DOMINION DIAMOND

ANNEX XIV

FISH AND FISH HABITAT BASELINE REPORT FOR THE JAY PROJECT

FISH AND FISH HABITAT BASELINE REPORT FOR THE JAY PROJECT

Prepared for: Dominion Diamond Ekati Corporation

Prepared by: Golder Associates Ltd.

September 2014

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Abbreviations

Abbreviation	Definition
AB	Alberta
AEMP	Aquatic Effects Monitoring Program
BC	British Columbia
BHP Billiton	BHP Billiton Canada Inc. including subsidiary BHP Billiton Diamonds Inc.
BSA	baseline study area
BsM	Broad-scale Fish Community Monitoring
CCME	Canadian Council of Ministers of the Environment
CO	Colorado
CPUE	catch-per-unit-effort
CV	coefficient of variation
DC	District of Columbia
DDMI	Diavik Diamond Mines Inc.
DELT	deformities, erosions, tumors, and lesions
Diavik Mine	Diavik Diamond Mine
DO	dissolved oxygen
Dominion Diamond	Dominion Diamond Ekati Corporation
e.g.	for example
Ekati Mine	Ekati Diamond Mine
et al.	and more than one additional author
FWIN	Fall Walleye Index Netting
GIS	Geographic Information Services
GPS	Global Positioning System
i.e.	that is
LiDAR	light detection and ranging
NWT	Northwest Territories
n	number of samples
Project	Jay Project
SD	standard deviation
sp.	species
TOC	total organic carbon
TS	target strength
USA	United States of America
UTM	Universal Transverse Mercator
var.	variety
YOY	young-of-the-year

Units of Measure

Unit	Definition
°	degree
%	%
<	less than
>	greater than
°C	degrees Celsius
µg/g ww	micrograms per gram wet weight
µS/cm	microSiemens per centimetre
cm	centimetre
dB	decibel
g	gram
ha	hectare
kHz	kilohertz
km	kilometre
km/hr	kilometres per hour
km^2	square kilometre
m	metre
masl	metres above sea level
m/s	metres per second
m^2	square metre
m^3	cubic metre
m^3/s	cubic metres per second
mg/L	milligram per litre
mm	millimetre
ms	millisecond
s	second
x	times

1 INTRODUCTION

1.1 Background and Scope

Dominion Diamond Ekati Corporation (Dominion Diamond) is a Canadian-owned and Northwest Territories (NWT) based mining company that mines, processes, and markets Canadian diamonds from its Ekati Diamond Mine (Ekati Mine). The existing Ekati Mine is located approximately 200 kilometres (km) south of the Arctic Circle and 300 km northeast of Yellowknife, NWT (Map 1.1-1).

Dominion Diamond is proposing to develop the Jay kimberlite pipe (Jay pipe) located beneath Lac du Sauvage. The proposed Jay Project (Project) will be an extension of the Ekati Mine, which is a large, stable, and successful mining operation that has been operating for 16 years. Most of the facilities required to support the development of the Jay pipe and to process the kimberlite currently exist at the Ekati Mine. The Project is located in the southeastern portion of the Ekati claim block approximately 25 km from the main facilities and approximately 7 km to the northeast of the Misery Pit, in the Lac de Gras watershed (Map 1.1-2).

This Fish and Fish Habitat Baseline Report is part of a comprehensive baseline program to document the natural and socio-economic environments near the Project. This baseline information will be used for the environmental assessment of Project effects on all valued components and will help to identify mitigation and protective actions that could be implemented to avoid or reduce potentially adverse effects from the Project to the existing environment.

LEGEND

- JAY PROJECT
- EXISTING MINE OR PROJECT
- TERRITORIAL CAPITAL
- POPULATED PLACE
- HIGHWAY
- ALL-SEASON ROAD
- WINTER ROAD
- TIBBITT TO CONTWOYTO WINTER ROAD
- NORTHERN PORTION OF TIBBITT TO CONTWOYTO WINTER ROAD
- TERRITORIAL/PROVINCIAL BOUNDARY
- TREELINE
- WATERCOURSE
- WATERBODY

150 0 150

SCALE 1:6,000,000 KILOMETRES

REFERENCE

WATER OBTAINED FROM ATLAS OF CANADA
NATURAL RESOURCES CANADA, CENTRE FOR TOPOGRAPHIC INFORMATION, 2012
PROJECTION: CANADA LAMBERT CONFORMAL CONIC

DOCUMENT

FISH AND FISH HABITAT BASELINE REPORT

PROJECT

DOMINION DIAMOND

JAY PROJECT
NORTHWEST TERRITORIES, CANADA

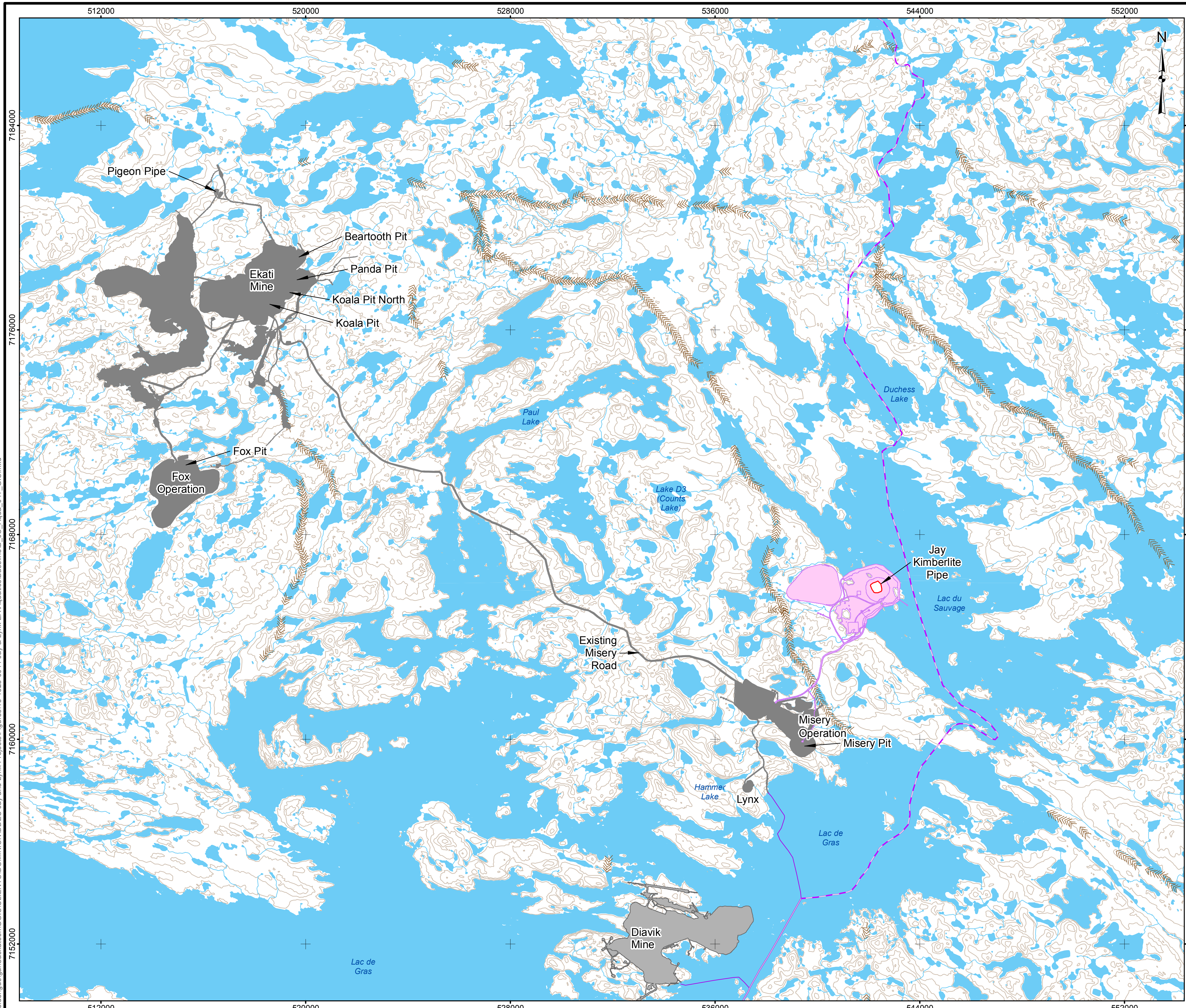
TITLE

LOCATION OF THE JAY PROJECT

Golder Associates

PROJECT		13-1328-0041	FILE No. B_JC_Aqua_039_GIS	
DESIGN	ANK	10/06/14	SCALE AS SHOWN	REV. 0
GIS	JG	10/09/14	MAP 1.1-1	
CHECK	CG	10/09/14		
REVIEW	SM	10/09/14		

\\golder.gds\gal\Saskatoon\GIS\CLIENTS\DOMINION\DDEC Jay and Lynx Projects\Figures\13-1328-0041 Jay & Lynx EA\Aquatics\Baseline\B_JC_Aqua_039_GIS.mxd



LEGEND

- EKATI MINE FOOTPRINT
- DIAVIK MINE FOOTPRINT
- PROPOSED JAY FOOTPRINT
- KIMBERLITE PIPE
- WINTER ROAD
- TIBBITT TO CONTWOYTO WINTER ROAD
- NORTHERN PORTION OF TIBBITT TO CONTWOYTO WINTER ROAD
- ELEVATION CONTOUR (10 m INTERVAL)
- ESKER
- WATERCOURSE
- WATERBODY

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

3 0 3
SCALE 1:150,000 KILOMETRES

PROJECT
DOMINION DIAMOND
JAY PROJECT
NORTHWEST TERRITORIES, CANADA

TITLE
EKATI PROPERTY MAP

Golder Associates

PROJECT	13-1328-0041	FILE No. B_JC_Aqua_047_GIS	
DESIGN	SM	12/08/14	SCALE AS SHOWN / REV 0
GIS	JG	10/09/14	MAP 1.1-2
CHECK	CG	10/09/14	
REVIEW	SM	10/09/14	

\\golder.gds\gal\Saskatoon\GIS\CLIENTS\DOMINION\DDEC Jay and Lynx Projects\Figures\13-1328-0041 Jay & Lynx EA\Aquatics\Baseline\B_JC_Aqua_047_GIS.mxd

1.2 Objectives

The main objective of this baseline study is to describe fish population characteristics and habitat in lakes and streams near the proposed Project. Field studies were performed to collect data in sufficient detail to support the design engineers (in planning the layout of the mine), to meet regulatory expectations, and to provide baseline conditions against which to evaluate the potential effects of the Project. A review of previously completed baseline reports and ongoing Aquatic Effects Monitoring Program (AEMP) studies in Lac de Gras and Lac du Sauvage was completed to supplement data collected from the 2013 field program. Fish abundance, species distributions, fish habitat, and life history were characterized for spatial and temporal variability based on both field studies and literature reviews.

1.3 Baseline Study Area

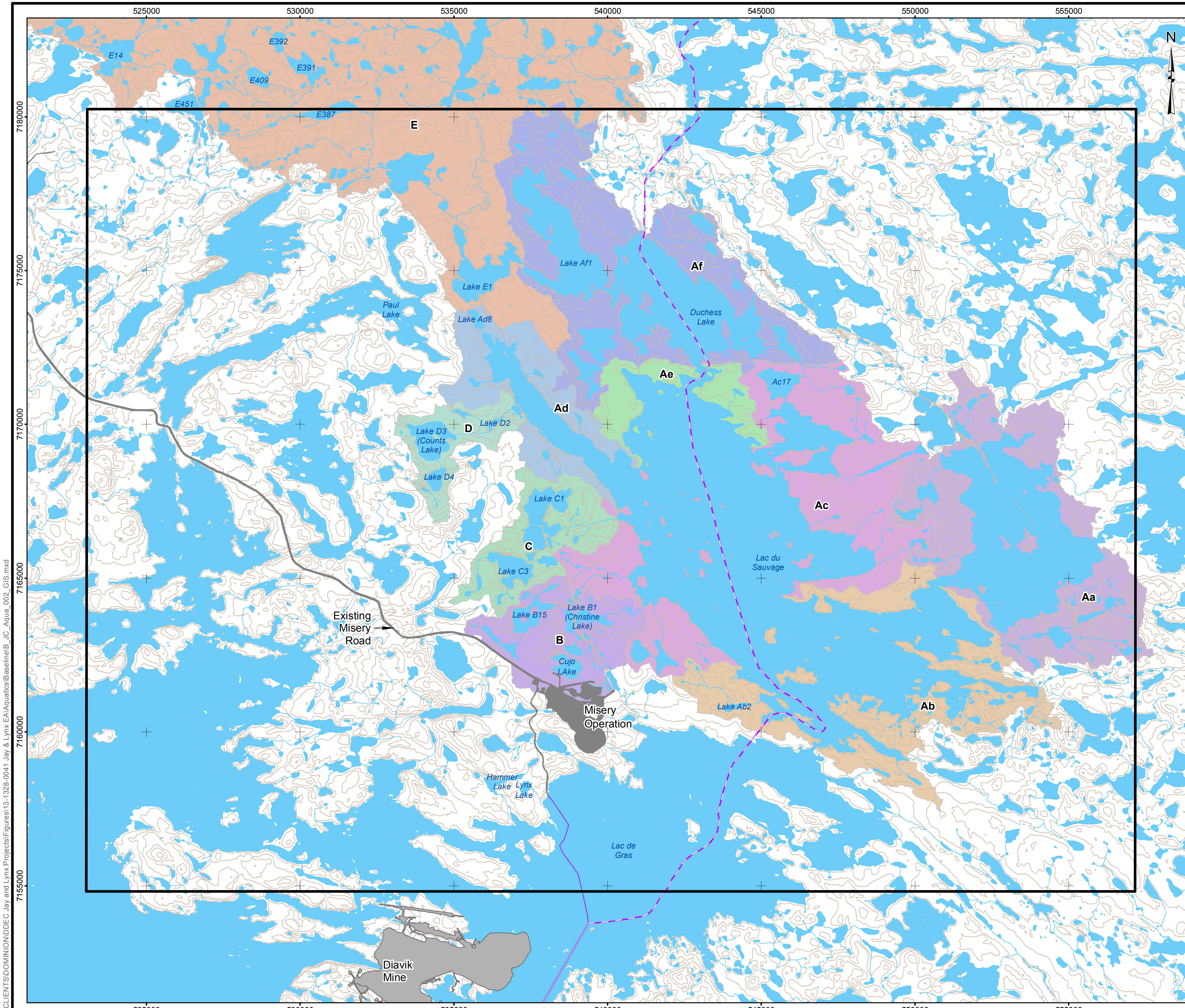
The fish and fish habitat baseline study area (BSA) is located within the headwaters of the Coppermine drainage, approximately 300 km northeast of Yellowknife, NWT, and 20 km northwest of the Rio Tinto/Dominion Diamond-owned Diavik Mine (Map 1.3-1).

The BSA consists of sub-basins that flow directly into Lac du Sauvage (Ab, Ac, Ad, Af, B, C, D,) or Lac de Gras (Paul, Lynx, and Hammer lakes). The lakes and streams within each sub-basin were named according to their position in the watershed. The naming convention starts at the mouth of the creek (e.g., at Lac du Sauvage) with the sub-basin letter and the number 1 (e.g., Stream C1), and increases sequentially upstream to the headwaters. Where applicable, lake and stream names incorporated the historical Ekati names consistent with the terminology in the 2006 Jay Pipe Aquatic Baseline study (Rescan 2007). The Ekati regional names are included in brackets after the sub-basin letter and number, for example, Lake B1 (Christine), Lake B4 (Cujo), Stream B1 (Christine Creek), and Lake D3 (Counts).

The BSA includes Lac du Sauvage, Paul Lake, Duchess Lake, and Lake E1, as well as smaller lakes and streams that connect these lakes or flow into them. The Paul Lake catchment flows in a southerly direction through Paul Creek into Lac de Gras. Adjacent to and east of Paul Lake is the Lake E1 catchment, flowing in a southerly direction into Duchess Lake. Downstream of Duchess Lake is Lac du Sauvage, followed by Lac du Gras. The surface elevations of the study lakes in the BSA range from approximately 416.1 metres above sea level (masl; Lac du Sauvage) to approximately 444.6 masl (Lake D4).

The surrounding terrain is rugged and characterized by an abundance of rock outcrops and eskers, resulting in numerous small lakes and streams in the depressions throughout the surrounding area. The area is within the sub-Arctic of the Canadian Shield, an area of continuous permafrost characterized by typical tundra vegetation. Lichens, mosses, heather, and dwarf shrub species dominate on the higher, well-drained areas, whereas sedges and grasses are predominant in the poorly drained areas, and along creeks and lakeshores.

Fish species expected to occur in the BSA and the codes used in this report are presented in Table 1.3-1. Eleven fish species are expected to occur in the BSA, based on previously completed work in the region (Section 2).



LEGEND

- EKATI MINE FOOTPRINT
- DIAVIK MINE FOOTPRINT
- WINTER ROAD
- TIBBITT TO CONTWOYTO WINTER ROAD
- NORTHERN PORTION OF TIBBITT TO CONTWOYTO WINTER ROAD
- ELEVATION CONTOUR (10 m INTERVAL)
- WATERCOURSE
- WATERBODY
- BASELINE STUDY AREA

BASIN

- Aa
- Ab
- Ac
- Ad
- Ae
- Af
- B
- C
- D
- E

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

3 0 3
SCALE 1:125,000 KILOMETRES

PROJECT
DOMINION DIAMOND
JAY PROJECT
NORTHWEST TERRITORIES, CANADA

TITLE
FISH AND FISH HABITAT BASELINE STUDY AREA, 2013

Golder Associates

PROJECT		13-1328-0041	FILE No. B_JC_Aqua_002_GIS	
DESIGN	CS	29/01/14	SCALE AS SHOWN	REV 0
GIS	JG	11/09/14	MAP 1.3-1	
CHECK	CG	11/09/14		
REVIEW	SM	11/09/14		

Table 1.3-1 Common and Scientific Names of Fish Species Expected to Occur in the Baseline Study Area

Family	Common Name	Code[a]	Scientific Name
Salmonidae	Lake Trout	LKTR	*Salvelinus namaycush* (Walbaum)
	Arctic Grayling	ARGR	*Thymallus arcticus* (Pallas)
	Cisco	CISC	*Coregonus artedi* (Lesueur)
	Lake Whitefish	LKWH	*Coregonus clupeaformis* (Mitchill)
	Round Whitefish	RNWH	*Prosopium cylindraceum* (Pallas)
Esocidae	Northern Pike	NRPK	*Esox lucius* (Linnaeus)
Gadidae	Burbot	BURB	*Lota lota* (Linnaeus)
Catostomidae	Longnose Sucker	LNSC	*Catostomus catostomus* (Forster)
Gasterosteidae	Ninespine Stickleback	NNST	*Pungitius pungitius* (Linnaeus)
Cyprinidae	Lake Chub	LKCH	*Couesius plumbeus* (Agassiz)
Cottidae	Slimy Sculpin	SLSC	*Cottus cognatus* (Richardson)

a) Source: Mackay et al. (1990).

2 HISTORICAL REPORT SUMMARY

2.1 Methods

2.1.1 General Approach

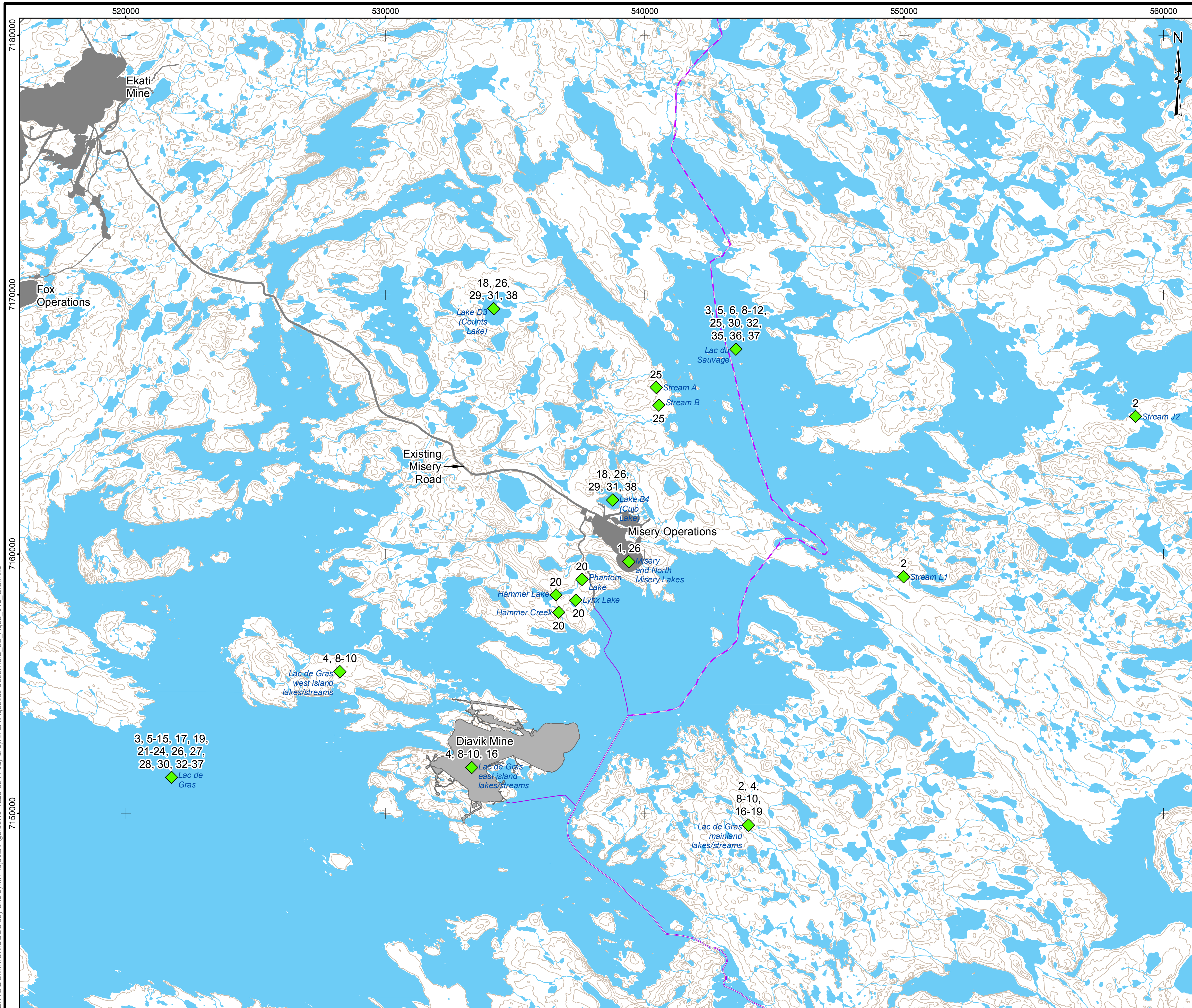
This historical report summary compiles and summarizes results from fish and fish habitat studies and general conclusions of reports related to BHP Billiton Canada Inc. (BHP Billiton) and Diavik Diamond Mines Inc. (DDMI) mining activities within and surrounding Lac du Sauvage and Lac de Gras.
The summary focuses on studies related to Lac du Sauvage, as this waterbody and the immediate surrounding waterbodies are of greatest relevance to the surrounding environment. Additional details are provided in Appendix A, Historical Report Review.

2.1.2 Sources

The primary sources of information were baseline evaluations and environmental monitoring reports related to the effects of diamond mining activities at the Ekati and Diavik mines in the BSA. A total of 38 documents were reviewed and included in this historical report summary. The earliest report included in this review was completed in 1995, and the most recent report was completed in 2013. More recent reports included pertinent fish tissue chemistry, species abundance and distribution, and general biological data, that were consolidated into a master dataset for analyses (2006 to 2013). Specifically, the 2006 Jay Pipe Aquatic Baseline Report (Rescan 2007), the 2007 and 2012 Ekati Mine AEMP reports (Rescan 2008; ERM Rescan 2013), and reports in support of the Diavik Mine 2008 and 2011 AEMPs were added to the 2013 baseline database for analyses (Golder 2009a, 2012a) (Map 2.1-1).

Seven of the reports included in this summary pertained primarily to Ekati Mine activities and the remaining 31 were associated primarily with Diavik Mine activities. The reports were organized by primary relevance to either Ekati Mine or Diavik Mine activities. Focal waterbodies were Lac du Sauvage, Lac de Gras, Lynx Lake, Hammer Lake (referred to as Fisher Lake in a few of the historical reports), Phantom Lake, Misery and North Misery lakes, Lake D3 (Counts), Lake B4 (Cujo), and local streams.

Studies in the waterbodies included information on 11 confirmed fish species within the BSA: Lake Trout, Slimy Sculpin, Round Whitefish, Burbot, Arctic Grayling, Cisco, Northern Pike, Lake Whitefish, Longnose Sucker, Ninespine Stickleback, and Lake Chub. The fisheries-related contents of each report reviewed and included in the Historical Report Review (Appendix A) is provided in Table 2.2-1. A map showing approximate locations of studies covered in the reports demonstrates the scope of this summary (Map 2.1-1).



LEGEND

- EKATI MINE FOOTPRINT
- DIAVIK MINE FOOTPRINT
- WINTER ROAD
- TIBBITT TO CONTWOYTO WINTER ROAD
- NORTHERN PORTION OF TIBBITT TO CONTWOYTO WINTER ROAD
- ELEVATION CONTOUR (10 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

3 0 3
SCALE 1:150,000 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_012_GIS	
DESIGN	CS	29/01/14	SCALE AS SHOWN	REV 0
GIS	JG	11/09/14	MAP 2.1-1	
CHECK	CG	11/09/14		
REVIEW	SM	11/09/14		

G:\CLIENTS\DOMINION\DDEC Jay and Lynx Projects\Figures\13-1328-0041 Jay & Lynx EA\Aquatics\Baseline\B_JC_Aqua_012_GIS.mxd

Table 2.1-1 Summary of Historical Reports That Were Reviewed

Report	Information Provided and Summarized in Historical Report				
	Species Abundance and Distribution	Life History	Habitat Use and Availability	Fish Health	Fish Tissue Chemistry
BHP 1995	✓	✓	✓	-	✓
Golder 1997a	✓	-	✓	-	-
Golder 1997b	-	-	✓	-	-
Golder 1997c	✓	-	✓	-	-
Golder 1997d	-	-	✓	-	-
Golder 1997e		-	✓	-	-
Golder 1997f	✓	✓	✓	-	-
Golder 1997g	✓	✓	-	✓	✓
Golder 1997h	-	-	-	-	✓
CEAA 1998[(a)]	-	-	-	-	-
DDMI 1998a	✓	-	-	-	-
DDMI 1998b	✓	✓	✓	-	-
Jacques Whitford 2001	✓	✓	-	✓	-
Dillon 2002a	-	-	✓	-	-
Dillon 2002b	-	-	-	-	✓
Golder 2002	✓	-	✓	✓	-
Jacques Whitford 2002	✓	✓	-	-	-
Rescan 2002	✓	✓	-	-	✓
DDMI 2003	-	-	-	-	✓
Rescan 2003	✓	✓	✓	-	✓
DDMI 2004	✓		-	-	-
Gray et al. 2005	✓	✓	-	-	✓
CRI 2006	✓	✓	-	✓	✓
DDMI 2006	✓	✓	-	-	✓
Rescan 2007	✓	✓	✓	-	✓
Golder 2008	✓	✓	-	✓	✓
Rescan 2008	✓	✓	-	✓	
Thistle and Tonn 2007	✓	✓	-	-	-
DDMI 2008	-	-	✓	-	-
Golder 2009a	✓	✓	-	✓	✓
Rescan 2009	✓	✓	-	-	-
Rio Tinto 2009	-	-	-	-	✓
Golder 2010	✓	✓	-	✓	✓
Rio Tinto 2010	-	-	-	-	✓
Rio Tinto 2011	-	✓	-	✓	✓
Golder 2012a	✓	✓	-	-	-
Rio Tinto 2012	-	-	-	-	✓
Rescan 2013	✓	✓	-	✓	✓

Note: This table indicates report information summarized under separate headings in the historical report summary.

a) This report included only summary information from other reports; data were not re-analyzed for this summary.

\- = not present.

2.2 Results

2.2.1 Key Findings

A diverse range of fish and fish habitat information was provided in the reports included in this summary. Numerous detailed studies on species abundance and distribution, life history, fish health, fish tissue chemistry, and habitat use and availability within the BSA are available. A summary of key findings and trends from these reports is provided in Sections 2.2.2 to 2.2.6. Additional details are provided in Appendix A.

2.2.2 Species Abundance and Distribution

Artic Grayling, Lake Trout, Lake Whitefish, Round Whitefish, Burbot, Slimy Sculpin, Cisco, and Northern Pike have all been captured or observed in Lac du Sauvage since 1994. Abundance values measured as catch-per-unit-effort (CPUE) were variable with different capture methods and fishing locations, as well as being influenced by seasonal variations in population distributions. Analyses generally focused on fish captured by gill netting, as this was the most effective fishing method based on the number of fish caught.

The reports indicate that Lake Trout was the most abundant species in Lac du Sauvage (DDMI 1998a; Golder 1997g, 2009a; Rescan 2007); up to 59 percent (%) of all fish in the lake were Lake Trout (Rescan 2007). The dominance hierarchy of other species in Lac du Sauvage was more variable, but Lake Whitefish and Round Whitefish were the next most abundant species (Golder 1997g, 2009a; Rescan 2007), followed by Cisco, and the remaining species appeared to be much less abundant (Golder 1997g; DDMI 1998a). However, this result may have been a reflection of capture methods, as gill netting was the most extensively used and Burbot, for example, were only caught in minnow traps (Rescan 2007).

Similar historical data are also available for smaller lakes surveyed for the Ekati and Diavik mines, including Lake D3 (Counts), Lake B4 (Cujo), and Hammer, Lynx, Phantom, and Misery lakes. Highly variable CPUE values were reported in the study lakes and were associated with differing capture methods, effort, and seasonality of surveys. Based on gill net CPUE values in the most recent historical reports, Round Whitefish was the most abundant species (78%) in Lake D3 (Counts), followed by Lake Trout (22%) (ERM Rescan 2013). In Lake B4 (Cujo), Lake Trout was the most abundant species (50%), followed by Round Whitefish (48%), and Arctic Grayling (2%) (ERM Rescan 2013). Only Lake Trout and Lake Whitefish were found in Lynx Lake and Hammer Lake by Rescan (2003). Based on CPUE values, Lake Whitefish were much more abundant than Lake Trout in both lakes with population estimates of 1,460 to 2,020 Lake Whitefish in Lynx Lake, and 1,290 to 3,000 Lake Whitefish in Hammer Lake. Lake Trout abundance in Lynx Lake was estimated to be 16% to 20% of the total fish population. Lake Trout abundance in Hammer Lake was estimated to be only 2% of the total fish population. In Phantom Lake, only Lake Chub were captured and relatively low CPUEs were reported (Rescan 2003). Only Lake Trout were identified in Misery Lake and no fish were identified in North Misery Lake (Thistle and Tonn 2007).

No clear relationship between mine-related effects and trends in the abundance or distribution of fish were identified by any of the historical reports for lakes in the BSA.

Historical data on species abundance and distribution in streams in the BSA were generally limited to species presence. Golder (1997a) observed a relatively high density of spawning adult Arctic Grayling in Stream L1 (referred to as FSR1 in the report), and a moderate density in Stream J2 (referred to as FSR2 in the report). Two small, unnamed ephemeral streams on the west side of internal basin Ac (between the B and C sub-basins) were also sampled. These streams were referred to as Streams A and B in the report. Rescan (2007) observed no fish presence at these sites, but water levels were low at the time of the survey and it is possible that fish do occur in the stream(s) with more favorable conditions. Rescan (2003) identified marginal fish habitat in Hammer Creek but, again, no fish were present at the time of the survey.

2.2.3 Life History

Although life history data were typically provided in reports produced for the Diavik and Ekati mines, the level of detail varied greatly between reports. Lengths and weights of ten fish or less were only available in certain reports, whereas others included in-depth biological examinations of traits such as reproductive characteristics, and age and diet of hundreds of fish of numerous species.

Focusing on Lac du Sauvage, detailed life history information was available for almost all species with recorded observations, i.e., Lake Trout, Lake Whitefish, Round Whitefish, Burbot, Arctic Grayling, and Cisco. As the most abundant fish in Lac du Sauvage (based on catch data) (Golder 1997g, 2009a; DDMI 1998a; Rescan 2007), Lake Trout was the focal species of many of the reports. As of 2007, there appeared to be no measurable difference in the mean length of Lake Trout in Lac du Sauvage since baseline studies in 1996 (Rescan 2007). In comparison to other species in Lac du Sauvage, Lake Trout had the widest ranging and most evenly distributed ages, and were on average older than all other species (Golder 1997g). In 2007, the mean age and age distribution of Lake Trout were consistent with previous assessments (Rescan 2007). Females were on average slightly younger than males (Golder 1997g), and first reached sexual maturity (4 years) earlier than males (10 years), but sexual maturity of all fish was reached at the same time for both males and females (11 years) (Golder 1997g). Rescan (2007) found that the sex ratios of all species were skewed towards males.

Based on maturity analysis, Rescan (2007) suggested that Lake Trout reproduction may not occur annually in Lac du Sauvage. This result may indicate inadequate energy reserves, which is the typical case in cold water systems (Martin 1966). Stomach contents of Lake Trout in Lac du Sauvage showed a diet abundant in fish; Rescan (2007) found that 74% by weight of the total stomach contents were fish. Condition factors indicated a healthy population of Lake Trout in Lac du Sauvage (DDMI 1998a; Golder 2009a). Populations of other fish species in Lac du Sauvage also appeared to be healthy. Additionally, juveniles and adult fish of all species appeared to experience similar growth conditions in Lac du Sauvage (Rescan 2007).

Life history characteristics of fish under baseline conditions in Lac de Gras (Table 2.2-1; Golder 1997g) also indicated that fish were healthy, although differences in life history characteristics (i.e., growth rates, diet, and maturity) between Lac de Gras and Lac du Sauvage are apparent (Table 2.2-1).

Table 2.2-1 Select Life History Characteristics of Fish in Lac du Sauvage and Lac de Gras

		Lake Trout						Cisco					
		Male		Female		Unknown		Male		Female		Unknown	
Variable	Stat.	LDS	LDG	LDS	LDG	LDS	LDG	LDS	LDG	LDS	LDG	LDS	LDG
	N	47	39	29	27	31	59	18	14	22	13	2	81
Age (years)	Mean	11.7	11.1	9.0	10.3	11.6	12.5	7.5	6.6	6.4	6.7	4.5	2.2
	SD	4.6	5.0	4.4	5.2	3.8	4.6	2.1	0.9	1.7	0.9	0.7	0.8
Length (mm)	Mean	537	484	457	486	588	596	257	261	253	261	189	141
	SD	158	163	180	172	133	173	33	16	32	19	30	18
Weight (g)	Mean	2,068	1,845	1,552	1,880	2,567	2,903	234	242	233	271	100	31
	SD	1,264	1,446	1,447	1,646	1,168	1,846	77	74	93	121	0	20
Condition	Mean	1.13	1.29	1.19	1.21	1.16	1.18	1.31	1.35	1.35	1.48	1.61	1.02
	SD	0.14	0.29	0.28	0.17	0.32	0.29	0.18	0.32	0.28	0.51	0.75	0.18
		Arctic Grayling						Round Whitefish					
		Male		Female		Unknown		Male		Female		Unknown	
Variable	Stat.	LDS	LDG	LDS	LDG	LDS	LDG	LDS	LDG	LDS	LDG	LDS	LDG
	N	27	25	12	12	10	4	24	10	25	14	—	2
Age (years)	Mean	6.1	6.2	5.8	6.6	4.7	2.8	11.6	12.9	11.0	11.1	—	2.0
	SD	0.9	1.5	0.8	0.5	1.9	0.5	2.0	2.0	1.8	3.3	—	—
Length (mm)	Mean	379	396	367	409	303	164	399	447	399	418	—	116
	SD	50	67	36	13	86	28	25	25	32	78	—	22
Weight (g)	Mean	712	806	692	891	353	38	755	1063	778	975	—	27
	SD	308	287	196	109	185	14	134	215	187	427	—	5
Condition	Mean	1.23	1.20	1.36	1.29	1.17	0.86	1.18	1.17	1.21	1.24	—	2.01
	SD	0.13	0.08	0.15	0.10	0.35	0.17	0.10	0.15	0.13	0.15	—	1.40

Source: Golder (1997g).

LDS = Lac du Sauvage; LDG = Lac de Gras; mm = millimetre; g = gram; N = sample size; SD = standard deviation;
— = not available; Stat. = statistic.

Life history information for fish in several of the smaller lakes in the BSA was also provided in historical reports, again with a common focus on Lake Trout, as one of the more abundant species. In Lake D3 (Counts) and Lake B4 (Cujo), and other reference and monitored lakes, an overall trend in decreased body condition since the start of Ekati Mine operation was identified for Lake Trout (ERM Rescan 2013). However, because this occurred in both reference and monitored lakes there was no indication of mine-related effects (ERM Rescan 2013). Overall growth rates were also found to be slower for Lake Trout in monitored and reference lakes, including Lake D3 (Counts) and Lake B4 (Cujo), by ERM Rescan (2013), but no relationship to mining activity was identified. A shift to older Lake Trout was apparent up until 2007 in Lake D3 (Counts), Lake B4 (Cujo), and other lakes, but 2012 data showed the return of a strong young cohort similar to that seen for samples before the Ekati Mine operation in the 1990s (ERM Rescan 2013).

In Lynx Lake, the most abundant Lake Trout were small adult fish between 18 and 23 years old (Rescan 2003), similar to what has been found in other northern lakes by researchers (Johnson 1976). Results in Rescan (2003) indicated a divergence of growth rates, with the heaviest fish not necessarily being the oldest. A slightly lower condition factor of Lake Trout in Lynx Lake than in other lakes of the Ekati claim block may relate to a more limited variety of prey items (Rescan 2003). The most abundant age-class of Lake Whitefish in Lynx Lake was young mature fish, aged 5 to 6 years (Rescan 2003). Divergence in growth rates within age cohorts was also identified in Lake Whitefish by Rescan (2003).

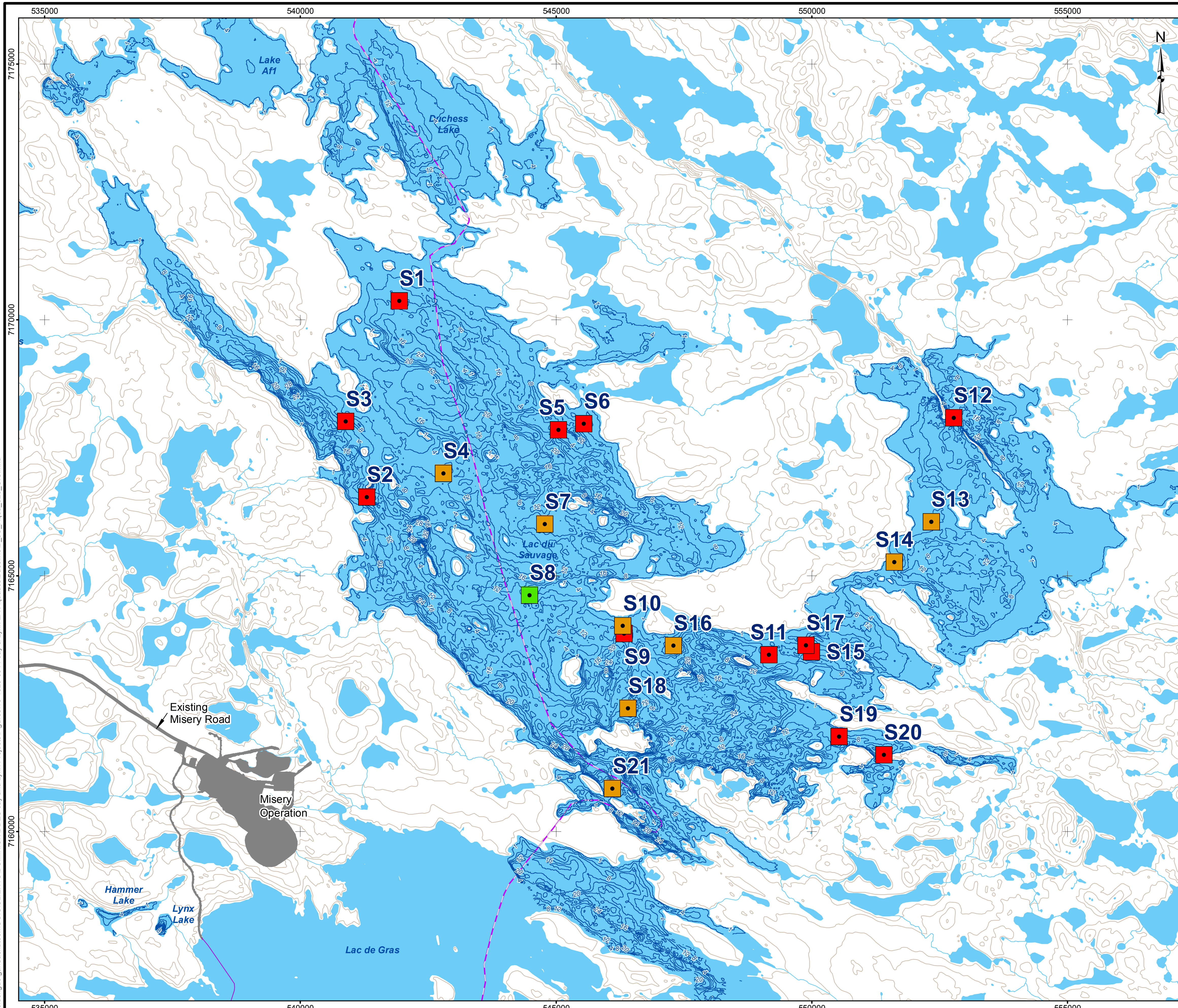
Inferences of life history characteristics of Lake Trout in Hammer Lake were limited in Rescan (2003) with only two fish captured. However, the high condition factor of the two Lake Trout may have indicated a small population size with an abundance of Lake Whitefish as prey. For Lake Whitefish, young mature fish were the most abundant size class in Hammer Lake, but with highly variable ages (Rescan 2003). Weight was also highly variable among age cohorts, particularly in younger mature fish (Rescan 2003). After reaching eight years of age, Lake Whitefish in Hammer Lake grow more rapidly than those in Lynx Lake; however, the mean overall condition factor of Lake Whitefish in both lakes was similar to that of other Lake Whitefish populations in the Lac de Gras watershed (Rescan 2003). As with other fall spawning northern species, both Lake Trout and Lake Whitefish appeared to spawn earlier than their southern counterparts (Rescan 2003; Scott and Crossman 1973).

The mean age of Lake Trout in Misery Lake, the only fish species identified, was estimated to be 10.9 years and their growth rate appeared slower than observed in other lakes in the NWT (BHP 1995). In Phantom Lake, Lake Chub, the only species captured in the lake by Rescan (2003), showed little variation in length, weight, and condition amongst individuals. Comparisons with earlier data did not identify any relationships between trends in life history characteristics and mining effects.

2.2.4 Habitat Use and Availability

Habitat surveys were performed for all large lakes and several streams in the BSA. Most of the surveys focused on spawning shoal habitat, but detailed bathymetric maps of entire waterbodies were also prepared in several studies. Detailed evaluations of habitat quality and use by various species were presented in many of the reports, while others were limited to classification of substrate types, or estimates of potential usability and access to habitats by fish (e.g., in small, low-flow streams).

A limited number of studies included habitat descriptions for Lac du Sauvage. However, the combined results of four habitat surveys, in particular, provided a detailed inventory of habitat availability and use (Golder 1997b,d,e; Rescan 2007). These baseline surveys described, with a high level of detail, shoal and shoreline habitats in Lac du Sauvage (and Lac de Gras). Specifically, 21 shoals were identified in Lac du Sauvage (Golder 1997b) (Maps 2.2-1 to 2.2-3). Of these, 43% of the shoal locations were determined to provide spawning habitat of “good” or “fair” quality for Lake Trout and Cisco, and only 10% for Round Whitefish. Most of the shoal locations were identified as being unsuitable for Lake Trout, Cisco, and Round Whitefish. By comparison, in Lac de Gras, shoal habitat ranked as fair was the most frequently encountered shoal habitat for Lake Trout and Cisco, and shoal habitat ranked as poor was the most frequently encountered habitat for Round Whitefish.



