there were several low-level and moderate-level effects seen in Slimy Sculpin. The moderate-level effects represented statistically significant differences between exposure and reference areas of greater than two reference-area standard deviations linked to the mine through observed changes in water quality and sediment quality. While changes in mercury concentrations could not be directly linked to the mine, the mine was considered to have a moderate effect due to the lack of an alternate explanation for the relatively high levels in the NF area. Despite the moderate-level effects seen in the fish tissue chemistry, there was no evidence in the study that the increases in metal concentrations in tissue are negatively impacting fish health for Slimy Sculpin.

From a human health perspective, mercury levels found in Slimy Sculpin were below Health Canada's maximum acceptable levels in the edible portion of retail fish (0.5 µg/g). Excessive levels of mercury can also adversely affect fish health; however, adverse effects are typically not seen at tissue concentration of less than 1.0 µg/g (Jarvinen and Ankley 1998).

Golder 2009

Results of the small-bodied fish survey performed in association with the AEMP in 2007 revealed that concentrations of mercury in Slimy Sculpin were significantly greater in the exposure population compared to concentrations in two reference populations. Therefore, a survey was undertaken to assess the changes in tissue metal concentrations in Lake Trout. The results of this survey indicated no increase in Lake Trout tissue metal concentrations including mercury, relative to baseline concentrations, and hence no mine-related effects on Lake Trout fish usability within Lac de Gras.

Rio Tinto 2009

The 2008 AEMP report included a summary of the 2008 study of metals in Lake Trout described above (Golder 2009). A comparison of 2008 results with Lake Trout fish tissue analyses from 1996 and 2005 was also made in the 2008 AEMP report, which concluded that there has been no increase in metal concentrations, including mercury, over that period. Therefore, there was no effect classification on the usability of Lake Trout. However, since increased levels of mercury and other metals in the NF study area were detected in small-bodied fish in a 2007 survey, 2007 results were still categorized as low and moderate effects on fish usability. A specialized core analysis study was conducted as a follow up to the 2008 mercury in Lake Trout study aimed at understanding if mercury in Slimy Sculpin tissue is related to mine effluent in Lac de Gras. All results were below the method detection limit, but the authors suggested that nutrient enrichment caused by discharge into the lake could cause localized increases in fish tissue mercury.

Golder 2010

The report presents results of the fish survey conducted under the DDMI 2010 AEMP. Results of the fish assessment concluded low-level effects on fish population health, and low- and moderate-level effects on fish usability as a result of exposure to mine-related activities. A total of 32 composite samples of Slimy Sculpin were analyzed for percentage moisture content and metals. The concentrations of several metals were higher in fish from the exposure area (NF) compared to fish in the reference areas. Key findings in 2010 for Lac de Gras were as follows:

- statistically significant increases in metal levels in tissues in Slimy Sculpin samples from the NF exposure area versus the reference areas for aluminum, barium, lead, lithium, molybdenum, silver, thorium, and yttrium;
- statistically significant increases in uranium levels in tissue in Slimy Sculpin samples from the FF2 exposure area versus the reference areas;
- statistically significant increases in tissue concentrations of bismuth, strontium, titanium, and uranium in Slimy Sculpin samples from the NF exposure area versus the reference areas; these differences were greater than the normal range of reference area body burdens and were linked to the mine-related activities through observed changes in water and sediment chemistry; and,
- statistically significant increases in body burdens of bismuth in Slimy Sculpin samples from the FF2 exposure area compared to the reference areas; these differences were greater than the normal range of reference area body burdens and were linked to the mine-related changes through observed changes in water and sediment chemistry.

Rio Tinto 2010

The primary objective of the 2009 fish palatability program was to obtain feedback from community members on taste, texture, and the general condition (or health) of Lac de Gras Lake Trout. Secondary objectives included fish tissue metal analyses to meet requirements of the DDMI Fisheries Authorization.

Fish tissue (muscle) submitted for laboratory analysis from the 2009 catch had mercury levels below Health Canada's guideline for consumption, and showed a similar relationship between fish size and mercury concentrations as was found in 2008. The largest fish captured weighed 3.8 kg, and was characterized by mercury concentrations that approached 0.5 micrograms per litre (µg/L). The fish were all described as healthy and edible.