LEGEND

- EKATI MINE FOOTPRINT
- NORTHERN PORTION OF TIBBITT TO CONTWOYTO WINTER ROAD
- WINTER ROAD
- BATHYMETRIC CONTOUR (4 m INTERVAL)
- ELEVATION CONTOUR (10 m INTERVAL)
- WATERCOURSE
- WATERBODY

SPAWNING HABITAT LAKE TROUT

- GOOD
- FAIR
- UNSUITABLE

SHOAL HABITAT IDENTIFIED BY GOLDER (1997A)

REFERENCE

CANVEC © NATURAL RESOURCES CANADA, 2012
NATURAL RESOURCES CANADA, CENTRE FOR TOPOGRAPHIC INFORMATION, 2012
BATHYMETRIC DATA OBTAINED FROM AURORA, 2013
DATUM: NAD83 PROJECTION: UTM ZONE 12N

DOCUMENT

FISH AND FISH HABITAT BASELINE REPORT

1.5 0 1.5
SCALE 1:75,000 KILOMETRES

PROJECT
DOMINION DIAMOND
JAY PROJECT
NORTHWEST TERRITORIES, CANADA

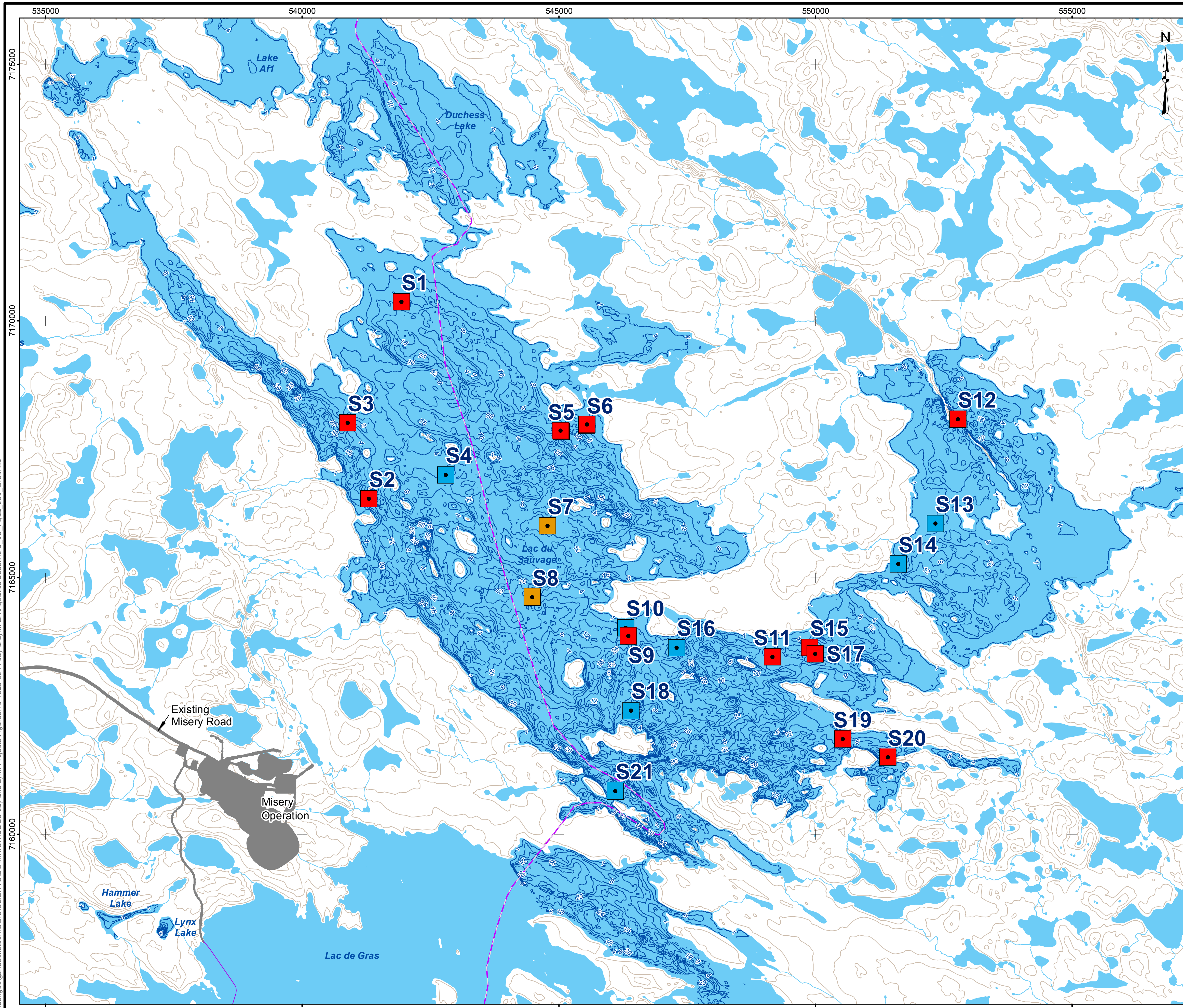
TITLE

SHOAL HABITAT FOR LAKE TROUT IN LAC DU SAUVAGE

Golder Associates

PROJECT	13-1328-0041	FILE No. B_JC_Aqua_029_GIS	
DESIGN	RC	10/09/14	SCALE AS SHOWN	REV 0
GIS	JG	10/09/14	MAP 2.2-1
CHECK	CG	10/09/14	
REVIEW	SM	10/09/14	

\\golder.gds\gal\Saskatoon\GIS\CLIENTS\DOMINION\DDEC Jay and Lynx Projects\Figures\13-1328-0041 Jay & Lynx EA\Aquatics\Baseline\B_JC_Aqua_029_GIS.mxd



LEGEND

- EKATI MINE FOOTPRINT
- WINTER ROAD
- NORTHERN PORTION OF TIBBITT TO CONTWOYTO WINTER ROAD
- BATHYMETRIC CONTOUR (4 M INTERVAL)
- ELEVATION CONTOUR (10 M INTERVAL)
- WATERCOURSE
- WATERBODY

SPAWNING HABITAT ROUND WHITEFISH

- FAIR
- POOR
- UNSUITABLE

SHOAL HABITAT IDENTIFIED BY GOLDER (1997A)

REFERENCE

CANVEC © NATURAL RESOURCES CANADA, 2012
NATURAL RESOURCES CANADA, CENTRE FOR TOPOGRAPHIC INFORMATION, 2012
BATHYMETRIC DATA OBTAINED FROM AURORA, 2013
DATUM: NAD83 PROJECTION: UTM ZONE 12N

DOCUMENT

FISH AND FISH HABITAT BASELINE REPORT

1.5 0 1.5
SCALE 1:75,000 KILOMETRES

PROJECT
DOMINION DIAMOND
JAY PROJECT
NORTHWEST TERRITORIES, CANADA

TITLE
SHOAL HABITAT FOR ROUND WHITEFISH IN LAC DU SAUVAGE

Golder Associates

PROJECT	13-1328-0041	FILE No. B_JC_Aqua_030_GIS	
DESIGN	RC	10/09/14	SCALE AS SHOWN REV 0
GIS	JG	10/09/14	MAP 2.2-2
CHECK	JG	10/09/14	
REVIEW	JG	10/09/14	

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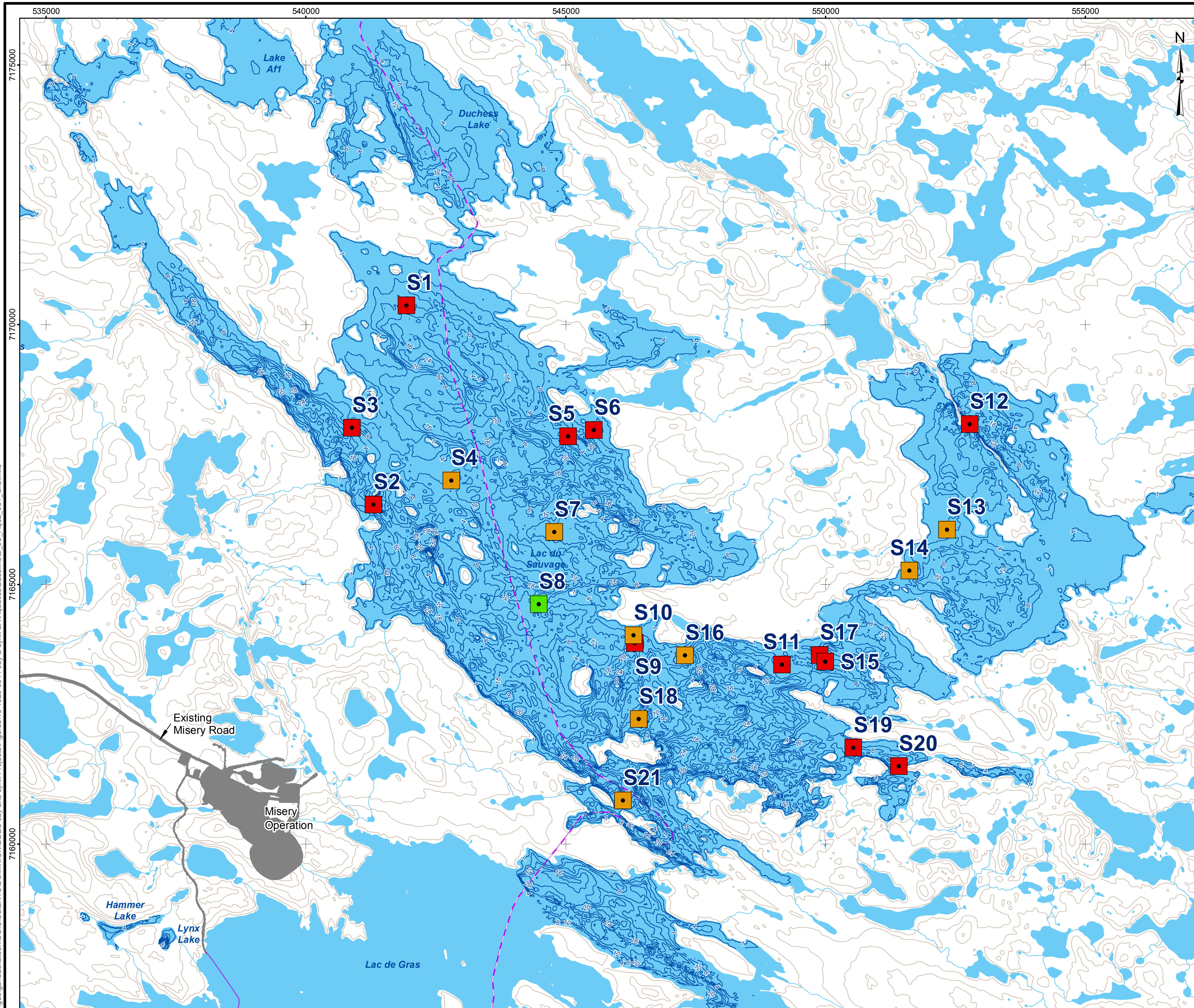


LEGEND

- EKATI MINE FOOTPRINT
- WINTER ROAD
- NORTHERN PORTION OF TIBBITT TO CONTWOYTO WINTER ROAD
- BATHYMETRIC CONTOUR (4 m INTERVAL)
- ELEVATION CONTOUR (10 m INTERVAL)
- WATERCOURSE
- WATERBODY

SPAWNING HABITAT CISCO

- FAIR
- GOOD
- UNSUITABLE

SHOAL HABITAT IDENTIFIED BY GOLDER (1997A)

REFERENCE

CANVEC © NATURAL RESOURCES CANADA, 2012
NATURAL RESOURCES CANADA, CENTRE FOR TOPOGRAPHIC INFORMATION, 2012
BATHYMETRIC DATA OBTAINED FROM AURORA, 2013
DATUM: NAD83 PROJECTION: UTM ZONE 12N

DOCUMENT

FISH AND FISH HABITAT BASELINE REPORT

1.5 0 1.5
SCALE 1:75,000 KILOMETRES

PROJECT
DOMINION DIAMOND
JAY PROJECT
NORTHWEST TERRITORIES, CANADA

TITLE

SHOAL HABITAT FOR CISCO IN LAC DU SAUVAGE

Golder Associates

PROJECT		13-1328-0041	FILE No. B_JC_Aqua_031_GIS
DESIGN	RC	10/09/14	SCALE AS SHOWN REV 0
GIS	JG	10/09/14	
CHECK	CG	10/09/14	**MAP 2.2-3**
REVIEW	SM	10/09/14	

\\golder.gds\gal\Saskatoon\GIS\CLIENTS\DOMINION\DDEC Jay and Lynx Projects\Figures\13-1328-0041 Jay & Lynx EA\Aquatics\Baseline\B_JC_Aqua_031_GIS.mxd

An estimated 18 million square metres (m^2) of Lake Trout spawning habitat of good and fair quality was present in Lac du Sauvage, much as non-attached shoals and shoals extending from small islands. However, the narrow features of the east side of Lac du Sauvage also provide for a relatively large proportion of suitable habitat as shoreline-attached shoals. By comparison, Lac de Gras may provide as much as 58 million m^2 of Lake Trout spawning habitat.

Golder (1997e) provided a detailed inventory of substrate composition along the shoreline of Lac du Sauvage. “Type 1” (boulder ledge at shoreline; drop-off composed of boulders leading into sand and boulder patches) was the most abundant shoreline habitat (30.5% of shoreline) followed by “Type 3” (bedrock outcrops surrounded by boulder and cobble leading to a mixture of large boulders and sand) (20.9%). The next most abundant was “Type 4b” shoreline habitat (mixture of boulders and sand, with sand dominant over boulder) (19.7%), followed by “Type 4a” (mixture of boulders and sand, with boulders dominant over sand) (13.7%), “Type 5” (mixture of boulder, cobble and gravel mounds that alternate through the other substrates in a linear, winding fashion) (5.3% of shoreline), and lastly “Type 2” habitat (gravel ledge at shoreline, shifting to cobble, then boulders) (0.8% of shoreline). Sand accounted for 5.9% of shoreline, and 3.2% of shoreline was unclassified.

Overall, relative to Lac de Gras, shoals were generally not as deep or numerous in Lac du Sauvage, which provided less potential spawning habitat of good to fair quality for Lake Trout, Cisco, and Round Whitefish (Golder 1997b; DDMI 1998a). Despite the potentially less-suitable spawning habitat in Lac du Sauvage, Rescan (2007) concluded that Lac du Sauvage provides habitat for the following:

- all life stages of Round Whitefish;
- spawning, young-of-the-year (YOY), and juvenile Lake Trout;
- spawning, YOY, and juvenile Burbot; and,
- spawning, juvenile, and adult Lake Whitefish.

Therefore, it appears that although spawning shoals may be limited for certain species in Lac du Sauvage, available habitat is adequate to sustain many species.

The narrows connecting Lac de Gras to Lac du Sauvage may provide an important corridor for connecting habitats between the two lakes. As a result of bathymetry and flow characteristics, open water can remain 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. Furthermore, the narrows connecting Lac de Gras to Lac du Sauvage were identified as a highly productive and important area for fish, providing above average spawning, rearing, and forage habitats (Dillon 2002a).

Limited fish habitat use and availability information for Misery Lake, Lynx Lake, Phantom Lake, and Hammer Lake was also provided in historical reports. In general, suitable Lake Trout spawning habitat was identified in these lakes. BHP (1995) identified optimal Lake Trout spawning habitat in the southern and western portions of Misery Lake. Rescan (2003) concluded that Lynx Lake, Phantom Lake, and Hammer Lake all appeared to contain adequate substrate to support Lake Trout, but lack of deep water and overwintering habitat prevented Phantom Lake from sustaining large-bodied species.

Limited Lake Trout spawning habitat was available in Hammer Lake as patches of cobble substrate (Rescan 2003). Suitable spawning, rearing, and overwintering habitat for Lake Whitefish was identified in Lynx, Phantom, and Hammer lakes in Rescan (2003).

While no fish were found In Hammer Creek at the time of the survey described in Rescan (2003), marginal fish habitat was identified, which could provide rearing and spawning habitat at both ends of the watercourse. Rescan (2007) reported possible habitat for fish in Streams A and B, but no fish were present at the time of the survey, possibly a result of low water levels and littered debris acting as barriers to fish movement. In Golder (1997), a survey of Streams L1 (referred to as FSR1 in the report) and J2 (referred to as FSR2 in the report) in 1996 identified availability of fish habitat in both streams, but of varying quality, particularly within Stream L1. The most abundant habitat in Stream L1 was low quality, deep runs, but it also contained portions of moderate and high quality run habitat, as well as low to moderate quality pools (Golder 1997a). Habitat in Stream J2 was more uniform, with 100% of the habitat ranked as high-quality run habitat braided through thick willows, with no pools (Golder 1997a).

2.2.5 Fish Health

Many studies described in historical reports included pathological observations of captured fish. These included evaluation for internal and external abnormalities, and disease and parasitic infections, with varying levels of detail provided in each report. The reports in the Historical Report Review (Appendix A) presented no clear indications of changes in fish health as an effect of mining activity in the BSA. The most detailed summary of fish pathology in Lac du Sauvage was provided in Golder (1997g)[1]. In this report, external abnormalities were observed in less than 25% of examined fish from Lac du Sauvage and Lac de Gras, with varying rates between species. The abnormalities noted were fin damage, parasites, fin haemorrhaging and lesions/wounds, and inflamed anus/urogenital opening (Golder 1997g). Cisco had the least incidence of abnormalities in either lake, with no abnormalities observed in Cisco from Lac du Sauvage (Golder 1997g).

Morphological signs of toxicity were not identified in Lac du Sauvage and Lac de Gras in fish captured during the 1996 survey (Golder 1997g). However, a baseline incidence of disease was observed, which was usually attributed to background disease, such as, parasitic or bacterial disease (Golder 1997g). A high incidence of heart disease was recorded for several species in both lakes (Golder 1997g). All Lake Trout and Round Whitefish in Lac du Sauvage had incidence of heart disease. This observation was double the incidence for Round Whitefish in Lac de Gras. A small number of Cisco and Arctic Grayling from both lakes also had heart disease.

In Lac du Sauvage and Lac de Gras, Cisco had the highest incidence (100% and 96%, respectively) of histopathological alterations of the gills (Golder 1997g). Incidence in Round Whitefish was 79% in Lac du Sauvage, and 66% in Lac de Gras (Golder 1997g). Liver pathology was also observed in a high number of Lake Trout in Lac du Sauvage (81%) and Lac de Gras (67%) (Golder 1997g). A lower proportion of muscle and kidney alterations incidence was noted in both lakes. In Lac du Sauvage, muscle alterations were observed in 13% of Lake Trout, and kidney alterations were observed in 26% of Round Whitefish (Golder 1997g).

[1] The histopathology assessment and parasite taxonomic identification were conducted by GlobalTox International Consultants. Golder (1997g) summarizes those results and copies of the GlobalTox reports were provided as accompanying documents when originally submitted.

The presence of a variety of parasites was common to all species in Lac de Gras and Lac du Sauvage (Golder 1997g). As with other pathologies, no trends were identified in the reports that showed a relationship to mine-related effects.

For the smaller lakes in the BSA, detailed fish health information was only available for Lake D3 (Counts) and Lake B4 (Cujo). Analyses for parasites, and deformities, erosions, tumors, and lesions (DELT), were part of the Ekati Mine AEMP (Rescan 2008 ERM Rescan 2013) for fish communities in the region. This included Lake Trout, Round Whitefish, and Slimy Sculpin from Lake D3 (Counts) and Lake B4 (Cujo). Overall, few deformities were observed in Lake Trout and Round Whitefish (ERM Rescan 2013). Eroded fins were observed by ERM Rescan (2013) more in 2012 than in 2007 for both species in the Koala watershed and King-Cujo watershed. However, this was not considered a mining-related effect, because the increase in fin erosions was also observed in reference lakes. A slight decrease in the rate of parasitic infection of Slimy Sculpin was noted for Lake D3 (Counts) by ERM Rescan (2013). Parasitism of Slimy Sculpin varied between lakes, but a visual trend of prevalence with proximity to the mine was noted in ERM Rescan (2013). However, since no baseline data for Slimy Sculpin were available, a mine-related effect could not be confirmed (ERM Rescan 2013).

2.2.6 Fish Tissue Chemistry

A consistent theme across previously completed studies of tissue chemistry for fish near the Diavik Mine and the Ekati Mine was natural variation in metal concentrations across time, space (both within and across lakes), and species. For mercury levels in fish tissue, increases in the study lakes over time may reflect widespread increases in mercury in this part of northern Canada. Golder (2012a) reported statistical differences in mercury concentrations in Lake Trout muscle in Lac du Sauvage between 2008 and 2011, and general increases in mercury concentrations in both Lac de Gras and Lac du Sauvage before the development of the Diavik Mine to 2011. Importantly, the increase in mercury concentration in Lake Trout from Lac du Sauvage since baseline was greater than observed in Lake Trout from Lac de Gras; thus, there was no clear indication that the mercury increase in Lake Trout from Lac de Gras was a result of the Diavik Mine.

Similar findings were reported for Koala watershed and Lac de Gras areas as part of monitoring for the Ekati Mine. Rescan (2008) reported that concentrations of several metals in Round Whitefish liver (barium, mercury, molybdenum, strontium) and muscle (aluminum, barium, mercury, molybdenum, strontium), and in Lake Trout liver (arsenic, mercury, molybdenum) and myomere (barium, mercury) were higher in 2007 versus levels recorded during baseline years; most increases appear to be due to natural variation. The mechanisms underlying changes in metal concentrations in tissue may be shifts in diet, increased metabolism, and natural changes in water and sediment chemistry.

Mine-related effects on fish tissue chemistry were reported in a few of the historical reports. The fish tissue chemistry study completed by Golder (2008) in support of the 2007 Diavik Mine AEMP annual report concluded that there were several low-level and moderate-level effects observed for Slimy Sculpin in Lac de Gras. The moderate-level effects were statistically significant differences in mercury concentrations in tissue 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. Similar trends in metal concentrations in Slimy Sculpin tissue were reported again in 2010 (Golder 2010), although not necessarily for mercury. Statistically significant increases in tissue concentrations of bismuth, strontium, titanium, and uranium in Slimy Sculpin samples were reported for the near-field 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 (Golder 2010). Key findings in fish community variables reported by Rescan (2012) for the King-Cujo watershed and reference lakes were increased selenium concentrations in Lake Trout muscle, and Round Whitefish muscle and liver tissue from Lake B4 (Cujo), and increased uranium concentrations in Round Whitefish liver tissue and Slimy Sculpin from Lake B4 (Cujo).

As expected, species responses to mine-related activities varied across space and time. Lake Trout were consistently reported as having elevated concentrations of mercury, owing to their top trophic position in the food web and susceptibility to effects from bioaccumulation as a relatively large, long-lived species. In 2007, the Diavik Mine completed the field component of an AEMP in Lac de Gras and results of the small-bodied fish survey revealed that concentrations of mercury in Slimy Sculpin were greater in the exposure population compared to concentrations in two reference populations. Given that Slimy Sculpin are used as an early warning indicator of potential effects on tissue quality of Lake Trout, a survey was undertaken to measure changes in mercury concentrations in Lake Trout tissue in 2008, and again in 2011. In contrast to trends reported for Slimy Sculpin, there was no clear indication that the mercury increase in Lake Trout from Lac de Gras was a result of the Diavik Mine.

From a human health perspective, mercury concentrations found in Lake Trout from Lac de Gras and Lac du Sauvage were generally below Health Canada's maximum acceptable levels for the edible portion of retail fish (0.5 micrograms per gram wet weight [μg/g ww]) (Golder 2012a). However, the larger fish sampled did have concentrations that exceeded the Health Canada criterion (Health Canada 2011). Thus, with the exception of the very largest fish, mercury concentrations in the muscle tissue of Lake Trout were not expected to affect human health if regularly consumed.

3 BASELINE FIELD PROGRAM

3.1 Methods

3.1.1 General Approach

In 2013, fish and fish habitat evaluations took place during four separate field programs from early August to mid-September.

The four field programs were completed over the following dates in 2013:

- August 7 to 22: evaluation of fish and fish habitat in Paul Lake (and outlet), Duchess Lake (and outlet), and Lake E1 (and outlet).
- August 13 to 29: evaluation of fish and fish habitat in Lac du Sauvage, Lynx Lake (and outlet), and Hammer Lake (and outlet).
- August 20 to September 5: evaluation of fish and fish habitat of high-priority lakes and streams in the BSA.
- September 4 to 18: evaluation of fish and fish habitat of remaining high-priority lakes and streams in the BSA.

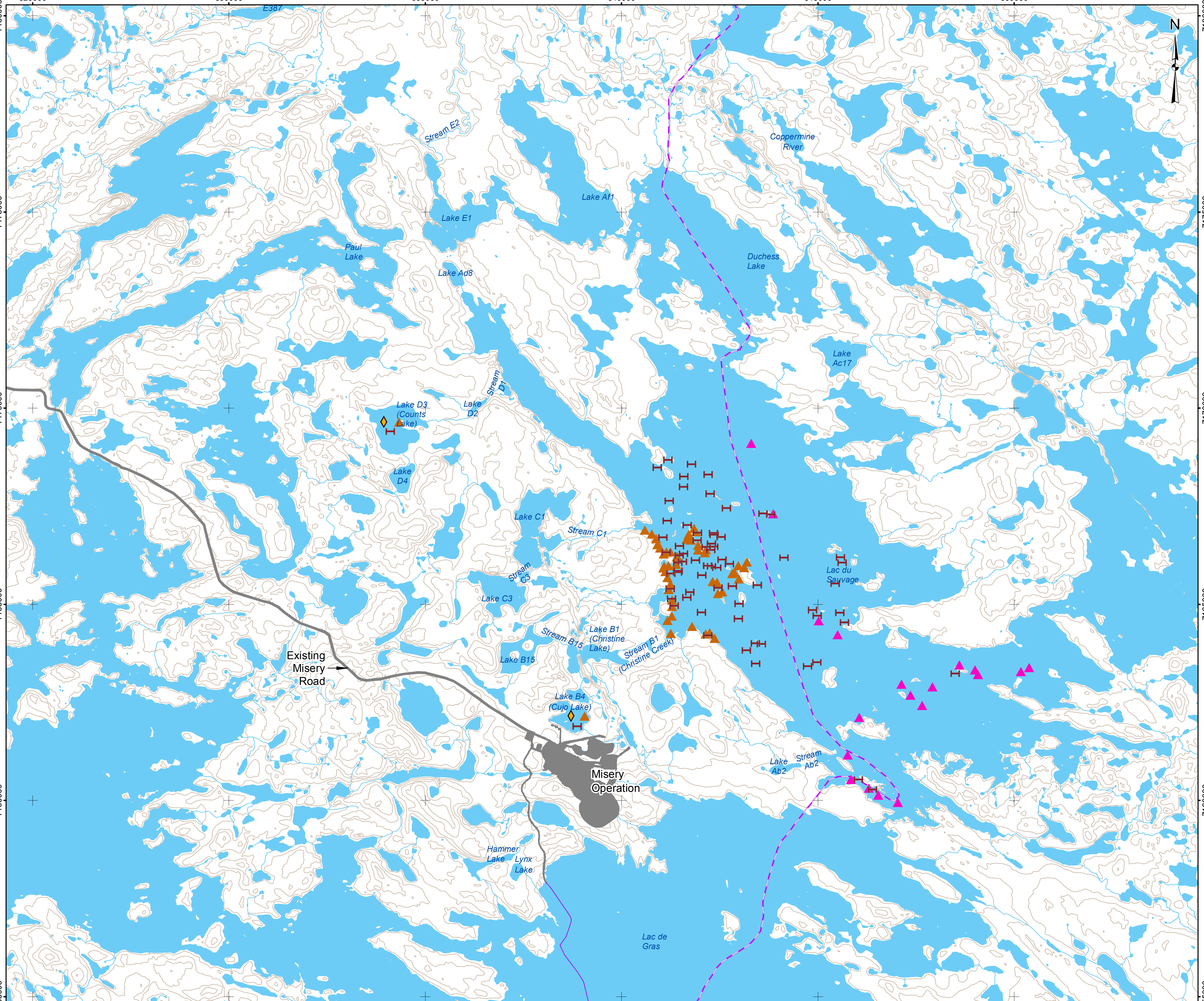
Methods followed standard protocols for sampling streams and lakes for fish (Bonar et al. 2009) and included overnight and short-duration gill net sets, overnight index netting sets, minnow trapping, backpack electrofishing, angling, and visual observations. Captured fish were identified to species, and measured for length and weight, when possible. Life history data were used to describe the structure of the local population of fish, and to understand body condition by species. Ageing structures (e.g., otoliths, fin rays, and scales) of mortalities were submitted to North-South Consultants Inc. (Winnipeg, Manitoba), such that age data were available to understand trends in growth.

The 2013 field data for Lac du Sauvage, Lake B4 (Cujo), and Lake D3 (Counts) were supplemented with catch information from selected previous fish programs in the BSA. The previously collected data which were incorporated to supplement 2013 catch information included data from the 2006 Jay Pipe Aquatic Baseline Report (Rescan 2007), the 2007 and 2012 Ekati Mine AEMP reports (Rescan 2008; ERM Rescan 2013), and reports in support of the Diavik Mine 2008 and 2011 AEMPs (Golder 2009a, 2012a) (Table 3.1-1, Map 3.1-1).

Table 3.1-1 Summary of Fish Sampling Method Deployed per Waterbody, 2006 to 2012

Lake	Gill Net	Backpack Electrofisher	Minnow Trap	Angling
Lac du Sauvage	2006, 2011	—	2006	2008, 2011
Lake B4 (Cujo)	2007, 2012	2007, 2012	2007	—
Lake D3 (Counts)	2007, 2012	2007, 2012	2007	—

— = sampling method not used.



LEGEND

- EKATI MINE FOOTPRINT
- WINTER ROAD
- NORTHERN PORTION OF TIBBITT TO CONTWOYTO WINTER ROAD
- ELEVATION CONTOUR (10 m INTERVAL)
- WATERCOURSE
- WATERBODY
- GILL NET LOCATION (HISTORICAL)
- ELECTROFISHING LOCATION (HISTORICAL)
- MINNOW TRAP LOCATION (HISTORICAL)
- ANGLING LOCATION (HISTORICAL)

NOTE

FISH SAMPLING LOCATIONS ARE A REPRESENTATION ONLY AND DO NOT INDICATE ACTUAL LOCATION FOR THE LAKES INDICATED WITH AN ASTERISK

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

2 0 2
SCALE 1:100,000 KILOMETRES

PROJECT
DOMINION DIAMOND
JAY PROJECT
NORTHWEST TERRITORIES, CANADA

TITLE
SAMPLING LOCATIONS FROM SELECT HISTORICAL PROGRAMS FOR FISH AND FISH HABITAT BASELINE STUDY AREA, 2006 TO 2012

Golder Associates

PROJECT		13-1328-0041	FILE No. B_JC_Aqua_005_GIS	
DESIGN	CS	29/01/14	SCALE AS SHOWN	REV 0
GIS	JG	11/09/14	MAP 3.1-1	
CHECK	CG	11/09/14		
REVIEW	SM	11/09/14		

G:\CLIENTS\DOMINION\DDEC Jay and Lynx Projects\Figures\13-1328-0041 Jay & Lynx EA\Aquatics\Baseline\B_JC_Aqua_005_GIS.mxd

3.1.2 Study Locations

Fish populations were studied and habitat was evaluated at 18 lakes in 2013, including Lac du Sauvage, Paul Lake, Duchess Lake, Lake Af1, and Lake E1 (Map 3.1-2). Fish populations were studied in 6 streams, and habitat was evaluated at 17 streams (including ephemeral streams) within the BSA (Map 3.1-2). Supplemental data were also collected, including aerial photographs, surface water quality, vertical lake profiles, lake bathymetry, and stream discharge (Table 3.1-2).

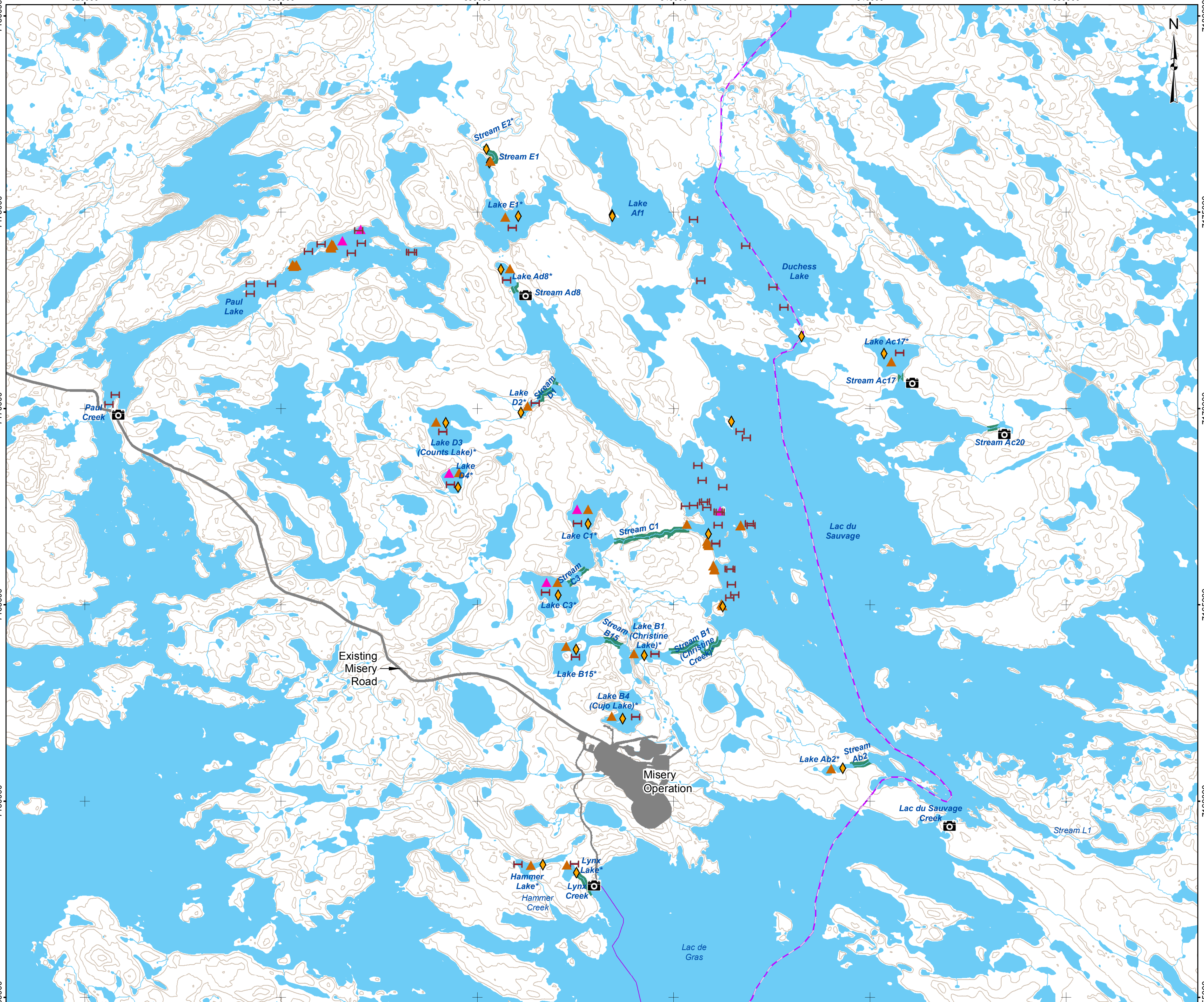
Table 3.1-2 Summary of Surveys and Sampling Methods Deployed per Waterbody, 2013

Lake or Stream	Survey Type						Fish Sampling Method			
	Fish Habitat	Aerial Photos	Surface Water Quality	Vertical Profiles	Bathymetry	Stream Discharge	Gill Net	Backpack Electro-fisher	Minnow Trap	Angling
Lac du Sauvage	✓	✓	✓	✓	✓	-	✓	✓	✓	✓
Paul Lake	✓	✓	✓	✓	-	-	✓	-	✓	✓
Duchess Lake	✓	✓	✓	✓	-	-	✓	✓	-	-
Lake Af1	✓	✓	✓	-	-	-		✓	-	-
Lake Ad8	✓	✓	✓	✓	✓	-	✓	✓	✓	-
Lake Ab2	✓	✓	✓	-	-	-		✓	✓	-
Lake Ac17	✓	✓	✓	-	✓	-	✓	✓	✓	-
Lake B1 (Christine)	✓	✓	✓	✓	✓	-	✓	✓	✓	-
Lake B4 (Cujo)	✓	✓	✓	✓	✓	-	✓	✓	✓	-
Lake B15	✓	✓	✓	✓	✓	-	✓	✓	✓	-
Lake C1	✓	✓	✓	✓	✓	-	✓	✓	✓	✓
Lake C3	✓	✓	✓	✓	✓	-	✓	-	✓	✓
Lake D2	✓	✓	✓	✓	✓	-	✓	✓	✓	-
Lake D3 (Counts)	✓	✓	✓	✓	✓	-	✓	✓	✓	-
Lake D4	✓	✓	✓	✓	✓	-	✓	✓	✓	✓
Lake E1	✓	✓	✓	✓	-	-	✓	✓	✓	-
Hammer Lake	✓	✓	✓	✓	-	-	✓	✓	✓	-
Lynx Lake	✓	✓	✓	✓	-	-	✓	✓	✓	-
Stream Ab2	✓	✓	-	-	-	-	-	-	-	-
Stream Ac17	✓	✓	-	-	-	-	-	-	-	-
Stream Ac20	✓	✓	-	-	-	-	-	-	-	-
Stream Ad8	✓	✓	-	-	-	-	-	-	-	-
Stream B1 (Christine Creek)	✓	✓	✓	-	-	✓	-	✓	-	-
Stream B15	✓	✓	✓	-	-	✓	-	✓	-	-
Stream C1	✓	✓	✓	-	-	✓	-	✓	-	-
Stream C3	✓	✓	✓	-	-	-	-	✓	-	-
Stream D1	✓	✓	✓	-	-	-	-	✓	-	-
Stream E1	-	✓	-	-	-	✓	-		-	-
Stream E2	✓	✓	✓	-	-	✓	-	✓	✓	-
Stream L1	-	✓	-	-	-	-	-	-		-

Table 3.1-2 Summary of Surveys and Sampling Methods Deployed per Waterbody, 2013

Lake or Stream	Survey Type					Fish Sampling Method				
	Fish Habitat	Aerial Photos	Surface Water Quality	Vertical Profiles	Bathymetry	Stream Discharge	Gill Net	Backpack Electro-fisher	Minnow Trap	Angling
Lac du Sauvage Creek	✓	✓	-	-	-	✓	-	-	-	-
Paul Creek	✓	✓	-	-	-	✓	-	-	-	-
Duchess Creek	-	✓	-	-	-	-	-	-	-	-
Hammer Creek	-	✓	-	-	-	-	-	-	-	-
Lynx Creek	-	✓	-	-	-	-	-	-	-	-

- = not present.



LEGEND

- EKATI MINE FOOTPRINT
- WINTER ROAD
- NORTHERN PORTION OF TIBBITT TO CONTWOYTO WINTER ROAD
- ELEVATION CONTOUR (10 m INTERVAL)
- WATERCOURSE
- WATERBODY
- STREAM HABITAT ASSESSED
- ANGLING LOCATION, 2013
- ELECTROFISHING LOCATION, 2013
- GILL NET LOCATION, 2013
- MINNOW TRAP LOCATION, 2013
- SCOPING LEVEL HABITAT ASSESSMENT

NOTE

FISH SAMPLING LOCATIONS ARE A REPRESENTATION ONLY AND DO NOT INDICATE ACTUAL LOCATION FOR THE LAKES INDICATED WITH AN ASTERISK

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

2 0 2
SCALE 1:100,000 KILOMETRES

PROJECT
DOMINION DIAMOND
JAY PROJECT
NORTHWEST TERRITORIES, CANADA

TITLE
SAMPLING LOCATIONS FOR FISH AND FISH HABITAT BASELINE STUDY AREA, 2013

Golder Associates

PROJECT	13-1328-0041		FILE No. B_JC_Aqua_004_GIS
DESIGN	CS	29/01/14	SCALE AS SHOWN REV 0
GIS	JG	09/09/14	MAP 3.1-2
CHECK	CG	09/09/14	
REVIEW	SM	09/09/14	

G:\CLIENTS\DOMINION\DDEC Jay and Lynx Projects\Figures\13-1328-0041 Jay & Lynx EA\Aquatics\Baseline\B_JC_Aqua_004_GIS.mxd

3.1.3 Habitat Surveys

3.1.3.1 Lake Habitat Surveys

Lake habitat evaluations were performed concurrently with the fish sampling efforts. Habitats of representative shoreline sections were characterized in all lakes by identifying unique features on a map and with georeferenced photographs. In all lakes, representative habitat types were evaluated from a boat travelling approximately 10 metres (m) from shore where substrate composition, riparian area, and habitat type were recorded and photographed. Evaluations also included recording of Universal Transverse Mercator (UTM) locations and taking multiple photographs from the boat for representative habitat features (Appendix B, Photos). Aerial photographs from a helicopter were taken to visually evaluate shoreline habitat at Paul Lake, Lake E1, Duchess Lake, Lake Af1, Lake Ad8, Lake Ac17, Lake B15, and Lake Ab2 (Appendix B).

Detailed shoreline habitat maps were created for Lac du Sauvage, Lynx Lake, Hammer Lake, Lake B1 (Christine), Lake C1, Lake D2, Lake D3 (Counts), Lake D4, and Lake B4 (Cujo). The habitat maps provided qualitative descriptions of shoreline substrate, shoreline vegetation type, shoreline stability, littoral substrate, submerged macrophytes, and depth at drop-off. At a subset of small lakes and at Lac du Sauvage, the habitat mapping assessments were combined with additional methods to quantitatively describe substrate types per depth stratum. These methods involved substrate mapping by visual interpretation of georeferenced orthophotographs and digital imagery from side-scanning equipment (Humminbird 997c SI Combo), and substrate classification and mapping using hydroacoustic data and ground-verified observations.

3.1.3.1.1 Lake Bathymetry

Between August 25 and September 12, 2013, bathymetric surveys for identifying maximum water depths were completed for Lake B1 (Christine), Lake B4 (Cujo), Lake D3 (Counts), and Lakes Ad8, Ac17, B15, C1, C3, D2, and D4 using a Garmin 531s Sonar Global Positioning System (GPS). Bathymetric surveys and raster maps of Lac du Sauvage, Paul Lake, Lake E1, Duchess Lake, and Lake Af1 were completed by Aurora GeoSciences Ltd. (2013).

Typically, the bathymetric surveys included one longitudinal transect that connected the two farthest shorelines and then subsequent cross transects (i.e., perpendicular to the longitudinal transect) that were evenly spaced along the longitudinal transect. Because most of the waterbodies were small, transect spacing was approximately every 25 to 50 m. The number of transects per site reflected the size of the lake and the irregularity of the shoreline.

For Lynx and Hammer lakes, depth and location (GPS) data were collected on August 26 and 27, 2013, concurrently with the side-scan sonar data. The georeferenced depth dataset was then analyzed using Sonar TRX (Version 13.1) and applied to create bathymetric maps for Hammer Lake and Lynx Lake in ArcGIS (ArcMapTM v9.3.1, 2009). Erroneous points were screened out using georeferenced orthophotographs and by eliminating unrealistic depths (e.g., depth changes greater than 1 m between adjacent points).

Depth-area graphs were created in Microsoft Excel by analyzing the bathymetric rasters. Maximum depths were reported, along with lake surface areas greater than 2 m deep, which represented the expected threshold for maximum ice thickness in winter.

3.1.3.1.2 Shoreline Substrate Characterization

Habitat data were sketched from a boat for the entire shoreline of Lac du Sauvage, and Hammer and Lynx lakes between August 15 and 28, 2013. Maps were then georeferenced using Geographic Information System (GIS) software (Global Mapper Version 14.0.2) and digitized into polygons based on observed substrate types at shallow water locations (Figure 3.1-1; Appendix C, Substrate Mapping and Hydroacoustic Survey Data). To complement these habitat maps, georeferenced orthophotographs (summer 2013) were also used to generate a detailed map of lake substrates. Given the high resolution of the orthophotographs and the clarity of the water, substrate types were identified and digitized for shallow water locations with the aid of the ground-truthed data. For example, approximately 95% of digitized mixed and coarse substrate types in Lac du Sauvage were in depths less than 5 m with certain polygons extending to depths of 7 m.

Figure 3.1-1 An Example of Digitizing Substrate Using Orthophotos

Substrate types were mapped for shallow areas of the study lakes, with the exception of fines, because the full extent of area for fines could not be determined in the deeper water (i.e., beyond 5 m depths). For the deeper portions of the lakes that were not visible on the orthophotographs or to field staff while ground-truthing, two types of additional data were collected. Side-scan sonar data were collected for Lynx and Hammer lakes as representative small lakes in the BSA (between August 26 and 27, 2013); hydroacoustic data were collected in Lac du Sauvage between August 4 and 5, 2013.

Once distinct habitats were digitized in GIS, the total area of each substrate type was calculated for each lake. Due to the large size of Lac du Sauvage, only a portion of the shallow lake habitats was digitized and mapped for habitat types (i.e., internal basins Ac, Ad, and Ae). The extent of area mapped also represented the dewatering area of the proposed mine. Substrate types identified during the ground-truthing survey were fines (Fi), boulder dominated by fines (Fi/Bo), fines dominated by boulder (Bo/Fi), cobble dominated by fines (Fi/Co), fines dominated by cobble (Co/Fi), cobble dominated by boulder (Bo/Co), boulder dominated by cobble (Co/Bo), and bedrock (Br). Detailed substrate data for shallow water areas of Lac du Sauvage (internal Basins Ac, Ad, Ae) and the entire surface area of Hammer and Lynx lakes were then overlaid with bathymetry data using GIS to determine substrate composition per depth stratum.

3.1.3.1.3 Deep Water Substrate Characterization

The primary purpose of the side-scan data was to visually confirm the dominant presence of fines at shallow and deep-water locations in the small lakes. For the side-scan data collected at Lynx and Hammer lakes, a mosaic of high-resolution georeferenced images of the lake bottom were generated using Sonar TRX (Version 13.1). Images were slant-range corrected to create seamless images from the left and right side transducers, and then cropped to 8 m from the position of the boat to focus on clear, non-distorted images. Side-scan images of the bottom substrate were overlaid with the substrate observed in the orthophotographs. This exercise confirmed that, for example, what appeared to be Bo/Co in shallow water in the side-scan data was indeed Bo/Co, as determined in the orthophotograph and, similarly, fines identified in shallow water in the side-scan data were confirmed by the orthophotographs (Appendix C). Side-scan data collected in deeper portions of the small lakes were visually confirmed as 100% fine substrates, and were assumed correct for habitat mapping purposes for small lakes.

In Lac du Sauvage, training (or calibration) hydroacoustic data were collected for various substrate types at anchored locations in the Ac internal basin between August 4 and 5, 2013. Transducer settings are described in Section 3.1.5. Anchored locations were selected to cover a wide variety of different substrate types at varying depths (0 to 2 m, 2 to 6 m, 6 to 10 m, and greater than 10 m). Calibration data were collected at a total of seven ‘fines’ sites encompassing the complete range of depth strata, but only three ‘mixed’ sites and two ‘coarse’ sites were evaluated due to the difficulties in finding each substrate type in depths greater than 6 m. A combination of Ekman grabs and underwater photographs was collected at each site to confirm the type of substrate being sampled by hydroacoustics (Appendix C).

The calibration hydroacoustic files for each substrate sampled were then analyzed using a cluster analysis in VBT software (Version 1.10.6.4). Clusters were defined using a fractal analysis algorithm following Lubniewski and Stepnowski (1998). The VBT software plotted each bottom echo ping by the fractal dimension of the first bottom echo against the normalized intensity of the second part of the first bottom echo. Every 100 echo pings were averaged over each calibration file and then manually assigned a cluster boundary (6 clusters were identified; Appendix C). Clusters were defined for each type of substrate in combination with ground-truthed information (photographs and Ekman grab data) and then grouped according to similarities and differences.

Hydroacoustic transect data collected throughout the Ac internal basin of Lac du Sauvage during the day between August 1 and 3, 2013, were then analyzed using VBT software and every 30 pings were averaged and assigned a georeferenced location and a substrate category based on the previous cluster analysis. Boat speed was typically 1.5 metres per second (m/s), with a ping rate of 5 pings per second set for the echosounder. The total distance covered during the daytime survey in the Ac basin was 45.2 km. The analysis, which assigned the cover of fine substrate and other substrate types across a range of depths, was performed for each depth stratum using transect data from the Ac internal basin; however, it did not generate spatially explicit substrate coverage for habitat mapping, as was done for Lynx and Hammer lakes.

Preliminary results showed that dense fines (e.g., hard clay substrates) and exposed coarse substrate had similar bottom echoes and overlap occurred, resulting in misclassification. Thus, in depths of less than 5 m, any points that were assigned to the ‘fines’ category by hydroacoustics but overlapped with known areas of Bo/Co in the shoreline substrate map were corrected to the “coarse” category. In total, 13.6% of values were incorrectly identified as dense fines and were then corrected to “coarse” for numerical summaries.

In addition, for areas with depths greater than 8 m, which are typically below the depositional area of Arctic lakes (Dick et al. 2009; Appendix C), substrate habitat was assigned “coarse” and assumed to have a layer of sediment due to deposition even if the hydroacoustic data suggested mixed or coarse substrates. In total, 12.0% of substrate values below 8 m depths were initially classified as “coarse” and were then changed to “fines” given the depositional depth boundary. The corrected and uncorrected data summaries are presented in Appendix C.

3.1.3.1.4 Surface Water Quality

In situ water quality parameters were measured in all lakes using a YSI Pro Plus multi-parameter meter with a 20-m cable. Surface measurements were taken in conjunction with fish sampling. Parameters measured were temperature (degrees Celsius [°C]), pH, conductivity (microSiemens per centimetre [µS/cm]), turbidity (nephelometric turbidity unit), and dissolved oxygen (DO, milligrams per litre [mg/L]). In situ surface water quality was measured at all 18 lakes visited in 2013.

Water quality profiles were measured at gill net set locations where water depth exceeded 5 m. Profiles were taken in Lac du Sauvage, Paul Lake, Lake E1, Duchess Lake, Lake B1 (Christine), Lake B4 (Cujo), Lake Ad8, Lake B15, Lake C1, Lake C3, Lake D2, Lake D3 (Counts), Lake D4, Hammer Lake, and Lynx Lake (Appendix C). Water quality parameters were measured at the surface and at subsequent 1.0 m depth intervals until the bottom was reached.

3.1.3.2 Stream Habitat Surveys

All streams were initially evaluated and photographed from a helicopter (Appendix B). The entire length of the stream was evaluated from the air with geo-referenced photographs taken along the entire length of the reach. Potential barriers to fish movements were noted and marked in GPS. On-the-ground habitat evaluations were conducted for all watercourses with defined bed and banks; those with undefined or dispersed channels were identified as ephemeral watercourses and were not evaluated in detail on the ground for habitat and fish (i.e., ephemeral streams were evaluated only from helicopter in the air).

For the on-the-ground evaluations, a 100-m representative section was surveyed at minimum, starting from just above the mouth of the watercourse (i.e., upstream from the inflow into receiving lake). Stream E2 is a relatively large permanent stream (i.e., greater than 10 m wide with flow throughout open-water season and); thus, a longer (600 m) section was surveyed for this stream.

3.1.3.3 Stream Characterization

Stream characteristics were considered at each surveyed site and involved measurements of mean bankfull channel and wetted width (m), depth (m), and stream velocity (m/s). Habitat was quantified using cross-sectional transects established at intervals along the accessible length of each wadeable stream. At each transect, habitat parameters (depth, velocity, and substrate size) were recorded. Stream habitat maps were created for Stream E2, Stream B1 (Christine Creek), Stream C1, and Stream D1, and then used for qualitative descriptions of habitat and substrate types at those locations.

Bankfull channel width was defined as the edge of the watercourse with a defined bank. On occasion, flooded sections of watercourses were observed at widths greater than the defined bankfull channel. In these cases, flooded or wetted width was a measurement of wetted width beyond, and including, that of the defined channel.

Stream velocity measurements were taken using a Marsh McBirney direct-velocity meter. Measurements were taken by wading along a tag line positioned across the tributary and measuring mean column velocities at 0.6 of the total water depth at a representative number of vertical stations along the cross-section. Stream discharge was calculated using methods from Bovee and Cochnauer (1977). Stream velocity measurements were only collected in streams with sufficient flows to allow such measurements.

Habitat type identification followed a modified classification by Hawkins et al. (1993):

- cascade = shallow turbulent water that may be passable to fish at high flows; usually less than 0.5 m deep; may be associated with a chute or set of rapids;
- riffle = moderately high velocity water (0.5 to 1.0 m/s); surface broken due to submerged and/or exposed bed material; coarse substrate; usually less than 0.5 m deep;
- run = generally deep, typically slow flowing water (0.05 to 1.0 m/s); coarse substrate; irregular, rarely broken surface; deeper water has more in-stream cover and higher class rank (Classes 1 to 3);
- pool = a discrete section of increased depth and lower water velocities (0.05 to 0.3 m/s); substrate is variable; deeper water has more in-stream cover and higher class rank (Classes 1 to 3);

- flat = section characterized by low gradient, smooth water surface, reduced velocity relative to run habitats and differentiated from pool habitat by high channel uniformity; and,
- boulder garden = dominating occurrence of large boulders providing instream cover; in association with an overall channel unit such as riffle or run.

Other stream variables involved standard measurements of cover for fish (e.g., instream vegetation, undercut banks, boulder garden), bank morphology, channel type (e.g., single, double, braided, dispersed), and the presence of movement barriers. Substrates were measured using a modified Wentworth scale:

- bedrock (Be);
- boulder (Bo) = greater than 256 millimetre (mm) diameter;
- cobble (Co) = 64 to 256 mm;
- gravel (Gr) = 2 to 64 mm; and,
- fines (Fi) = less than 2 mm.

3.1.3.3.1 Surface Water Quality

In situ water quality parameters in streams were measured using a YSI Pro Plus multi-parameter meter with a 20-m cable. Measurements were taken in conjunction with habitat evaluations and fish sampling at Stream B1 (Christine Creek), Stream B15, Stream C1, Stream C3, Stream D1, and Stream E2. Parameters measured were temperature (°C), pH, conductivity (µS/cm), turbidity (nephelometric turbidity unit), and DO (mg/L).

3.1.3.4 Geographic Information System-Based Habitat

Geographic Information System-based habitat data were obtained to supplement habitat information collected in the field. This dataset included lake characteristics, such as elevation, area, and sub-basin (or sub-catchment) area at the lake outlet, as well as stream characteristics, such as length, slope (%) and sub-basin area (at the mouth of the stream where it enters the downstream lake). Key data sources included light detection and ranging (LiDAR) (Aurora Geosciences Ltd. 2013) for lake elevation, sub-basin area, stream slope, and 2012 CanVec data (from the Natural Resources Canada Earth and Sciences Sector Centre for topographic information) for lake polygons.

3.1.4 Fish Sampling

Fish populations in BSA lakes and watercourses were evaluated using a variety of sampling methods during the 2013 field season and during previous surveys included in this baseline (Map 3.1-1). The sampling methods used in lakes were gill nets (short-duration and overnight sets), minnow traps, and angling. Backpack electrofishing was used primarily to collect fish from streams, but was also used to evaluate use of lake shorelines by small-bodied fish species. Brief descriptions of fish capture methods are provided below and generally they followed standards of the American Fisheries Society (Bonar et al. 2009). Detailed information on fish sampling effort is presented in Appendix E, Fish Catch Data.

3.1.4.1 Gill Netting

In 2013, Fall Walleye Index Netting (FWIN) gill nets were set at 17 lakes in the BSA during the August and September programs. Each FWIN gill net was made up of eight panels of multifilament mesh that ranged from 25 to 152 mm (the stretched measure). The nets were 61 m long by 1.8 m high, with a total area of 110 m^2. Gill nets were equipped with a braided float line and a lead line. Anchors attached to the lead line secured gill net position on the bottom of the lake. Buoys were attached to the float line with floating polypropylene rope to mark the net and then anchored to keep the net tight.

The FWIN short-duration (2- to 6-hour) gill net sets were deployed in Lac du Sauvage, Paul Lake, Duchess Lake, Lake E1, Lake Ad8, Lake Ac17, Lake B1 (Christine), Lake B4 (Cujo), Lake B15, Lake C1, Lake C3, Lake D2, Lake D3 (Counts), Lake D4, Lynx Lake, and Hammer Lake. Overnight gill net sets were deployed in Paul Lake and Duchess Lake.

Broad-scale Fish Community Monitoring (BsM) gill nets were also used in Lac du Sauvage in 2013 in conjunction with the hydroacoustics program. The BsM gill nets are similar to the FWIN gill nets in that they are an eight-panel multifilament net. Each BsM gill net consisted of eight panels, with mesh sizes ranging from 13 to 38 mm for small mesh gill nets, and 38 to 127 mm for large mesh gill nets. Short-duration (2 hour) BsM sets were deployed in Lac du Sauvage.

In 2011, Lake Trout were targeted in Lac du Sauvage by short-duration gill net sets (Golder 2012a). Gill nets were used to capture smaller fish, which were difficult to catch by angling.

In 2006, gill nets were set in Lac du Sauvage. Each index gill net was made up of three panels (each 15 m long by 2.4 m deep) of 38 mm mesh with a total net area of 108 m^2. Nets were anchored along the bottom of the lake and held by floats along the top. Gill nets were set for short durations only (Rescan 2007).

In 2007 and 2012, gill nets were set at Lake D3 (Counts) and Lake B4 (Cujo) to target Lake Trout and Round Whitefish. The same methods and equipment were used in 2007 and 2012 as in 2006 (Rescan 2008; ERM Rescan 2013).

3.1.4.2 Minnow Trapping

In August and September 2013, Gee-type minnow traps were used to confirm species presence/absence and describe small fish populations in 16 lakes and 1 stream. Three to five sets of four traps per set were baited with dry cat food and deployed at selected locations within the littoral zone of each lake. Minnow traps were set overnight in 14 lakes (Lac du Sauvage, Paul Lake, Lake E1, Lake Ad8, Lake Ac17, Lake B1 (Christine), Lake B4 (Cujo), Lake B15, Lake C1, Lake C3, Lake D2, Lake D3 (Counts), Lake D4, and Hammer Lake) and short-duration sets (3 to 6 hours) were deployed in Lake Ab2 and Lynx Lake. In Stream E2, 20 traps were baited with dry cat food and deployed within the stream channel.

In 2007, Slimy Sculpin were targeted with minnow traps in Lake D3 (Counts) and Lake B4 (Cujo) (Rescan 2008). In 2006, minnow traps were set in Lac du Sauvage. Baited Gee-type minnow traps were placed in shallow water within the island complexes of Lac du Sauvage for approximately 24 hours (Rescan 2007).

3.1.4.3 Backpack Electrofishing

In 2013, a Smith-Root Type LR-20 backpack electrofisher was used to sample fish at the shoreline of 15 lakes (Lac du Sauvage, Lake Af1, Lake B1 (Christine), Lake E1, Lake Ad8, Lake Ac17, Lake B4 (Cujo), Lake B15, Lake C1, Lake C3, Lake D2, Lake D3 (Counts), Lake D4, Hammer Lake, and Lynx Lake) and six streams (Stream B1 [Christine Creek], Stream B15, Stream C2, Stream C3, Stream D1, and Stream E2) during the August and September programs. The electrofisher was typically set between 400 and 900 Volts, at 60-Hertz frequency, with a 15% duty cycle.

In lakes, the field crew fished a section of shoreline where suitable fish habitat was observed. In small study streams, field crews completed one pass of approximately 100 m of a representative section of the stream (or the entire reach, time permitting), starting from the mouth of the stream and proceeding in the upstream direction. In Stream E2, crews fished in accessible locations over a length of 600 m. The effective electrofisher sampling times in lakes ranged from 144 to 1,644 seconds (s) per site. For streams, the sampling times ranged from 252 to 909 s.

In August 2012, a Smith-Root LR-24 backpack electrofisher was used to target Slimy Sculpin in Lake B4 (Cujo) and Lake D3 (Counts). Sampling times ranged from 5,536 s in Lake D3 (Counts) to 9,925 s in Lake B4 (Cujo) (ERM Rescan 2013).

In 2007, Slimy Sculpin were targeted using nearshore backpack electrofishing in Lake D3 (Counts) and Lake B4 (Cujo). Sampling times were 2,785 s in Lake D3 (Counts) and 3,158 s in Lake B4 (Cujo) (Rescan 2008).

3.1.4.4 Angling

In August and September 2013, angling was used at five locations (Lac du Sauvage, Paul Lake, Lake C1, Lake C3, and Lake D4) to supplement the catch from fish sampling techniques for large-bodied fish. Fish were angled by casting from a boat. Spoons (e.g., five of diamonds) and soft lures were used as bait.

In 2008 and 2011, Lake Trout were captured in Lac du Sauvage by trolling with large spoons and flat fish lures (Golder 2009a, 2012a).

3.1.4.5 Life History

Fish species expected to occur in the BSA and the codes used in this report are presented in Table 1.3-1. Captured fish were identified to species, measured for length (fork and total), and weighed. When possible, sex and reproductive status were determined. Data were then used to develop length-frequency distributions and length-weight equations for understanding population structure and patterns in growth (Guy and Brown 2007).The length-weight equations were also developed for calculating relative weights as part of future monitoring. Note that existing 2006 to 2013 data did not provide the minimum number of populations (i.e., 10 or more) for calculating relative weight equations for species (Murphy et al. 1990).

Scale and fin ray samples were taken from a subset of 2013 fish to determine age of released fish. If a fish died, an otolith or cleithrum was taken for age determination, as appropriate. Ageing structures that were analyzed in the laboratory are presented in Table 3.1-3. Multiple structures were collected for most fish species. For example, otoliths, a fin ray, and scales were collected for seven Arctic Grayling (Table 3.1-3). The resulting dataset of fish ages was used to evaluate length-at age, and generate von Bertalanffy growth parameters (Guy and Brown 2007). Detailed life history information is presented in Appendix F, Fish Life History Data.

Table 3.1-3 Ageing Structures Submitted for Ageing Individual Fish, 2013

Species	Number of Individuals (N) per Combination of Ageing Structures Analyzed							
	OT, FR, SC	OT, FR	OT, SC	OT	FR, SC	FR	CL, FR, SC	SC
Arctic Grayling	7	—	—	—	20	—	—	—
Lake Trout	22	4	—	—	52	14	—	—
Northern Pike	1	—	1	—	36	—	5	—
Lake Whitefish	27	—	3	66	37	—	—	13
Round Whitefish	35	2	1	—	25	—	—	—
Ninespine Stickleback	—	—	—	2	—	—	—	—

OT = otolith; FR = fin ray; SC = scale; CL = cleithrum; — = structure not collected for ageing analysis.

When multiple structures (including otoliths) were submitted per fish sample, otolith ages were used to evaluate the reliability of using only fin rays, and to develop regression equations to correct ageing values for individuals without otolith structures. Use of fin rays for ageing may be a reliable option for non-lethal sampling. The resulting equations were:

Equation 3.1-1 Lake Trout Otolith-Fin Ray Age Relationship

$$Age = 3.28 + (Fin\ Ray\ Age \times 1.38)(R^2 = 0.70)$$

Equation 3.1-2 Round Whitefish Otolith-Fin Ray Age Relationship

$$Age = 0.65 + (Fin\ Ray\ Age \times 1.17)(R^2 = 0.92)$$

Equation 3.1-3 Lake Whitefish Otolith-Fin Ray Age Relationship

$$Age = -1.05 + (Fin\ Ray\ Age \times 1.47)(R^2 = 0.89)$$

3.1.5 Hydroacoustics

3.1.5.1 Study Design

In addition to gill netting and minnow trapping methods, mobile hydroacoustic surveys were used to sample fish populations in Lac du Sauvage. Hydroacoustic surveys target species that exhibit pelagic-like behaviour. In Lac du Sauvage, targeted species were numerically abundant pelagic species, such as Cisco, and other species that may be demersal and only occasionally pelagic, such as Lake Trout, Arctic Grayling, Lake Whitefish, and Round Whitefish. The surveys were also designed to detect larger fish, such as yearling and older fish, (i.e., fish greater than 90 mm in length in mid-summer; Golder 2012b) in deep-water locations. The study design avoided shallow water (less than 2 m) where hydroacoustics are generally ineffective, even though these waters can support fish. For example, YOY Lake Trout in Arctic lakes typically move to shallow water, shorelines, and adjacent streams (Golder 2009b). This may be a behavioural strategy to avoid predation from large fish in the pelagic zone.

During July and August 2013, the hydroacoustic surveys were performed over two separate field programs. At the beginning of each program, each transducer was calibrated with a standard copper sphere for later determination of required offsets during post-processing. The first program was completed from July 31 to August 7, 2013, and included both a day-shift and a night-shift crew to collect data in Lac du Sauvage. The day-shift crew performed hydroacoustics for mapping substrate over shallow and deep water sections of the Ac internal basin of Lac du Sauvage, and involved hydroacoustic surveys and ground-truthing of substrate at anchored locations (Section 3.1.3.1.3). The night surveys collected hydroacoustics data along predetermined transects in each of the five internal basins of Lac du Sauvage (Aa to Ae), with the purpose of estimating fish population size in Lac du Sauvage.

The second hydroacoustic program was also completed in each of the five internal basins of Lac du Sauvage (Aa to Ae) (Map 3.1-3). Surveys along transects were repeated on August 13 to 22, 2013, when the field crew travelled the same transects (with same orientation) as during the first program to obtain directly comparable data. However, poor weather conditions (e.g., high winds) posed a challenge during this program because many nights were too windy to effectively collect reliable data. Hydroacoustic surveys for fish were completed only when winds were regularly less than 14 kilometres per hour (km/hr), because winds above that threshold caused scattered whitecaps, large wavelets and crests, which resulted in excessive transducer movement and lower quality of the data. Weather data (collected at the Ekati Mine) for the duration of the hydroacoustic surveys are presented in Appendix C.

The sampling unit for the hydroacoustic study was defined as a transect with multiple transects within a study area to provide satisfactory spatial coverage of varying habitats and depths. The goal of the hydroacoustic surveys was to provide a population estimate with a 20% coefficient of variation (CV) or lower. The calculation of the minimum necessary sampling effort or degree of coverage (Λ) was defined by Equation 3.1-4:

Equation 3.1-4 Recommended Degree of Sampling Effort

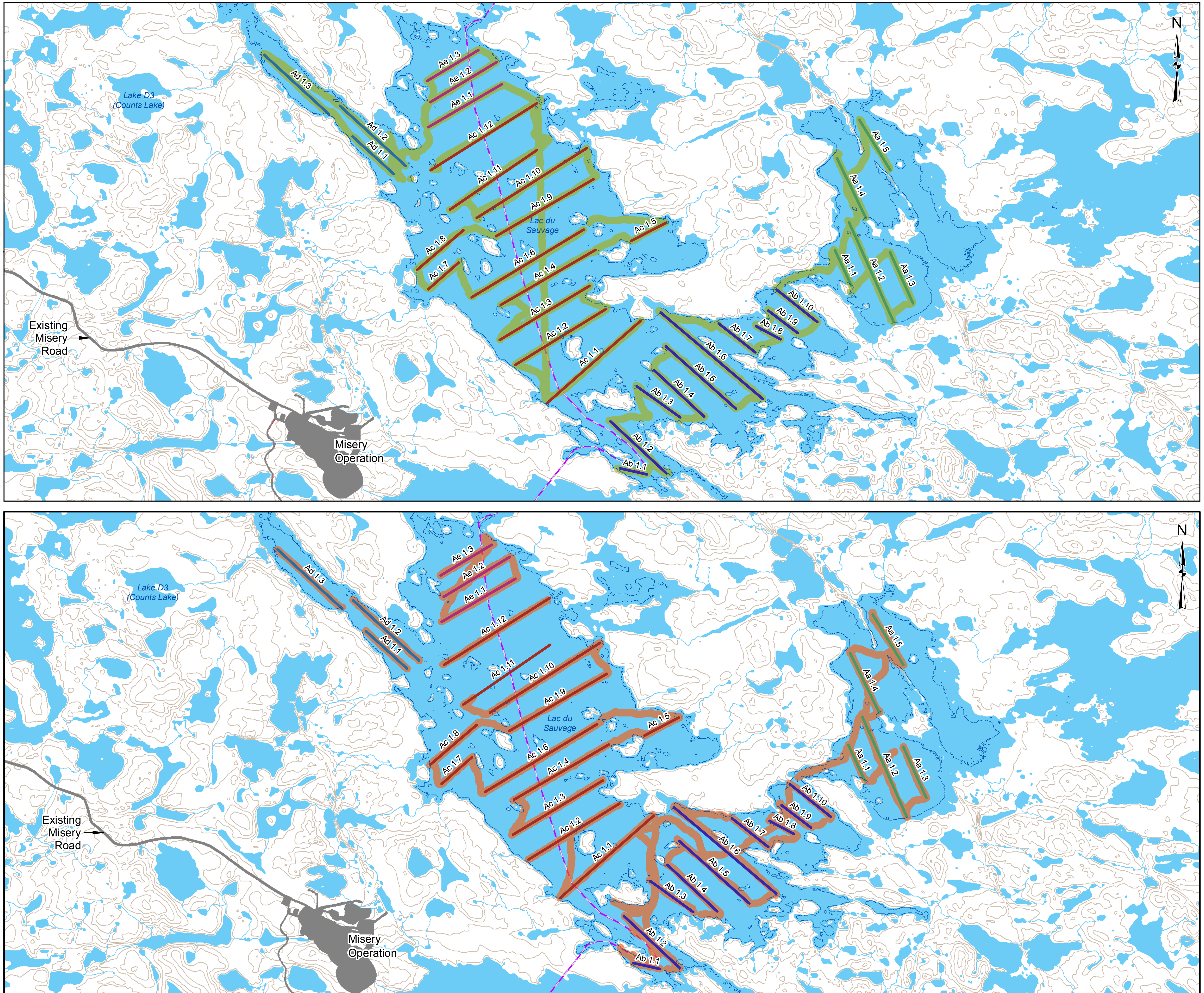
$$\Lambda = D \div \sqrt{A}$$

where D is the total transect length sampled, and A is the size of the Study Area. According to Algen (1983), the empirical relationship between the CV and Λ followed Equation 3.1-5:

Equation 3.1-5 Relationship between Variability and Sampling Effort

$$CV = 0.5 \div \sqrt{\Lambda}$$

Given that Lac du Sauvage has a surface area of approximately 86.4 square kilometres (km^2), the minimum level of effort (in km) per survey pass was approximately 58.1 km, as determined by the above equations. The plan based on the configuration of transects positioned from shoreline to shoreline in water deeper than 2 m involved 65.8 km of surveys, applied over 33 transects and 5 internal basins in Lac du Sauvage (Aa, Ab, Ac, Ad, and Ae) (Map 3.1-3).



LEGEND

- EKATI MINE FOOTPRINT
- NORTHERN PORTION OF TIBBITT TO CONTWOYTO WINTER ROAD
- ELEVATION CONTOUR (10 m INTERVAL)
- WATERCOURSE
- WATERBODY
- 2 METRE DEPTH BATHYMETRY CONTOUR

HYDROACOUSTIC TRANSECT

- Aa
- Ab
- Ac
- Ad
- Ae
- GPS TRACK - SHIFT 1
- GPS TRACK - SHIFT 2

REFERENCE

CANVEC © NATURAL RESOURCES CANADA, 2012
NATURAL RESOURCES CANADA, CENTRE FOR TOPOGRAPHIC INFORMATION, 2012
BATHYMETRIC DATA OBTAINED FROM AURORA, 2013
DATUM: NAD83 PROJECTION: UTM ZONE 12N

DOCUMENT

FISH AND FISH HABITAT BASELINE REPORT

2 0 2
SCALE 1:100,000 KILOMETRES

PROJECT

DOMINION DIAMOND

JAY PROJECT
NORTHWEST TERRITORIES, CANADA

TITLE

HYDROACOUSTIC SAMPLING LOCATIONS AND TRANSECTS FOR FISH IN LAC DU SAUVAGE, 2013

Golder Associates

PROJECT		13-1328-0041	FILE No. B_JC_Aqua_008_GIS
DESIGN	CS	29/01/14	SCALE AS SHOWN REV 0
GIS	JG	09/09/14	
CHECK	CG	09/09/14	MAP 3.1-3
REVIEW	SM	09/09/14	

G:\CLIENTS\DOMINION\DDEC Jay and Lynx Projects\Figures\13-1328-0041 Jay & Lynx EA\Aquatics\Baseline\B_JC_Aqua_008_GIS.mxd

3.1.5.2 Echosounder Settings

All hydroacoustics data were collected with the Biosonics DT-X echosounder system oriented for both horizontal and vertical split-beam sonar (Table 3.1-4). Use of horizontal beaming is the recommended approach for estimating fish densities in shallow water and in lakes where fish may be distributed near the surface (e.g., Kubecka and Wittingerov 1998; Gangl and Whaley 2004). Horizontal beaming allows for fish detection near the surface (i.e., less than approximately 5 m in depth), where fish are typically missed by a vertically oriented transducer beam. The advantage of vertical beaming is the application of reliable equations for calculating fish length using data on target strength (TS; Love 1971). However, the application of vertical beaming alone is generally not recommended for shallow water conditions, which are common throughout Lac du Sauvage.

Table 3.1-4 Parameter Inputs for the Transducer and Analysis of Hydroacoustic Data

	Horizontal Beaming	Vertical Beaming
Equipment		
Boat speed (m/s)	1.5	1.5
Ping rate (per second)	>5	>5
Transducer beam width (°)	7.2	6.8
Transducer frequency (kHz)	418	199
Pulse width (ms)	0.2	0.2
Data collection threshold (dB)	-130	-130
Processing		
Analysis threshold (TS dB)	-48.06	-46.47
Analysis threshold reduced 10% (TS dB)	-52.87	-51.11
Surface blanking zone range (m)	2.0	2.0
Bottom threshold (dB)	-70	-70
Bottom blanking zone (m)	1.0	0.3
Target min. pulse width	0.6	0.6
Target max. pulse width	1.5	1.5
Pulse length determination (dB)	6	6
Maximum beam compensation (dB)	9	9
Single target detection operand	Method 2	Method 2
Track Detection		
Minimum pings	3	3
Minimum single targets	2	3
Maximum gap between single targets	5	5

Note: Default inputs in Echoview 5.4 were applied or followed recommended settings in Parker-Stetter et al. (2009).

m/s = metres per second; ° = degree; kHz = kilohertz; ms = milliseconds; TS = target strength; dB = decibels; m = metre; > = greater than; % = percent.

In this study, the horizontal (or 'side-scanning') beam was a 418 kilohertz (kHz) transducer operating at a 7.2 degree (°) beam angle; the vertical (or 'down-scanning') beam was a 199 kHz transducer operating at a 6.8° beam angle (Table 3.1-4). The transducers (positioned approximately 0.4 m below the water surface off the side of the boat) were mounted to the end of a plank securely fastened to the boat so that no transducer movement occurred during data collection. The side-scanning transducer was positioned so that the sampling cone captured shallow regions of the water column, while avoiding interference from the surface. The beaming angle was approximately 6° to 7° from the surface.

Data were collected with a pulse-duration of 0.2 milliseconds (ms) to a Toughbook computer running BioSonics Visual Acquisition Program 6.0.6. An SF-2050 NavCom Starfire GPS (and/or handheld Garmin GPS with WAAS-enabled wide-area augmentation system) was used jointly with the Biosonics echosounder to collect accurate position information and to maintain the boat along the predetermined transects.

3.1.5.3 Post-Processing and Analysis

Data were processed in Echoview 5.4, and followed standard operating procedures for fisheries acoustic surveys in the Great Lakes (Parker-Stetter et al. 2009; Myriax Software Pty Ltd. 2012). The first step was to identify the lake bottom and the zone of analysis in the water column. In Echoview, bottom detection algorithms were applied using the 'best bottom candidate' function, followed by manual inspection of the bottom line and an adjustment (if necessary) to not only avoid bottom intrusion but to capture individual fish positioned near the lake bottom in analyses (Table 3.1-4; Figure 3.1-2). A second line was created at 2 m depths so that unwanted noise and interference near the surface could be excluded from analyses. Next, transducer-specific thresholds were applied to the data, which was collected at -130 decibels (dB), based on the minimum expected TS of the fish of interest, which was determined to be 9 centimetres (cm) in length (see explanation of TS below). This approach eliminated targets resembling invertebrates or interference, and emphasized yearling and older Lake Trout, Lake Whitefish, Round Whitefish, Arctic Grayling, and Cisco for analyses.

For vertical beaming, the -46.47 dB threshold for TS eliminated fish that were less than 9 cm in length according to the TS equation for 199 kHz data (Love 1971). Love's (1971) equation (Equation 3.1-6) has been applied in numerous studies and is based on a multitude of fishes and various frequencies ranging from 15 to 1,000 kHz:

Equation 3.1-6 Love's Target Strength Equation for Fish Length

$$L = 10^{((TS+26.18)\div 19.4)}$$

where L refers to fish length (m). However, the threshold of -46.47 dB was lowered by 10% to -51.11 dB as a conservative approach to include all yearling fish because Love's equation represents an average TS for a given fish length and smaller TS values in Lac du Sauvage could also reflect yearling fish.
Fish TS is primarily dependent on swimbladder size, shape, state of maturity, and fat content, all of which can vary for a species of a given length (reviewed in Parker-Stetter et al. 2009).

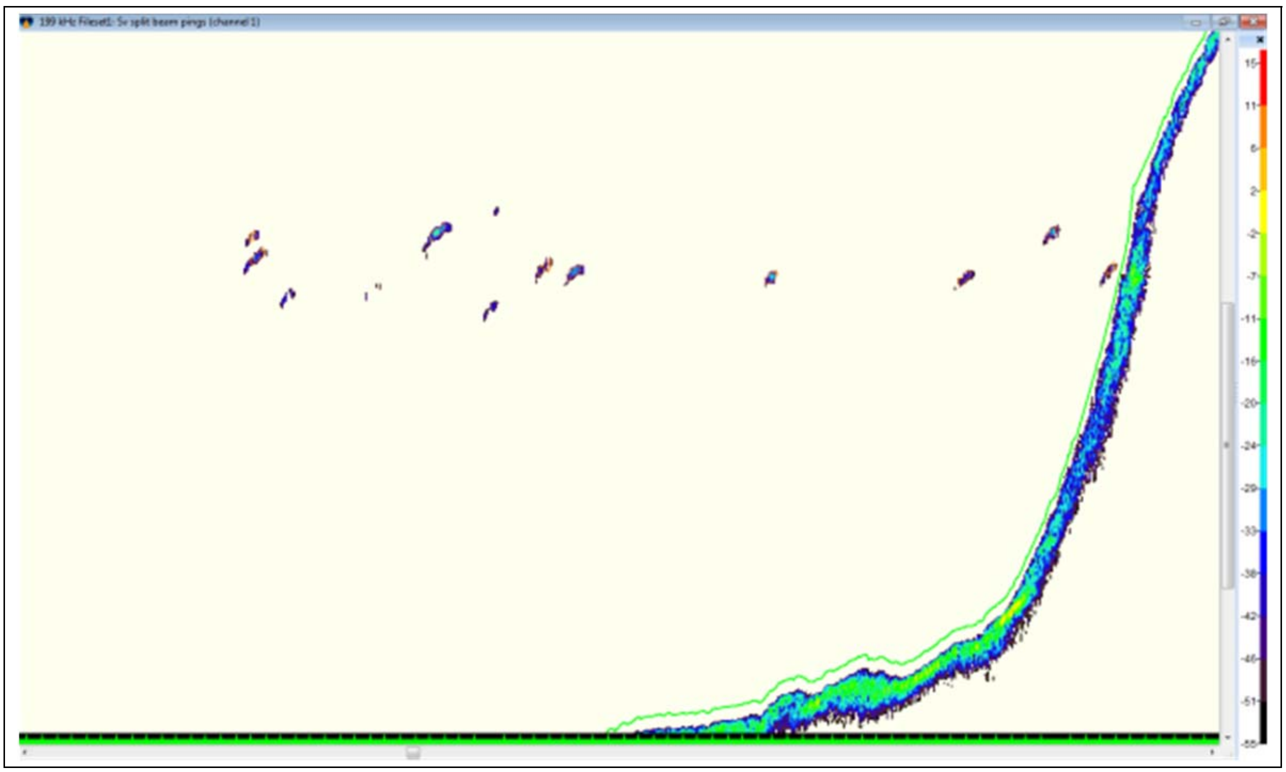
For horizontal beaming, the -48.06 dB threshold for TS eliminated fish less than 9 cm in length according to the TS equation below, developed for a 420 kHz transducer (Kubecka 1994). Kubecka's (1994) equation (Equation 3.1-7) is based on Brown Trout (*Salmo trutta*):

Equation 3.1-7 Kubecka's Target Strength Equation for Fish Length

$$L = 10^{((TS+102)\div 27.6)}$$

where L refers to fish length (cm). As done for the vertical beaming data, the proposed TS threshold was reduced by 10% to -52.87 dB as a conservative approach to capture all yearling fish per focal species in the analysis.

Figure 3.1-2 A Screenshot Example of the Echogram of Fish Targets Above Bottom Exclusion Line (Green) Recorded in the Vertical Beam at Ac 1.8, August 18, 2013



3.1.5.4 Fish Length Estimations

The TS values can assist with understanding the characteristics of the fish detected during hydroacoustic surveys (e.g., fish length via Love's equation). Therefore, the distributions of maximum TS values for fish tracks were used to predict fish length distributions in Lac du Sauvage. When predicting fish length using TS, Love's (1971) equation is valid only in the range of 0.7 less than or equal to L/λ less than or equal to 90, where λ is wavelength. Thus, estimating fish length can be unreliable for targets approaching and exceeding -30 dB, which would represent a fish longer than approximately 860 mm. Furthermore, TS formulas applied in this study may not accurately address the fish species in Lac du Sauvage, because the formulas were developed using different species and under different environmental conditions (Love 1971; Kubecka 1994).

3.1.5.5 Population Estimation

Echoview derived the number of fish per unit volume (cubic metre [m^3] or 100,000 m^3), including TS (i.e., fish length) distributions per transect and transducer beam. Horizontal beaming densities were calculated for the volume of water from the surface to 5 m depth (i.e., 5 m represented the approximate maximum depth sampled given the maximum horizontal range or extent of the beam, which was typically set at approximately 45 m). Vertical beaming densities were calculated for volumes at depths greater than 5 m.

Two analytical methods were applied: echo integration and fish tracking. Echo integration is a common method for estimating fish density in the hydroacoustic literature and is preferred over fish tracking or echo counting when schooling is the predominate behavior that characterizes study species (e.g., Cisco) (e.g., Yule et al. 2007; Parker-Stetter et al. 2009). In brief, integration is an analysis of Sv data (volume backscattering strength data logged from an echosounder). A key assumption with the echo integration method is the anticipated mean TS (or fish length) of fish in the survey area. For Lac du Sauvage, this was determined to be 171 mm, based on the results of the fish-out salvage completed in nearby Lac de Gras in 2002 (McEachern et al. 2003). This assumption does not apply to fish tracking where individual fish and their TS values are summarized in the export file. Fish track detection was based on algorithms applied to single target (or echo) data (Table 3.1-4; Figure 3.1-2), and is the preferred approach (over integration methods) when lakes have low densities of fish (Yule 2000; Gangl and Whaley 2004; Parker-Stetter et al. 2009).

Using fish density values per transect, non-parametric summaries of fish densities were calculated in Stata 12.1. Sample medians were presented to describe the central tendency of each survey and depth stratum given the highly skewed nature of count data. The density estimates combined with known volumes per depth stratum were then used together to derive fish abundance estimates in Lac du Sauvage. Estimates were provided per 'east' and 'west' section of Lac du Sauvage given the potential differences in lake habitat. For example, depths are shallower in the 'east' section where total shoreline length is longer with more shoreline-extending shoal habitats.

3.2 Results

3.2.1 Surface Water Quality

In situ surface water quality results for lakes are presented in Table 3.2-1. Vertical profile data for Lac du Sauvage, Duchess Lake, Lake E1, and Paul Lake are presented in the following sections. Profile data for all other lakes are presented in Appendix D, Limnology Profiles.

Surface water temperatures ranged from 6.6°C in Lake Ab2 (September 14, 2013) to 20.1°C in Duchess Lake (August 14, 2013) (Table 3.2-1). Surface dissolved oxygen concentrations in all lakes were within the guidelines for the protection of freshwater aquatic life for coldwater species (DO greater than 6.5 mg/L) (CCME 2013). The pH levels in Lac du Sauvage and Lake Ab2 were below the Canadian Council of Ministers of the Environment (CCME) guideline for the protection of aquatic life (CCME 2013) (pH range = 6.5 to 9.0).

Table 3.2-1 Surface Water Quality of Lakes in the Baseline Study Area, 2013

Lake	Date	UTM (Zone 12W)		Temp. (°C)	Dissolved Oxygen (mg/L)	pH	Conductivity (µS/cm)	Specific Conductivity (µS/cm)
		Easting	Northing					
Lac du Sauvage	17-August	541931	7167072	16.8	9.68	6.22	14.6	n/a
Paul Lake	10-August	531980	7174538	18.3	7.45	7.43	16.4	n/a
Duchess Lake	14-August	541840	7174142	20.1	8.03	7.11	12.5	n/a
Lake Af1	20-August	538429	7174936	15.4	8.79	6.96	12.0	n/a
Lake Ad8	5-September	535676	7173446	9.2	10.51	7.03	10.5	14.9
Lake Ab2	14-September	544406	7160913	6.6	11.44	6.25	127.5	195.8
Lake Ac17	7-September	545343	7171287	9.5	10.56	7.57	24.4	34.7
Lake B1 (Christine)	25-August	539516	7163829	11.3	9.68	7.24	-	55.6
Lake B4 (Cujo)	03-September	538438	7162450	8.6	11.03	7.49	-	214.2
Lake B15	11-September	537136	7163899	7.0	10.47	6.93	12.3	18.8
Lake C1	26-August	537626	7165896	11.1	9.53	7.25	-	17.9
Lake C3	13-September	536758	7165651	8.4	10.69	7.25	22.0	32.2
Lake D2	2-September	536305	7170060	9.4	9.92	7.23	15.5	-
Lake D3 (Counts)	30-August	533955	7169862	10.3	10.1	6.88	17.5	-
Lake D4	31-August	534268	7167963	11.2	9.56	7.08	15.4	-
Lake E1	13-August	535528	7174620	17.0	9.01	6.98	11.8	-
Hammer Lake	25-August	536459	7159365	10.5	9.13	8.53	22.2	-
Lynx Lake	27-August	537304	7158166	10.3	12.07	7.16	22.4	-

Note: Specific Conductivity = conductivity corrected to ambient temperature by the field meter.

UTM = Universal Transverse Mercator; Temp = temperature; °C = degrees Celsius; mg/L = milligrams per litre; µS/cm = microSiemens per centimetre; - = parameter not measured; n/a = not available.

In situ surface water quality results for streams are presented in Table 3.2-2. Surface water temperatures ranged from 5.0°C in Stream C1 (September 15) to 16.7°C in Stream C3 (September 12). Dissolved oxygen concentrations in all streams were within the CCME (2013) guidelines for the protection of freshwater aquatic life. Stream Ab2 had the highest conductivity and the lowest pH compared to other streams (Table 3.2-2). The pH in Stream Ab2 was below the CCME (2013) guideline.

Table 3.2-2 Surface Water Quality and Channel Characteristics of Streams in the Baseline Study Area, 2013

Stream	Date	UTM (Zone 12W)		Temp. (°C)	Dissolved Oxygen (mg/L)	pH	Conductivity (µS/cm)	Mean Wetted Width (m)	Max. Depth (m)	Discharge (m^3/s)
		Easting	Northing							
Stream Ab2	14-Sep	544406	7160913	6.6	11.4	6.3	127.5	4.0	0.5	-
Stream B1 (Christine Creek)	24-Aug	540102	7163841	8.4	8.4	7.2	54.5	18.1	2.0	0.009
Stream B15	12-Sep	538342	7164082	9.2	10.8	7.0	25.8	1.4	0.7	0.005
Stream C1	15-Sep	540237	7166944	5.0	10.8	6.6	41.7	1.9	1.8	0.011
Stream C3	12-Sep	537353	7165538	10.1	9.7	7.0	24.0	4.0	0.4	-
Stream D1	15-Sep	536959	7170657	8.5	11.0	6.8	27.3	4.5	1.0	-
Stream E2	16-Sep	535227	7176612	7.5	10.4	6.7	17.6	19.2	2.2	0.629
Lac du Sauvage Creek	11-Aug	546850	7159585	16.7	10.5	-	-	74	-	11.908

Aug = August; Sep = September; UTM = Universal Transverse Mercator; Temp = Temperature; mg/L = milligrams per litre; µS/cm = microSiemens per centimetre; m = metre; Max = maximum; m^3/s = cubic metres per second; - = parameter not measured; °C = degrees Celsius.

3.2.2 Geographic Information System-Based Habitat Variables

The study lakes range from approximately 5 hectares (ha) in size (Lake Ac20) to 8,550 ha (Lac du Sauvage) (Table 3.2-3). Lac du Sauvage is approximately eight times larger than the next biggest lake sampled in the BSA (i.e., Duchess Lake = 1,016 ha). Fourteen study lakes were less than 100 ha in size. Sampled streams also varied from only 80 m in length (Stream Af1) to 6,777 m in length (Stream E2). Stream gradients were low to moderate with the steepest mean gradient (2.4%) recorded at Lynx Creek; however, eleven streams were less than 1% in slope (Table 3.2-3). Streams with very low gradient (0.1% or lower) included Lac du Sauvage, Duchess, C3, and E2 lake outlets.

Table 3.2-3 Spatial Characteristics of a Subset of Lakes and Streams in the Baseline Study Area

Lake	Mean Elevation (masl)	Lake Area (ha)	Cumulative Watershed Area (ha)	Stream Outlet	Length (m)	Slope (%)
Lac du Sauvage	416.1	8.550	146,381	Lac du Sauvage Creek	210	0.1
Paul Lake	417.0	964	12,506	Paul Creek	186	0.6
Duchess Lake	416.2	1,016	34,633	Duchess Creek	1,371	<0.1

Table 3.2-3 Spatial Characteristics of a Subset of Lakes and Streams in the Baseline Study Area

Lake	Mean Elevation (masl)	Lake Area (ha)	Cumulative Watershed Area (ha)	Stream Outlet	Length (m)	Slope (%)
Lake Af1	417.0	512	22,320	Stream Af1	80	1.0
Lake Ad8	418.3	17	104	Stream Ad8	225	1.0
Lake Ab2	424.0	11	247	Stream Ab2	448	1.6
Lake Ac17	417.1	77	404	Stream Ac17	118	0.9
Lake Ac20[(a)]	419.4	5	182	Stream Ac20	199	1.6
Lake B1 (Christine)	427.9	49	1,340	Stream B1 (Christine)	1,317	0.7
Lake B4 (Cujo)	437.6	46	326	Stream B4 (Cujo)[(a)]	165	1.6
Lake B15	435.2	63	568	Stream B15	470	1.5
Lake C1	435.4	163	1,173	Stream C1	2,061	0.9
Lake C3	436.3	85	395	Stream C3	132	<0.1
Lake D1[(a)]	417.0	6	725	Stream D1	126	0.8
Lake D2	427.4	6	674	Stream D2[(a)]	448	2.3
Lake D3 (Counts)	440.7	115	499	Stream D3[(a)]	1,232	1.1
Lake D4	444.6	30	158	Stream D4[(a)]	466	0.9
Lake E1	417.9	169	20,650	Stream E1[(a)]	140	0.2
Lake E2[(a)]	421.9	12	15,972	Stream E2	6,777	<0.1
Lynx Lake	431.5	11	33	Lynx Creek	646	2.4
Hammer Lake	432.5	22	155	Hammer Creek	872	1.9

Note: Lake and stream characteristics were derived in GIS using 2012 CanVec data (from the Natural Resources Canada Earth and Sciences Sector Centre for topographic information). In Map Figures for Streams B1, D2-D1, and E2, stream lengths included the length across adjoining lakes or connection features and thus are reported as a higher length value.

a) Not sampled for fish and fish habitat.

masl = metres above sea level; ha = hectare; m = metre; % = percent; < = less than.

3.2.3 Lac du Sauvage Watershed

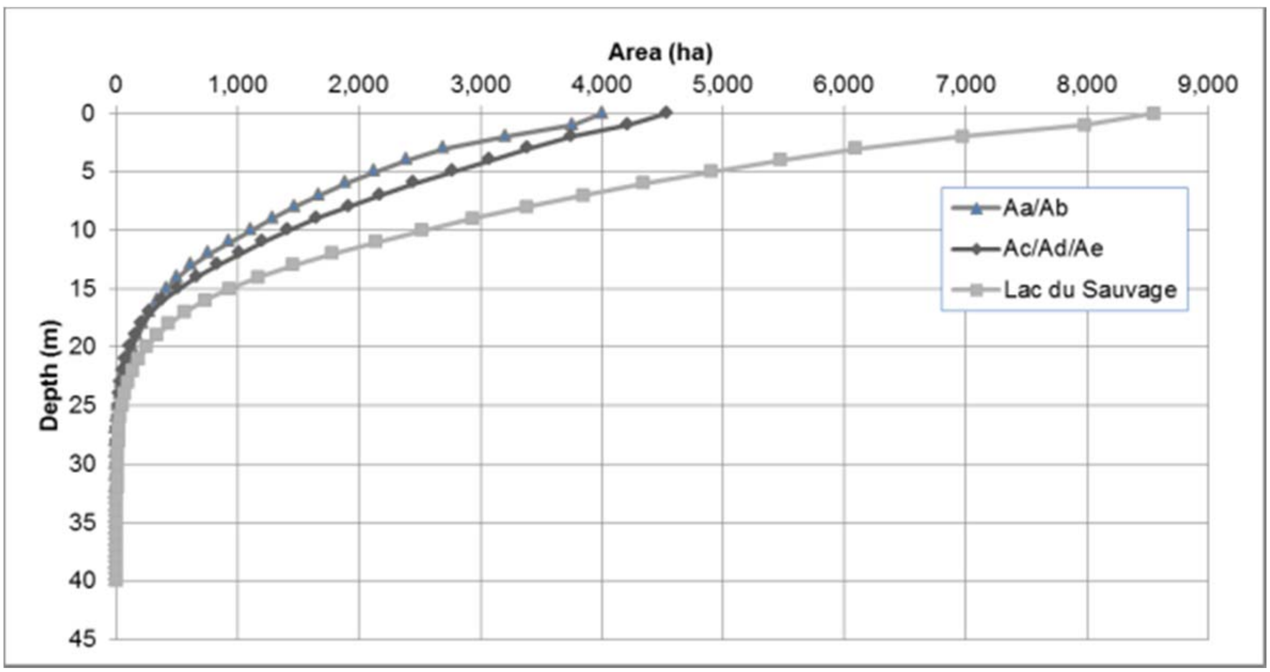
3.2.3.1 Lac du Sauvage

The Lac du Sauvage catchment spans a total area of 146,381 ha (Table 3.2-3). The 2013 baseline program focused on internal basins Ac, Ad, and Ae of Lac du Sauvage, as well as their major tributaries and sub-catchments. A major sub-catchment in the western part of Lac du Sauvage is the E sub-basin, which measures 34,633 ha in area and flows into Duchess Lake. The Lac du Sauvage Creek is a relatively wide (minimum bankfull width of approximately 45 m) and short (210 m in length) outlet stream that drains to Lac de Gras, which is locally known as the “Narrows”. It has a low gradient (less than 0.1%). The stream discharge on September 9, 2013, was 11.9 cubic metres per second (m^3/s).

3.2.3.1.1 Bathymetry

Based on previously collected bathymetry data, Lac du Sauvage (all internal basins, Aa, Ab, Ac, Ad, and Ae) has a surface area of 8,550 ha and a total volume of 630,320,529 m^3 (Table 3.2-4). Lac du Sauvage has a mean depth of 6.8 m and a maximum depth of 40.4 m. Over 81% (6,972 ha) of the surface area of Lac du Sauvage is deeper than 2 m (Table 3.2-4); therefore, only 19% (1,578 ha) of Lac du Sauvage may freeze to the bottom during winter (Figure 3.2-1). The western portion of Lac du Sauvage (i.e., internal basins Ac, Ad, and Ae), representing Lac du Sauvage 'west' (Map 3.1-3), has a total surface area of 4,543 ha and a total volume of 347,538,000 m^3 (Table 3.2-4). The maximum depth recorded in this section was approximately 40 m. The eastern section of Lac du Sauvage (i.e., internal basins Aa and Ab, representing Lac du Sauvage 'east'; Map 3.1-3) has a total area of 4,007 ha and a total volume of 282,782,582 m^3. The maximum depth recorded in this section was approximately 33 m. For comparison, Lac de Gras is almost 7 times larger in area than Lac du Sauvage with a total surface area of 57,223 ha and a total volume of 6,155,786,146 m^3, with a maximum and mean depth of approximately 50 m and 10.8 m, respectively.

Figure 3.2-1 Depth-Area Relationship for Lac du Sauvage, Internal Basins Ac, Ad, and Ae Combined, and Internal Basins Aa and Ab Combined



m = metre; ha = hectare.

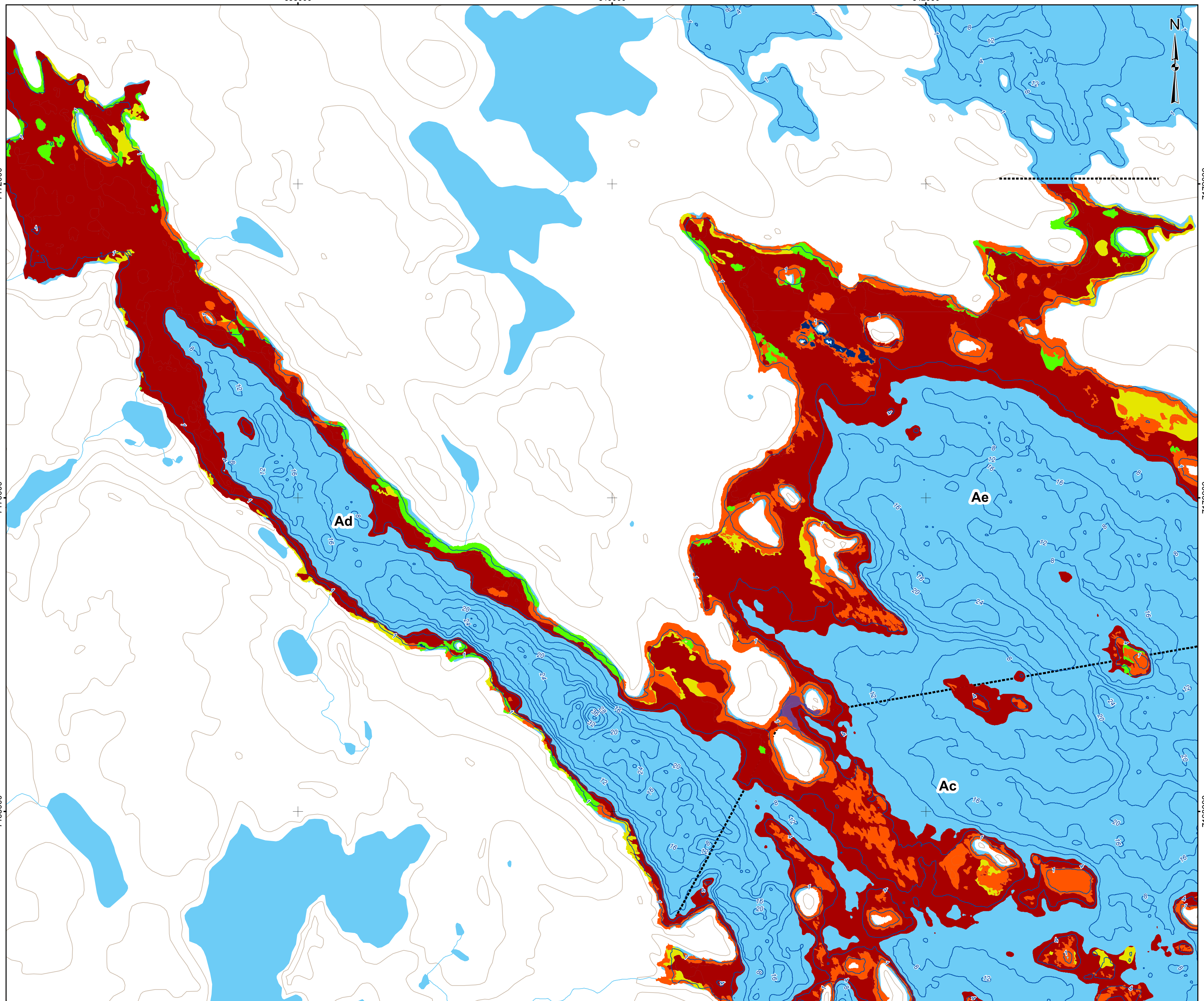
Table 3.2-4 Vertical Distribution of Lake Area and Volume in Lac du Sauvage

Depth (m)	Lac du Sauvage			
	Area		Volume	
	(ha)	(%)	($m^3 \times 10^3$)	(%)
>0	8,550	100.0	630,321	100
>1	7,988	93.4	547,921	86.9
>2	6,972	81.6	473,046	75.0
>3	6,093	71.3	408,176	64.8
>4	5,475	64.0	350,461	55.6
>5	4,904	57.4	298,610	47.4
>6	4,346	50.8	252,433	40.0
>7	3,855	45.1	211,487	33.6
>8	3,389	39.6	175,274	27.8
>9	2,942	34.4	143,673	22.8
>10	2,524	29.5	116,377	18.5
>11	2,141	25.0	93,120	14.8
>12	1,782	20.8	73,547	11.7
>13	1,456	17.0	57,428	9.1
>14	1,172	13.7	44,340	7.0
>15	933	10.9	33,871	5.4
>16	730	8.5	25,586	4.1
>17	560	6.6	19,189	3.0
>18	432	5.0	14,275	2.3
>19	332	3.9	10,477	1.7
>20	249	2.9	7,593	1.2
>21	183	2.1	5,455	0.9
>22	131	1.5	3,908	0.6
>23	94	1.1	2,800	0.4
>24	68	0.8	2,000	0.3
>25	46	0.5	1,437	0.2
>26	31	0.4	1,063	0.2
>27	22	0.3	809	0.1
>28	17	0.2	621	0.1
>29	13	0.2	474	0.1
>30	37	0.4	973	0.2
>35	4.7	<0.1	54	<0.1
>40	<0.1	<0.1	0.1	<0.1

Source: Based on 2013 bathymetry surveys by Aurora Geosciences Ltd. (2013).
m = metre; ha = hectare; % = percent; m^3 = cubic metres; > = great than; < = less than; x = times.

3.2.3.1.2 Shoreline Area Substrates

Approximately 95% of digitized habitat types in Lac du Sauvage 'west' (internal basins Ac, Ad, and Ae),were visible in depths less than 5 m, but substrate types in certain locations were visible at depths of up to 7 m (Map 3.2-1A, B, C). Most of the visible habitat was fines (1,261.2 ha or 69.7% of the 1808.8 ha), followed by boulder/cobble (417.0 ha or 23.1%) with fines/boulder (55.6 ha or 3.0%) and boulder/fines (55.0 ha or 3.0%) representing smaller portions of shoreline habitat (Map 3.2-1A,B,C). Other substrate types visually identified and quantified were: boulder (less than 0.1%), bedrock (0.1%), cobble/boulder (0.4%), cobble/fines (0.2%), and fines/cobble (0.4%) (Photos 3.2-1 to 3.2-6; additional photographs in Appendix B). Substrates identified as cobble in the field often included small areas of gravel that could be used as potential spawning locations for Whitefish species, Lake Trout, and Cisco.