Rio Tinto 2011

The AEMP report showed that Slimy Sculpin in the NF exposure area in Lac de Gras had greater concentrations of six metals than the normal range, and 2007 and 2010 studies showed that bismuth, molybdenum, and titanium concentrations may be increasing with time. However, the report stated that additional data would likely be required to identify the presence of a trend, as these metals were either not consistently detected, or analyzed in the studies. Uranium and barium concentrations were greater than the normal range in 2007 and 2010, but there was no indication of a trend over time.

The report also assessed differences in Lake Trout metal concentrations by comparing results from 1996, 2005, 2008, and 2009 studies in Lac de Gras and Lac du Sauvage. Average concentrations of most metals in muscle tissue had remained in the normal range since 1996 in Lac de Gras. An apparent increase in mercury and zinc was identified in 2008, but larger, older fish captured in 2008 explained the higher mercury levels. Zinc concentrations were greater in 2008 than 1996, but lower than in 2005, and were back to baseline levels in 2009. Median mercury concentrations in fish muscle did not show a pattern in Lac de Gras, but were greater in 2008 than in 1996 in Lac du Sauvage. However, in both lakes, median mercury concentrations in liver and kidney tissue were lower in 2008 than 2006. When mercury concentrations were adjusted for the length of the fish to account for mercury accumulation in fish tissue, the results indicated that mercury concentrations in Lake Trout fish tissue had not increased since the 1996 baseline year in Lac de Gras or Lac du Sauvage. Results in the 2008 AEMP report (Rio Tinto 2009) suggested that mercury concentrations in Lake Trout organs might be decreasing, particularly in Lac du Sauvage.

Golder 2012

In 2007, DDMI conducted the field component of an AEMP in Lac de Gras. Results of the small-bodied fish survey revealed that concentrations of mercury in Slimy Sculpin were significantly greater in the exposure population compared to concentrations in two reference populations. Given that Slimy Sculpin is an early warning indicator of potential effects on tissue quality of Lake Trout, a survey was undertaken to assess changes in mercury concentrations in Lake Trout tissue in 2008, and again in 2011. This report presents the results of the 2011 Lake Trout survey (n = 60) to assess mercury concentrations in Lake Trout muscle. The survey employed a non-lethal monitoring method (i.e., dermal plugs), which has been shown to be very accurate for measuring mercury concentrations in Lake Trout muscle.

Mercury concentrations in Lake Trout muscle in Lac de Gras were not significantly different between 2008 and 2011; however, mercury concentrations were significantly different in Lac du Sauvage between 2008 and 2011. Furthermore, mercury concentrations increased in both lakes over the period of 2005 to 2008 (where trend was apparent after mercury concentrations in tissues were corrected for fish length). The increase in mercury concentration in Lac du Sauvage Lake Trout since baseline was greater than that observed in Lake Trout from Lac du Gras; thus, there was no clear indication that the mercury increase in Lac de Gras Lake Trout was a result of the Diavik Mine. The increase in mercury in both lakes is likely a reflection of widespread increases in mercury in this part of northern Canada.

From a human health perspective, mercury levels found in Lac de Gras and Lac du Sauvage Lake Trout were generally below Health Canada's maximum acceptable levels for the edible portion of retail fish (0.5 µg/g ww) (Health Canada 2011). However, the larger fish sampled did have concentrations that exceeded the Health Canada criterion. Thus, with the exception of the very largest fish, current mercury concentrations in muscle tissue in Lake Trout are not expected to affect human health if consumed.

Rio Tinto 2012

The 2011 AEMP included an overview of the 2011 Mercury in Lake Trout Report for DDMI (Golder 2012). Overall, Lake Trout tissue analyses from 1996, 2005, 2008, and 2011 indicated an increase in mercury concentrations since 1996, resulting in a low-level effect classification for Lake Trout usability. This increase was observed in Lac de Gras, where the Diavik Mine is located, as well as Lac du Sauvage; therefore, the increase in mercury could not be attributed to mine effects.

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