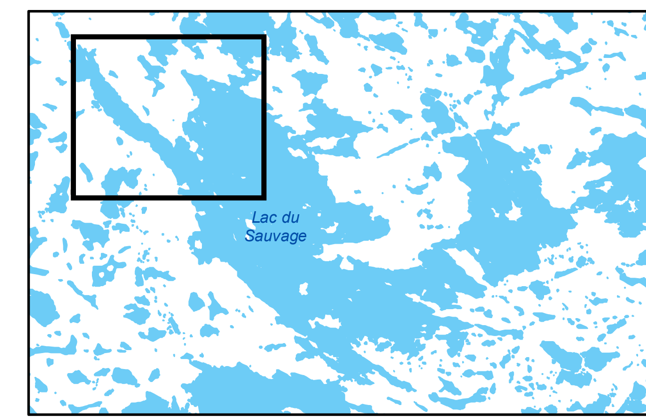


LEGEND

- BATHYMETRIC CONTOUR (4 m INTERVAL)
- ELEVATION CONTOUR (10 m INTERVAL)
- WATERCOURSE
- WATERBODY
- BASIN DIVIDE

SUBSTRATE TYPE

- Bo - BOULDER
- Bo/Co - BOULDER/COBBLE
- Bo/Fi - BOULDER/FINES
- Br - BEDROCK
- Fi - FINES
- Fi/Bo - FINES/BOULDER
- Fi/Co - FINES/COBBLE



REFERENCE

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BATHYMETRIC DATA OBTAINED FROM AURORA, 2013
DATUM: NAD83 PROJECTION: UTM ZONE 12N

DOCUMENT

FISH AND FISH HABITAT BASELINE REPORT

500 0 500
SCALE 1:25,000 METRES

PROJECT
DOMINION DIAMOND
JAY PROJECT
NORTHWEST TERRITORIES, CANADA

TITLE
DIGITIZED SHORELINE HABITAT MAP OF LAC DU SAUVAGE USING ORTHOPHOTOS AND GROUND-TRUTHED SURVEYS

Golder Associates

PROJECT	13-1328-0041		FILE No. B_JC_Aqua_009_GIS
DESIGN	CS	29/01/14	SCALE AS SHOWN REV 0
GIS	JG	09/09/14	
CHECK	CG	09/09/14	MAP 3.2-1A
REVIEW	SM	09/09/14	

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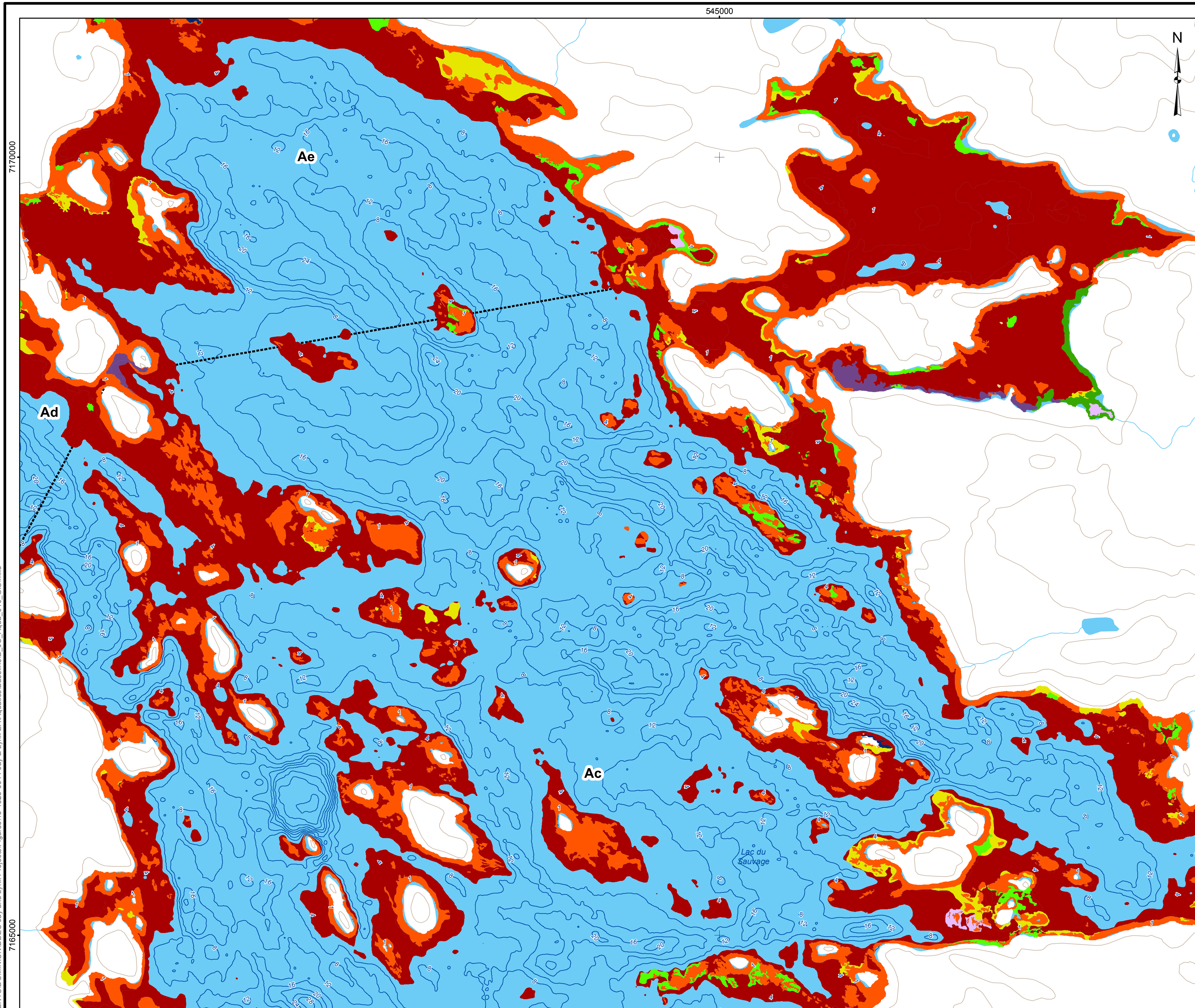
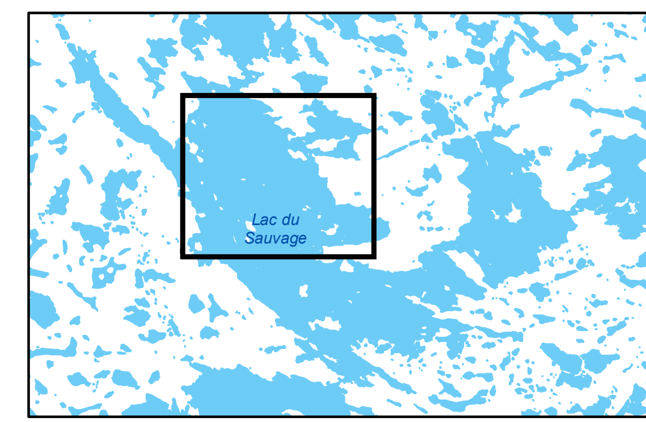


LEGEND

- BATHYMETRIC CONTOUR (4 m INTERVAL)
- ELEVATION CONTOUR (10 m INTERVAL)
- WATERCOURSE
- WATERBODY
- BASIN DIVIDE

SUBSTRATE TYPE

- Bo - BOULDER
- Bo/Co - BOULDER/COBBLE
- Bo/Fi - BOULDER/FINES
- Br - BEDROCK
- Co/Bo - COBBLE/BOULDER
- Co/Fi - COBBLE/FINES
- Fi - FINES
- Fi/Bo - FINES/BOULDER
- Fi/Co - FINES/COBBLE



REFERENCE

CANVEC © NATURAL RESOURCES CANADA, 2012
NATURAL RESOURCES CANADA, CENTRE FOR TOPOGRAPHIC INFORMATION, 2012
BATHYMETRIC DATA OBTAINED FROM AURORA, 2013
DATUM: NAD83 PROJECTION: UTM ZONE 12N

DOCUMENT

FISH AND FISH HABITAT BASELINE REPORT

500 0 500
SCALE 1:25,000 METRES

PROJECT

DOMINION DIAMOND

JAY PROJECT
NORTHWEST TERRITORIES, CANADA

TITLE

DIGITIZED SHORELINE HABITAT MAP OF LAC DU SAUVAGE USING ORTHOPHOTOS AND GROUND-TRUTHED SURVEYS

Golder Associates

PROJECT		13-1328-0041	FILE No. B_JC_Aqua_010_GIS	
DESIGN	CS	29/01/14	SCALE AS SHOWN	REV 0
GIS	JG	09/09/14	MAP 3.2-1B	
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REVIEW	SM	09/09/14		

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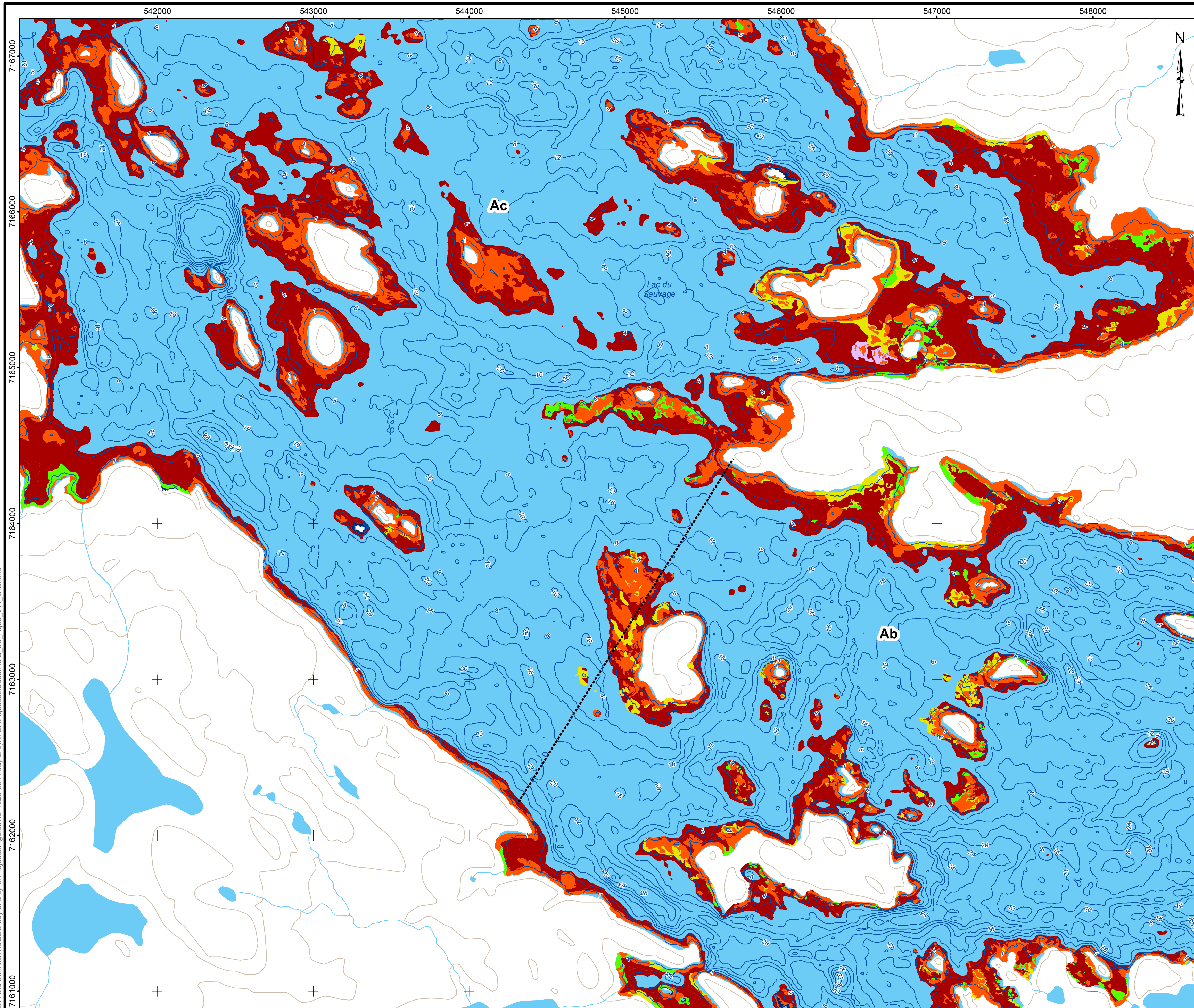

LEGEND

- BATHYMETRIC CONTOUR (4 m INTERVAL)
- ELEVATION CONTOUR (10 m INTERVAL)
- WATERCOURSE
- WATERBODY
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SUBSTRATE TYPE

- Bo - BOULDER
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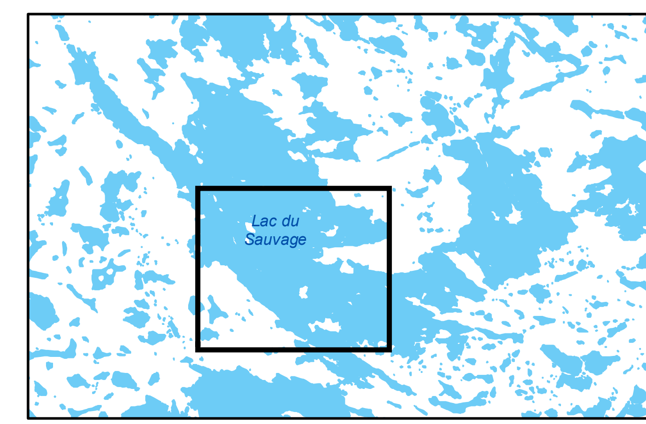
- Co/Fi - COBBLE/FINES
- Fi - FINES
- Fi/Bo - FINES/BOULDER
- Fi/Co - FINES/COBBLE



REFERENCE

CANVEC © NATURAL RESOURCES CANADA, 2012
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BATHYMETRIC DATA OBTAINED FROM AURORA, 2013
DATUM: NAD83 PROJECTION: UTM ZONE 12N

DOCUMENT

FISH AND FISH HABITAT BASELINE REPORT

500 0 500
SCALE 1:25,000 METRES

PROJECT
DOMINION DIAMOND
JAY PROJECT
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TITLE
DIGITIZED SHORELINE HABITAT MAP OF LAC DU SAUVAGE USING ORTHOPHOTOS AND GROUND-TRUTHED SURVEYS

Golder Associates

PROJECT	13-1328-0041		FILE No. B_JC_Aqua_011_GIS	
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GIS	JG	09/09/14	MAP 3.2-1C	
CHECK	CG	09/09/14		
REVIEW	SM	09/09/14		

G:\CLIENTS\DOMINION\DDEC Jay and Lynx Projects\Figures\13-1328-0041 Jay & Lynx EA\Aquatics\Baseline\B_JC_Aqua_011_GIS.mxd

Photo 3.2-1 Lac du Sauvage Creek Outlet Facing Upstream at 541751E 7166788N, August 12, 2013

Photo 3.2-2 Lac du Sauvage Shoreline at 540344E 7167058N, August 27, 2013

Photo 3.2-3 Lac du Sauvage Shoreline Facing South at 541043E 7165891N, August 23, 2013

Photo 3.2-4 Lac du Sauvage Aerial Shoreline at 541208E 7167397N, August 6, 2013

Photo 3.2-5 Lac du Sauvage Shoreline at 541072E 7166494N, August 6, 2013

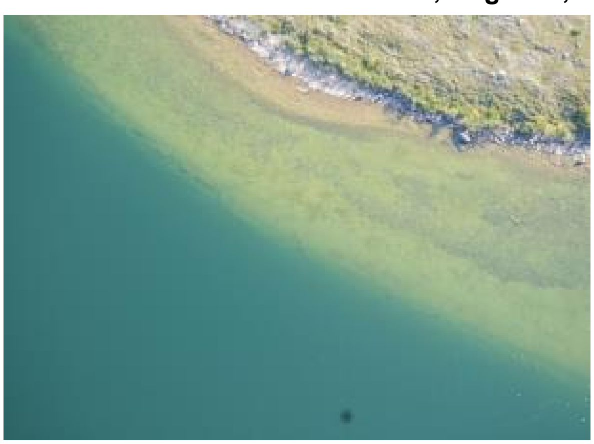


Photo 3.2-6 Lac du Sauvage Shoreline at 541751E 7166788N, August 6, 2013

3.2.3.1.3 Lake Substrate Analysis

Six distinct substrate types were defined in the cluster analysis of hydroacoustic data from Ac internal basin of Lac du Sauvage: soft fines (organics, mud), exposed coarse (Bo/Co/Gr), dense fines (silt, clay), exposed coarse (Bo/Co), mixed (Bo/Fi), and hard/loose fines (sand) (See Appendix C). These substrate types were grouped into three categories of fines, mixed, and coarse for numerical summaries. The mixed category was considered a mix of fines and coarse substrates. The coarse category included all coarse substrates (i.e., gravel, cobble, and boulder). All coarse substrates had similar bottom echoes. The fines category consisted of sand, silt, and organics.

In total, the proportion of sediment in the Ac basin transects was primarily fines (75.0%) with mixed and coarse substrates comprising 10.4% and 13.8%, respectively (Table 3.2-5). At shallower depths, ranging from 0 to 2 m, coarse substrates (52.3%) were dominant; however, at depths greater than 2 m, fines were dominant (Table 3.2-5). Depths greater than 10 m were assigned 100% fines due to deposition.

Table 3.2-5 Substrate Type Distribution by Depth Strata in the Ac Basin of Lac du Sauvage, 2013

Substrate Type	Depth				Percentage Total (%)
	0 to 2 m (%)	2 to 6 m (%)	6 to 10 m (%)	>10 m (%)	
Fines	45.1	56.7	70.0	100.0	75.0
Mixed	2.6	9.2	25.1	0.0	10.4
Coarse	52.3	34.1	4.9	0.0	13.8
Total	**100**	**100**	**100**	**100**	**100**

m = metre; % = percent; > = greater than.

3.2.3.1.4 Vertical Profiles

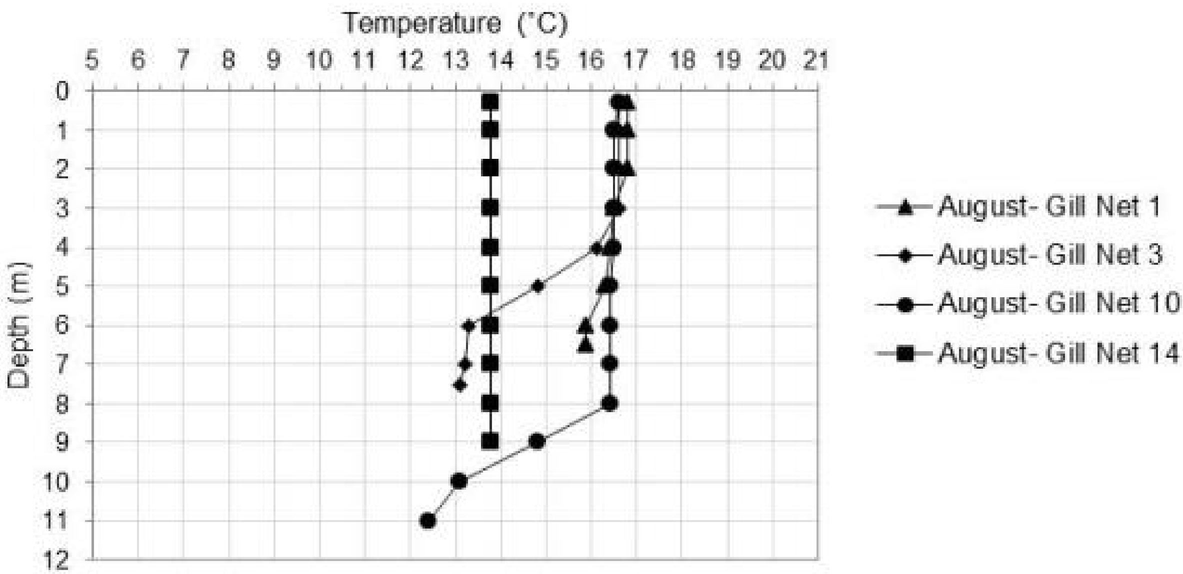
Vertical profiles were taken at four gill net set locations (sets 1, 3, 10, and 14) in Lac du Sauvage between August 17 and 23, 2013. Water depths at the measurement locations ranged from 6.5 to 11 m. Temperature profiles indicated limited thermal stratification in Lac du Sauvage at gill net sets 3 and 10; sets 1 and 14 were in areas with uniform temperatures throughout the water column. The thermocline was observed between 4 and 6 m at set 3 and below 8 m at set 10 (Figure 3.2-2).

Temperatures in the top 5 m of water ranged from 13.8°C to 16.8°C. The highest temperature was recorded at 0.3 m, 1.0 m, and 2.0 m depths at gill net set 1. Temperatures were slightly lower from 6 m to the lake bottom and ranged from 12.4°C to 16.4°C (Figure 3.2-2). The lowest temperature was recorded at the 11 m depth at gill net set 10. At gill net set 14, the temperature remained constant at 13.8°C from surface to bottom (9 m depth).

The DO concentrations were stable throughout the water column in Lac du Sauvage from surface to bottom (9-m depth) at most of the locations (range = 8.5 to 10.4 mg/L). However, DO concentrations at gill net set 10 were variable throughout the column and increased to 10.3 mg/L near the bottom (9.18 to 10.3 mg/L) (Figure 3.2-3). Values of pH followed a similar trend to DO and average levels were similar throughout the water column (average range = 6.2 to 7.0) (Figure 3.2-4).

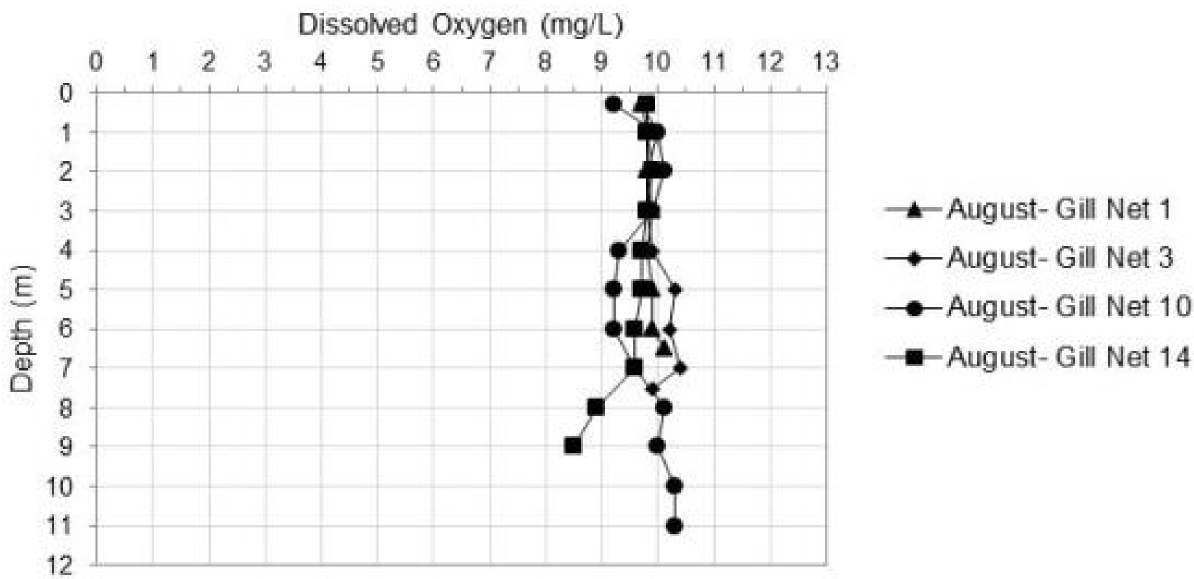
Overall, DO concentrations (CCME guideline greater than 6.5 mg/L), and pH levels (CCME 2013 guideline = 6.5 to 9.0) were typically within the range to support fish populations throughout the entire water column, with the exception of certain deep-water locations.

Figure 3.2-2 Depth-Temperature Profile of Gill Net Sets in Lac du Sauvage, August 2013



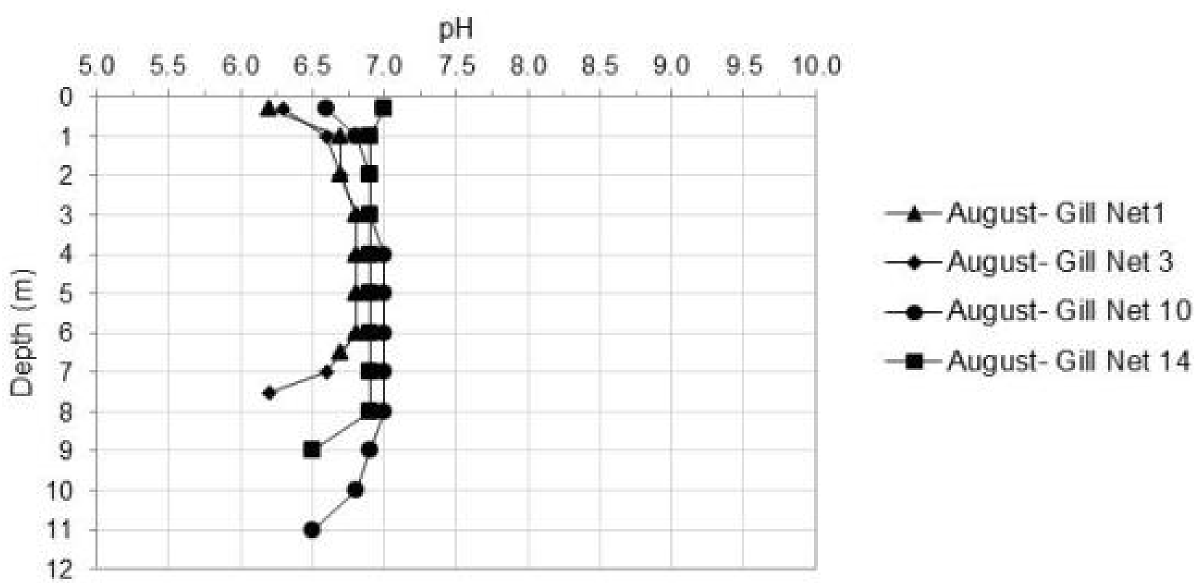
°C = degrees Celsius; m = metre.

Figure 3.2-3 Depth-Dissolved Oxygen Profile of Gill Net Sets in Lac du Sauvage, August 2013



mg/L = milligrams per litre; m = metre.

Figure 3.2-4 Depth-pH Profile of Gill Net Sets of Lac du Sauvage, August 2013



m = metre.

3.2.3.2 Duchess Lake Sub-Basin

The Duchess Lake sub-catchment encompasses 24% of the Lac du Sauvage drainage area, and includes Duchess Lake, Lake Af1, and Lake E1 where baseline sampling was completed in 2013. Duchess Lake is a medium-sized lake that drains into internal basin Ae of Lac du Sauvage 'west' (Table 3.2-3; Appendix B photographs). The outlet stream, Duchess Creek, is a wide stream (minimum width approximately 125 m) characterized by a reach length of 1,371 m and a gradient of less than 0.1%. Duchess Creek was too deep to wade in August 2013.

Upstream of Duchess Lake is Lake Af1. Lake Af1 is approximately half the size of Duchess Lake and is located to the northwest of Duchess Lake (photographs in Appendix B). The outlet stream, Stream Af1, connects Lake Af1 to Duchess Lake. Stream Af1 is a short stream (80 m) with a gradient of approximately 1% (Table 3.2-3).

Upstream of Lake Af1 is Stream E1, which is a major tributary to Duchess Lake (photographs in Appendix B). Stream E1 is 140 m in length, and has a very low gradient of 0.2% (Table 3.2-3). It provides shallow, flat water (i.e., lake-like) conditions throughout most of the stream (photographs in Appendix B). Stream E1 discharge was measured at 1.0 m^3/s on August 12, 2013.

Upstream of Stream E1 is Lake E1, which is 197 ha in size, and was the only lake in sub-basin E evaluated as part of the 2013 program. The 2013 program also evaluated Stream E2, which is a wide, low-gradient stream flowing south from a small lake (Lake E2 = 12 ha) and is a major tributary for Lake E1 (photographs in Appendix B).

3.2.3.2.1 Duchess Lake

Bathymetry

Based on bathymetry surveys performed by Aurora Geosciences Ltd., Duchess Lake has a surface area of 1,016 ha and a total volume of 40,342,750 m^3 (Aurora Geosciences Ltd. 2013). Duchess Lake has a mean depth of 3.8 m and a maximum depth of 16.3 m. Over 71% (731 ha) of the surface area of Duchess Lake is deeper than 2 m (Table 3.2-6, Figure 3.2-5); therefore, less than 30% (285 ha) of Duchess Lake may freeze to the bottom during winter.

Table 3.2-6 Vertical Distribution of Lake Area and Volume in Duchess Lake

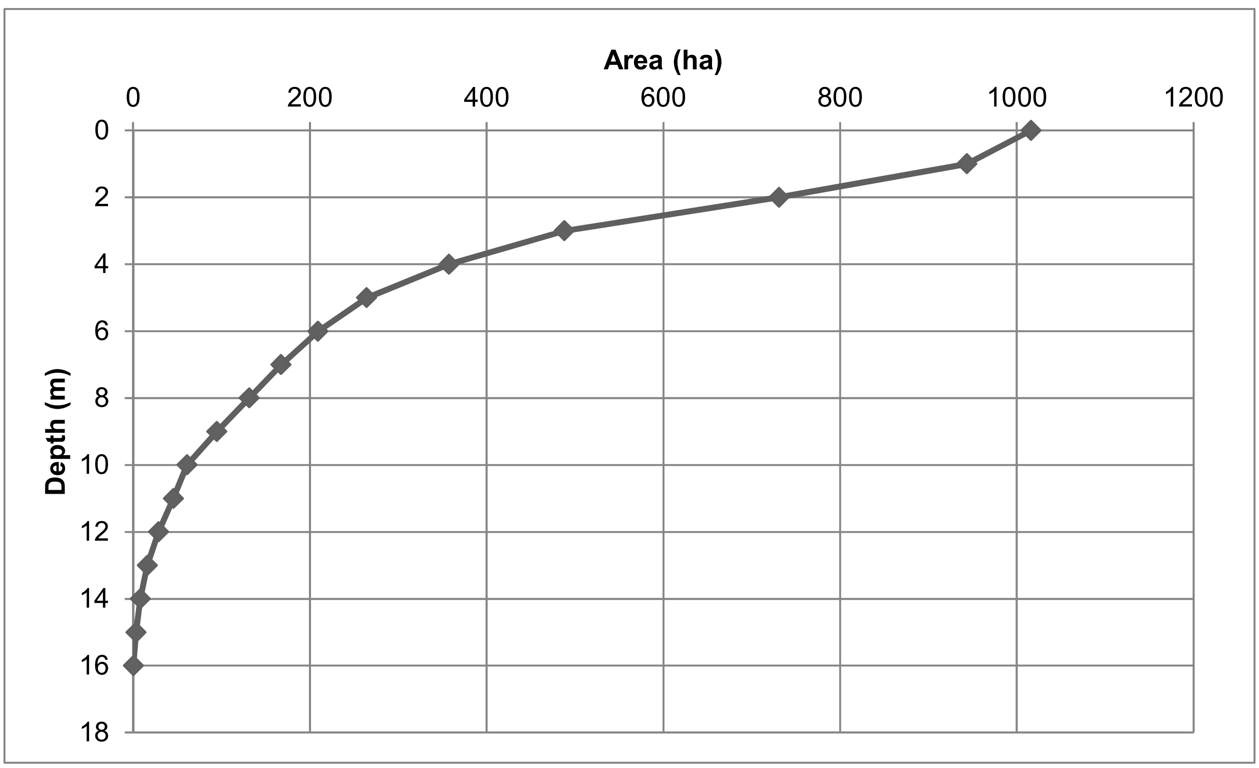
	Duchess Lake			
	Area		Volume	
Depth (m)	(ha)	(%)	(m^3 x 10^3)	(%)
>0	1,016	100	40,343	100
>1	943	92.8	30,524	75.7
>2	731	71.9	22,124	54.8
>3	488	48.0	16,123	40.0
>4	358	35.2	11,954	29.6
>5	264	26.0	8,894	22.0
>6	209	20.6	6,538	16.2

Table 3.2-6 Vertical Distribution of Lake Area and Volume in Duchess Lake

Depth (m)	Duchess Lake			
	Area		Volume	
	(ha)	(%)	($m^3 \times 10^3$)	(%)
>7	167	16.5	4,660	11.6
>8	131	12.9	3,170	7.9
>9	95	9.3	2,039	5.1
>10	61	6.0	1,301	3.2
>11	46	4.5	769	1.9
>12	29	2.8	400	1.0
>13	16	1.6	183	0.5
>14	8	0.8	70	0.2
>15	3	0.3	16	<0.1
>16	0.2	<0.1	0.2	<0.1

Source: Based on surveys performed by Aurora Geosciences Ltd. (2013).
m = metre; ha = hectare; % =percent; m^3 = cubic metre; > = greater than; < = less than; x = times.

Figure 3.2-5 Depth-Area Relationship in Duchess Lake



ha = hectare; m = metre.

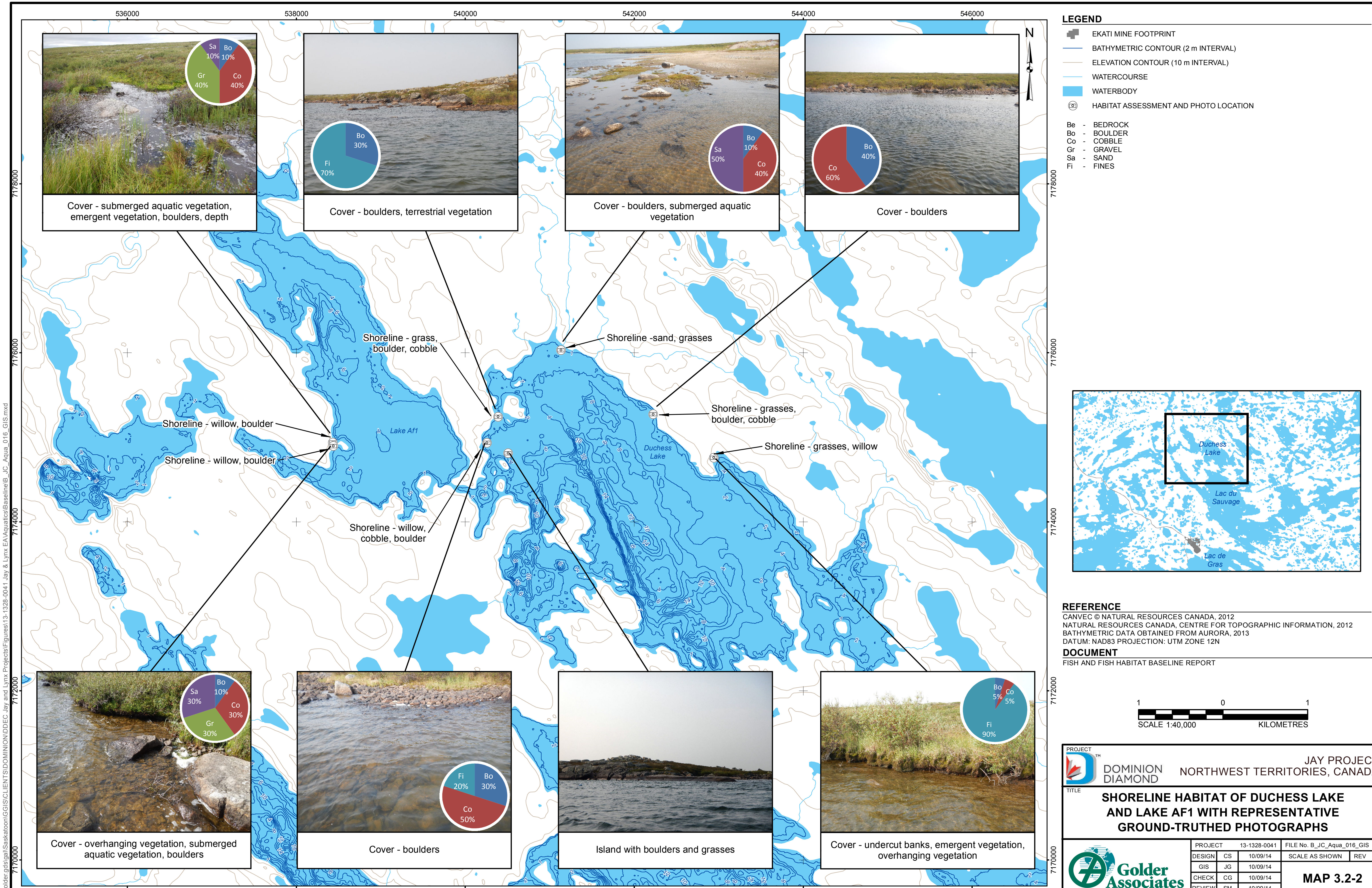
Shoreline Area Habitat

Six representative habitat locations were evaluated for Duchess Lake. The shoreline consisted mainly of shrubs, boulder, and cobble with many areas of grasses and occasional areas of bedrock (Map 3.2-2). The littoral zone typically contained cobble (5% to 60% cover) and boulder (5% to 40% cover) substrates, and certain areas dominated by fines (70% to 90%) with emergent vegetation (Table 3.2-7). Cover for fish in shoreline areas was provided mainly by coarse substrate (boulders), emergent vegetation, and overhanging riparian vegetation (shrubs). Emergent vegetation was present in sedge wetlands (*Carex aquatilis* variety [var.] *aquatilis*) that extended into shallow water. The lake was shallow in most areas, with a gradual decrease in slope and few steep drop-offs. There were locations where depths were less than 2 m as far as 50 m from the shoreline. The recorded maximum depth was 16.3 m. On the north shore, there was a large shallow bay with fine substrates and sand/gravel beach. The winter ice road crosses the lake between the southeast and northeast corners. Surface water quality parameters measured on August 14, 2013 were as follows: 20.1°C temperature, 12.5 µS/cm conductivity, 7.1 pH, and 8.0 mg/L DO (88.4% saturation).

Table 3.2-7 Representative Shoreline Habitat in Duchess Lake

Habitat Sample Number	Zone 12W		Lake Location	Dominant Riparian Features			Littoral Substrate (%)				Dominant Cover Types				
	Easting	Northing		Grass	Willow	Exposed Substrate	Boulder	Cobble	Gravel	Fines	Riparian Vegetation	Emergent Vegetation	Boulders	Undercut Banks	Depth
1	540505	7174813	Northwest shore	√	-	√	-	-	-	-	-	-	√	-	√
2	540256	7174935	Northwest shore	-	√	√	30	50	-	20	-	-	√	-	-
3	540389	7175243	Northwest shore	√	-	√	30	-	-	70	√	-	√	-	-
4	541134	7176031	North shore at winter road	√	-	√	10	40	-	50	-	√	√	-	-
5	542224	7175273	North shore	√	-	√	-	60	40	-	-	-	√	-	-
6	542942	7174756	North shore	√	√	-	5	5	-	90	√	√	-	√	-

% = percent; - = not present.


536000
538000
540000
542000
544000
546000
7178000
7176000
7174000
7172000
7170000
N
Sa 10%
Bo 10%
Gr 40%
Co 40%
Cover - submerged aquatic vegetation, emergent vegetation, boulders, depth
Bo 30%
Fi 70%
Cover - boulders, terrestrial vegetation
Sa 50%
Bo 10%
Co 40%
Cover - boulders, submerged aquatic vegetation
Bo 40%
Co 60%
Cover - boulders
Shoreline - grass, boulder, cobble
Shoreline -sand, grasses
Shoreline - willow, boulder
Shoreline - willow, boulder
Lake Af1
Shoreline - grasses, boulder, cobble
Duchess Lake
Shoreline - grasses, willow
Shoreline - willow, cobble, boulder
Sa 30%
Bo 10%
Co 30%
Gr 30%
Cover - overhanging vegetation, submerged aquatic vegetation, boulders
Fi 20%
Bo 30%
Co 50%
Cover - boulders
Island with boulders and grasses
Bo 5%
Co 5%
Fi 90%
Cover - undercut banks, emergent vegetation, overhanging vegetation
LEGEND
EKATI MINE FOOTPRINT
BATHYMETRIC CONTOUR (2 m INTERVAL)
ELEVATION CONTOUR (10 m INTERVAL)
WATERCOURSE
WATERBODY
HABITAT ASSESSMENT AND PHOTO LOCATION
Be - BEDROCK
Bo - BOULDER
Co - COBBLE
Gr - GRAVEL
Sa - SAND
Fi - FINES
Duchess Lake
Lac du Sauvage
Lac de Gras
REFERENCE
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NATURAL RESOURCES CANADA, CENTRE FOR TOPOGRAPHIC INFORMATION, 2012
BATHYMETRIC DATA OBTAINED FROM AURORA, 2013
DATUM: NAD83 PROJECTION: UTM ZONE 12N
DOCUMENT
FISH AND FISH HABITAT BASELINE REPORT
1 0 1
SCALE 1:40,000
KILOMETRES
PROJECT
DOMINION DIAMOND
JAY PROJECT
NORTHWEST TERRITORIES, CANADA
TITLE
SHORELINE HABITAT OF DUCHESS LAKE AND LAKE AF1 WITH REPRESENTATIVE GROUND-TRUTHED PHOTOGRAPHS
Golder Associates
PROJECT 13-1328-0041
FILE No. B_JC_Aqua_016_GIS
DESIGN CS 10/09/14
SCALE AS SHOWN
REV 0
GIS JG 10/09/14
CHECK CG 10/09/14
REVIEW SM 10/09/14
MAP 3.2-2
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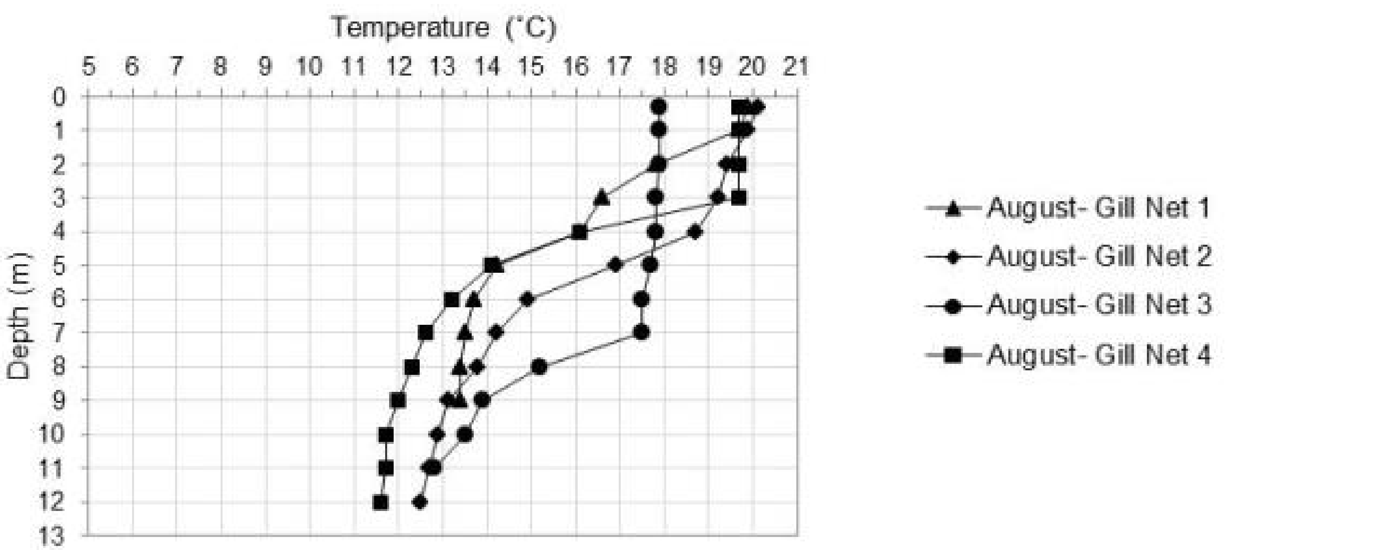
Vertical Profiles

Vertical profiles were taken at four gill net set locations (sets 1 to 4) in Duchess Lake on August 14 to 16, 2013. Water depths of the measurement locations ranged from 9 to 12 m. Temperature and DO profiles indicated thermal stratification in Duchess Lake. The thermocline was observed between 3 and 7 m, depending on location (Figure 3.2-6).

Temperatures in the top 5 m of water in Duchess Lake ranged from 14.1°C to 20.1°C. The highest temperature was recorded at 0.3 m depth at gill net set 2. Temperatures were lower from 6 m until bottom and ranged from 11.6°C to 17.5°C (Figure 3.2-6). The lowest temperature was recorded at 12 m depth at gill net set 4. Dissolved oxygen concentrations were variable, but were similar in the top 7 m of the water column (range = 7.2 to 9.9 mg/L) and decreased from 8 m to bottom (range = 4.2 to 8.7 mg/L) (Figure 3.2-7). The lowest DO concentrations were recorded at the 10 to 12 m depth at gill net set 4. These concentrations ranged from 4.2 to 4.5 mg/L, which are below the CCME (2013) guideline for the protection of aquatic life of 6.5 mg/L (Figure 3.2-7). The pH levels followed a similar trend to temperature and were higher in the top 5 m of the water column (range = 6.8 to 7.4) than from 6 m to bottom (range = 6.0 to 7.1) (Figure 3.2-8).

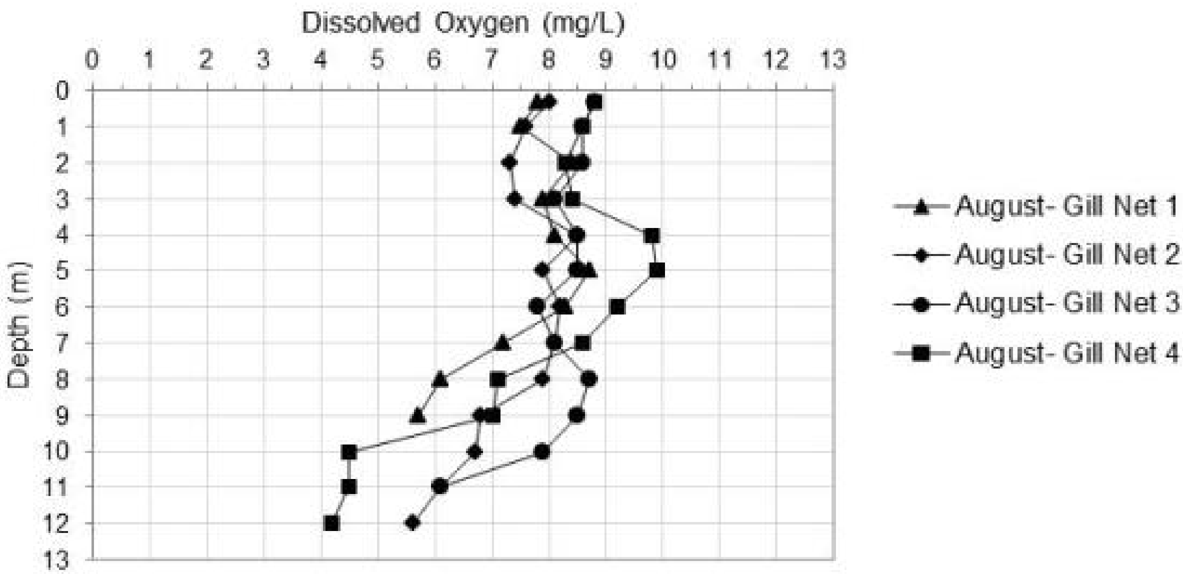
Overall, DO concentrations (CCME guideline greater than 6.5 mg/L), and pH levels (CCME guideline = 6.5 to 9.0) were typically within the range to support fish populations throughout the entire water column in Duchess Lake, with the exception of certain deep-water locations.

Figure 3.2-6 Depth-Temperature Profile for Gill Net Sets in Duchess Lake, August 2013



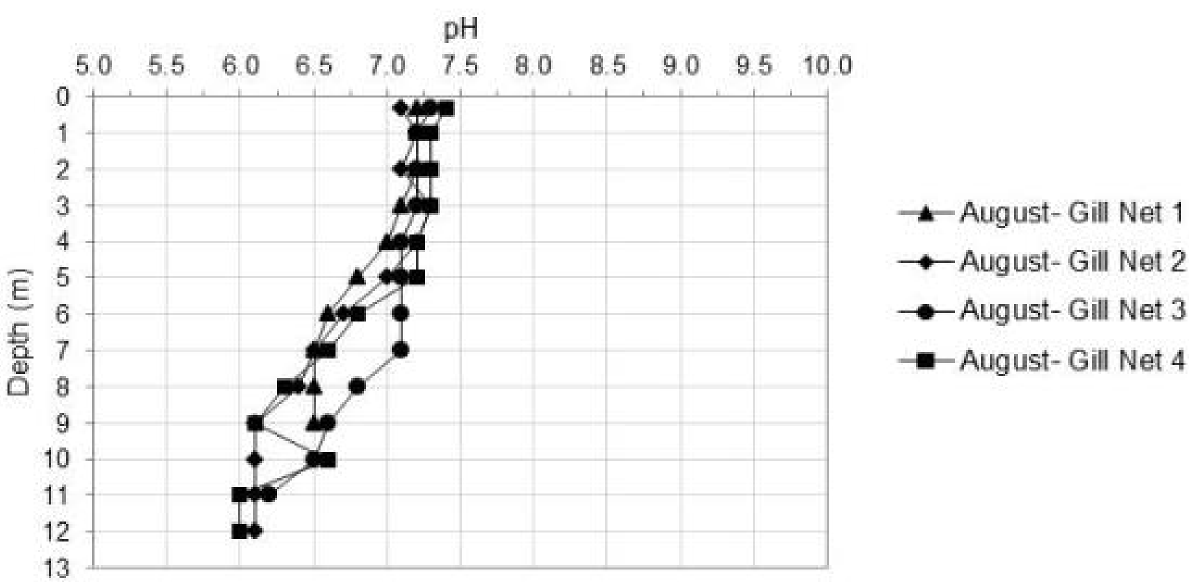
°C = degrees Celsius; m = metre.

Figure 3.2-7 Depth-Dissolved Oxygen Profile for Gill Net Sets in Duchess Lake, August 2013



mg/L = milligrams per litre; m = metre.

Figure 3.2-8 Depth-pH Profile for Gill Net Sets in Duchess Lake, August 2013



m = metre.

3.2.3.2.2 Lake Af1

Bathymetry

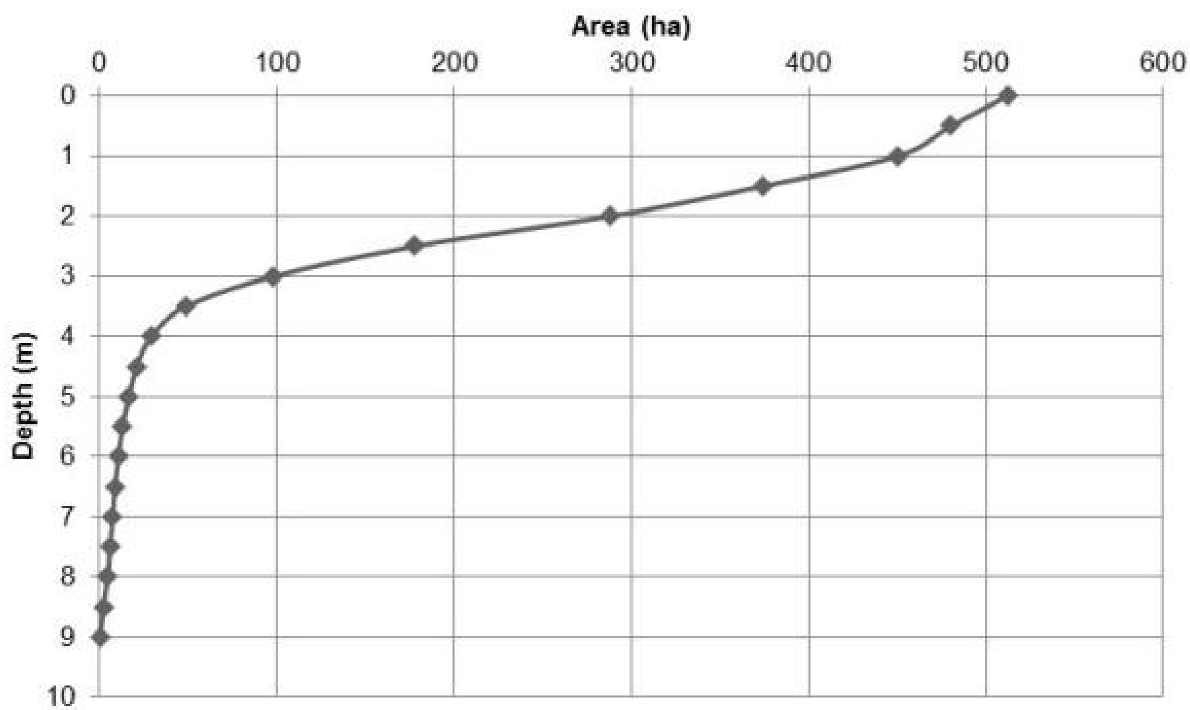
Based on bathymetry surveys performed by Aurora Geosciences Ltd., Lake Af1 has a surface area of 512 ha and a total volume of 11,399,615 m^3 (Aurora Geosciences Ltd. 2013). Lake Af1 has a mean depth of 2.2 m and a maximum depth of 9.3 m. Over 56% (288 ha) of the surface area of Lake Af1 is deeper than 2 m (Table 3.2-8, Figure 3.2-9); therefore, over 40% (224 ha) of Lake Af1 may freeze to the bottom during winter.

Table 3.2-8 Vertical Distribution of Lake Area and Volume in Lake Af1

	Lake Af1			
	Area		Volume	
Depth (m)	(ha)	(%)	(m^3 x 10^3)	(%)
>0	512	100	11,400	100
>1	450	87.9	6,596	57.9
>2	288	56.3	2,847	25.0
>3	98	19.2	1,035	9.1
>4	29	5.7	515	4.5
>5	17	3.2	302	3.5
>6	11	2.1	170	1.5
>7	7	1.4	82	0.7
>8	5	0.9	23	0.2
>9	0.4	0.1	1	<0.1

Source: Based on 2013 bathymetry surveys by Aurora Geosciences Ltd. (2013).
m = metre; ha = hectare; % =percent; m^3 = cubic metre; > = greater than; < = less than; x = times.

Figure 3.2-9 Depth-Area Relationship in Lake Af1



m = metre; ha = hectare.

Shoreline Area Habitat

Two representative habitat locations were evaluated for Lake Af1. The shoreline consisted mainly of shrubs, boulder, and cobble with many areas of grasses and occasional areas of bedrock (Map 2.2-2, Table 3.2-9). The littoral zone typically contained cobble (30% to 40% cover) and gravel (30% to 40% cover) substrates, and areas of fines (10% to 30%) or boulder (10%) (Table 3.2-9). Cover for fish in shoreline areas was provided mainly by coarse substrate (boulders), emergent vegetation, depth, and overhanging riparian vegetation (shrubs). Surface water quality parameters measured on August 20, 2013 were as follows: 15.4°C temperature, 12.0 µS/cm conductivity, 7.0 pH, and 8.8 mg/L DO (88.0% saturation).

Table 3.2-9 Representative Shoreline Habitat in Lake Af1

Habitat Sample Number	Zone 12W		Lake Location	Dominant Riparian Features			Littoral Substrate (%)				Dominant Cover Types				
	Easting	Northing		Grass	Willow	Exposed Substrate	Boulder	Cobble	Gravel	Fines	Riparian Vegetation	Emergent Vegetation	Boulders	Undercut Banks	Depth
1	538429	7174936	West shore	-	√	√	10	40	40	10	-	√	√	-	√
2	538438	7174896	West shore	-	√	√	10	30	30	30	√	√	√	-	-

% = percent; - = not present.

3.2.3.2.3 Lake E1

Bathymetry

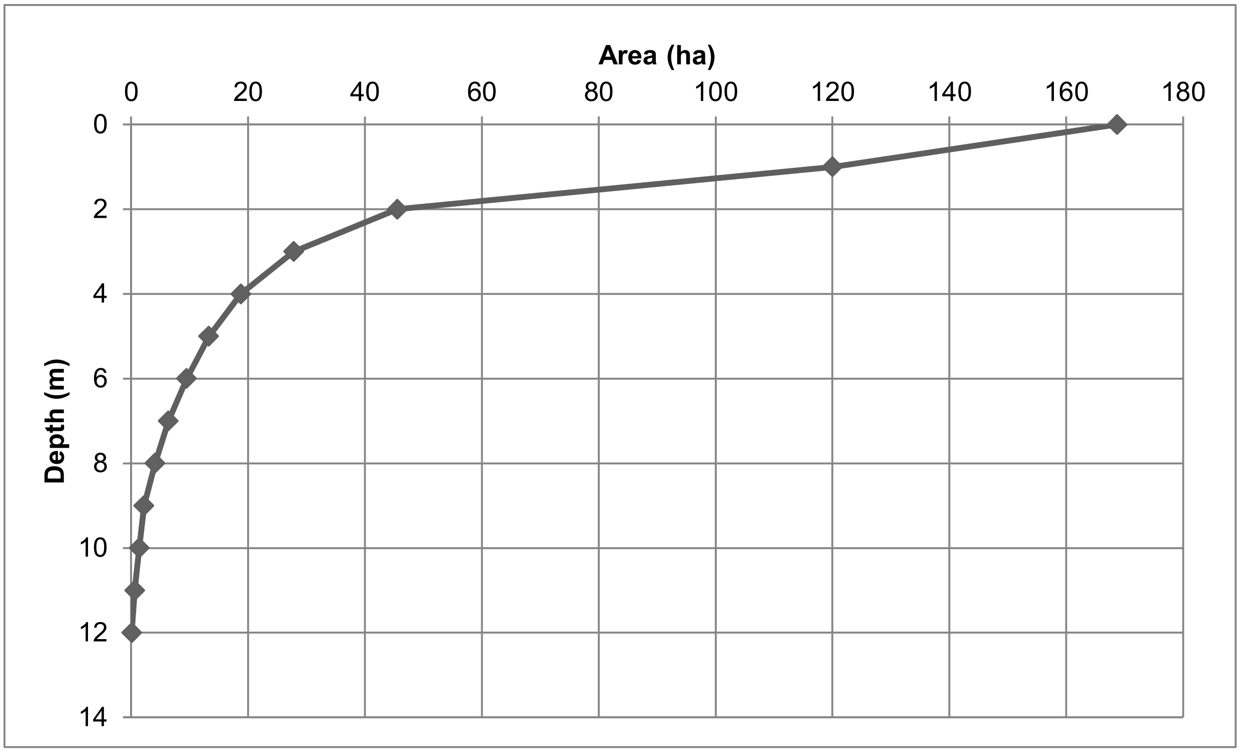
Based on 2013 bathymetry surveys by Aurora Geosciences Ltd., Lake E1 has a surface area of 169 ha and a total volume of 3,212,150 m^3 (Aurora Geosciences Ltd. 2013). Lake E1 has a mean depth of 1.9 m and a maximum depth of 12.3 m. Only 27% (46 ha) of the surface area of Lake E1 is deeper than 2 m (Table 3.2-10, Figure 3.2-10). Therefore, 73% (123 ha) of Lake E1 may freeze to the bottom during winter.

Table 3.2-10 Vertical Distribution of Lake Area and Volume in Lake E1

Depth (m)	Lake E1			
	Area		Volume	
	(ha)	(%)	(m^3 x 10^3)	(%)
>0	169	100.0	3,212	100.0
>1	120	71.1	1,782	55.5
>2	46	27.0	1,035	32.2
>3	28	16.5	689	21.4
>4	19	11.1	461	14.4
>5	13	7.9	304	9.5
>6	10	5.6	191	5.9
>7	6	3.8	113	3.5
>8	4	2.4	60	1.9
>9	2	1.3	31	1.0
>10	1.4	0.8	13	0.4
>11	0.6	0.4	3	0.1
>12	0.1	0.1	0.2	<0.1

Source: Based on 2013 bathymetry surveys by Aurora Geosciences Ltd. (2013).
m = metre; ha = hectare; % = percent; m^3 = cubic metre; > = greater than; < = less than; x = times.

Figure 3.2-10 Depth-Area Relationship in Lake E1



m - metre; ha = hectare.

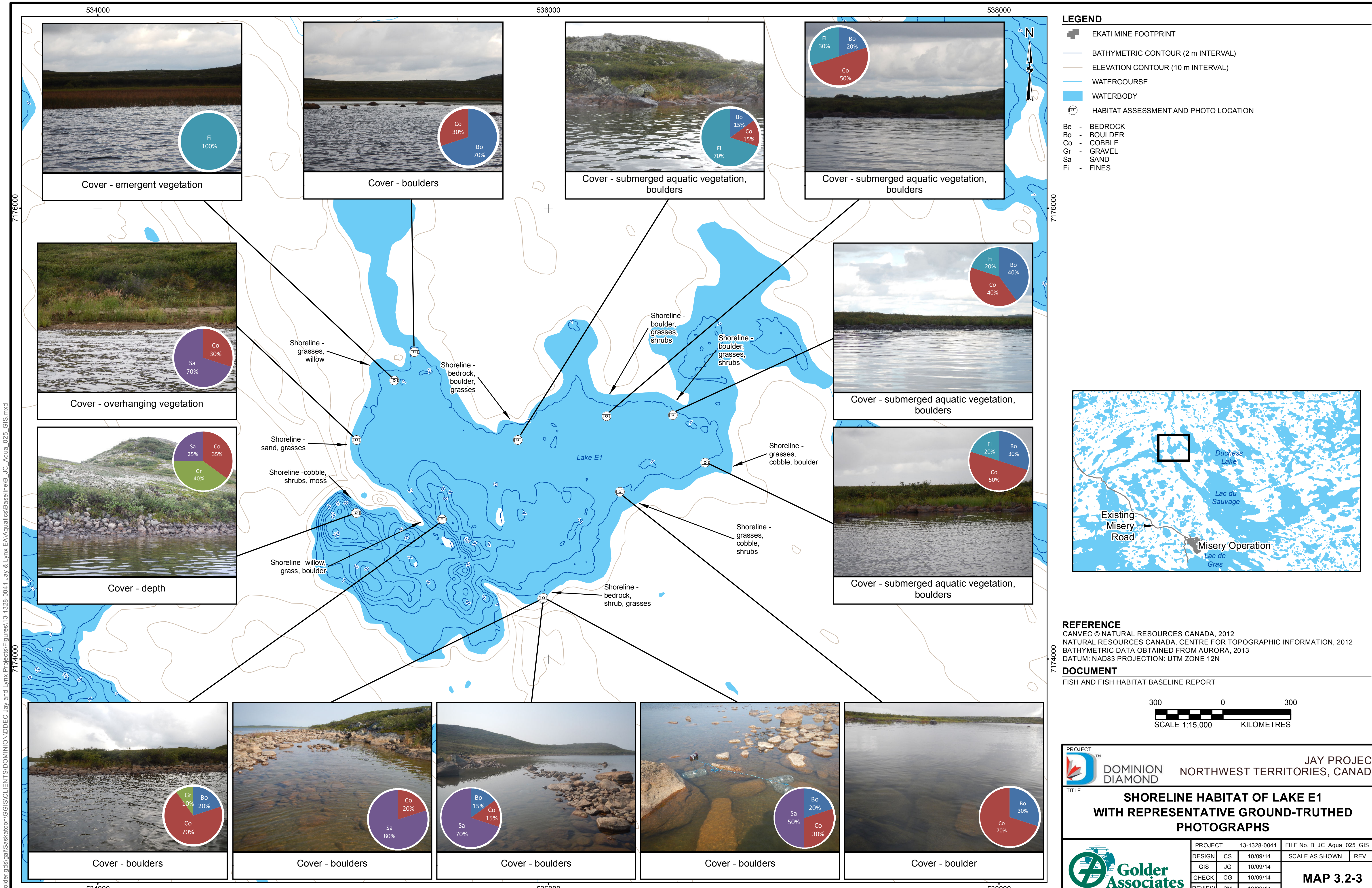
Shoreline Area Habitat

Thirteen representative habitat locations were evaluated in Lake E1 (Table 3.2-11; Map 3.2-3). A mix of shrubs, boulder, and cobble, with areas of grasses/sedges and fines, dominated the shoreline. There were occasional areas of sandy and gravel/cobble beaches. An esker was observed near the west side of the lake and extended approximately 500 m towards the lake's centre. The littoral zone consisted of coarse substrate locations with boulder/cobble (15% to 70% cover), as well as grassy (emergent vegetation) areas with fine substrates (25% to 100% cover). A few areas of the lake had steep drop-offs in the near shore area, but most areas consisted of a gradual decline. Cover in shallow water was mainly of substrate (boulder), emergent vegetation (e.g., sedge wetlands), and terrestrial riparian vegetation, such as overhanging shrubs (Table 3.2-11), providing suitable foraging habitat for species such as Northern Pike. The maximum depth recorded in Lake E1 was 12.3 m. Surface water quality parameters taken during the field evaluation on August 13, 2013, were: 17.0°C temperature, 11.8 μS/cm conductivity, 7.0 pH, and 9.0 mg/L DO (93.2% saturation). The Lake E1 outlet (i.e., Stream E1) was a shallow, dispersed stream with submerged riparian vegetation, and riffle habitat that could provide potential spawning locations for Arctic Grayling.

Table 3.2-11 Representative Shoreline Habitat in Lake E1

	Zone 12W			Dominant Riparian Features			Littoral Substrate (%)					Dominant Cover Types				
Habitat Sample Number	Easting	Northing	Lake Location	Grass	Willow	Exposed Substrate	Bedrock	Boulder	Cobble	Gravel	Fines	Riparian Vegetation	Emergent Vegetation	Boulders	Undercut Banks	Depth
1	535973	7174265	SE shore	√	√	√	-	-	-	20	80	-	-	√	-	-
2	535972	7174268	SE shore	√	√	√	-	5	15	-	50	-	-	√	-	-
3	535978	7174270	SE shore	√	√	√	-	20	30	-	50	-	-	√	-	-
4	535528	7174620	W shore near esker	√	√	√	-	20	70	10	-	-	-	√	-	-
5	535148	7174972	W shore	√	-	√	-	-	30	-	70	√	-	-	-	-
6	535316	7175235	NW shore	√	√	-	-	-	-	-	100	√	√	-	-	-
7	535404	7175361	NW shore	-	-	√	-	70	30	-	-	-	-	√	-	-
8	535864	7174971	N shore	√	-	√	-	15	15	-	70	-	√	√	-	-
9	536258	7175077	N shore	√	√	√	-	20	50	-	30	-	√	√	-	-
10	536553	7175082	N shore	√	√	√	-	40	40	-	20	-	√	-	-	-
11	536696	7174871	NE shore	√	-	√	-	30	50	-	20	-	√	√	-	-
12	536318	7174741	E shore	√	√	√	-	30	70	-	-	-	-	√	-	-
13	535146	7174648	W shore in south bay	√	√	√	-	-	35	40	25	-	-	-	-	√

% = percent; - = not present.


534000
536000
538000
7176000
7174000
Cover - emergent vegetation
Fi 100%
Cover - boulders
Co 30%
Bo 70%
Cover - submerged aquatic vegetation, boulders
Bo 15%
Co 15%
Fi 70%
Cover - submerged aquatic vegetation, boulders
Fi 30%
Bo 20%
Co 50%
Cover - overhanging vegetation
Co 30%
Sa 70%
Cover - depth
Sa 25%
Co 35%
Gr 40%
Cover - submerged aquatic vegetation, boulders
Fi 20%
Bo 40%
Co 40%
Cover - submerged aquatic vegetation, boulders
Fi 20%
Bo 30%
Co 50%
Shoreline - grasses, willow
Shoreline - bedrock, boulder, grasses
Shoreline - boulder, grasses, shrubs
Shoreline - boulder, grasses, shrubs
Shoreline - sand, grasses
Shoreline -cobble, shrubs, moss
Shoreline -willow, grass, boulder
Lake E1
Shoreline - grasses, cobble, boulder
Shoreline - grasses, cobble, shrubs
Shoreline - bedrock, shrub, grasses
Cover - boulders
Gr 10%
Bo 20%
Co 70%
Cover - boulders
Co 20%
Sa 80%
Cover - boulders
Bo 15%
Co 15%
Sa 70%
Cover - boulders
Bo 20%
Sa 50%
Co 30%
Cover - boulder
Bo 30%
Co 70%
N
LEGEND
EKATI MINE FOOTPRINT
BATHYMETRIC CONTOUR (2 m INTERVAL)
ELEVATION CONTOUR (10 m INTERVAL)
WATERCOURSE
WATERBODY
HABITAT ASSESSMENT AND PHOTO LOCATION
Be - BEDROCK
Bo - BOULDER
Co - COBBLE
Gr - GRAVEL
Sa - SAND
Fi - FINES
Duchess Lake
Lac du Sauvage
Existing Misery Road
Misery Operation
Lac de Gras
REFERENCE
CANVEC © NATURAL RESOURCES CANADA, 2012
NATURAL RESOURCES CANADA, CENTRE FOR TOPOGRAPHIC INFORMATION, 2012
BATHYMETRIC DATA OBTAINED FROM AURORA, 2013
DATUM: NAD83 PROJECTION: UTM ZONE 12N
DOCUMENT
FISH AND FISH HABITAT BASELINE REPORT
300 0 300
SCALE 1:15,000 KILOMETRES
PROJECT
DOMINION DIAMOND
JAY PROJECT
NORTHWEST TERRITORIES, CANADA
TITLE
SHORELINE HABITAT OF LAKE E1
WITH REPRESENTATIVE GROUND-TRUTHED PHOTOGRAPHS
Golder Associates
PROJECT 13-1328-0041 FILE No. B_JC_Aqua_025_GIS
DESIGN CS 10/09/14 SCALE AS SHOWN REV 0
GIS JG 10/09/14
CHECK CG 10/09/14
REVIEW SM 10/09/14
MAP 3.2-3
\\golder.gds\gal\Saskatoon\GIS\CLIENTS\DOMINION\DDEC Jay and Lynx Projects\Figures\13-1328-0041 Jay & Lynx EA\Aquatics\Baseline\B_JC_Aqua_025_GIS.mxd

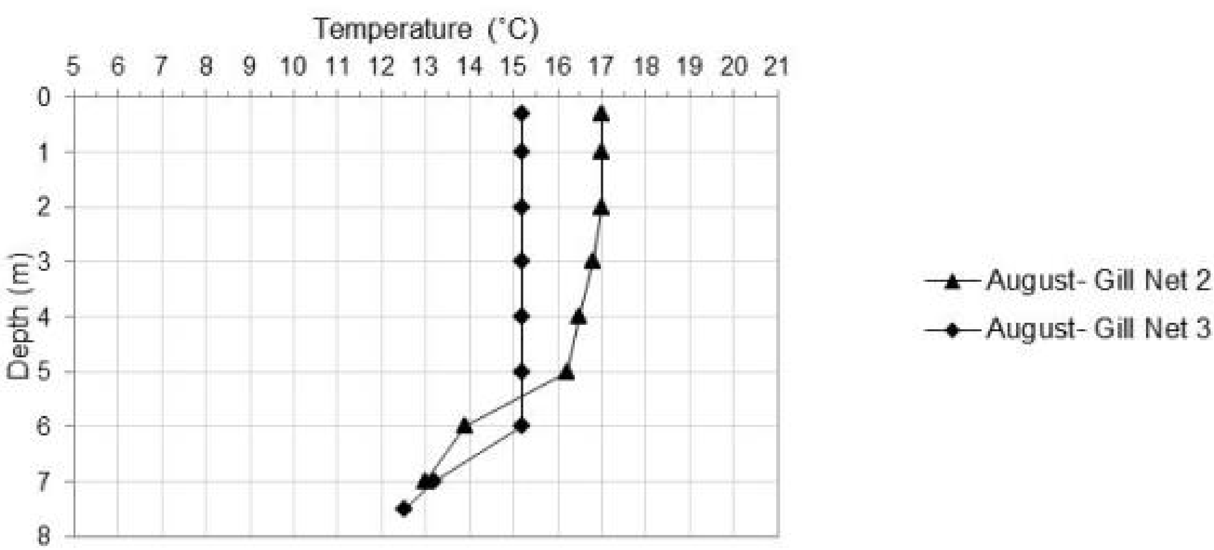
Vertical Profiles

Vertical profiles were taken at gill net sets 2 and 3 in Lake E1 on August 19 and 21, 2013. Depths of the profiles were 7.0 and 7.5 m. Temperature and DO profiles suggested thermal stratification in Lake E1. The thermocline was observed between 5 and 7 m depths where the temperature decreased (Figure 3.2-11).

Temperatures in the top 5 m of water in Lake E1 ranged from 15.2°C to 17.0°C. The highest temperature was recorded at 0.3 m, 1.0 m, and 2.0 m depths at gill net set 2. Temperatures were lower from 6 m to the lake bottom and ranged from 12.5°C to 15.2°C (Figure 3.2-11). The lowest temperature was recorded at the 7.5 m depth at gill net set 3. Dissolved oxygen concentrations were variable, but were stable in the top 5 m of the water column (range = 8.4 to 9.9 mg/L) and decreased from 6 m to the lake bottom (range = 5.1 to 8.6 mg/L) (Figure 3.2-12). At gill net set 2, DO at the bottom (7 m depth) was 5.1 mg/L, which is below the CCME (2013) guideline for the protection of aquatic life of 6.5 mg/L (Figure 3.2-12). The pH levels followed the same trend as temperature and were higher in the top 5 m of the water column (range = 6.8 to 7.0) than from 6 m to bottom (average range = 6.0 to 6.9) (Figure 3.2-13).

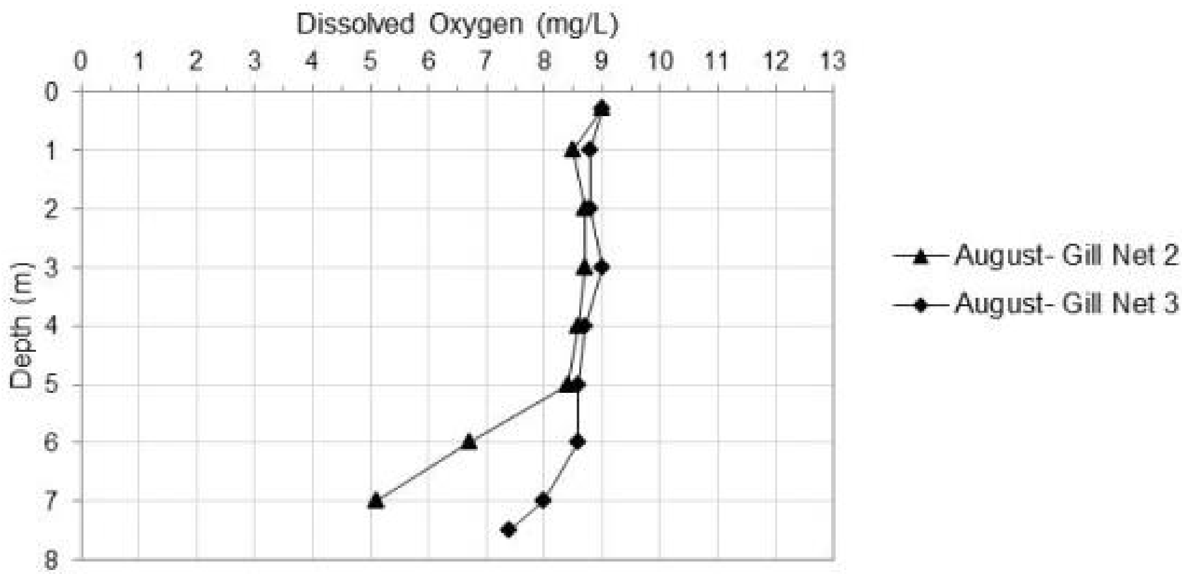
Overall, DO concentrations (CCME guideline greater than 6.5 mg/L), and pH levels (CCME guideline = 6.5 to 9.0) were within the range to support fish populations throughout most of the water column, with the exception of DO concentrations at the 7-m bottom depth at gill net set 2 (5.1 mg/L), which was below CCME (2013) guidelines.

Figure 3.2-11 Depth-Temperature Profile for Gill Net Sets in Lake E1, August 2013



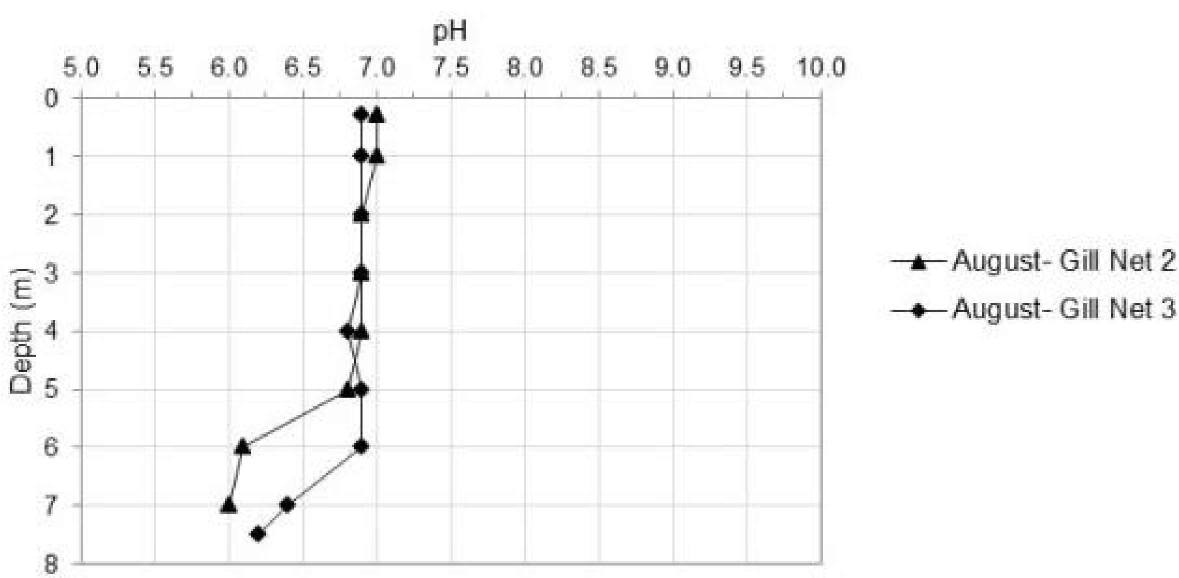
°C = degrees Celsius; m = metre.

Figure 3.2-12 Depth-Dissolved Oxygen Profile for Gill Net Sets in Lake E1, August 2013



mg/L = milligrams per litre; m = metre.

Figure 3.2-13 Depth-pH Profile for Gill Net Sets in Lake E1, August 2013



m = metre.

3.2.3.2.4 Stream E2

Habitat

Stream E2 is a low-gradient stream (less than 0.1%) that meanders in a defined, entrenched channel for a distance of 6.78 km from Lake E2 to Lake E1 (Table 3.2-3). In August 2013, approximately 547 m of the stream was evaluated in detail near the outlet to Lake E1. At the survey location, Stream E2 had a mean bankfull width of 19.2 m and a maximum bankfull depth of 1.78 m (discharge was approximately 0.63 m^3/s). Habitat consisted mostly of deep runs (greater than 1.0 m) (85%) and moderately deep runs (0.5 to 1.0 m) (15%). Cover for fish was dominated by depth and turbidity, but also included emergent/aquatic vegetation, boulders, and undercut banks. Bed substrate largely consisted of silt and organics, with patches of cobble, boulders, and gravel deposits. Dissolved oxygen during the evaluation was adequate (7.5 mg/L) (Table 3.2-2). Gravel/cobble substrate was observed in areas of the surveyed location, potentially providing suitable spawning conditions for Arctic Grayling. An aerial evaluation of the entire stream found the presence of riffle/run habitats, no barriers to fish passage, and an abundance of boulders providing refuge from the current. Water depth and cover provided good juvenile and adult rearing habitat. In general, Stream E2 contains good-quality habitat for sportfish and forage species (Map 3.2-4).

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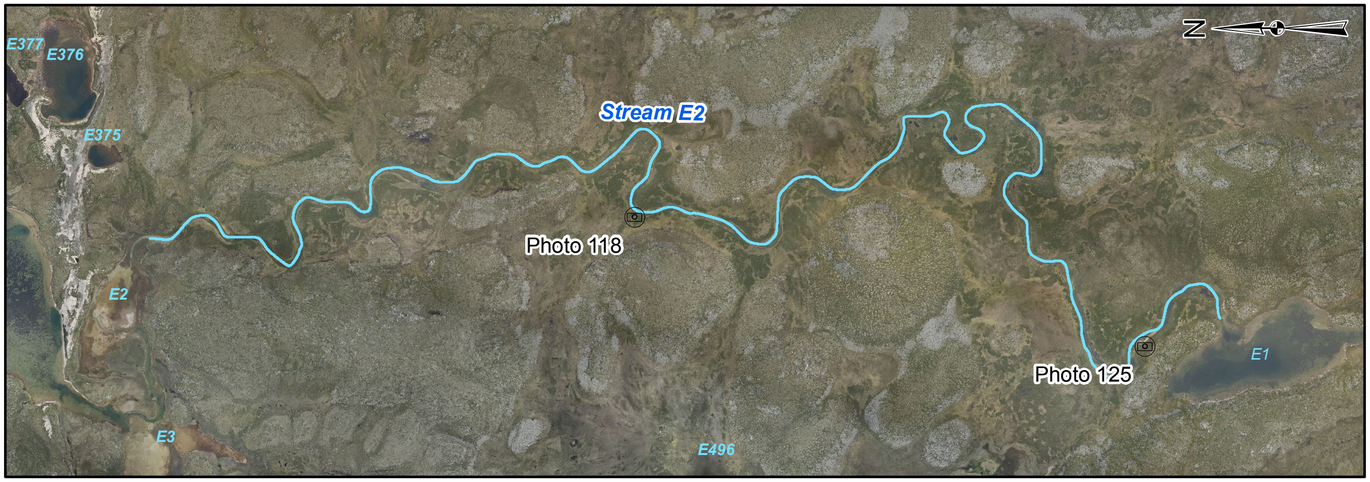
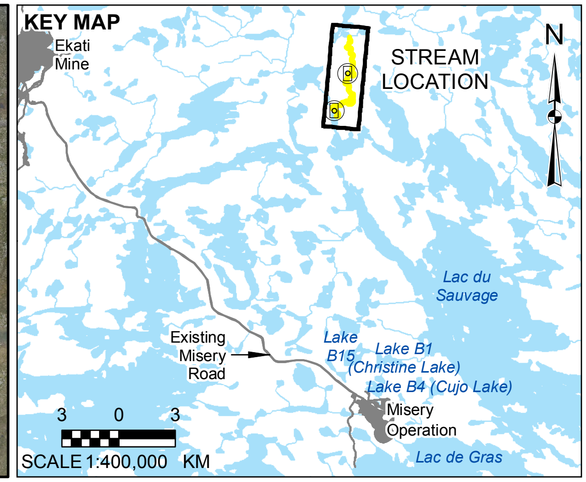
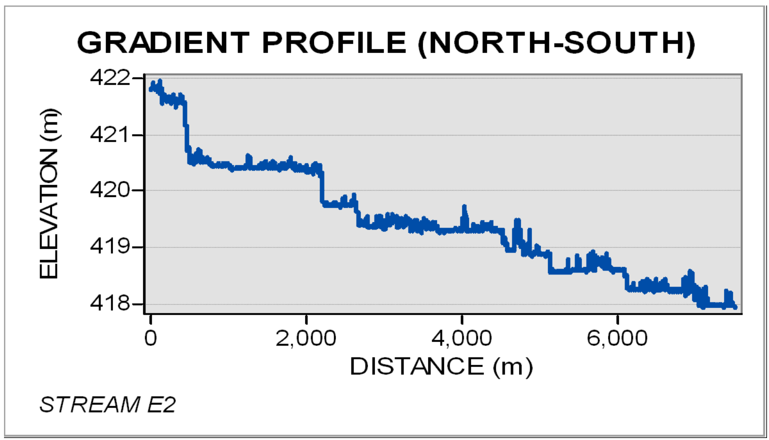






LEGEND

- EKATI MINE FOOTPRINT
- WATERCOURSE
- WATERBODY
- PHOTO LOCATION
- STREAM LOCATION

STATISTICS

LENGTH = 7494.1 M
UPSTREAM ELEVATION = 421.8 M
DOWNSTREAM ELEVATION = 418.0 M
ELEVATION DIFFERENCE = 3.8 M
GRADIENT PERCENT = 0.05%
SUB BASIN AREA = 20,649 HA

REFERENCE

ELEVATION DATA: LIDAR, 2013
IMAGERY: ORTHOPHOTO, 2013
DATUM: NAD83 PROJECTION: UTM ZONE 12

DOCUMENT

FISH AND FISH HABITAT BASELINE REPORT

PROJECT

DOMINION DIAMOND

JAY PROJECT
NORTHWEST TERRITORIES, CANADA

TITLE

GRADIENT PROFILE FOR STREAM E2

Golder Associates

PROJECT		13-1328-0041	FILE No. B_JC_Aqua_018_GIS
DESIGN	ANK	17/01/2014	SCALE AS SHOWN REV. 0
GIS	JG	9/9/2014	
CHECK	CG	9/9/2014	MAP 3.2-4
REVIEW	SM	9/9/2014	

3.2.3.3 Other Lac du Sauvage Sub-Basins

3.2.3.3.1 B Sub-Basin

Sub-basin B is west of Lac du Sauvage internal basin Ad, and has a drainage area of 1,458 ha. Lakes reviewed as part of the 2013 field program were Lake B1 (Christine), Lake B4 (Cujo), and Lake B15 (Map 3.1-2). Stream B1 (Christine Creek) and Stream B15 were also evaluated Lake B1 (Christine) sub-catchment covers 1,340 ha, of which Lake B1 (Christine) itself represents 49 ha (Table 3.2-3). Stream B1 (Christine Creek) drains east from Lake B1 (Christine) for a distance of approximately 1.3 km before emptying into internal basin Ac of Lac du Sauvage. Stream B15 is a tributary to Lake B1 (Christine) and drains southeast from Lake B15 (63 ha) for distance of approximately 407 m before entering Lake B1 (Christine). Photographs of the waterbodies are provided in Appendix B.

Lake B1 (Christine)

Lake B1 (Christine) consisted of similar habitat throughout the lake. In general, the shoreline was boulder and bedrock dominant with submerged mosses and grasses. The littoral zone consisted mainly of boulder and cobble substrates with traces of silt and gravel. Sandy shorelines were observed at the south shore and northwest corner of the lake. Sedge wetlands comprised of *Carex aquatilis* var. *aquatilis* were also present. The deepest area surveyed was 14.6 m. Shoreline cover for fish was provided by substrate, depth, and vegetation (macrophytes). Boulder/cobble shoals were common and had macrophyte growth. Surrounding riparian vegetation comprised small shrubs, grasses, and tundra vegetation. At the west shoreline of the lake, steep boulder and bedrock habitats were present where depths reached 4 m within short distances of shore. Surface water quality parameters measured during the field evaluation on August 25, 2013 are provided in Table 3.2-1.

Lake B4 (Cujo)

Lake B4 (Cujo) shoreline was boulder and bedrock dominant with grasses and shrubs. The littoral zone consisted mainly of boulder and cobble substrates with scattered patches of clay/silt/organics, and traces of gravel. The deepest area surveyed was 10 m. Shoreline area cover was provided by substrate, undercut banks, overhanging woody vegetation, and submerged and emergent (*Carex aquatilis* var. *aquatilis*) vegetation. Surrounding riparian vegetation comprised grasses and shrubs. Boulder/bedrock outcrops were common along the south shore. Surface water quality parameters measured during the field evaluation on September 3, 2013 are provided in Table 3.2-1.

Lake B15

Lake B15 shoreline was boulder dominant with grasses, shrub, and moss. The littoral zone consisted mainly of boulder and cobble substrates with scattered patches of gravel and sand. The deepest surveyed area was 8.2 m. Shoreline cover was provided by substrate (boulder), submergent and emergent (*Carex* species [sp.] and *Eriophorum* sp.) vegetation, undercut banks, terrestrial (*Carex* sp., possibly *Ranunculus* sp.) and overhanging vegetation, and depth. Surrounding riparian vegetation comprised grasses and shrubs. A boulder garden prevented boat access at the south side of the islands, but was not likely a fish barrier. Steep slopes were identified at the southwest and west shorelines of Lake B15 where depths were greater than 3.5 m within 3 to 5 m of shore. Surface water quality parameters were measured during the field evaluation on September 11, 2013 are provided in Table 3.2-2.

Stream B1 (Christine Creek)

A detailed habitat evaluation of Stream B1 (Christine Creek) was completed on August 22, 2013, along 1,636 m of the watercourse from the outlet of Lake B1 (Christine) (Map 3.2-5). The watercourse had a mean bankfull width of 20.3 m, with a wetted width of 18.1 m and a maximum depth of 2.0 m. Discharge in Stream B1 (Christine Creek) was 0.0087 m^3/s. Surface water quality parameters measured during the field evaluation on August 24, 2013 are provided in Table 3.2-2.

The stream included a large pool (or small pond) that comprised most of the stream area (81%). Excluding the 'pond', stream habitat was characterized by shallow run cover (84%) with occasional flats (12%) and riffle (3%) (Table 3.2-12). Stream cover was abundant, particularly as aquatic and riparian vegetation at the lower end of the stream. Cover was provided primarily by emergent/aquatic vegetation, and overhanging riparian vegetation, and to a lesser extent by undercut banks, depth/turbidity, and substrate. The substrate was dominated by organics and silts with similar contributions from boulder and the occasional patch of cobble. Potential barriers to upstream movements of fish from Lac du Sauvage were identified (e.g., boulder gardens, sub-surface flows) at the time of sampling. The slope of the creek was less than 1%, as determined by GIS (Table 3.2-3).

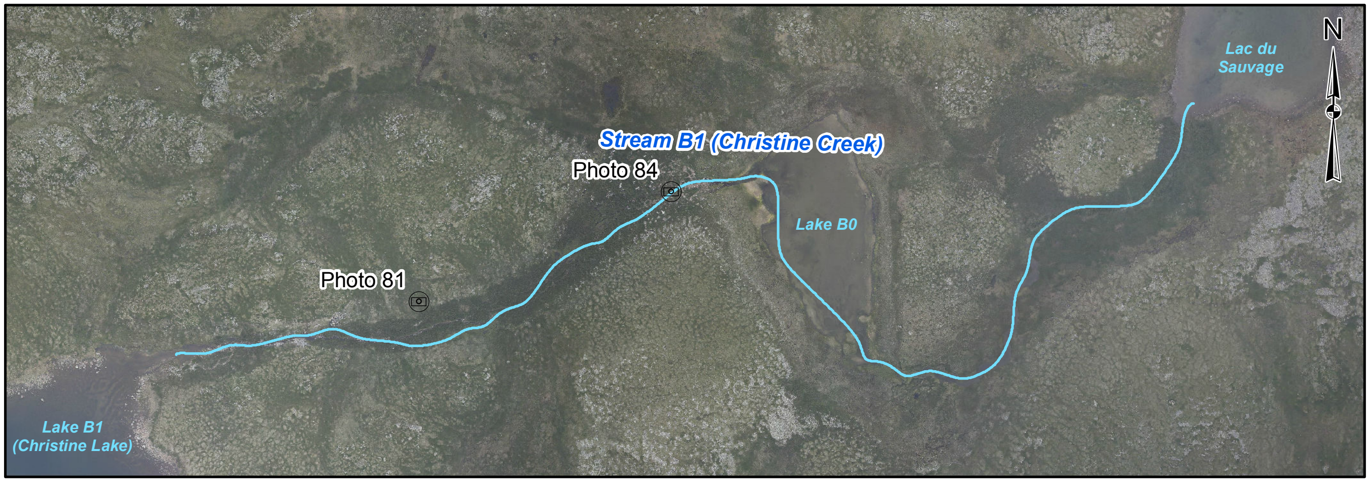
Table 3.2-12 Fish Habitat Summary for Small Streams, 2013

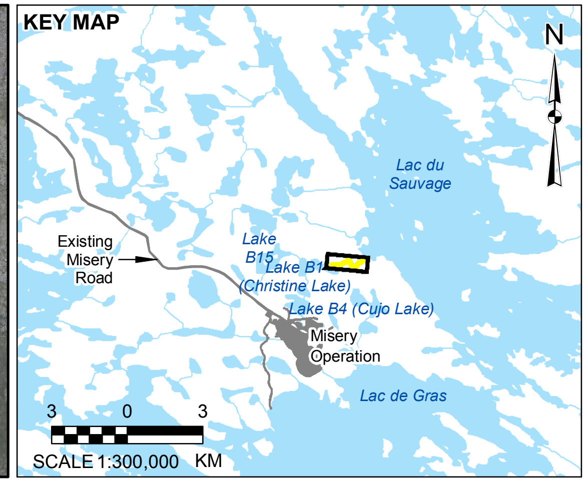
Stream	Survey Date	Mean Maximum Depth (m)[a]	Habitat Type		Substrate Type (%)			In-Stream Cover (%)					Potential Fish Barrier Present
			Primary or Dominant	Secondary	Organics/ Fines	Gravel/ Cobble	Boulder/ Bedrock	Emergent / Aquatic Vegetation	Riparian Vegetation	Undercut Banks	Depth / Turbidity	Substrate	
Stream Ab2	14-Sept	0.50	Run	-	40	10	50	15	0	0	0	5	Yes
Stream B1 (Christine Creek)	22-Aug	2.00	Run	Flat	48	8	44	38	38	20	14	19	Yes
Stream B15	12-Sept	0.74	Run/Pool	Run	100	0	0	15	28	6	8	0	No
Stream C1	14-Sept	1.80	Run	Pool	100	0	0	38	38	8	16	0	Yes
Stream C3	12-Sept	0.36	Run	-	10	50	40	10	0	0	0	30	Yes
Stream D1	15-Sept	1.02	Pool	Run	74	23	3	23	19	2	1	3	No
Stream E2[b]	16-Sept	2.00	Run	-	83	10	7	6	0	5	68	7	No

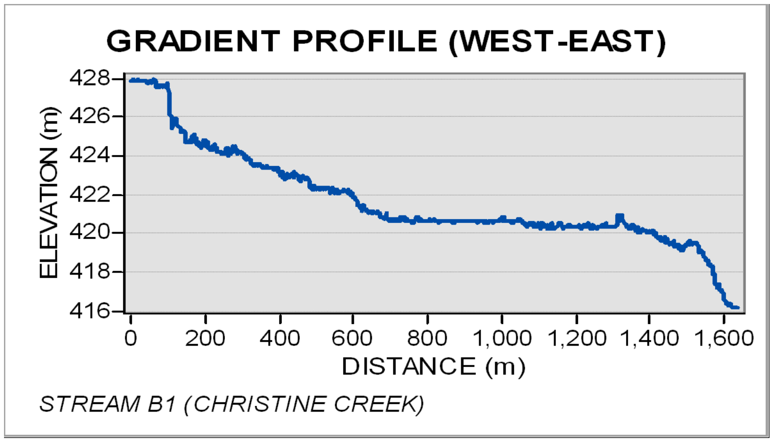
a) Mean of all maximum depths across habitat units.

b) A relatively large stream (bankfull width = 19.2 m) for comparison.

% = percent; m = metre; Aug = August; Sep = September; - = not applicable.







LEGEND

EKATI MINE FOOTPRINT
WATERCOURSE
WATERBODY
STREAM LOCATION

STATISTICS

LENGTH = 1636.4 M
UPSTREAM ELEVATION = 427.9 M
DOWNSTREAM ELEVATION = 416.1 M
ELEVATION DIFFERENCE = 11.8 M
GRADIENT PERCENT = 0.72%
SUB BASIN AREA = 1458 HA

REFERENCE

ELEVATION DATA: LIDAR, 2013
IMAGERY: ORTHOPHOTO, 2013
DATUM: NAD83 PROJECTION: UTM ZONE 12

DOCUMENT

FISH AND FISH HABITAT BASELINE REPORT

PROJECT

DOMINION DIAMOND

JAY PROJECT
NORTHWEST TERRITORIES, CANADA

TITLE

GRADIENT PROFILE FOR STREAM B1 (CHRISTINE CREEK)

Golder Associates

PROJECT	13-1328-0041		FILE No. B_JC_Aqua_020_GIS
DESIGN	ANK	17/01/2014	SCALE AS SHOWN REV. 0
GIS	JG	9/9/2014	
CHECK	CG	9/9/2014	MAP 3.2-5
REVIEW	SM	9/9/2014	

Stream B15

A detailed habitat evaluation of Stream B15 was completed on September 12, 2013, along 100 m of the watercourse from the outlet of Lake B15 (Map 3.2-6). The watercourse had a mean bankfull width of 0.7 m with a mean wetted width of 1.4 m and a maximum depth of 0.7 m. Discharge was 0.005 m^3/s. Surface water quality parameters measured during the field evaluation on September 12 are provided in Table 3.2-2.

Instream habitat consisted mostly of shallow runs (78%) and moderately deep runs (8%), with shallow pools (7%) and shallow (5%) and moderately deep (2%) flats and pools (1%). Cover was provided by overhanging vegetation and emergent/aquatic vegetation, with cover provided by depth/turbidity, and undercut banks. The substrate consisted entirely of organics. There were no obvious barriers to fish movement in the stream. The slope of the creek was 1.4%, as determined by GIS (Table 3.2-3).

3.2.3.3.2 C Sub-Basin

Sub-basin C is west of Lac du Sauvage internal basin Ac. Waterbodies that were evaluated as part of the 2013 field program were Lake C1 and C3 and their associated outlet streams. Lake C1 sub-catchment encompasses 1,173 ha, of which Lake C1 itself covers 163 ha (Table 3.2-3). Stream C1 drains east from Lake C1 for 2.1 km before entering Lac du Sauvage internal basin Ac. Upstream of Lake C1 is a small lake, Lake C2 (4 ha in size), and then Lake C3 (85 ha in size) located higher in the watershed. Photographs of the waterbodies are in Appendix B.

Lake C1

Lake C1 shoreline was boulder and cobble dominant, with vegetated sections of grasses and shrubs and sandy shorelines. The littoral zone consists mainly of sand substrate with cobble and boulders. The deepest area surveyed was 23.5 m. Cover was provided by submerged macrophytes, substrate, and depth. Surrounding vegetation consisted of small shrubs, sedges, and grasses. Macrophytes are interspersed throughout Lake C1. Shorelines are very steep (west) and others are in shallow bays (northeast shore). Surface water quality parameters measured during the field evaluation on August 26, 2013 are provided in Table 3.2-1.

Lake C3

Lake C3 shoreline was boulder and bedrock dominant, with vegetated sections of grasses, shrubs, and moss. The littoral zone consisted mainly of boulder substrate with cobble and sand/gravels.
Sandy substrates were observed at the lake bottom at the deep areas (15 to 20 m) where the gill nets were set. A sandy shoal was present at the east shore. The deepest surveyed area was 17.7 m.
Cover was provided by substrate (boulder) and depth. Surrounding vegetation consisted of small shrubs and sedges (*Carex* sp.), grasses, and moss. A large bedrock cliff was present at the north shore where drop offs greater than 17 m were observed less than 5 m from shore. Surface water quality parameters measured during the field evaluation on September 13, 2013 are provided in Table 3.2-1.

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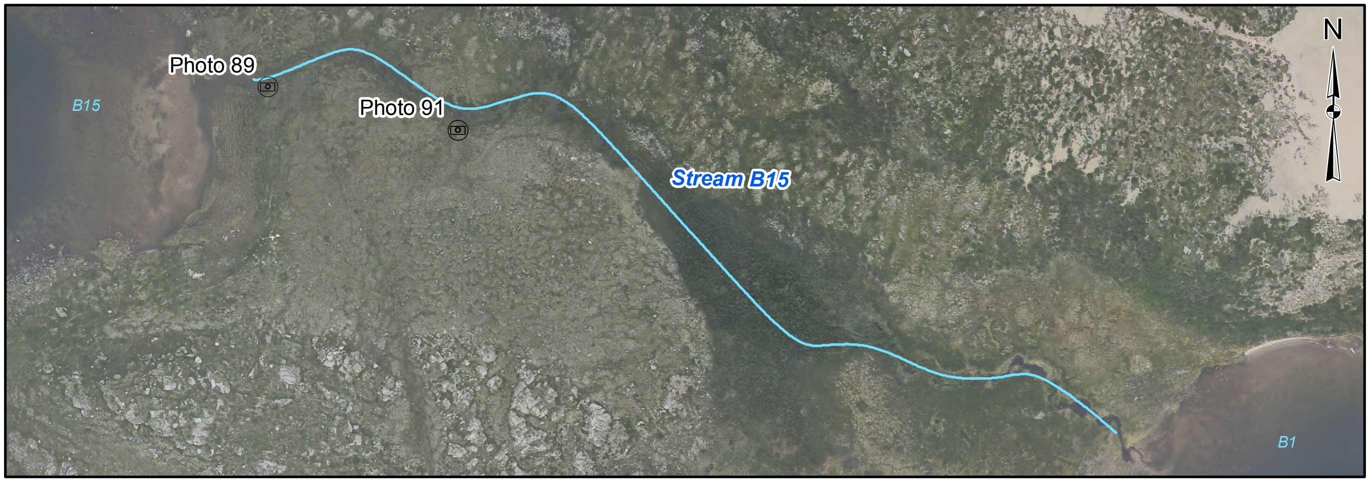
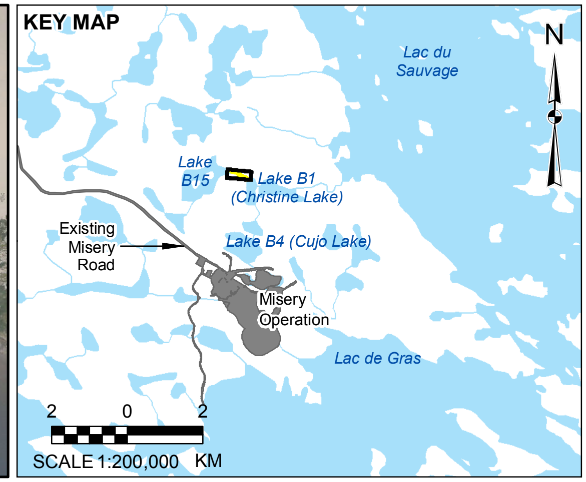
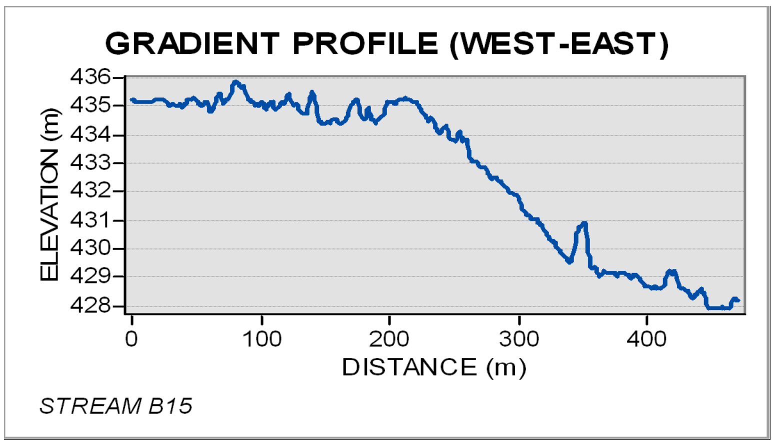
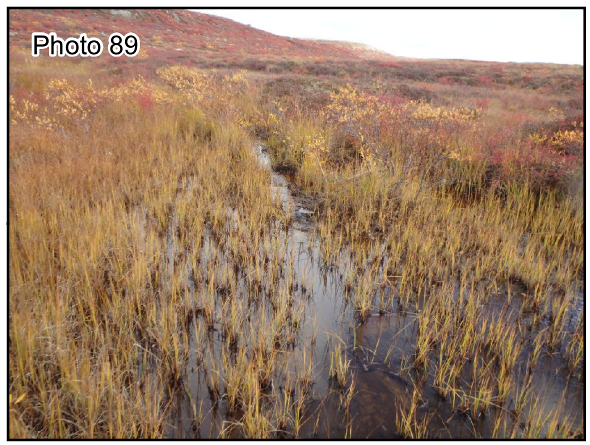








LEGEND

EKATI MINE FOOTPRINT
WATERCOURSE
WATERBODY
STREAM LOCATION

STATISTICS

LENGTH = 470.1 M
UPSTREAM ELEVATION = 435.2 M
DOWNSTREAM ELEVATION = 428.2 M
ELEVATION DIFFERENCE = 7.0 M
GRADIENT PERCENT = 1.48%
SUB BASIN AREA = 568 HA

REFERENCE

ELEVATION DATA: LIDAR, 2013
IMAGERY: ORTHOPHOTO, 2013
DATUM: NAD83 PROJECTION: UTM ZONE 12

DOCUMENT

FISH AND FISH HABITAT BASELINE REPORT

PROJECT

DOMINION DIAMOND™

JAY PROJECT
NORTHWEST TERRITORIES, CANADA

TITLE

GRADIENT PROFILE FOR STREAM B15

Golder Associates

PROJECT		13-1328-0041	FILE No. B_JC_Aqua_021_GIS
DESIGN	ANK	17/01/2014	SCALE AS SHOWN REV. 0
GIS	JG	9/10/2014	MAP 3.2-6
CHECK	CG	9/10/2014	
REVIEW	SM	9/10/2014	

Stream C1

A detailed habitat evaluation of Stream C1 was completed on September 14, 2013, along 318 m of the watercourse from the inlet of Lac du Sauvage (Map 3.2-7). The watercourse had a mean bankfull width of 1.9 m. The surveyed section had a mean wetted width of 1.9 m and a maximum depth of 1.8 m. Discharge in Stream C1 was 0.011 m^3/s. Surface water quality parameters measured during the field evaluation on September 15, 2013 are provided in Table 3.2-2.

Instream habitat consisted mostly of shallow run habitat (51%) and moderately deep pools (31%), with shallow pool habitat (13%), and deep run habitat (5%). Cover was provided by overhanging riparian vegetation, aquatic/emergent vegetation, and woody debris, with cover provided by depth, and undercut banks. The substrate consisted entirely of organics. Barriers to upstream movement of fish from Lac du Sauvage were noted at the time of sampling (e.g., sub-surface flows, shallow water where flow was dispersed, and channels lacking an obvious defined bed and bank). The slope of Stream C1 is 1%, as determined by GIS (Table 3.2-3).

Stream C3

A detailed habitat evaluation t of Stream C3 was completed on September 12, 2013, along 70 m of the watercourse from the outlet of Lake C3 toward Lake C2. The watercourse had a mean bankfull width of 20 m with a mean wetted width of 4 m and a maximum depth of 0.36 m. Surface water quality parameters were also measured during the field estimation on September 12, 2013 (Table 3.2-2).

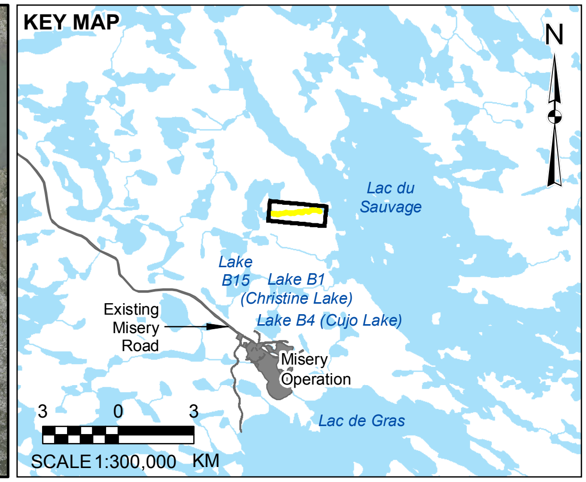
Instream habitat consisted entirely of shallow runs. Stream cover was provided primarily by substrate, such as boulder, and included cover from emergent/aquatic vegetation. The substrate consisted of cobble and boulder, with patches of gravel and silt. Upstream passage for fish may be impeded for Stream C3 because of dispersed flows and shallow depths recorded at the time of sampling. The slope of the stream is very low measuring less than 0.1% (Table 3.2-3) (Map 3.2-8).

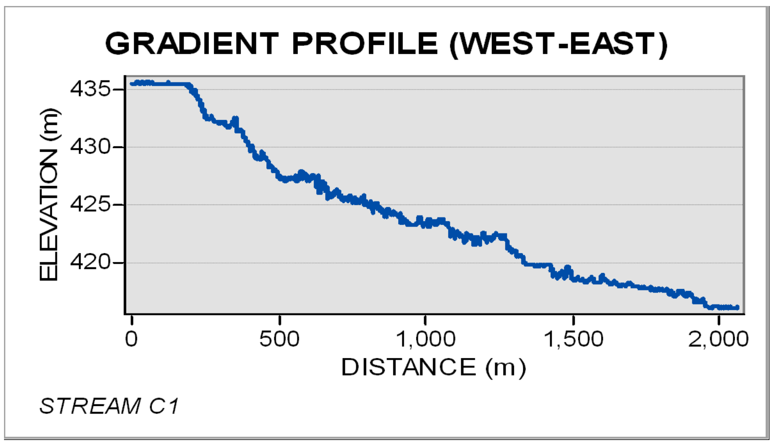
3.2.3.3.3 D Sub-Basin

Sub-basin D is west of Lac du Sauvage internal basin Ad. Waterbodies considered as part of the 2013 field program were Lake D2, Lake D3 (Counts), and Lake D4. Stream D1, which drains northeast from Lake D1 for a distance of 126 m before entering Lac du Sauvage internal basin Ad, was also a considered (Table 3.2-3). The sub-catchment area at Lake D1 is 725 ha. Lake D1 and D2 are 6 ha each, and Lake D3 (Counts) is 115 ha and Lake D4 is 30 ha in size. Photographs of the waterbodies are provided in Appendix B.

Lake D2

Lake D2 shoreline was mostly cobble and boulder dominant with bedrock, sand, grasses, and shrubs. The littoral zone consisted mainly of sand and boulder substrates with occasional gravel and cobble. The deepest area surveyed was 5.9 m. The potential for limited overwintering habitat was identified given that water depths exceeded potential maximum ice thickness of 2 m. Shoreline cover was provided by submerged vegetation, substrate, and depth. Surrounding riparian vegetation comprised small shrubs, willows, and grasses. Surface water quality parameters were measured during the field evaluation on September 2, 2013 are provided in Table 3.2-1.





LEGEND

EKATI MINE FOOTPRINT
WATERCOURSE
WATERBODY
STREAM LOCATION

STATISTICS

LENGTH = 2060.6 M
UPSTREAM ELEVATION = 435.5 M
DOWNSTREAM ELEVATION = 416.1 M
ELEVATION DIFFERENCE = 19.4 M
GRADIENT PERCENT = 0.94%
SUB BASIN AREA = 1173 HA

REFERENCE

ELEVATION DATA: LIDAR, 2013
IMAGERY: ORTHOPHOTO, 2013
DATUM: NAD83 PROJECTION: UTM ZONE 12

DOCUMENT

FISH AND FISH HABITAT BASELINE REPORT

PROJECT

DOMINION DIAMOND

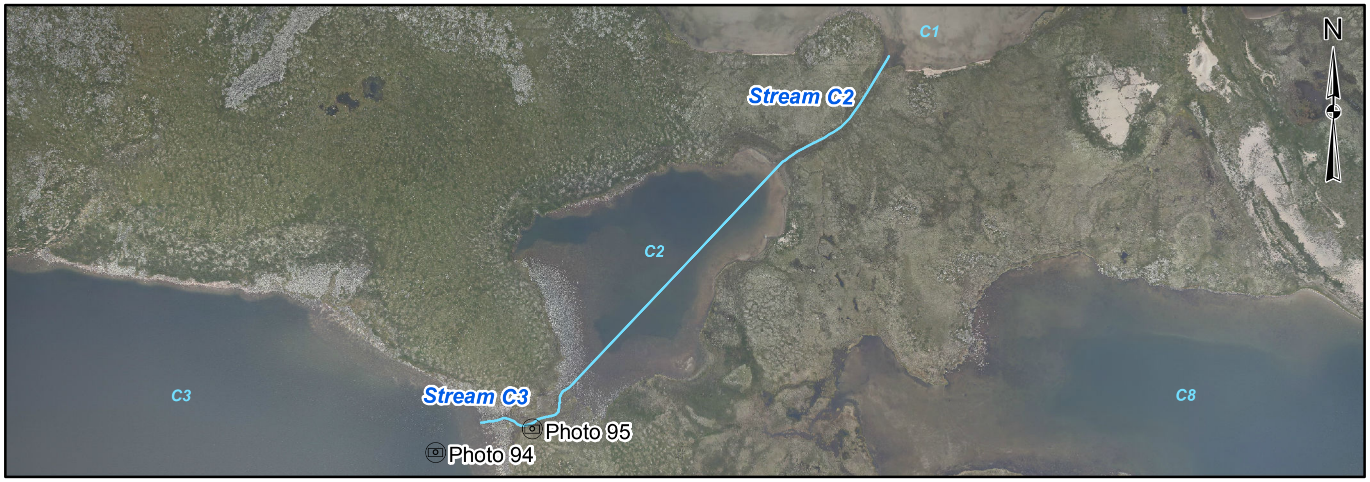
JAY PROJECT
NORTHWEST TERRITORIES, CANADA

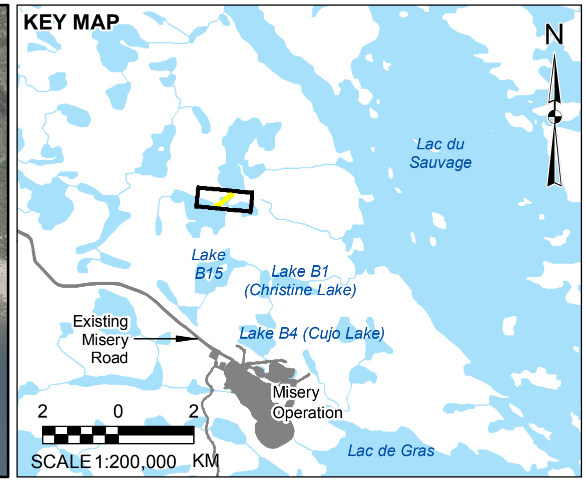
TITLE

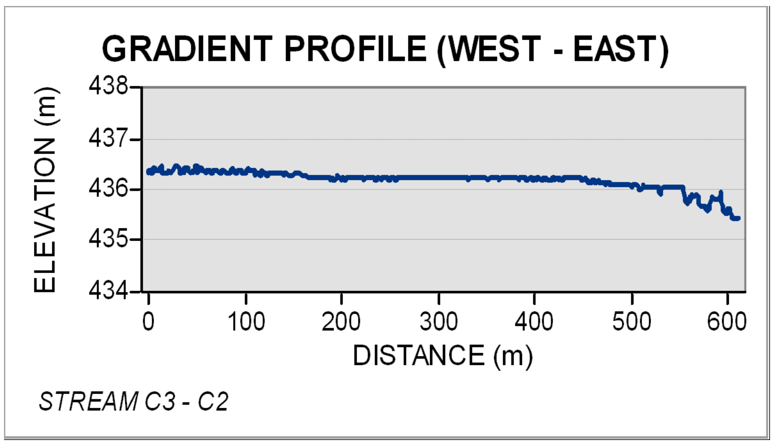
GRADIENT PROFILE FOR STREAM C1

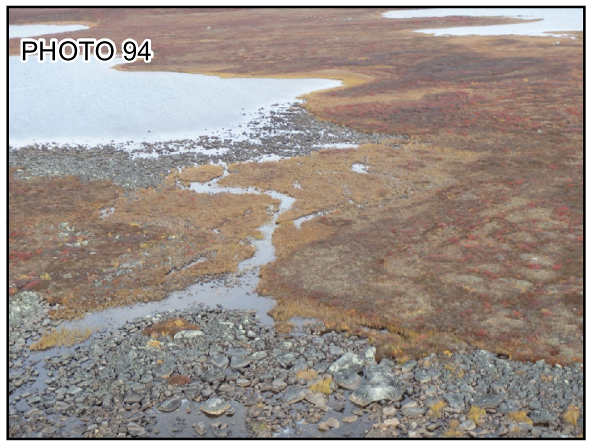
Golder Associates

PROJECT		13-1328-0041	FILE No. B_JC_Aqua_022_GIS
DESIGN	ANK	17/01/2014	SCALE AS SHOWN REV. 0
GIS	JG	9/10/2014	MAP 3.2-7
CHECK	CG	9/10/2014	
REVIEW	SM	9/10/2014	









LEGEND

- EKATI MINE FOOTPRINT
- WATERCOURSE
- WATERBODY
- STREAM LOCATION

STATISTICS

LENGTH = 611 M
UPSTREAM ELEVATION = 436.3 M
DOWNSTREAM ELEVATION = 435.4 M
ELEVATION DIFFERENCE = 0.9 M
GRADIENT PERCENT = 0.15%
SUB BASIN AREA = 467 HA

REFERENCE

ELEVATION DATA: LIDAR, 2013
IMAGERY: ORTHOPHOTO, 2013
DATUM: NAD83 PROJECTION: UTM ZONE 12

DOCUMENT

FISH AND FISH HABITAT BASELINE REPORT

PROJECT

DOMINION DIAMOND™

JAY PROJECT
NORTHWEST TERRITORIES, CANADA

TITLE

GRADIENT PROFILE FOR STREAM C3 - C2

Golder Associates

PROJECT		13-1328-0041	FILE No. B_JC_Aqua_023_GIS
DESIGN	ANK	17/01/2014	SCALE AS SHOWN REV. 0
GIS	JG	9/10/2014	
CHECK	CG	9/10/2014	MAP 3.2-8
REVIEW	SM	9/10/2014	

Lake D3 (Counts)

The shoreline of Lake D3 (Counts) was boulder dominant with shrubs, mosses, cobble, and grasses. The littoral zone consisted of cobble and boulder substrates with occasional patches of gravel and sand. The deepest area surveyed was 26.8 m. Shoreline area cover was provided by substrate, emergent vegetation (*Carex* sp.), and depth. Surrounding riparian vegetation comprised small shrubs, grasses, and moss. No true macrophytes were present at the time of the survey. At the west shoreline, steep bedrock and boulder habitats were present with deep water near the shoreline. A boulder garden was identified in the southeast corner of the lake, which prevented boat passage to that location. Surface water quality parameters measured during the field evaluation on August 30, 2013 are provided in Table 3.2-1.

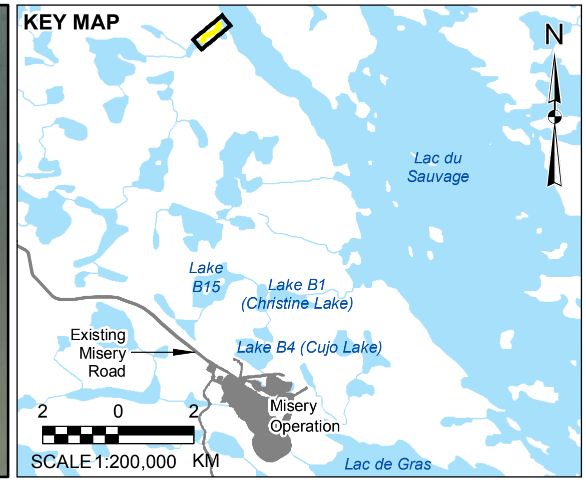
Lake D4

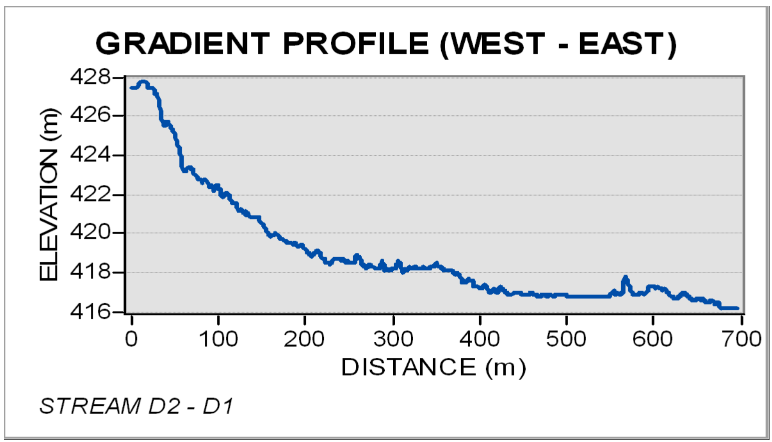
Lake D4 shoreline consisted of boulders and large cobble (95%) with grassy zones (5%). Surrounding riparian vegetation was comprised of grasses, forbs, and small shrubs. The littoral zone consisted mainly of cobble and bedrock substrates (95%), with clay and silt in a grassy shrubby area (5%). The deepest area surveyed was relatively deep, measuring at least 29.7 m. Shoreline area cover for fish was provided by emergent vegetation (*Carex* sp.), substrate, and depth. There are very steep slopes along all shores of Lake D4 with no gradual change in depth (i.e., the availability of littoral habitats may be limited). Surface water quality parameters measured during the field evaluation on August 31, 2013 are provided in Table 3.2-1.

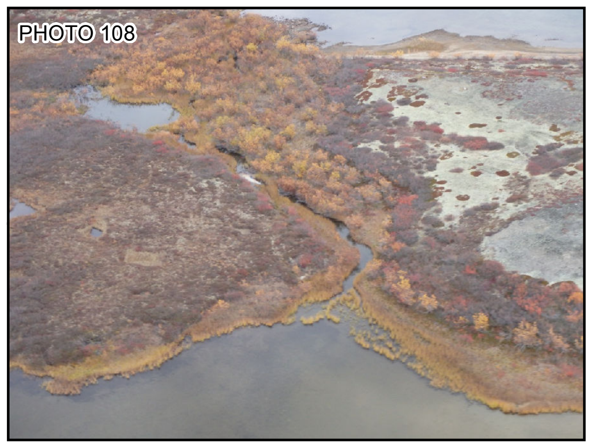
Stream D1

A detailed habitat evaluation of Stream D1 was completed on September 15, 2013, along 129 m of the entire watercourse from Lac du Sauvage to the outlet of Lake D1 (Map 3.2-9). The watercourse had a mean bankfull width of 4.7 m, a mean wetted width of 4.5 m, and a maximum depth of 1.0 m. Water quality parameters measured during the field evaluation are provided in Table 3.2-2.

Instream habitat consisted mostly of shallow pools (69%), with shallow (18%) and moderately deep run habitat (4%), and riffles (1%). Cover comprised aquatic/emergent vegetation and overhanging riparian vegetation, with small patches of cover provided by woody debris, substrate, undercut banks, and depth. The substrate consisted mostly of organics with patches of cobble and gravel, certain locations had sand and boulder. Organics covered most of the substrate in the stream. No obvious barriers to fish movements were identified on Stream D1 at the time of sampling. The slope of the stream measured 0.6% by GIS (Table 3.2-3).







LEGEND

EKATI MINE FOOTPRINT
WATERCOURSE
WATERBODY
STREAM LOCATION

STATISTICS

LENGTH = 695.9 M
UPSTREAM ELEVATION = 427.4 M
DOWNSTREAM ELEVATION = 416.1 M
ELEVATION DIFFERENCE = 11.3 M
GRADIENT PERCENT = 1.62%
SUB BASIN AREA = 725 HA

REFERENCE

ELEVATION DATA: LIDAR, 2013
IMAGERY: ORTHOPHOTO, 2013
DATUM: NAD83 PROJECTION: UTM ZONE 12

DOCUMENT

FISH AND FISH HABITAT BASELINE REPORT

PROJECT
DOMINION DIAMOND
JAY PROJECT
NORTHWEST TERRITORIES, CANADA

TITLE
GRADIENT PROFILE FOR STREAM D2 - D1

Golder Associates

PROJECT	13-1328-0041		FILE No. B_JC_Aqua_024_GIS
DESIGN	ANK	17/01/2014	SCALE AS SHOWN REV. 0
GIS	JG	9/10/2014	MAP 3.2-9
CHECK	CG	9/10/2014	
REVIEW	SM	9/10/2014	

3.2.3.3.4 Small Sub-Basins

Ab Sub-Basin

Sub-basin Ab is located to the southeast of Lac du Sauvage internal basin Ab. Lake Ab2 is the only waterbody in the sub-basin evaluated as part of the 2013 program. Lake Ab2 is relatively small, only 11 ha (Table 3.2-3). Stream Ab2 drains east from Lake Ab2 for a distance of 448 m before entering internal basin Ab of Lac du Sauvage. Photographs of the waterbodies are provided in Appendix B.

Lake Ab2

Lake Ab2 shoreline was grass and shrub dominant with boulder. The littoral zone consisted mainly of grasses and fines covering a layer of bedrock and boulders with emergent vegetation (*Carex* sp.). The substrate in the centre of the lake was predominately fine and organic substrates. The lake was shallow, with depths typically 0.5 m. The deepest area was 0.63 m. Although CanVec data describe the waterbody as one contiguous lake (Table 3.2-3), the site visit described Lake Ab2 as two lakes split by a low-gradient, small stream consisting of grasses and boulders. Flows within this stream-like area were present at the time of sampling but passage for large fish would be impeded during low water conditions (see photographs in Appendix B). Cover was mostly provided by riparian vegetation at the shoreline (e.g., overhanging shrubs). Surface water quality parameters measured during the field evaluation on September 14, 2013 are provided in Table 3.2-1.

Stream Ab2

A detailed habitat evaluation of Stream Ab2 was completed on September 14, 2013, along 50 m of the watercourse from the outlet of Lake Ab2. The watercourse had a mean bankfull and wetted width of 4 m, with a maximum bankfull depth of approximately 0.5 m, and would likely freeze to the bed in winter months given the shallow depths of the stream (Table 3.2-2). Surface water quality parameters measured during the field evaluation on September 14, 2013 are provided in Table 3.2-2.

Instream habitat for Ab2 consisted entirely of shallow runs. Cover was provided by emergent/aquatic vegetation, with cover provided by substrate. The substrate was dominated by boulder and organics, with cover provided by bedrock and occasional patches of cobble, and silt. Sub-surface flows and low-flow areas were noted in the stream at the time of sampling as a possible barrier to upstream movements of fish from Lac du Sauvage.

Ac Sub-Basin

Sub-basin Ac is northeast of Lac du Sauvage internal basin Ac, and includes Lake Ac17 (77 ha) and Lake Ac20 (5 ha) (Table 3.2-3). Lake Ac17 was evaluated as part of the 2013 field program. Lake Ac17 sub-catchment is relatively small, measuring 404 ha. Stream Ac17 drains south from Lake Ac17 for a short distance before entering internal basin Ac of Lac du Sauvage. Stream Ac20 drains west from Lake Ac20 into the internal basin Ac of Lac du Sauvage. Lake Ac20 sub-catchment is only 182 ha in size. Photographs of the waterbodies are provided in Appendix B.

Lake Ac17

Lake Ac17 shoreline was boulder and bedrock dominant with grasses and shrubs (willow [*Salix* sp.]). The littoral zone consisted mainly of boulder and cobble substrates with occasional areas of fines. Fines were dominant in the centre of the lake. The lake was shallow, with depths of approximately 1 m. The deepest area was 2.2 m. Shoreline cover was mostly provided by overhanging riparian vegetation, turbidity, substrate, and depth, with occasional areas of emergent vegetation (*Carex aquatilis* var. *aquatilis*), flooded terrestrial vegetation (e.g., *Ranunculus* sp.), small woody debris, and undercut banks. Surface water quality parameters measured during the field evaluation on September 7, 2013 are provided in Table 3.2-1.

Stream Ac17

Stream Ac17 is an ephemeral stream leading from Lake Ac17 to Lac du Sauvage. At the time of the survey, the outlet of Lake Ac17 had standing water, but downstream locations lacked a defined channel and were often overgrown with dense willow and grasses. The watercourse was dry at many locations downstream of the lake outlet but was surveyed for its entire length. The low-flows or lack of flows observed in Stream Ac17 during late summer clearly represent a barrier for upstream movement of fish from Lac du Sauvage.

Stream Ac20

Stream Ac20 is an ephemeral watercourse without defined bed or banks. Substrates consisted of boulder and cobble at the mouth where the watercourse enters Lac du Sauvage. Stream Ac20 was dry with a few wet patches as the drainage moves through dense willows. Gravels were observed in dry areas. The low-flows or lack of flows in Stream Ac20 observed during late summer clearly represented a barrier for upstream movement of fish from Lac du Sauvage.

Ad Sub-Basin

Sub-basin Ad is northwest of Lac du Sauvage internal basin Ad. Lake Ad8 was the only lake waterbody in the sub-basin evaluated as part of the 2013 field program. Lake Ad8 encompasses a relatively small sub-catchment area of only 104 ha, of which Lake Ad8 itself represents 17 ha (Table 3.2-3). Stream Ad8, which was also considered, drains south from Lake Ad8 for approximately 225 m before entering internal basin Ad of Lac du Sauvage. Photographs of the waterbodies are provided in Appendix B.

Lake Ad8

Lake Ad8 shoreline was shrub and grass dominant with boulder and undercut banks. The littoral zone consisted mainly of boulder and cobble substrates with areas of fines, and submergent and emergent (*Carex aquatalis aquatalis* sp.) vegetation. The limnetic zone consisted mainly of fine substrates with few boulders. The southern part of Lake Ad8 was shallow, typically less than 1 m, and encompassed most of the aquatic and emergent vegetation found in the lake, while the north end of the lake was deeper, typically 4 to 5 m. The deepest area surveyed was 5.3 m. Sedge wetlands were present along the shoreline, which graded into shallow water. Shoreline area cover was provided by boulder substrate, overhanging riparian vegetation, undercut banks, depth, and emergent and submergent (species unknown) vegetation. Surface water quality parameters measured during the field evaluation on September 5, 2013 are provided in Table 3.2-1.

Stream Ad8

Stream Ad8 is an ephemeral watercourse without defined bed or banks that connects Lake Ad8 to Lac du Sauvage. Grasses and shrubs have overgrown the drainage. Wet areas were noted along the watercourse during the time of the survey but the entire area was more of a dry marsh than a stream. The stream provided no habitat for fish at the time of sampling (Map 3.2-10).

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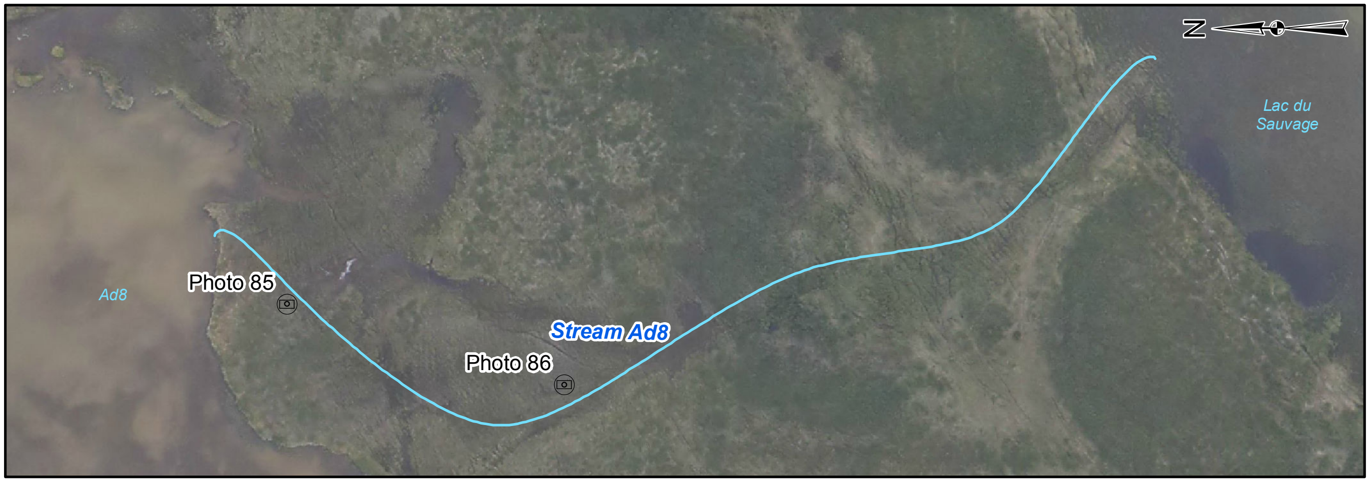
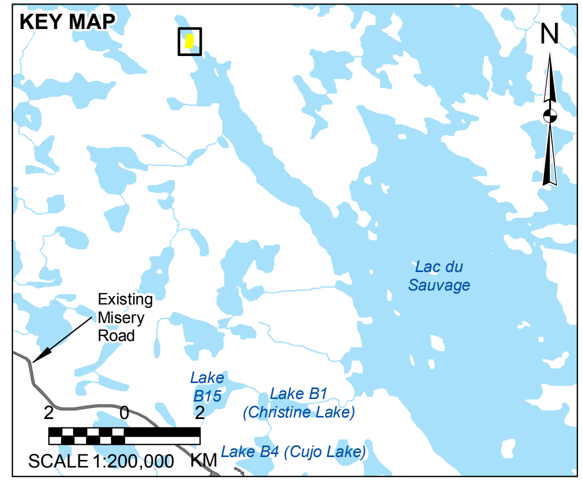
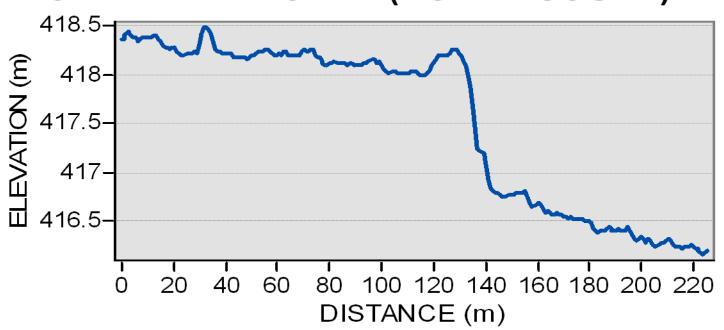
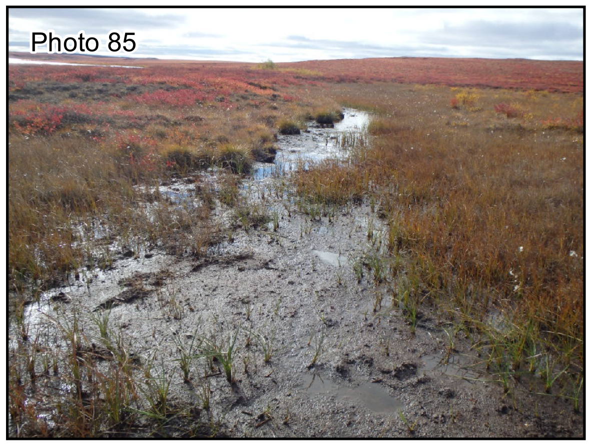


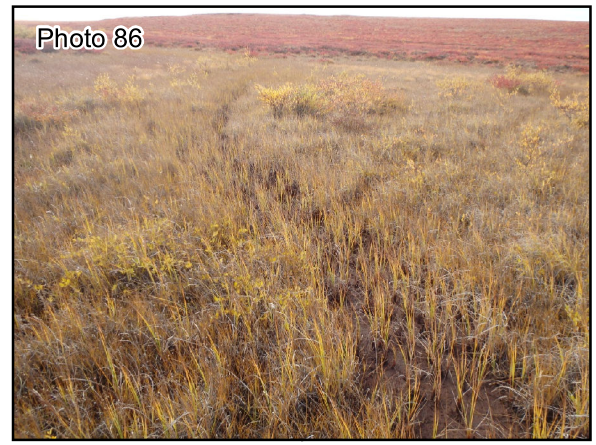


GRADIENT PROFILE (NORTH-SOUTH)



STREAM Ad8





LEGEND

EKATI MINE FOOTPRINT
WATERCOURSE
WATERBODY
STREAM LOCATION

STATISTICS

LENGTH = 225.2 M
UPSTREAM ELEVATION = 418.4 M
DOWNSTREAM ELEVATION = 416.1 M
ELEVATION DIFFERENCE = 2.3 M
GRADIENT PERCENT = 1.02%
SUB BASIN AREA = 104 HA

REFERENCE

ELEVATION DATA: LIDAR, 2013
IMAGERY: ORTHOPHOTO, 2013
DATUM: NAD83 PROJECTION: UTM ZONE 12

DOCUMENT

FISH AND FISH HABITAT BASELINE REPORT

PROJECT

DOMINION DIAMOND

JAY PROJECT
NORTHWEST TERRITORIES, CANADA

TITLE

GRADIENT PROFILE FOR STREAM Ad8

Golder Associates

PROJECT		13-1328-0041	FILE No. B_JC_Aqua_019_GIS	
DESIGN	ANK	17/01/2014	SCALE AS SHOWN	REV. 0
GIS	JG	9/10/2014	MAP 3.2-10	
CHECK	CG	9/10/2014		
REVIEW	SM	9/10/2014		

3.2.4 Lac de Gras Watershed

3.2.4.1 Paul Lake

Paul Lake is a medium-sized lake, located northwest of Lac du Sauvage and west of Lake E1 (Appendix B). Paul Lake sub-catchment includes 12,506 ha and drains to the south into Lac de Gras through Paul Creek (Table 3.2-3). Paul Creek is a low-gradient stream (0.6% slope), measuring 186 m in length before entering Lac de Gras (Appendix B). A discharge of 0.9403 m^3/s was measured in Paul Creek on September 9, 2013 as part of the hydrology baseline study.

3.2.4.1.1 Bathymetry

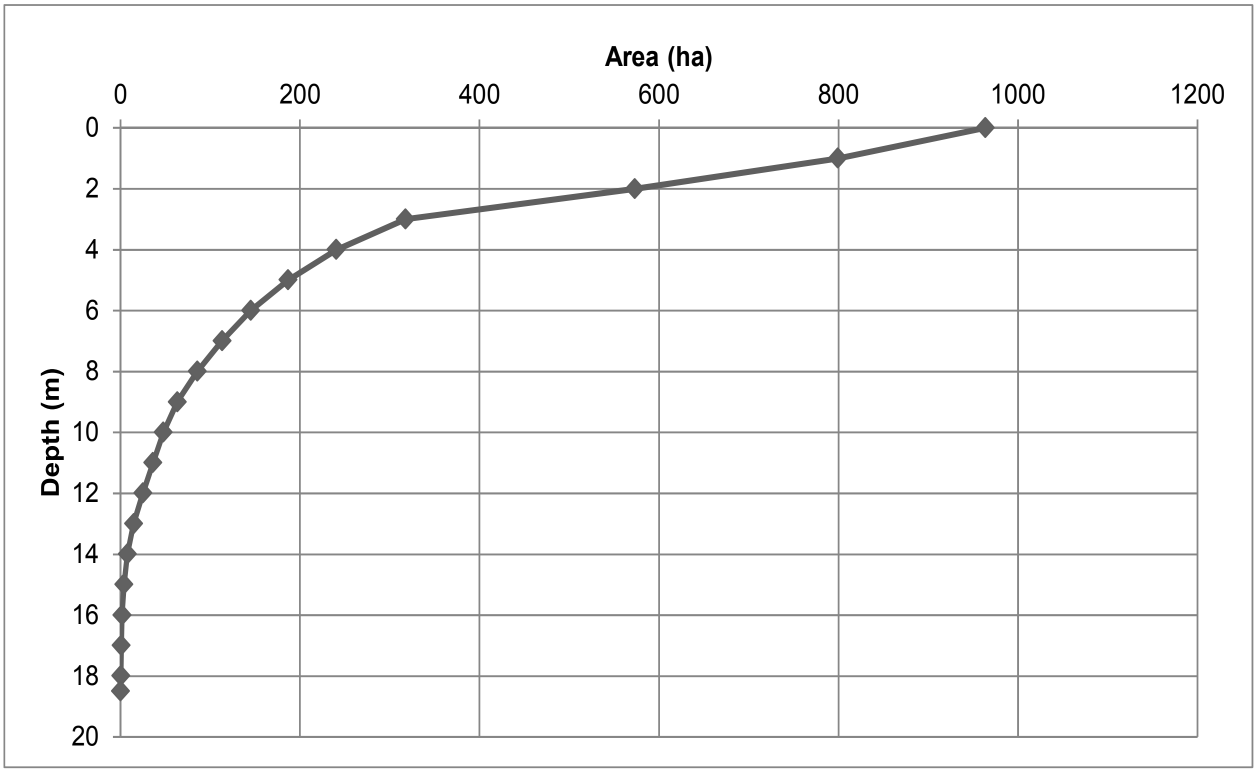
Based on previously collected bathymetry data, Paul Lake has a surface area of 964 ha and a total volume of 31,073,671 m^3. Paul Lake has a mean depth of 3 m and a maximum depth of 18.9 m. Almost 60% (573 ha) of the surface area of Paul Lake is deeper than 2 m (Table 3.2-13, Figure 3.2-14). Therefore, over 40% (391 ha) of Paul Lake may freeze to the bottom during winter.

Table 3.2-13 Vertical Distribution of Lake Area and Volume in Paul Lake

Depth (m)	Paul Lake			
	Area		Volume	
	(ha)	(%)	(m^3 x 10^3)	(%)
>0	964	100	31,074	100
>1	799	82.9	22,324	71.8
>2	573	59.5	15,401	49.6
>3	318	33.0	11,159	35.9
>4	240	24.9	8,426	27.1
>5	187	19.4	6,306	20.3
>6	145	15.1	4,663	15.0
>7	113	11.7	3,380	10.9
>8	85	8.9	2,396	7.7
>9	63	6.6	1,662	5.3
>10	48	4.9	1,115	3.6
>11	36	3.7	698	2.2
>12	25	2.6	393	1.3
>13	15	1.5	202	0.6
>14	8	0.8	95	0.3
>15	4	0.4	41	0.1
>16	2	0.2	17	0.1
>17	0.7	0.1	6	<0.1
>18	0.3	<0.1	1	<0.1
>18.5	0.1	<0.1	0	<0.1

Source: Based on 2013 bathymetry surveys by Aurora Geosciences Ltd. (2013).
m = metre; ha = hectare; % = percent; m^3 - cubic metre; > = greater than; < = less than; x = times.

Figure 3.2-14 Depth-Area Relationship for Paul Lake



m - metre; ha = hectare.

3.2.4.1.2 Shoreline Habitat

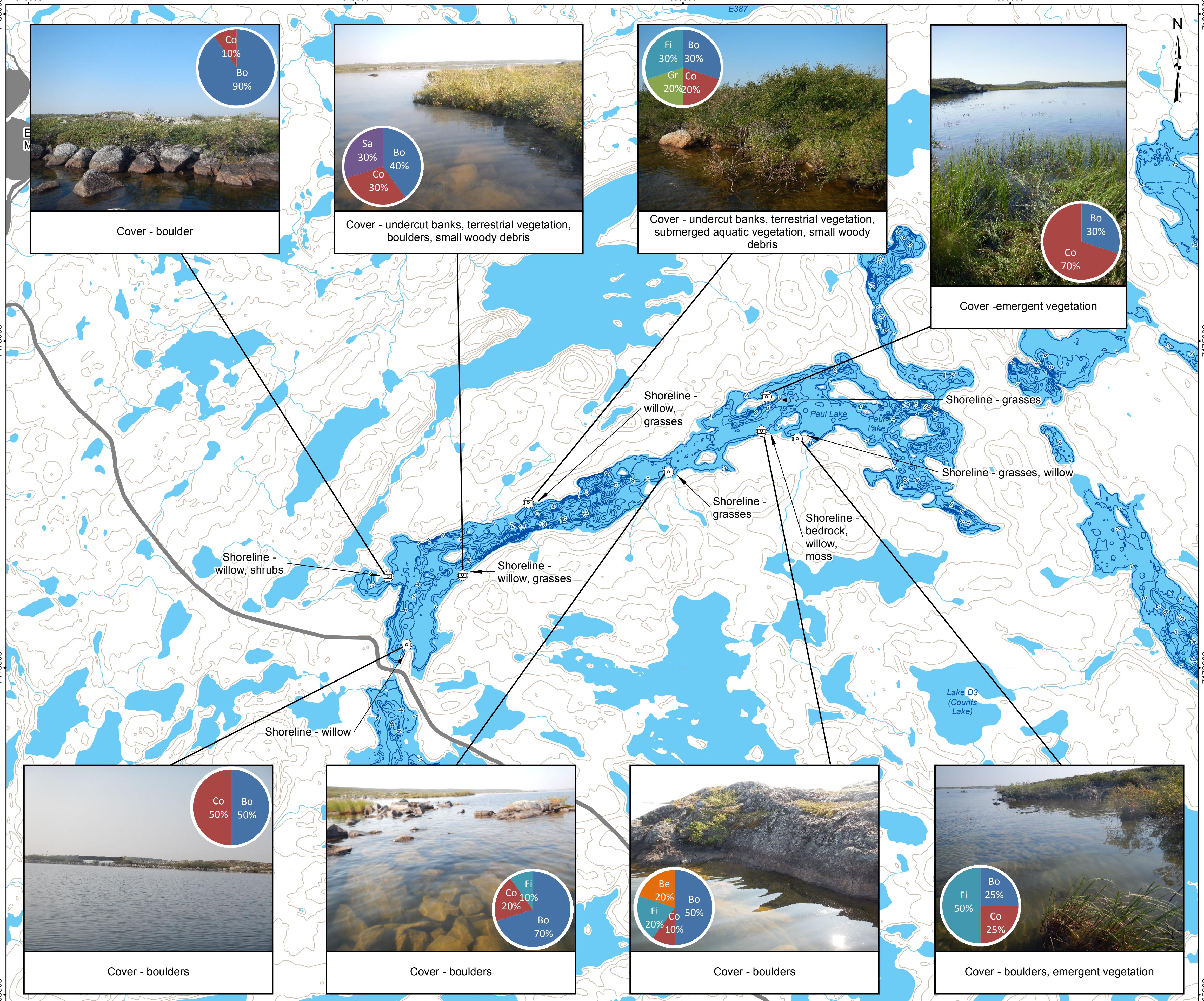
Ten representative habitat locations were considered for Paul Lake (Table 3.2-14; Map 3.2-11). The shoreline was willow dominant with many sections of boulder/bedrock and occasional areas of cobble and grasses. The littoral zone consists mainly of boulder substrate (30% to 90%) with cobble (10% to 50%) and fines (30% to 50%), and areas of emergent (i.e., sedge wetlands with *Carex aquatilis* var. *aquatilis*) and submergent vegetation. Shoreline area cover was mostly provided by substrate (boulder), depth, and areas of emergent/submergent vegetation, and overhanging shrubs, likely providing suitable foraging habitat for species such as Northern Pike (Table 3.2-14). The deepest area was 18.9 m. Many small and medium sized islands are present throughout the lake. Areas of the lake had steep drop offs in the littoral zone but most consisted of areas with a gradual decline. Surface water quality parameters taken during the field evaluation on August 10, 2013, were 18.3°C temperature, 16.4 µS/cm conductivity, 7.43 pH, and 7.45 mg/L DO (78.9% saturation).

Downstream of Paul Lake, in Paul Creek, the substrate was heavily dominated by large boulder/cobble that emerged from the water surface. The bank habitat consisted mainly of bedrock, boulders and shrubs with few areas of grasses. Gravels and fines were present underneath the bridge (likely from bridge construction activities). The bridge crosses over Paul Creek as part of the Misery Haul Road.

Table 3.2-14 Representative Shoreline Habitat in Paul Lake

Habitat Sample Number	Zone 12W		Lake Location	Dominant Riparian Features			Littoral Substrate (%)					Dominant Cover Types				
	Easting	Northing		Grass	Willow	Exposed Substrate	Bedrock	Boulder	Cobble	Gravel	Fines	Riparian Vegetation	Emergent /Submergent Vegetation	Boulders	Undercut Banks	Depth
1	531274	7174144	North shore at centre of lake	√	-	-	-	30	70	-	-	√	√	-	-	-
2	531563	7174274	Angling location at eastern side of lake; open water	-	-	√	-	-	-	-	100	-	-	-	-	√
3	532033	7174560	Angling location at eastern side of lake; open water	-	-	√	-	-	-	-	100	-	-	-	-	√
4	525779	7170349	At south shore near Paul Creek	-	√	-	-	50	50	-	-	-	-	√	-	-
5	525491	7171395	West shore at west side of lake	-	√	-	-	90	10	-	-	-	-	√	-	-
6	526633	7171412	South shore at west side of lake	√	√	-	-	40	30	30	-	√	-	√	√	-
7	527638	7172522	North shore at west side of lake	√	√	-	-	30	20	20	30	√	√	-	√	-
8	529774	7172994	South shore at centre of lake	√	-	-	-	70	20	-	10	-	-	√	-	-
9	531196	7173615	Island at south shore at east side of lake	√	√	√	20	50	10	-	20	-	-	√	-	-
10	531749	7173501	South shore at east side of lake	√	√	-	-	25	25	-	50	-	√	√	-	-

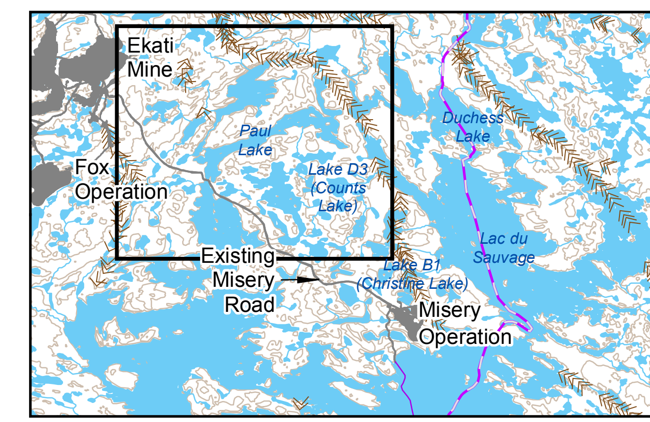
% = percent; - = not present.



LEGEND

- EKATI MINE FOOTPRINT
- BATHYMETRIC CONTOUR (2 m INTERVAL)
- ELEVATION CONTOUR (10 m INTERVAL)
- WATERCOURSE
- WATERBODY
- HABITAT ASSESSMENT AND PHOTO LOCATION

Be - BEDROCK
Bo - BOULDER
Co - COBBLE
Gr - GRAVEL
Sa - SAND
Fi - FINES



REFERENCE

CANVEC © NATURAL RESOURCES CANADA, 2012
NATURAL RESOURCES CANADA, CENTRE FOR TOPOGRAPHIC INFORMATION, 2012
BATHYMETRIC DATA OBTAINED FROM AURORA, 2013
DATUM: NAD83 PROJECTION: UTM ZONE 12N

DOCUMENT

FISH AND FISH HABITAT BASELINE REPORT

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JAY PROJECT
NORTHWEST TERRITORIES, CANADA

TITLE

SHORELINE HABITAT OF PAUL LAKE WITH REPRESENTATIVE GROUND-TRUTHED PHOTOGRAPHS

Golder Associates

PROJECT		13-1328-0041	FILE No. B_JC_AQUA_026_GIS	
DESIGN	CS	10/09/14	SCALE AS SHOWN	REV 0
GIS	JG	10/09/14		
CHECK	CG	10/09/14	MAP 3.2-11	
REVIEW	SM	10/09/14		

\\golder.gds\gal\Saskatoon\GIS\CLIENTS\DOMINION\DDEC Jay and Lynx Projects\Figures\13-1328-0041 Jay & Lynx EA\Aquatics\Baseline\B_JC_Aqua_026_GIS.mxd

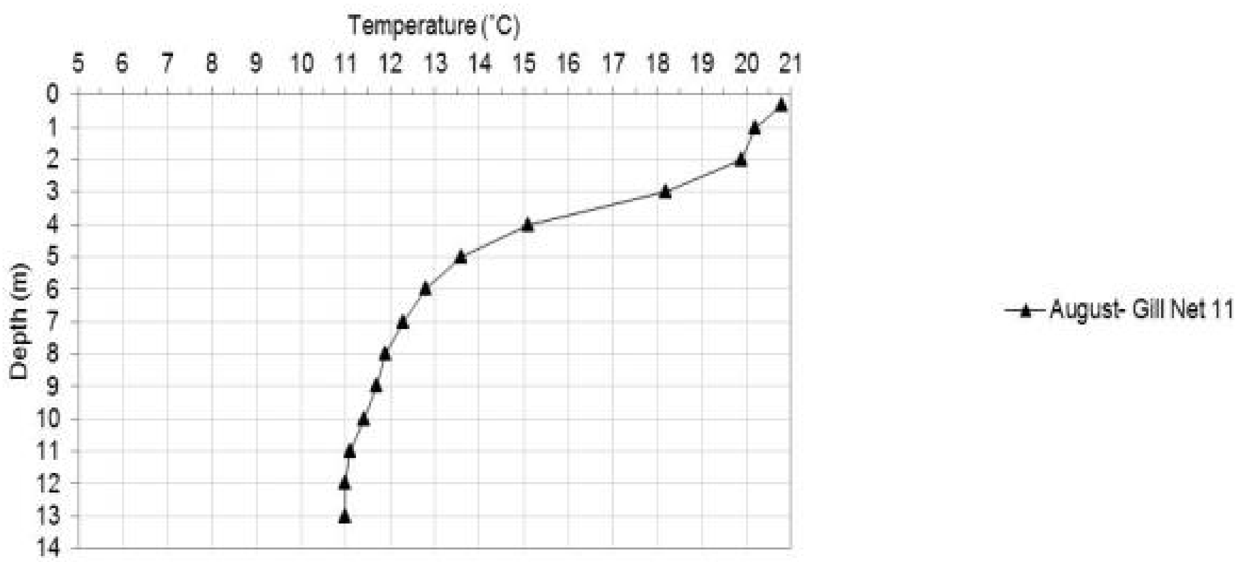
3.2.4.1.3 Vertical Profiles

Vertical profiles were taken at one gill net set (11) in Paul Lake on August 13, 2013. The profile depth was 13 m. The temperature profile generally suggested thermal stratification in Paul Lake. The thermocline was observed between 3 and 5 m depths where the temperature decreased (Figure 3.2-15). Temperatures in Paul Lake ranged from 20.8°C to 18.2°C from the surface to 3 m depths and then decreased to 15.1°C at 4 m. The temperature in the 4 to 7 m depths ranged between 15.1°C and 12.3°C. From 8 m to bottom, the temperature decreased further (range = 11.9°C to 11.0°C) (Figure 3.2-15).

Dissolved oxygen concentrations in the top 3 m ranged from 8.6 to 9.6 mg/L. Concentrations then increased at 4 to 6 m deep (range = 10.3 to 10.2 mg/L), and decreased from 7 m to bottom (range = 8.8 to 4.8 mg/L) (Figure 3.2-16). The pH levels followed the same trend as temperature and were slightly higher in the top 3 m of the water column (range = 7.3 to 7.4) than from 4 m to bottom (range = 7.2 to 6.1). The lowest pH of 6.1 was recorded at the 11 m depth (Figure 3.2-17).

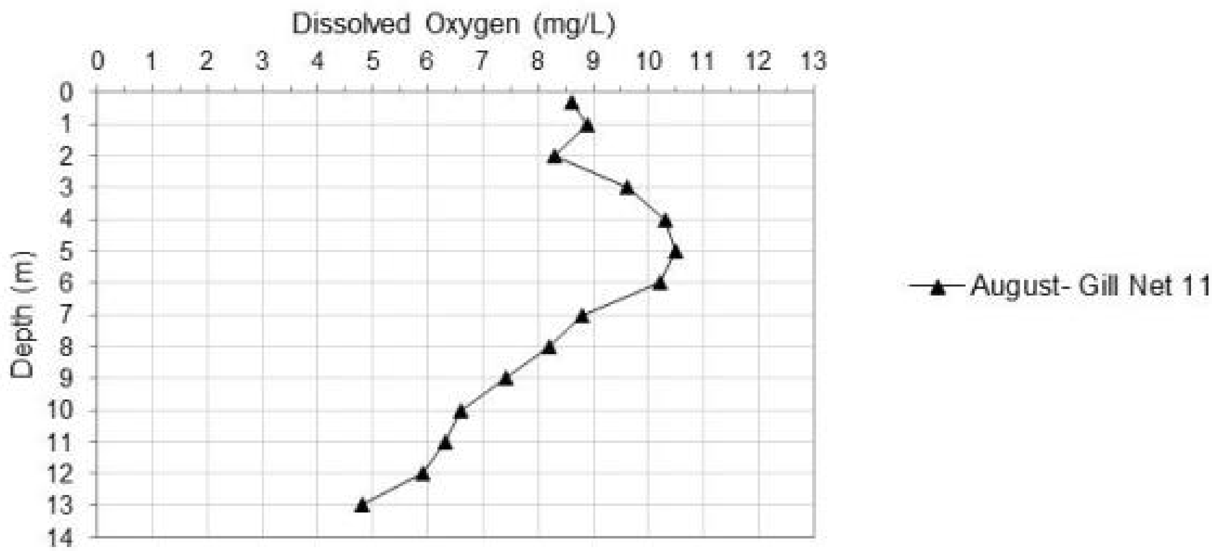
Overall, DO concentrations (CCME guideline greater than 6.5 mg/L), and pH levels (CCME guideline = 6.5 to 9.0) were typically within the range to support fish populations throughout the water column. However, pH levels were below CCME guidelines (less than 6.5) at the bottom of the lake (from 7 m to bottom). Dissolved oxygen concentrations were substantially lower (4.8 to 6.3 mg/L) from 11 m to bottom and were below CCME (2013) guidelines for the protection of aquatic life.

Figure 3.2-15 Depth-Temperature Profile for Gill Net Set 11 in Paul Lake, August 2013



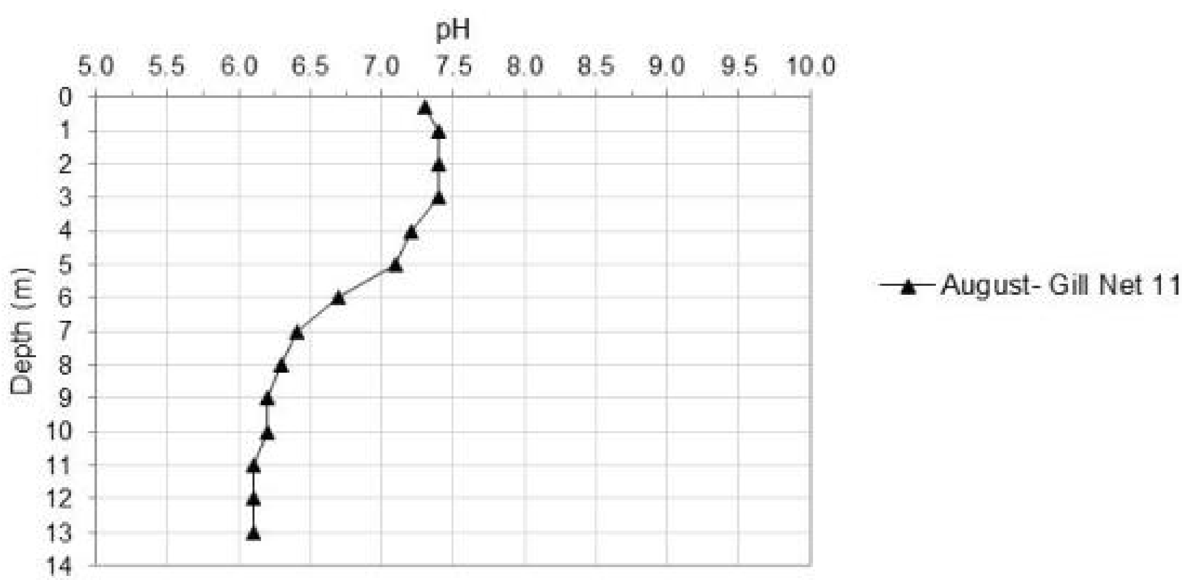
°C = degrees Celsius; m = metre.

Figure 3.2-16 Depth-Dissolved Oxygen Profile for Gill Net Set 11 in Paul Lake, August 2013



mg/L = milligrams per litre; m = metre.

Figure 3.2-17 Depth-pH Profile for Gill Net Set 11 in Paul Lake, August 2013



m = metre.

3.2.4.2 Hammer and Lynx Lakes

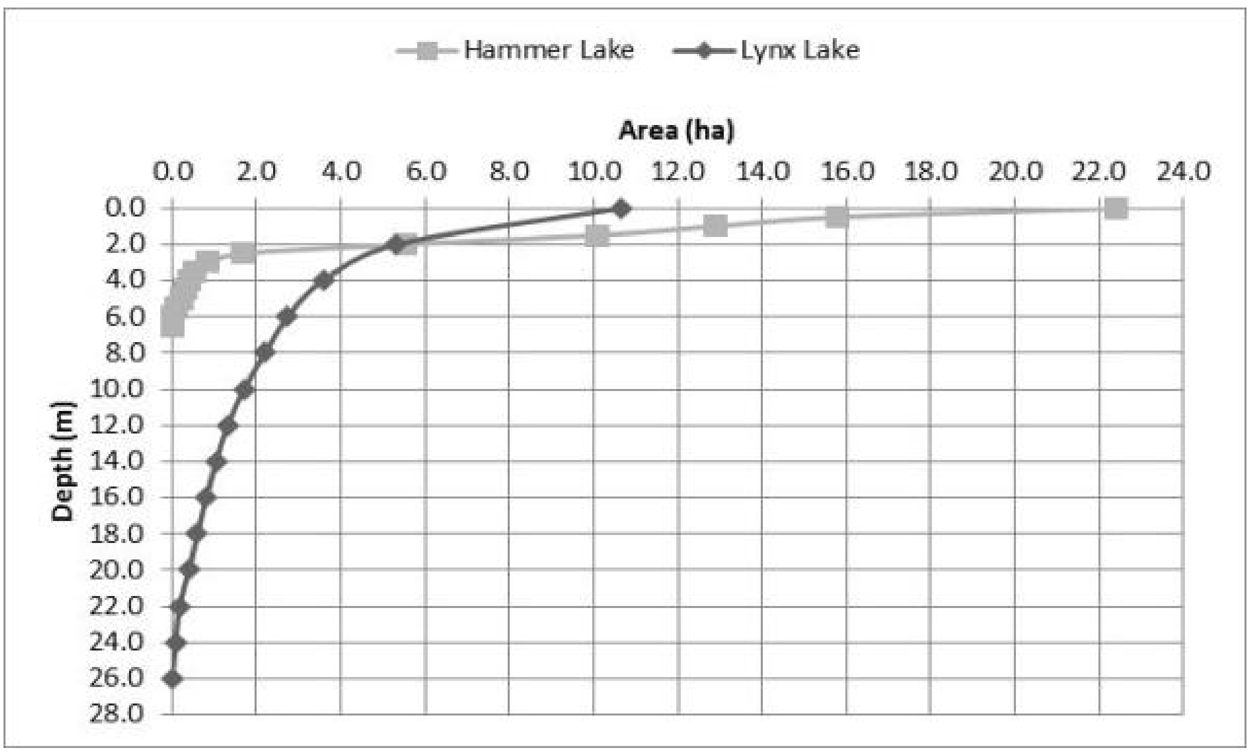
Hammer and Lynx lakes are located to the northeast of Lac de Gras and to the southwest of the B sub-basin of Lac du Sauvage (photographs in Appendix B). Both lakes represent small, representative catchments in the BSA (Table 3.2-3). Hammer Lake is 22 ha in size with a sub-catchment of 155 ha, whereas Lynx Lake is 11 ha in size with a sub-catchment of 33 ha. Both lakes drain southeast into Lac de Gras. The outlets of both lakes are ephemeral streams without defined bed and banks with modest slopes of 1.9% (Hammer Creek) and 2.4% (Lynx Creek). Photographs of the waterbodies are in Appendix B.

3.2.4.2.1 Bathymetry

Hammer Lake has a mean depth of 1.2 m and a maximum depth of 6.4 m. Hammer Lake has a total surface area of 22.4 ha and a total calculated volume of 290,464 m^3 (Appendix C, Map C-3). Lynx Lake has a mean depth of 4.6 m and a maximum depth of 25.8 m. The total surface area of Lynx Lake is 10.7 ha with a total volume of 507,599 m^3 (Appendix C).

Approximately 25% (5.5 ha) of the surface area of Hammer Lake is deeper than 2 m (Table 3.2-15), Therefore, over 75% (16.9 ha) of Hammer Lake may freeze to the bottom during winter (Figure 3.2-18). In Lynx Lake, 50% (5.33 ha) of the surface area is deeper than 2 m (Table 3.2-15), Therefore, 50% (5.33 ha) of Lynx Lake may freeze to the bottom during winter (Figure 3.2-18).

Figure 3.2-18 Depth-Area Relationship for Hammer Lake and Lynx Lake



m - metre; ha = hectare.

Table 3.2-15 Vertical Distribution of Lake Area and Volume in Lynx Lake and Hammer Lake

Depth (m)	Lynx Lake				Hammer Lake			
	Area		Volume		Area		Volume	
	(ha)	(%)	($m^3 \times 10^3$)	(%)	(ha)	(%)	($m^3 \times 10^3$)	(%)
>0	10.7	100.0	507.6	100.0	22.4	100	290.5	100
>1	8.6	80.9	413.5	81.5	12.9	57.6	129.9	44.7
>2	5.3	50.0	340.1	67.0	5.5	24.6	32.3	11.1
>3	4.1	38.8	294.8	58.1	0.8	3.7	10.2	3.5
>4	3.6	33.7	256.2	50.5	0.4	1.9	4.5	1.6
>5	3.1	29.1	222.8	43.9	0.2	1.0	1.3	0.4
>6	2.7	25.8	193.6	38.1	<0.1	0.1	<0.1	<0.1
>7	2.5	23.1	167.5	33.0	-	-	-	-
>8	2.2	20.7	144.2	28.4	-	-	-	-
>9	2.0	18.4	123.3	24.3	-	-	-	-
>10	1.7	16.0	104.9	20.7	-	-	-	-
>11	1.5	13.9	89.1	17.5	-	-	-	-
>12	1.3	12.4	75.1	14.8	-	-	-	-
>13	1.2	11.0	62.6	12.3	-	-	-	-
>14	1.0	9.8	51.5	10.2	-	-	-	-
>15	0.9	8.7	41.7	8.2	-	-	-	-
>16	0.8	7.6	33.1	6.5	-	-	-	-
>17	0.7	6.6	25.5	5.0	-	-	-	-
>18	0.6	5.7	19.0	3.7	-	-	-	-
>19	0.5	4.7	13.4	2.6	-	-	-	-
>20	0.4	3.8	8.9	1.8	-	-	-	-
>21	0.3	2.6	5.4	1.1	-	-	-	-
-	-	-	-	-	-	-	-	-
>22	0.2	1.7	3.2	0.6	-	-	-	-
>23	0.1	1.2	1.7	0.3	-	-	-	-
>24	0.1	0.8	0.7	0.1	-	-	-	-
>25	0.0	0.4	0.1	<0.1	-	-	-	-

- = not applicable; m = metre; ha = hectare; % = percent; m^3 = cubic metre; > = greater than; < = less than; x = times.

3.2.4.2.2 Shoreline Habitat

Hammer Lake was dominated by boulder/cobble (59.2%) and fines/boulder (36.6%) with boulder/fines also present (4.23%) (Appendix C). Lynx Lake was primarily composed of boulder/cobble (34.6%) and fines/boulder (13.1%) at shoreline locations (Appendix C). Side-scan sonar confirmed the deeper portions of Lynx Lake were dominated by fines, and therefore fines covered 47% of total lake area. Other substrate types found in Lynx Lake were boulder/fines (5.1%) and bedrock (0.3%).

3.2.5 Fish Community

Based on the historical reports reviewed and the 2013 sampling, a total of 513 sampling events were completed at 61 locations in the BSA during investigations of fish communities between 2006 and 2013 (Table 3.2-16; Appendix E). Of these sampling events, 35 were backpack electrofishing events, 27 were single angling events, 232 were individual gill net sets, and 219 were minnow trapping sets. Gill netting was the most commonly used sampling technique in lakes (Table 3.2-16) followed by minnow trapping, backpack electrofishing, and angling. Backpack electrofishing was the most commonly used fish capture technique used in streams, followed by minnow trapping (Table 3.2-16).

The total fish catch from surveys completed for the BSA from 2006 to 2013 (all locations and fishing methods combined) was 1,390 fish (Table 3.2-16). Of these, 1,322 fish were captured in lakes and 68 fish were captured in streams (Table 3.2-16). Sampling performed in 2013 confirmed the 11 fish species identified from previous sampling in the BSA. The 11 species were Lake Trout, Arctic Grayling, Northern Pike, Cisco, Round Whitefish, Lake Whitefish, Burbot, Longnose Sucker, Ninespine Stickleback, Lake Chub, and Slimy Sculpin.

Table 3.2-16 Summary of Fish Sampling Effort and Catch in the Baseline Study Area, 2006 to 2013

Method	Waterbody Type	Number of Sampling Events	Number of Locations Sampled	Total Effort	Total Number of Fish Captured or Observed	Overall CPUE
Gill net	Lake	232	16	472 net-units[(a)]	861	1.83 fish/net-unit
Backpack electrofishing	All	35	21	46,238 s	295	0.64 fish/100 s
	Lake	27	15	41,655 s	227	0.54 fish/100 s
	Stream	8	6	4,583 s	68	1.48 fish/100 s
Minnow trapping	All	219	17	711.2 trap-d[(b)]	143	0.20 fish/trap-d
	Lake	214	16	708.2 trap-d[(b)]	143	0.20 fish/trap-d
	Stream	5	1	2.98 trap-d[(b)]	0	0.00 fish/trap-d
Angling	Lake	27	7	115.8 rod-h	91	0.79 fish/rod-h
Total		**513**	**61**	**-**	**1,390**	**-**

a) 1 net-unit = 100 square metres (m^2) of gill net set for 1 hour.
b) 1 trap-d = one minnow trap set for 24 hours.
CPUE = catch-per-unit-effort; s = seconds; rod-h = rod hour.

3.2.5.1 Lac du Sauvage

Fish sampling effort in Lac du Sauvage between 2006 and 2013 yielded 272 captured or observed fish (Table 3.2-17). Of the 272 fish, 84 were part of 2013 sampling (Appendix E). Sampling effort focused on the western section of Lac du Sauvage, including internal basins Ac, Ad, and Ae. The overall catch comprised nine fish species. Lake Trout were the most abundant (63%), followed by Lake Whitefish (18%), Round Whitefish (11%), Slimy Sculpin (4%), Cisco (3%), Burbot (1%) and Arctic Grayling, Northern Pike and Ninespine Stickleback (less than 1% per species) (Figure 3.2-19). Note that the summary table for fish sampling effort and catch for Lac du Sauvage (Table 3.2-17) and each subsequent sub-basin shows the fish species captured or observed in that sub-basin compared to the entire list of species for the BSA to allow for comparison.

Table 3.2-17 Summary of Fish Sampling Effort and Catch in Lac du Sauvage, 2006 to 2013

Sampling Method	Effort	LKTR	ARGR	NRPK	CISC	RNWH	LKWH	BURB	LNSC	NNST	LKCH	SLSC	Total	Total CPUE
GN	131.28 net-units	87	-	-	7	27	50	-	-	-	-	-	171	1.30 fish/ net-unit
EF	3,231 s	-	1	-	-	1	-	-	-	1	-	9	12	0.37 fish/ 100 s
AN	108.77 rod-h	83	-	1	-	-	-	-	-	-	-	-	84	0.77 fish/ rod-h
MT	182.95 trap-d	-	-	-	-	1	-	3	-	-	-	1	5	0.03 fish/ trap-d
	Total	**170**	**1**	**1**	**7**	**29**	**50**	**3**	**0**	**1**	**0**	**10**	**272**	**-**

- = none caught; CPUE = catch-per-unit-effort; GN = gill net; EF = backpack electrofishing; MT = minnow trapping; 1 net-unit = 100 square metres (m^2) of net set for 1 hour; s = seconds; 1 trap-d = 1 minnow trap set for 24 hours; LKTR = Lake Trout; ARGR = Arctic Grayling; NRPK = Northern Pike; CISC = Cisco; RNWH = Round Whitefish; LKWH = Lake Whitefish; BURB = Burbot; NNST = Ninespine Stickleback; SLSC = Slimy Sculpin; LNSC = Long Nose Sucker; LKCH = Lake Chub.

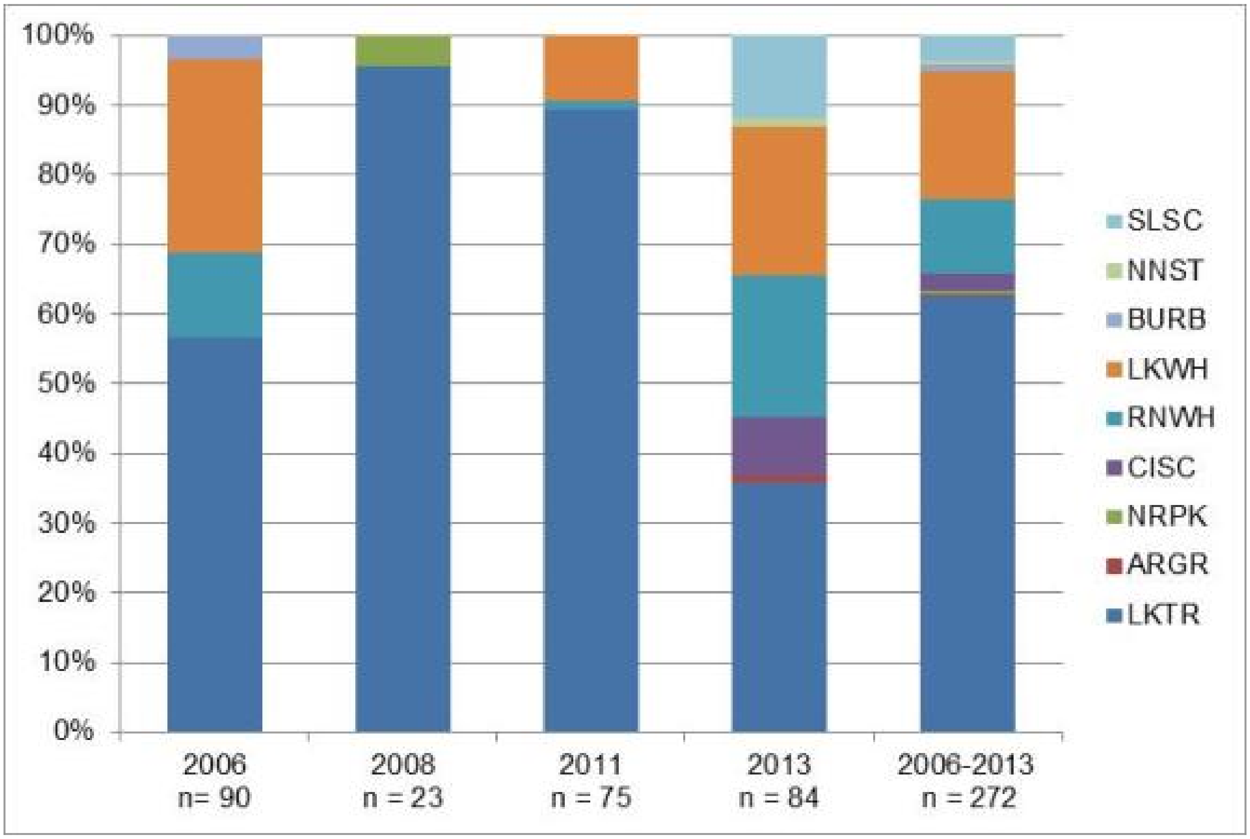
Community composition of fish varied across sampling years, which likely reflects the different methods and level of effort deployed. In 2008 and 2011, Lake Trout were targeted with angling and gill nets. In 2006 and 2013, baseline sampling targeted Lake Trout, as well as other species of the community using a variety of methods.

In 2006, 90 fish were captured or observed in Lac du Sauvage (Figure 3.2-19), with the catch consisting of four species. Lake Trout were the most abundant (57%), followed by Lake Whitefish (28%), Round Whitefish (12%), and Burbot (3%).

In 2008, 23 fish were captured or observed in Lac du Sauvage: 22 Lake Trout and 1 Northern Pike (Figure 3.2-19). In 2011, 75 fish were captured in Lac du Sauvage, with the catch consisting of 67 Lake Trout, 7 Lake Whitefish, 1 Northern Pike, and 1 Round Whitefish (Figure 3.2-19).

During 2013 field sampling, 84 fish were captured or observed in Lac du Sauvage (Figure 3.2-19). The catch consisted of seven species. Lake Trout were the most abundant (36%), followed by Lake Whitefish (22%), Round Whitefish (20%), Slimy Sculpin (12%), Cisco (8%), Arctic Grayling (1%), and Ninespine Stickleback (1%).

Figure 3.2-19 Fish Species Composition in Lac du Sauvage, 2006 to 2013



% = percent; n = number of samples; SLSC = Slimy Sculpin; NNST = Ninespine Stickleback; BURB = Burbot; LKWH = Lake Whitefish; RNWH = Round Whitefish; CISC = Cisco; NRPK = Northern Pike; ARGR = Arctic Grayling; LKTR = Lake Trout.

3.2.5.2 Duchess Lake Sub-Basin

Fish sampling efforts in 2013 in the Duchess Lake sub-basin using all methods combined yielded 274 fish of eight species. Lake Whitefish was the dominant species in Lake E1 and Duchess Lake.

3.2.5.2.1 Duchess Lake and Lake Af1

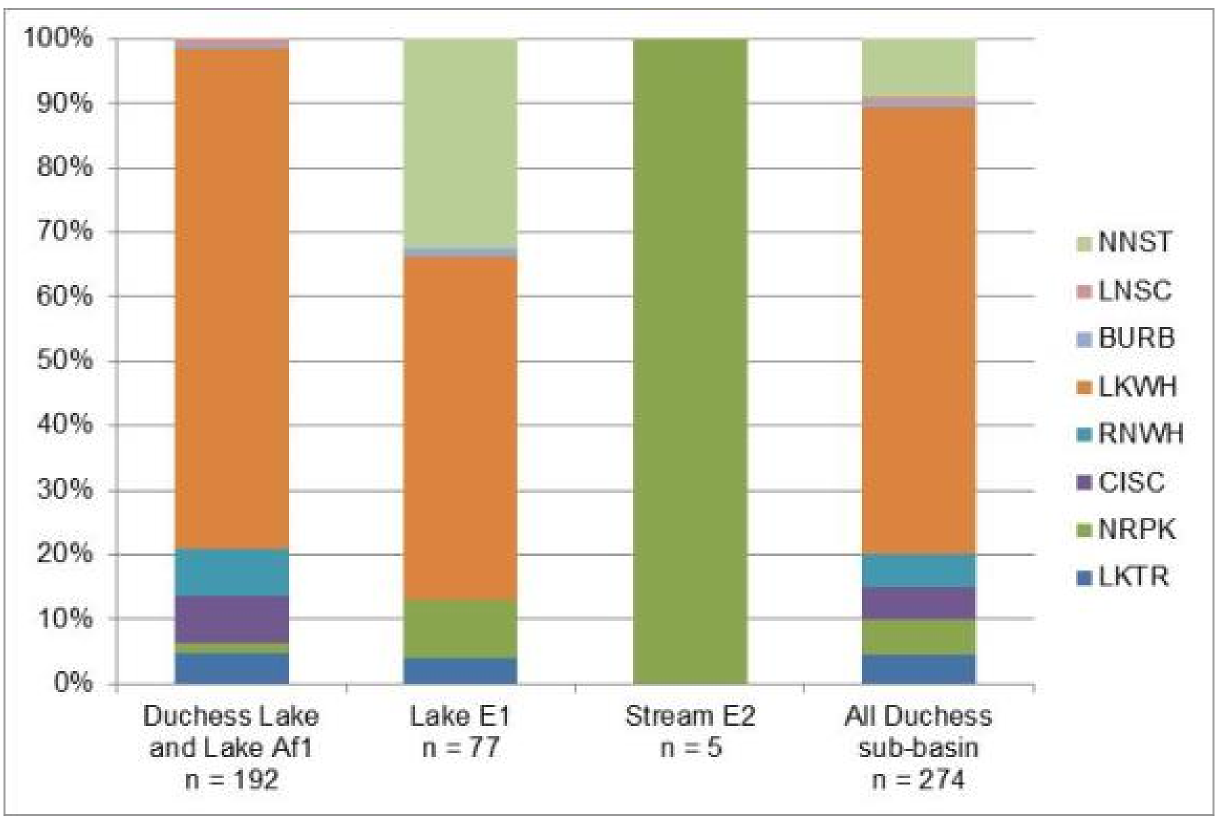
In total, 191 fish were captured or observed in Duchess Lake in 2013 (Table 3.2-18, Figure 3.2-20). The catch consisted of eight species. Lake Whitefish were the most abundant (78%), followed by Ninespine Stickleback (9%), Cisco (7%), Round Whitefish (7%), Lake Trout (5%), Northern Pike (2%), Longnose Sucker (less than 1%), and Burbot (less than 1%). The only fish captured in Lake Af1 was one Northern Pike (Table 3.2-18).

Table 3.2-18 Summary of Fish Sampling Effort and Catch in Duchess Lake, Lake E1, and Stream E2, 2013

Location	Sampling Method	Effort	LKTR	ARGR	NRPK	CISC	RNWH	LKWH	BURB	LNSC	NNST	LKCH	SLSC	Total	Total CPUE
Duchess Lake	GN	42.79 net-units	9	-	2	14	14	149	1	2	-	-	-	191	4.46 fish/ net-unit
Lake Af1	EF	2,607 s	-	-	1	-	-	-	-	-	-	-	-	1	0.038 fish/100 s
Lake E1	GN	14.91 net-units	3	-	5	-	-	41	-	-	-	-	-	49	3.29 fish/ net-unit
	EF	501 s	-	-	-	-	-	-	-	-	3	-	-	3	0.60 fish/100 s
	MT	40.87 trap-d	-	-	2	-	-	-	1	-	22	-	-	25	0.61 fish/ trap-d
Stream E2	EF	1464 s	-	-	5	-	-	-	-	-	-	-	-	5	0.34 fish/100 s
	MT	2.98 trap-d	-	-	-	-	-	-	-	-	-	-	-	0	0.00 fish/ trap-d
		Total	**12**	**0**	**15**	**14**	**14**	**190**	**2**	**2**	**25**	**0**	**0**	**274**	**-**

- = none caught; CPUE = catch-per-unit-effort; GN = gill net, EF = backpack electrofishing, AN = angling, MT = minnow trapping;1 net-unit = 100 square metres (m^2) of net set for 1 hour; s = seconds; rod-h = rod hour; 1 trap-unit = one minnow trap set for 24 hours; LKTR = Lake Trout; ARGR = Arctic Grayling; NRPK = Northern Pike; CISC = Cisco; RNWH = Round Whitefish; LKWH = Lake Whitefish; BURB = Burbot; NNST = Ninespine Stickleback; SLSC = Slimy Sculpin.

Figure 3.2-20 Fish Species Composition in Duchess Lake, Lake E1, and Stream E2, 2013



Note: Duchess Lake fish include 1 NRPK from Lake Af1.
% = percent; n = number of fish; NNST = Ninespine Stickleback; LNSC = Longnose Sucker; BURB = Burbot; LKWH = Lake Whitefish; RNWH = Round Whitefish; CISC = Cisco; NRPK = Northern Pike; LKTR = Lake Trout.

3.2.5.2.2 Lake E1

A total of 77 fish were captured or observed in Lake E1 in 2013 (Table 3.2-16, Figure 3.2-20). The catch consisted of five species. Lake Whitefish were the most abundant (53%), followed by Ninespine Stickleback (33%), Northern Pike (9%), Lake Trout (4%), and Burbot (1%).

3.2.5.2.3 Stream E2

A total of five fish were captured or observed during sampling in the lower section of Stream E2 in 2013 (Table 3.2-18, Figure 3.2-20). The catch consisted of only one species, Northern Pike (100%).

3.2.5.3 Other Lac du Sauvage Sub-Basins

Fish sampling effort in all years combined using all methods in the other sub-basins of Lac du Sauvage (Ab, Ac, Ad, B, C, D) yielded a total of 731 captured or observed fish. Round Whitefish, Arctic Grayling, Lake Trout, and Slimy Sculpin were typically the dominant species in the lakes. Catch details for each sub-basin are described in the following sections.

3.2.5.3.1 B Sub-Basin

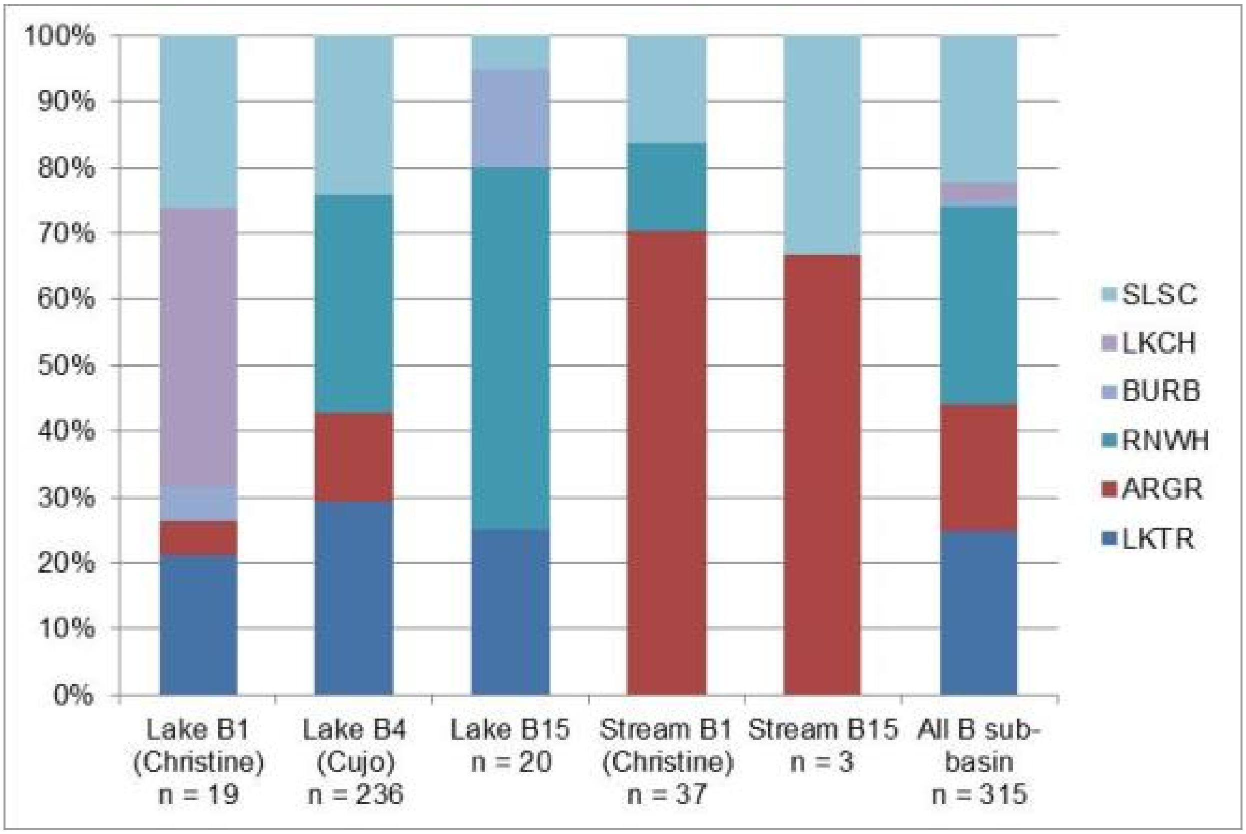
A total of 315 fish were captured or observed in the B sub-basin lakes and streams in 2007 to 2013 (Table 3.2-19, Figure 3.2-21). The catch consisted of six species. Round Whitefish were the most abundant (30%), followed by Lake Trout (25%), Slimy Sculpin (22%), Arctic Grayling (19%), Lake Chub (3%), and Burbot (1%).

Table 3.2-19 Summary of Fish Sampling Effort and Catch in the B Sub-Basin, 2007 to 2013

Location	Method	Effort	LKTR	ARGR	NRPK	CISC	RNWH	LKWH	BURB	LNSC	NNST	LKCH	SLSC	Total	Total CPUE
Lake B1 (Christine)	GN	1.83 net-units	3	-	-	-	-	-	-	-	-	-	-	3	1.64 (fish/ net-unit)
	EF	698 s	-	1	-	-	-	-	-	-	-	5	2	8	1.15 (fish/100s)
	MT	27.67 trap-d	1	-	-	-	-	-	1	-	-	3	3	8	0.29 (fish/ trap-d)
Lake B4 (Cujo)	GN	46.68 net-units	66	10	-	-	78	-	-	-	-	-	-	154	3.30 (fish/ net-unit)
	EF	14,177 s	3	22	-	-	-	-	-	-	-	-	57	82	0.56 (fish/100 s)
	MT	34.86 trap-d	-	-	-	-	-	-	-	-	-	-	-	0	0.00 (fish/ trap-d)
Lake B15	GN	7.80 net-units	5	-	-	-	11	-	-	-	-	-	-	16	2.05 (fish/ net-unit)
	EF	843 s	-	-	-	-	-	-	1	-	-	-	1	2	0.24 (fish/100 s)
	MT	35.85 trap-d	-	-	-	-	-	-	2	-	-	-	-	2	0.056 (fish/ trap-d)
Stream B1 (Christine Creek)	EF	575 s	-	26	-	-	5	-	-	-	-	-	6	37	6.43 (fish/100 s)
Stream B15	EF	603 s	-	2	-	-	-	-	-	-	-	-	1	3	0.50 (fish/100 s)
		Total	**78**	**61**	**0**	**0**	**94**	**0**	**4**	**0**	**0**	**8**	**70**	**315**	**-**

- = none caught; CPUE = catch-per-unit-effort; GN = gill net; EF = backpack electrofishing; MT = minnow trapping;1 net-unit = 100 square metres (m^2) of net set for 1 hour; s = seconds; 1 trap-d = 1 minnow trap set for 24 hours; LKTR = Lake Trout; ARGR = Arctic Grayling; NRPK = Northern Pike; CISC = Cisco; RNWH = Round Whitefish; LKWH = Lake Whitefish; BURB = Burbot; LNSC = Longnose Sucker; NNST = Ninespine Stickleback; LKCH = Lake Chub; SLSC = Slimy Sculpin.

Figure 3.2-21 Fish Species Composition for Lakes and Streams in the B Sub-Basin, 2007 to 2013



% = percent; n = number of samples; SLSC = Slimy Sculpin; LKCH = Lake Chub; BURB = Burbot; RNWH = Round Whitefish; ARGR = Arctic Grayling; LKTR = Lake Trout.

Lake B1 (Christine)

A total of 19 fish were captured or observed in Lake B1 (Christine) in 2013 (Table 3.2-19, Figure 3.2-21). The catch consisted of five species. Lake Chub were the most abundant (42%), followed by Slimy Sculpin (27%), and Lake Trout (21%). The least abundant species were Arctic Grayling and Burbot (5% each).

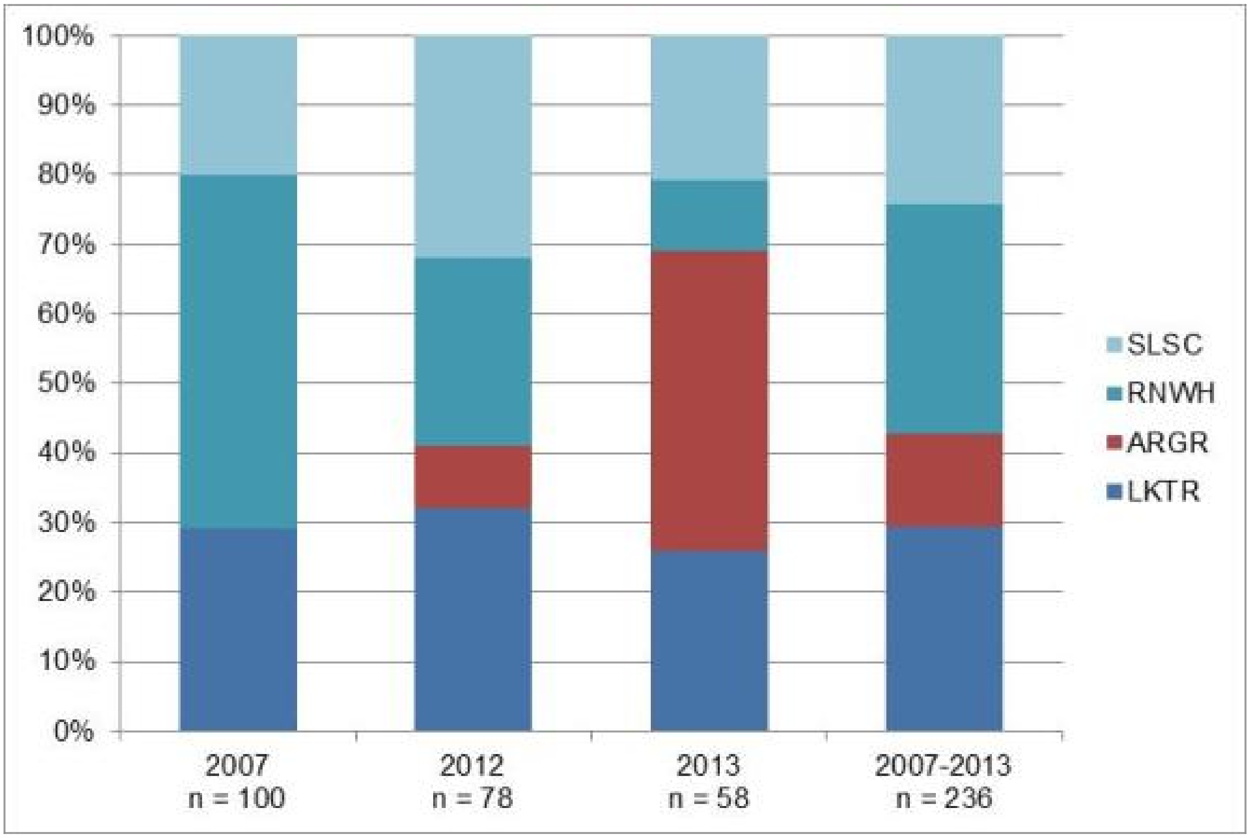
Lake B4 (Cujo)

A total of 236 fish were captured or observed in Lake B4 (Cujo) in 2007, 2012, and 2013 combined (Table 3.2-19, Figure 3.2-21). The catch consisted of four species. Round Whitefish were the most abundant (33%), followed by Lake Trout (29%), Slimy Sculpin (24%), and Arctic Grayling (14%).

Of the 236 fish captured or observed in Lake B4 (Cujo), 100 were caught in 2007 (Figure 3.2-22, Appendix E). The 2007 catch consisted of three species, with Round Whitefish being the most abundant (51%), followed by Lake Trout (29%), and Slimy Sculpin (20%).

In 2012, 78 fish were captured in Lake B4 (Cujo) (Figure 3.2-22, Appendix E). The catch consisted of four species. Lake Trout and Slimy Sculpin were the most abundant (32% each), followed by Round Whitefish (27%), and Arctic Grayling (9%).

Figure 3.2-22 Fish Species Composition in Lake B4 (Cujo), 2007 to 2013



% = percent; n = number of samples; SLSC = Slimy Sculpin; RNWH = Round Whitefish; ARGR = Arctic Grayling; LKTR = Lake Trout.

In 2013, 58 fish were captured in Lake B4 (Cujo) (Figure 3.2-21, Appendix E). The catch consisted of the same four species as in 2012, but with different relative abundances. Arctic Grayling were the most abundant (43%), followed by Lake Trout (26%), Slimy Sculpin (21%), and Round Whitefish (10%).

Community composition in Lake B4 (Cujo) was relatively consistent over the three years of sampling (Figure 3.2-22), the exception being the relative abundance of Arctic Grayling, which increased from 2007 to 2013. The increase may reflect the encounter of a patch of habitat with abundant YOY while electrofishing in 2013 (Appendix F).

Lake B15

A total of 20 fish were captured or observed in Lake B15 in 2013 (Table 3.2-19, Figure 3.2-21). The catch consisted of four species. Round Whitefish were the most abundant (55%), followed by Lake Trout (25%), Burbot (15%), and Slimy Sculpin (5%).

Stream B1 (Christine Creek)

A total of 37 fish were captured or observed in Stream B1 (Christine Creek) in 2013 (Table 3.2-19, Figure 3.2-21). The catch consisted of three species. Arctic Grayling were the most abundant (70%), followed by Slimy Sculpin (16%), and Round Whitefish (14%).

Stream B15

Three fish were captured or observed in Stream B15 in 2013 (Table 3.2-19, Figure 3.2-21), with the catch consisting of two Arctic Grayling and one Slimy Sculpin. Stream B15 and Stream B1 were characterized by a dominance of Arctic Grayling.

3.2.5.3.2 C Sub-Basin

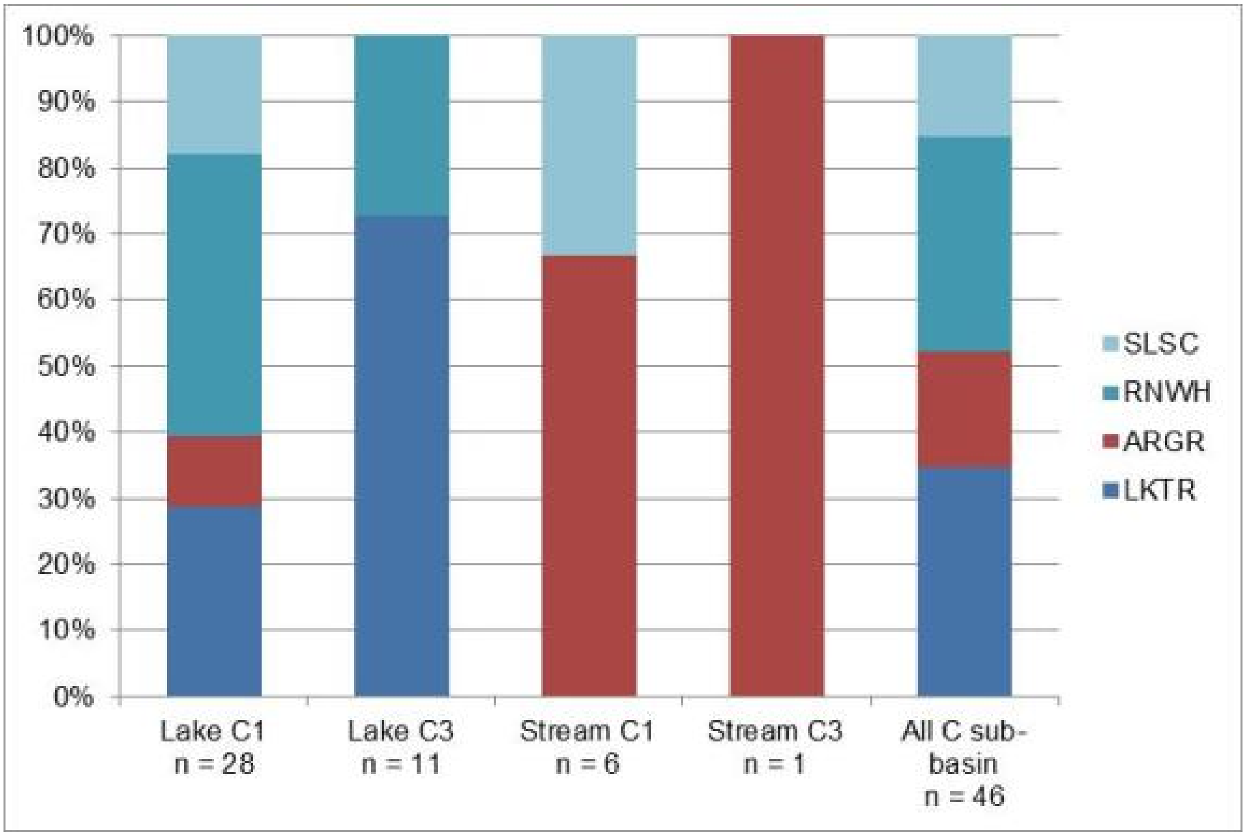
A total of 46 fish were captured or observed in the C sub-basin lakes and streams in 2013 (Table 3.2-20, Figure 3.2-23). The catch consisted of four species. Lake Trout were the most abundant (35%), followed by Round Whitefish (33%), Arctic Grayling (17%), and Slimy Sculpin (15%).

Table 3.2-20 Summary of Fish Sampling Effort and Catch in the C Sub-Basin, 2007 to 2013

Location	Method	Effort	LKTR	ARGR	NRPK	CISC	RNWH	LKWH	BURB	LNSC	NNST	LKCH	SLSC	Total	Total CPUE
Lake C1	GN	9.74 net-units	4	-	-	-	12	-	-	-	-	-	-	16	1.64 (fish/ net-unit)
	EF	1,510 s	-	3	-	-	-	-	-	-	-	-	5	8	0.53 (fish/100 s)
	AN	3.25 rod-h	4	-	-	-	-	-	-	-	-	-	-	4	1.23 (fish/rod-h)
	MT	38.54 trap-d	-	-	-	-	-	-	-	-	-	-	-	0	0.00 (fish/ trap-d)
Lake C3	GN	10.56 net-units	5	-	-	-	3	-	-	-	-	-	-	8	0.76 (fish/ net-unit)
	AN	0.8 rod-h	3	-	-	-	-	-	-	-	-	-	-	3	3.75 (fish/rod-h)
	MT	17.14 trap-d	-	-	-	-	-	-	-	-	-	-	-	0	0.00 (fish/rod-h)
Stream C1	EF	758 s	-	4	-	-	-	-	-	-	-	-	2	6	0.79 (fish/100 s)
Stream C3	EF	542 s	-	1	-	-	-	-	-	-	-	-	-	1	0.18 (fish/100 s)
Total			**16**	**8**	**0**	**0**	**15**	**0**	**0**	**0**	**0**	**0**	**7**	**46**	**-**

- = none caught; CPUE = catch-per-unit-effort; GN = gill net, EF = backpack electrofishing, AN = angling, MT = minnow trapping;1 net-unit = 100 square metres (m^2) of net set for 1 hour; s = seconds; rod-h = rod hour; 1 trap-d = 1 minnow trap set for 24 hours; LKTR = Lake Trout; ARGR = Arctic Grayling; NRPK = Northern Pike; CISC = Cisco; RNWH = Round Whitefish; LKWH = Lake Whitefish; BURB = Burbot; LNSC = Longnose Sucker; NNST = Ninespine Stickleback; LKCH = Lake Chub; SLSC = Slimy Sculpin.

Figure 3.2-23 Fish Species Composition in Lakes and Streams in C Sub-Basin, 2013



% = percent; n = number of samples; SLSC = Slimy Sculpin; RNWH = Round Whitefish; ARGR = Arctic Grayling; LKTR = Lake Trout.

Lake C1

A total of 28 fish were captured or observed in Lake C1 in 2013 (Table 3.2-20, Figure 3.2-23).The catch consisted of four species. Round Whitefish were the most abundant (43%), followed by Lake Trout (28%), Slimy Sculpin (18%), and Arctic Grayling (11%).

Lake C3

A total of 11 fish were captured or observed in Lake C3 in 2013 (Table 3.2-20, Figure 3.2-23). The catch consisted of two species: Lake Trout (73%), and Round Whitefish (27%). Arctic Grayling and Slimy Sculpin were not captured in Lake C3.

Stream C1

A total of six fish were captured or observed in Stream C1 while backpack electrofishing in 2013 (Table 3.2-20, Figure 3.2-23). The catch consisted of Arctic Grayling (4 fish), and Slimy Sculpin (2 fish).

Stream C3

Stream C3 was sampled by backpack electrofishing in 2013, which resulted in the capture of one Arctic Grayling (Table 3.2-20, Figure 3.2-23).

3.2.5.3.3 D Sub-Basin

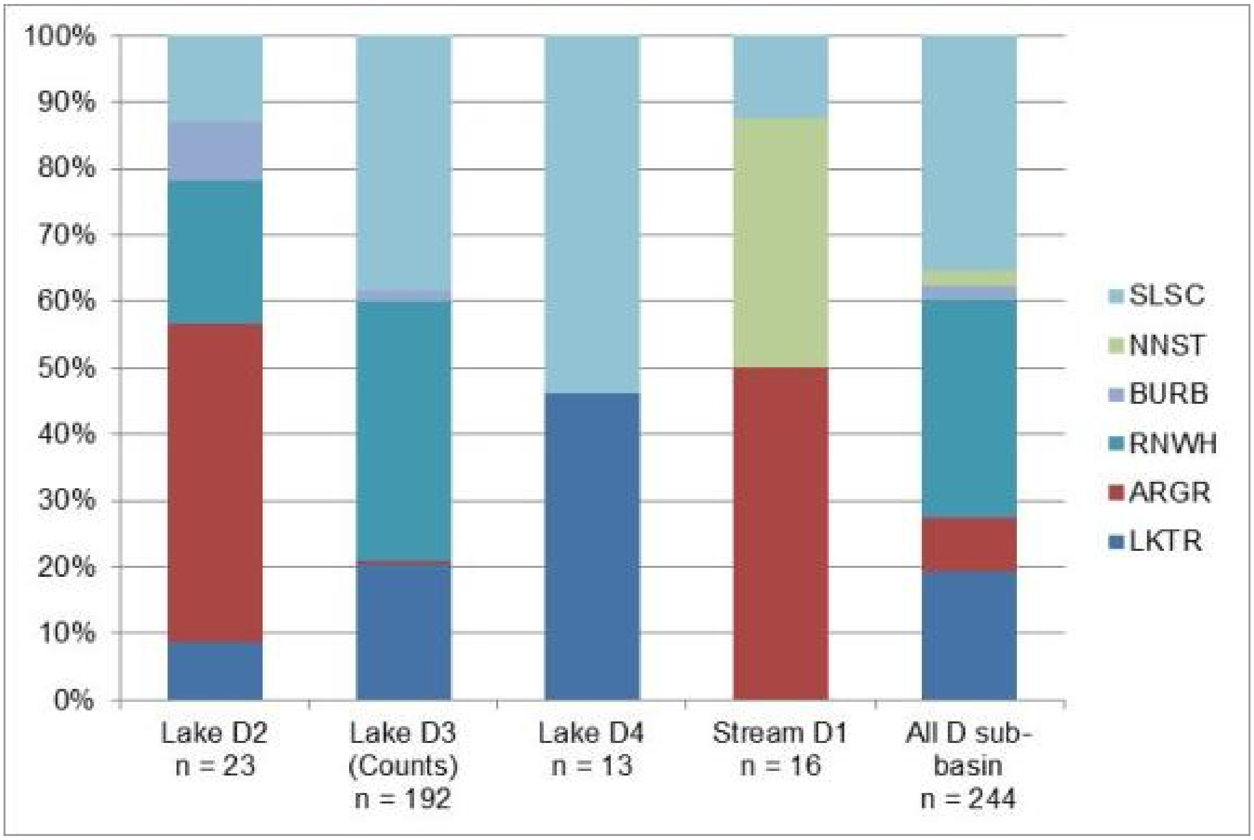
A total of 244 fish were captured or observed in the D sub-basin lakes and streams in 2013 (Table 3.2-21, Figure 3.2-24). The catch consisted of six species. Slimy Sculpin were the most abundant (35%), followed by Round Whitefish (33%), Lake Trout (19%), Arctic Grayling (8%), Ninespine Stickleback (3%), and Burbot (2%).

Table 3.2-21 Summary of Fish Sampling Effort and Catch in the D Sub-Basin, 2007 to 2013

Location	Method	Effort	LKTR	ARGR	NRPK	CISC	RNWH	LKWH	BURB	LNSC	NNST	LKCH	SLSC	Total	Total CPUE
Lake D2	GN	4.39 net-units	2	8	-	-	5	-	-	-	-	-	-	15	3.42 (fish/ net-unit)
	EF	1,042 s	-	2	-	-	-	-	1	-	-	-	3	6	0.56 (fish/100 s)
	MT	18.28 trap-d	-	1	-	-	-	-	1	-	-	-	-	2	0.11 (fish/ trap-d)
Lake D3 (Counts)	GN	54.03 net-units	36	-	-	-	74	-	-	-	-	-	-	110	2.04 (fish/ net-unit)
	EF	10,096 s	3	1	-	-	1	-	3	-	-	-	71	79	0.78 (fish/100 s)
	AN	0.5 rod-h	-	-	-	-	-	-	-	-	-	-	-	0	0.00 (fish/rod-h)
	MT	89.07 trap-d	-	-	-	-	-	-	-	-	-	-	3	3	0.034 (fish/ trap-d)
Lake D4	GN	10.25 net-units	5	-	-	-	-	-	-	-	-	-	-	5	0.49 (fish/ net-unit)
	EF	1,026 s	1	-	-	-	-	-	-	-	-	-	6	7	0.68 (fish/100 s)
	MT	35.83 trap-d	-	-	-	-	-	-	-	-	-	-	1	1	0.028 (fish/ trap-d)
Stream D1	EF	641 s	-	8	-	-	-	-	-	-	6	-	2	16	2.50 (fish/100 s)
		Total	**47**	**20**	**0**	**0**	**80**	**0**	**5**	**0**	**6**	**0**	**86**	**244**	**-**

- = none caught; CPUE = catch-per-unit-effort; GN = gill net, EF = backpack electrofishing, AN = angling, MT = minnow trapping;1 net-unit = 100 square metres (m^2) of net set for 1 hour; s = seconds; rod-h = rod hour; 1 trap-d = 1 minnow trap set for 24 hours; LKTR = Lake Trout; ARGR = Arctic Grayling; NRPK = Northern Pike; CISC = Cisco; RNWH = Round Whitefish; LKWH = Lake Whitefish; BURB = Burbot; LNSC = Longnose Sucker; NNST = Ninespine Stickleback; LKCH = Lake Chub; SLSC = Slimy Sculpin.

Figure 3.2-24 Fish Species Composition in Lakes and Streams in D Sub-Basin, 2007 to 2013



% = percent; n = number of samples; SLSC = Slimy Sculpin; NNST = Ninespine Stickleback; BURB = Burbot; RNWH = Round Whitefish; ARGR = Arctic Grayling; LKTR = Lake Trout.

Lake D2

A total of 23 fish were captured or observed in Lake D2 in 2013 (Table 3.2-21, Figure 3.2-24). The catch consisted of five species. Arctic Grayling were the most abundant (48%), followed by Round Whitefish (22%), Slimy Sculpin (13%), Lake Trout (9%), and Burbot (9%).

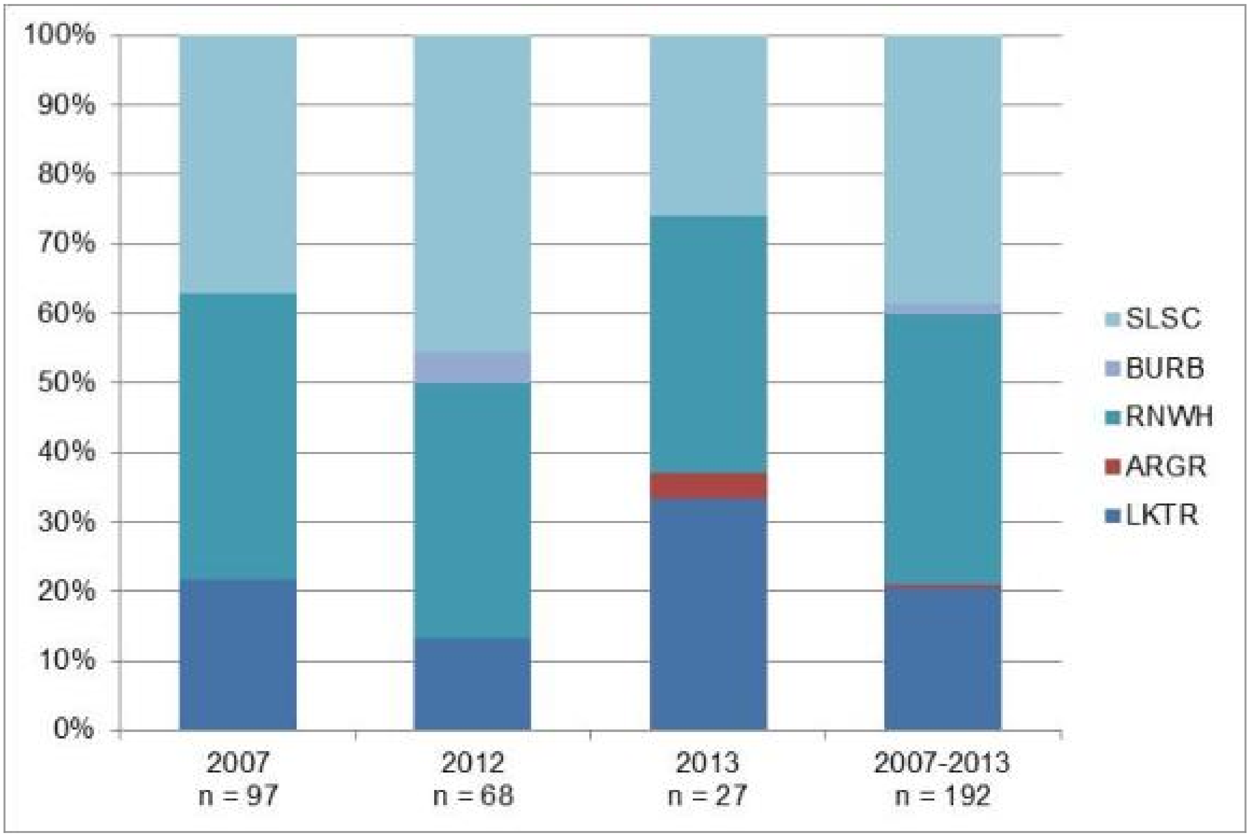
Lake D3 (Counts)

A total of 192 fish were captured or observed in Lake D3 (Counts) from 2007 to 2013 (Table 3.2-21, Figure 3.2-23). The catch consisted of five species. Round Whitefish were the most abundant (39%), followed by Slimy Sculpin (39%), Lake Trout (20%), Burbot (2%), and Arctic Grayling (less than 1%). The composition of fish was consistent across study years (Figure 3.2-25).

Of the total 192 fish documented in Lake D3 (Counts), 97 were captured in 2007 (Figure 3.2-25, Appendix E). The catch consisted of three species. Round Whitefish were the most abundant (41%), followed by Slimy Sculpin (37%), and Lake Trout (22%).

A total of 68 fish were captured in Lake D3 (Counts) in 2012 (Figure 3.2-25, Appendix E). The catch consisted of four species. Slimy Sculpin were the most abundant (46%), followed by Round Whitefish (37%), Lake Trout (13%), and Burbot (2%).

Figure 3.2-25 Fish Species Composition in Lake D3 (Counts), 2007 to 2013



% = percent; n = number of samples; SLSC = Slimy Sculpin; BURB = Burbot; RNWH = Round Whitefish; ARGR = Arctic Grayling; LKTR = Lake Trout.

A total of 27 fish were captured in Lake D3 (Counts) in 2013 (Figure 3.2-25, Appendix E). The catch also consisted of four species. Round Whitefish were the most abundant (37%), followed by Lake Trout (33%), Slimy Sculpin (26%), and Arctic Grayling (4%).

Lake D4

A total of 13 fish were captured or observed in Lake D4 in 2013 (Table 3.2-21, Figure 3.2-24). The catch consisted of two species: Slimy Sculpin (54%) and Lake Trout (46%).

Stream D1

A total of 16 fish were captured or observed in Stream D1 in 2013 (Table 3.2-21, Figure 3.2-24). The catch consisted of three species. Arctic Grayling were the most abundant (50%), followed by Ninespine Stickleback (37%), and Slimy Sculpin (13%).

3.2.5.3.4 Small Sub-Basins

A total of 126 fish were captured or observed in lakes in small sub-basins (Ab, Ac, Ad) of Lac du Sauvage in 2013 (Table 3.2-22). The catch consisted of three species. Ninespine Stickleback were the most abundant (77%), followed by Lake Whitefish (22%), and Northern Pike (less than1%).

Table 3.2-22 Summary of Fish Sampling Effort and Catch in Small Sub-Basins in the Baseline Study Area, 2007 to 2013

Location	Method	Effort	LKTR	ARGR	NRPK	CISC	RNWH	LKWH	BURB	LNSC	NNST	LKCH	SLSC	Total	Total CPUE
Lake Ab2	EF	858 s	-	-	-	-	-	-	-	-	-	-	-	0	0.00 (fish/100 s)
	MT	2.51 trap-d	-	-	-	-	-	-	-	-	-	-	-	0	0.00 (fish/ trap-d)
Lake Ac17	GN	7.04 net-units	-	-	-	-	-	-	-	-	-	-	-	0	0.00 (fish/net-unit)
	EF	966 s	-	-	-	-	-	-	-	-	1	-	-	1	0.10 (fish/100 s)
	MT	17.87 trap-d	-	-	-	-	-	-	-	-	96	-	-	96	5.37 (fish/ net-unit)
Lake Ad8	GN	5.49 net-units	-	-	1	-	-	28	-	-	-	-	-	29	5.28 (fish/ net-unit)
	EF	1,027 s	-	-	-	-	-	-	-	-	-	-	-	0	0.00 (fish/100 s)
	MT	19.00 trap-d	-	-	-	-	-	-	-	-	-	-	-	0	0.00 (fish/ trap-d)
		Total	**0**	**0**	**1**	**0**	**0**	**28**	**0**	**0**	**97**	**0**	**0**	**126**	**-**

- = none caught; CPUE = catch-per-unit-effort; GN = gill net; EF = backpack electrofishing; MT = minnow trapping;1 net-unit = 100 square metres (m^2) of net set for 1 hour; s = seconds; 1 trap-d = 1 minnow trap set for 24 hours; LKTR = Lake Trout; ARGR = Arctic Grayling; NRPK = Northern Pike; CISC = Cisco; RNWH = Round Whitefish; LKWH = Lake Whitefish; BURB = Burbot; LNSC = Longnose Sucker; NNST = Ninespine Stickleback; LKCH = Lake Chub; SLSC = Slimy Sculpin.

No fish were caught in Lake Ab2 during backpack electrofishing and minnow trapping in 2013 (Table 3.2-22). Gill nets were not used in this lake because water depths were less than 2 m.

A total of 97 fish were captured or observed in Lake Ac17 in 2013 (Table 3.2-22). The catch comprised one species, Ninespine Stickleback.

A total of 29 fish were captured or observed in Lake Ad8 in 2013 (Table 3.2-22). Lake Whitefish were the most abundant species (97%), followed by Northern Pike (3%).

3.2.5.4 Lac de Gras Sub-Basins

3.2.5.4.1 Paul Lake

A total of 81 fish were captured or observed in Paul Lake in 2013 (Table 3.2-23). The catch consisted of six species. Northern Pike were the most abundant (41%), followed by Lake Whitefish (33%), Longnose Sucker (14%), Arctic Grayling (6%), Lake Trout (4%), and Round Whitefish (2%).

DOMINION DIAMOND

Table 3.2-23 Summary of Fish Sampling Effort and Catch in Paul Lake, 2013

Sampling Method	Effort	LKTR	ARGR	NRPK	CISC	RNWH	LKWH	BURB	LNSC	NNST	LKCH	SLSC	Total	Total CPUE
GN	100.85 net-units	3	5	32	-	2	27	-	11	-	-	-	80	0.79 fish/ net-unit
AN	0.45 rod-h	-	-	-	-	-	-	-	-	-	-	-	0	0.00 fish/rod-h
MT	122.67 trap-d	-	-	1	-	-	-	-	-	-	-	-	1	0.0082 fish/ trap-d
	Total	**3**	**5**	**33**	**0**	**2**	**27**	**0**	**11**	**0**	**0**	**0**	**81**	**-**

- = none caught; CPUE = catch-per-unit-effort; GN = gill net, AN = angling, MT = minnow trapping;1 net-unit = 100 square metres (m^2) of net set for 1 hour; rod-h = rod hour; LKTR = Lake Trout; ARGR = Arctic Grayling; NRPK = Northern Pike; CISC = Cisco; RNWH = Round Whitefish; LKWH = Lake Whitefish; BURB = Burbot; LNSC = Longnose Sucker; NNST = Ninespine Stickleback; LKCH = Lake Chub; SLSC = Slimy Sculpin.

3.2.5.4.2 Hammer and Lynx Lakes

A total of 32 fish were captured or observed in Hammer and Lynx lakes, combined, in 2013 (Table 3.2-24). The catch consisted of five species. Lake Whitefish were the most abundant (28%), followed by Burbot (25%), Slimy Sculpin (22%), Lake Trout (16%), and Lake Chub (9%).

Table 3.2-24 Summary of Fish Sampling Effort and Catch in Hammer and Lynx Lakes, 2013

Location	Method	Effort	LKTR	ARGR	NRPK	CISC	RNWH	LKWH	BURB	LNSC	NNST	LKCH	SLSC	Total	Total CPUE
Hammer Lake	GN	17.48 net-units	2	-	-	-	-	2	-	-	-	-	-	4	0.23 (fish/ net-unit)
	EF	1,407 s	-	-	-	-	-	-	3	-	-	3	4	10	0.71 (fish/100 s)
	MT	20.91 trap-d	-	-	-	-	-	-	-	-	-	-	-	0	0.00 (fish/ trap-d)
Lynx Lake	GN	6.46 net-units	3	-	-	-	-	7						10	1.55 (fish/net-unit)
	EF	1,666 s							5				3	8	0.48 (fish/100 s)
	AN	1.25 rod-h												0	0.00 fish/rod-h
	MT	4.23 trap-d												0	0.00 (fish/ trap-d)
		Total	**5**	**0**	**0**	**0**	**0**	**9**	**8**	**0**	**0**	**3**	**7**	**32**	

- = none caught; CPUE = catch-per-unit-effort; GN = gill net, EF = backpack electrofishing, AN = angling, MT = minnow trapping;1 net-unit = 100 square metres (m^2) of net set for 1 hour; s = seconds; rod-h = rod hour; 1 trap-d = 1 minnow trap set for 24 hours; LKTR = Lake Trout; ARGR = Arctic Grayling; NRPK = Northern Pike; CISC = Cisco; RNWH = Round Whitefish; LKWH = Lake Whitefish; BURB = Burbot; LNSC = Longnose Sucker; NNST = Ninespine Stickleback; LKCH = Lake Chub; SLSC = Slimy Sculpin.

Hammer Lake

A total of 14 fish were captured or observed in Hammer Lake in 2013 (Table 3.2-24). The catch consisted of five species. Slimy Sculpin were the most abundant (29%), followed by Burbot and Lake Chub (22% each), and Lake Trout and Lake Whitefish (14% each).

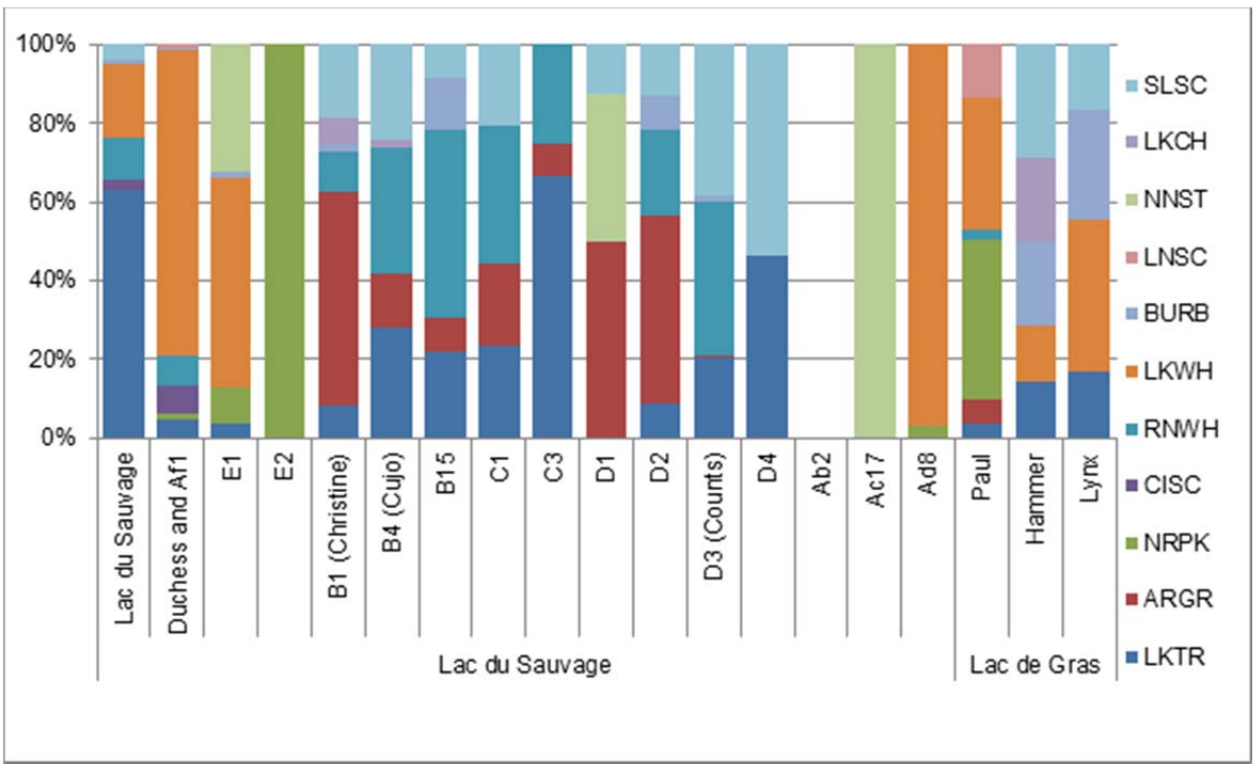
Lynx Lake

A total of 18 fish were captured or observed in Lynx Lake in 2013 (Table 3.2-24). The catch consisted of four species. Lake Whitefish were the most abundant (39%), followed by Burbot (28%), Slimy Sculpin and Lake Trout (17% each).

3.2.5.5 Summary

Based on all capture methods combined (Figure 3.2-26), fish were recorded in all sampled waterbodies and watercourses, except for Lake Ab2. Lake Trout, Arctic Grayling, Round Whitefish, and Slimy Sculpin were the dominant species found in waterbodies and watercourses in the B, C, and D sub-basins; Lake Whitefish were not captured in these sub-basins. Lake Whitefish were only caught in the Lac de Gras sub-basins, Lac du Sauvage, Lake Ad8, Duchess Lake, and Lake E1 (Figure 3.2-26). Very few Arctic Grayling were captured outside of the B, C, and D sub-basins.

Figure 3.2-26 Fish Species Composition in Lakes and Streams Sampled in the Baseline Study Area, 2006 to 2013



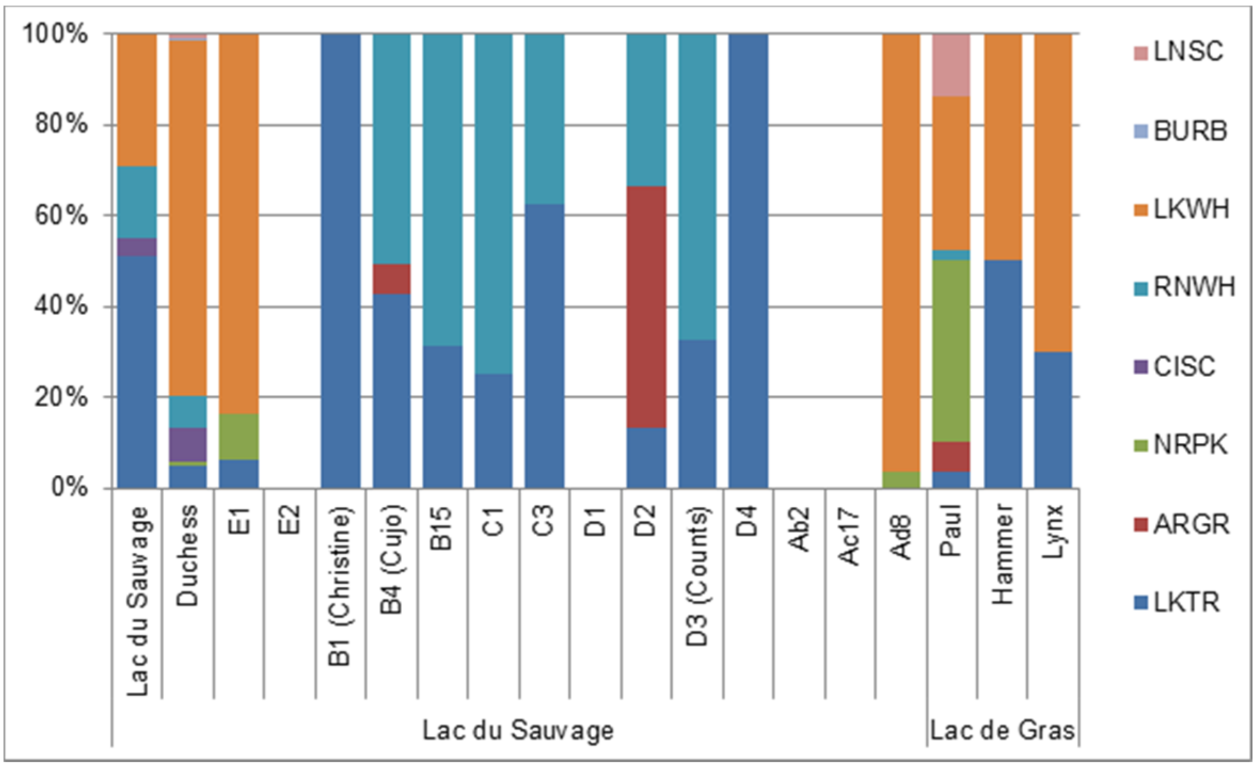
Note: Lake Af1 consists of 1 NRPK caught.

% = percent; SLSC = Slimy Sculpin; LKCH = Lake Chub; NNST = Ninespine Stickleback; LNSC = Longnose Sucker; BURB = Burbot; LKWH = Lake Whitefish; RNWH = Round Whitefish; CISC = Cisco; NRPK = Northern Pike; ARGR = Arctic Grayling; LKTR = Lake Trout.

Species relative abundance values reflect not only where effort was directed, but also the sampling methods that were used, which typically included gill netting for lakes and electrofishing for streams. However, backpack electrofishing was also conducted on lake shorelines.

Lake Trout and Round Whitefish were the dominant species caught by gill net in lakes in the B, C, and D sub-basins. Most other lakes in the BSA were dominated by Lake Whitefish and Lake Trout. In Lac du Sauvage, gill netting resulted in the capture of a large number of all three salmonids: Lake Trout, Round Whitefish, and Lake Whitefish. (Figure 3.2-27).

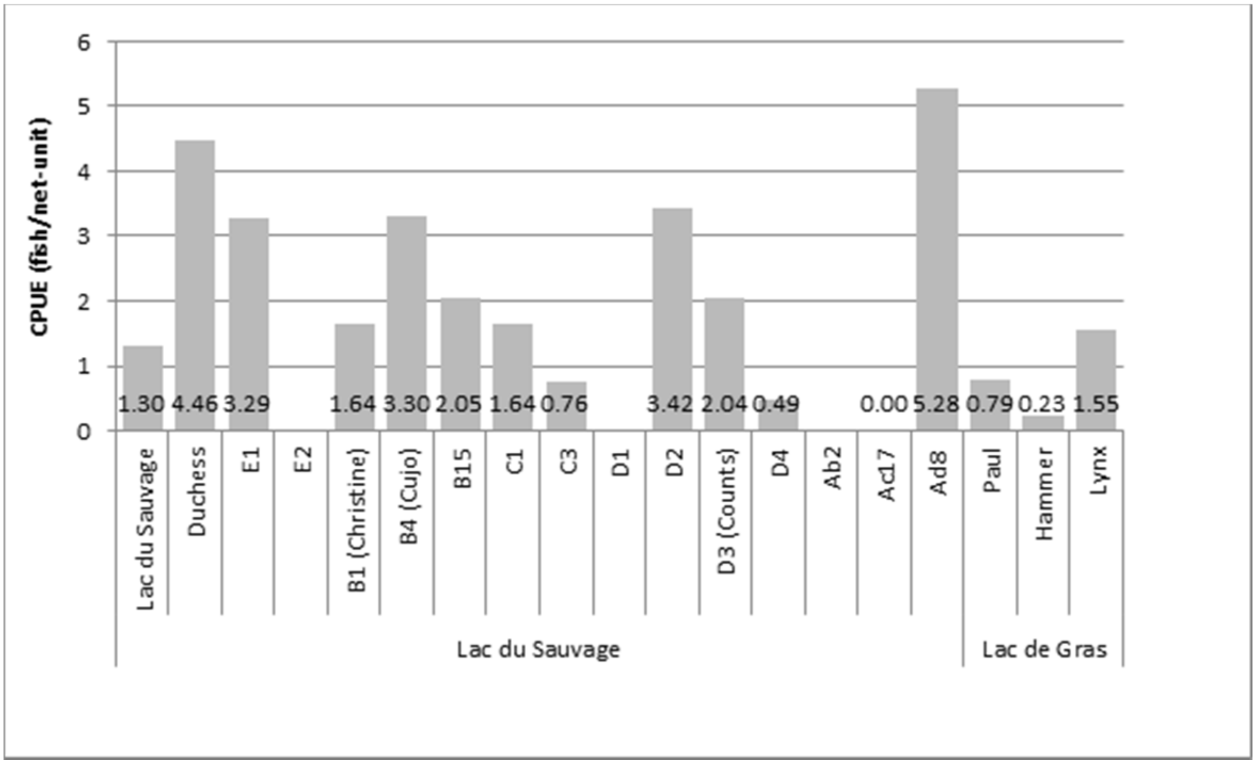
Figure 3.2-27 Fish Species Composition in Gill Nets, 2006 to 2013



% = percent; LNSC = Longnose Sucker; BURB = Burbot; LKWH = Lake Whitefish; RNWH = Round Whitefish; CISC = Cisco; NRPK = Northern Pike; ARGR = Arctic Grayling; LKTR = Lake Trout.

Gill net CPUE was the highest in Lake Ad8 and Duchess Lake, where the catches were composed mostly of Lake Whitefish. The lowest CPUE was in Lake Ac17, where no fish were caught in gill nets. In the Lake Trout and Round Whitefish-dominated lakes, Lake D2 and Lake B4 had the highest CPUE, while Lake D4 had the lowest (Figure 3.2-28). Gill nets were not set in Lake Ab2, Stream E2, or Stream D1.

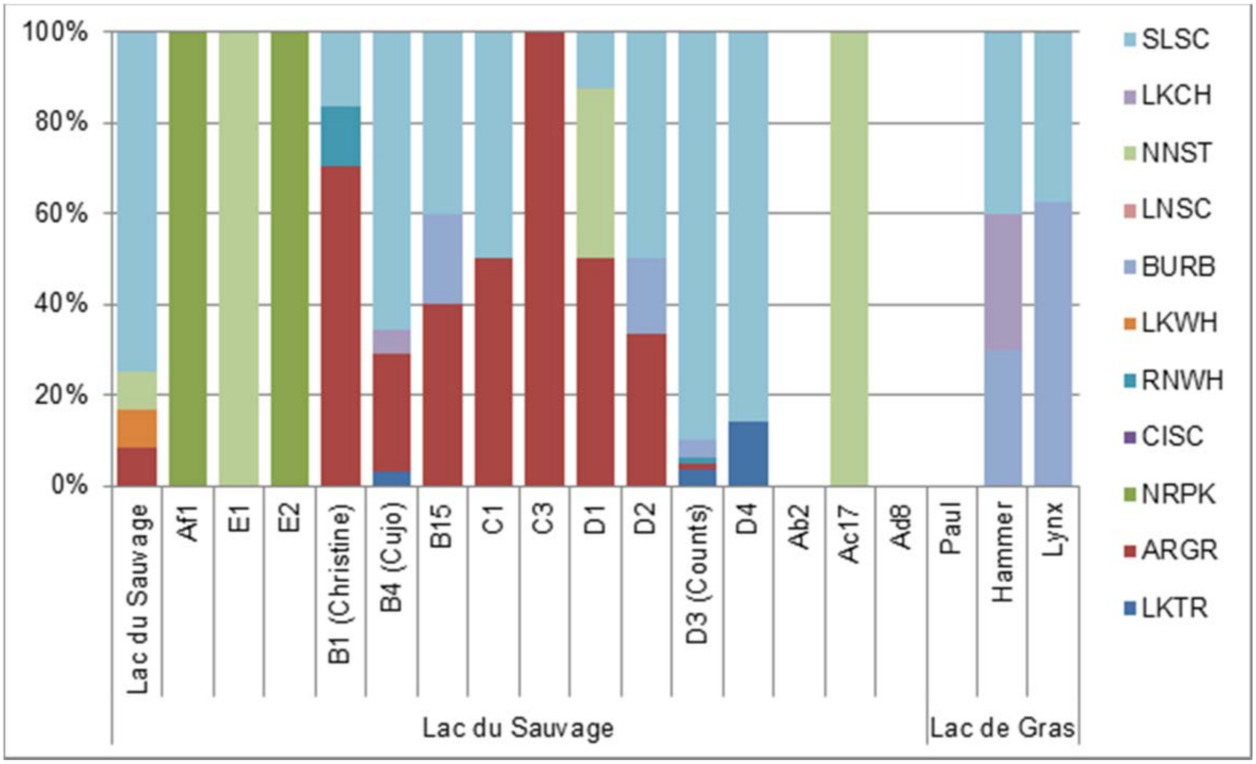
Figure 3.2-28 Fish Catch-Per-Unit-Effort Using Gill Nets, 2006 to 2013



CPUE = catch-per-unit-effort; fish/net-unit = fish caught per 100 square metres of net set for 1 hour.

Using a backpack electrofisher, Arctic Grayling were only captured in Lac du Sauvage and in lakes and streams in the B, C, and D sub-basins. The majority of the backpack electrofishing catch in Lac du Sauvage was Slimy Sculpin. Only Northern Pike were captured by electrofishing in Duchess Lake and Stream E2. Only one fish was captured during electrofishing in Lake Af1 and five in Stream E2 (Figure 3.2-29).

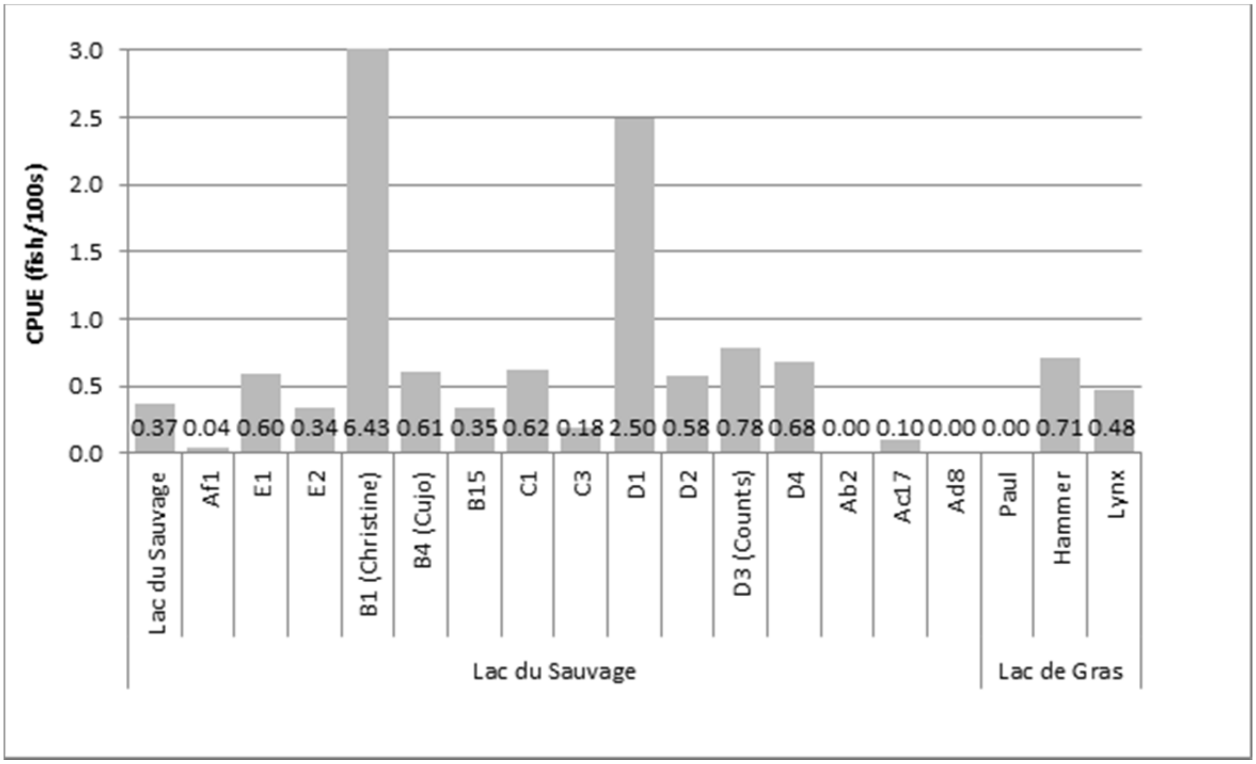
Figure 3.2-29 Fish Species Composition Using Backpack Electrofishing, 2007 to 2013



% = percent; SLSC = Slimy Sculpin; LKCH = Lake Chub; NNST = Ninespine Stickleback; LNSC = Longnose Sucker; BURB = Burbot; LKWH = Lake Whitefish; RNWH = Round Whitefish; CISC = Cisco; NRPK = Northern Pike; ARGR = Arctic Grayling; LKTR = Lake Trout.

Backpack electrofishing CPUE was the highest in Lake B1 (Christine Lake) and Stream D1, where the catches were composed mostly of Arctic Grayling. The lowest CPUE was in Lake Ab2 and Lake Ad8 where no fish were captured using backpack electrofishing. Across sub-basins B, C, and D, the highest CPUE was recorded in Lake D2 and Lake B4, while Lake D4 had the lowest CPUE (Figure 3.2-30). Backpack electrofishing was not conducted in Paul Lake.

Figure 3.2-30 Fish Catch-Per-Unit-Effort Using Backpack Electrofishing, 2007 to 2013



CPUE = catch-per-unit-effort; fish/100 s = fish caught per 100 seconds of electrofishing.

3.2.6 Species Life History

Sample sizes, length, and weight of fish captured in the BSA from 2006 to 2013 are summarized in Table 3.2-25. The size range of captured fish were 57 to 947 mm for Lake Trout, 50 to 385 mm for Arctic Grayling, 62 to 960 mm for Northern Pike, 105 to 255 mm for Cisco, 102 to 467 mm for Round Whitefish, 104 to 615 mm for Lake Whitefish, 47 to 240 mm for Burbot, 198 to 469 mm for Longnose Sucker, 26 to 68 mm for Ninespine Stickleback, 29 to 139 mm for Lake Chub, and 41 to 93 mm for Slimy Sculpin.

Table 3.2-25 Sample Size, Length, and Weight of Fish Collected in the Baseline Study Area, 2006 to 2013

Species	Location	Fork Length (mm)					Weight (g)				
		n	Mean	SD	Min	Max	n	Mean	SD	Min	Max
Lake Trout	all waterbodies	261	522	159	57	947	246	1,894	1,604	2	9,750
	Lac du Sauvage	115	599	109	299	850	111	2,345	1,029	261	4,601
	Duchess Lake	9	436	126	240	595	9	1,070	734	168	2,440
	Lake E1	2	682	11	674	689	2	3,415	346	3,170	3,660
	Paul Lake	3	639	67	587	715	3	2,506	942	1,566	3,450
	Lake B4 (Cujo)	63	467	176	69	947	52	1,699	2,290	2	9,570
	Lake D3 (Counts)	35	433	158	62	910	35	1,246	1,865	2	9,750
	Lynx Lake	3	388	49	331	422	3	738	304	420	1,025
	Hammer Lake	2	525	21	510	540	2	2,123	357	1,870	2,375
	other lakes	29	460	171	57	772	29	1,493	1,486	2	5,200
Arctic Grayling	all waterbodies	58	178	127	50	385	57	178	237	1	734
	Paul Lake	4	233	57	155	289	4	192	114	47	322
	Lake B4 (Cujo)	17	219	139	50	383	17	287	277	1	734
	Lake D3 (Counts)	1	78	n/a	78	78	1	5	n/a	5	5
	Lake D2	11	269	128	71	385	11	355	255	4	663
	other Lakes	4	83	38	61	139	4	9	13	2	28
	Stream B1 (Christine Creek)	11	89	93	55	369	10	2	0	2	3
	other streams	10	129	79	60	268	10	54	85	2	265
Northern Pike	all waterbodies	45	582	286	62	960	43	2,571	2,015	2	7,350
	Duchess Lake	2	767	11	759	774	2	3,860	127	3,770	3,950
	Lake Af1	1	124	n/a	124	124	1	15	n/a	15	15
	Lake E1	7	501	363	112	950	7	2,330	2,786	8	7,350
	Paul Lake	30	657	231	62	960	28	3,006	1,749	2	6,000
	Lake Ad8	1	719	n/a	719	719	1	2,185	n/a	2,185	2,185
	Stream E2	4	150	62	108	242	4	40	58	9	127
Cisco	all waterbodies	19	179	49	105	255	19	88	71	11	240
	Lac du Sauvage	7	126	17	105	143	7	21	8	11	29
	Duchess Lake	12	210	30	163	255	12	127	61	50	240

Table 3.2-25 Sample Size, Length, and Weight of Fish Collected in the Baseline Study Area, 2006 to 2013

Species	Location	Fork Length (mm)					Weight (g)				
		n	Mean	SD	Min	Max	n	Mean	SD	Min	Max
Round Whitefish	all waterbodies	194	308	76	102	467	181	375	222	9	897
	Lac du Sauvage	26	235	91	102	378	26	195	205	9	627
	Duchess Lake	10	288	44	222	379	10	256	147	105	638
	Paul Lake	2	343	32	320	365	2	463	151	356	570
	Lake B4 (Cujo)	54	345	55	192	421	42	514	219	70	897
	Lake B15	11	250	58	136	300	11	185	88	20	288
	Lake C1	11	297	99	152	399	11	390	303	30	779
	Lake C3	3	264	125	127	372	3	256	249	18	515
	Lake D2	5	331	50	275	377	5	419	159	242	583
	Lake D3 (Counts)	67	330	51	125	467	67	422	157	15	753
	Stream B1 (Christine Creek)	5	183	37	133	220	4	53	35	19	103
Lake Whitefish	all waterbodies	202	376	134	104	615	188	903	741	13	3,199
	Lac du Sauvage	39	477	51	354	560	36	1,398	402	437	2,027
	Duchess Lake	64	252	118	104	509	64	325	448	13	1,738
	Lake E1	39	379	133	134	565	30	838	806	30	2,530
	Paul Lake	26	437	56	297	514	24	1,147	410	549	1,949
	Lake Ad8	26	467	74	358	615	26	1,567	832	555	3,199
	Hammer Lake	2	263	138	165	360	2	290	354	39	540
	Lynx Lake	6	398	11	387	411	6	783	141	546	970
Burbot	all waterbodies	21	72	43	47	240	21	7	18	1	83
	Lac du Sauvage	3	63	2	61	64	3	4	1	3	5
	Duchess Lake	1	240	n/a	240	240	1	83	n/a	83	83
	Lake E1	1	113	n/a	113	113	1	n/a	n/a	9	9
	Lake D3 (Counts)	3	51	5	47	56	3	1	1	1	2
	Hammer Lake	3	64	11	54	76	3	2	1	1	3
	Lynx Lake	4	53	4	48	58	4	1	0	1	2
	other lakes	6	71	27	52	124	6	3	4	1	10
Longnose Sucker	all waterbodies	13	363	102	198	469	13	770	450	111	1,365
	Duchess Lake	2	293	130	201	385	2	517	570	114	920
	Paul Lake	11	376	98	198	469	11	816	442	111	1,365
Ninespine Stickleback	all waterbodies	125	50	6	26	68	125	1	0	0	3
	Lake E1	24	47	6	34	57	24	1	0	0	2
	Lake Ac17	95	51	5	30	68	95	1	0	0	3
	Stream D1	6	45	17	26	65	6	1	1	0	2

Table 3.2-25 Sample Size, Length, and Weight of Fish Collected in the Baseline Study Area, 2006 to 2013

Species	Location	Fork Length (mm)					Weight (g)				
		n	Mean	SD	Min	Max	n	Mean	SD	Min	Max
Lake Chub	all waterbodies	8	79	51	29	139	8	12	14	0	33
	Lake B1 (Christine)	5	86	53	29	139	5	13	12	0	28
	Hammer Lake	3	66	57	32	132	3	11	19	0	33
Slimy Sculpin	all waterbodies	152	61	12	41	93	152	2	1	1	9
	Lac du Sauvage	5	53	9	43	64	5	1	0	1	2
	Lake B4 (Cujo)	47	62	10	45	87	47	2	1	1	7
	Lake D3 (Counts)	74	58	12	41	85	74	2	1	1	5
	Hammer Lake	1	64	n/a	64	64	1	2	n/a	2	2
	other lakes	16	68	14	48	93	16	3	2	1	9
	all streams	9	73	8	57	87	9	4	1	1	6

mm = millimetre; g = gram; n = number of samples; SD = standard deviation; Min = minimum; Max = maximum, n/a = not applicable.

Length-weight regressions and length-frequency summaries are presented for Lake Trout (n = 246), Arctic Grayling (n = 57), Northern Pike (n = 43), Round Whitefish (n = 181), Lake Whitefish (n = 188), and Slimy Sculpin (n = 152) in the following subsections. Length-weight regressions are also presented for Cisco (n = 19), Burbot (n = 21), Longnose Sucker (n = 13), and Ninespine Stickleback (n = 125). Length-at-age analyses are presented for Lake Trout (n = 218), Arctic Grayling (n = 27), Northern Pike (n = 38), Round Whitefish (n = 163), and Lake Whitefish (n = 163). These species were numerically abundant, allowing for meaningful statistical summaries for baseline reporting. Detailed length, weight, and age data are presented for all species captured in Appendix F.

3.2.6.1.1 Length-Weight Relationship

Length-weight regressions were established by lake and species (Table 3.2-26) and were calculated for all species except for Lake Chub (n = 8 in all waterbodies). The goal was to develop length-weight regression models to provide a general understanding of patterns in growth, and for calculation of relative weights as part of future monitoring programs.

Model fit values, measured by R^2 (coefficient of determination), were generally above the 0.9 guideline for being useful in predicting weights (Murphy et al. 1990), with the exception of the equation developed for YOY Arctic Grayling in Stream B1 (Christine Creek). Model fit values of less than 0.9 were also reported for Ninespine Stickleback and Burbot in all waterbodies and Lake Whitefish in Lac du Sauvage and Paul Lake.

A slope of 3.0 suggests isometric growth across length categories, and all slopes were within the typical range between 2.5 and 4.0, except for the slope calculated for YOY Arctic Grayling in Stream B1 (Christine Creek; 1.74) (Table 3.2-26). Other reported low slopes (i.e., below 3.0) were Ninespine Stickleback in all waterbodies (2.60), Lake Trout in Lac du Sauvage (2.68), Burbot in all waterbodies (2.70), and Longnose Sucker in all waterbodies (2.88). The respective equations with low slopes suggest that fish do not maintain their shape or body condition as they grow longer and older.

Table 3.2-26 Length-Weight Relationships for Fish Species in the Baseline Study Area, 2006 to 2013

Species	Waterbody	Year	Slope	Intercept	n	(R^2)	Minimum Fork Length (mm)	Maximum Fork Length (mm)
Lake Trout	all waterbodies	2006-2008, 2011-2013	3.00	-5.00	246	0.9812	57	947
	Lac du Sauvage	2006, 2008, 2011, 2013	2.68	-4.13	111	0.9012	299	850
	Lake D3 (Counts)	2007, 2012, 2013	3.10	-5.24	35	0.9922	62	910
	Lake B4 (Cujo)	2007, 2012, 2013	3.06	-5.17	52	0.9882	69	947
		2007	3.03	-5.06	13	0.9817	355	947
		2012, 2013	3.05	-5.14	39	0.9891	69	819
Arctic Grayling	all waterbodies	2012, 2013	3.18	-5.35	57	0.9970	50	385
	Lake B4 (Cujo)	2012, 2013	3.23	-5.47	17	0.9958	50	383
	Lake D2	2013	3.11	-5.19	11	0.9999	71	385
	Stream B1 (Christine Creek)	2013	1.74	-2.75	10	0.4975	55	68
Northern Pike	all waterbodies	2013	3.03	-5.21	43	0.9978	62	960
	Paul Lake	2013	2.97	-5.02	28	0.9972	62	960
Cisco	all waterbodies	2013	3.48	-6.00	19	0.9926	105	255
	Duchess Lake	2013	3.35	-5.70	12	0.9637	163	255
Round Whitefish	all waterbodies	2006, 2007, 2012, 2013	3.25	-5.58	181	0.9830	102	467
	Lac du Sauvage	2006, 2013	3.18	-5.46	26	0.9951	102	378
	Lake D3 (Counts)	2007, 2012, 2013	3.01	-4.97	67	0.9050	125	467
		2007	3.01	-4.97	32	0.7992	244	392
		2012, 2013	3.01	-4.80	35	0.9323	125	467
	Lake B4 (Cujo)	2007, 2012, 2013	3.21	-5.47	42	0.9853	192	421
		2007	3.34	-5.78	17	0.9848	232	400
		2012, 2013	3.16	-5.37	25	0.9956	192	421
	Duchess Lake	2013	3.07	-5.17	10	0.9619	222	379
	Lake B15	2013	3.36	-5.86	11	0.9946	136	300
	Lake C1	2013	3.27	-5.64	11	0.9963	152	399
Lake Whitefish	all waterbodies	2006, 2013	3.17	-5.34	188	0.9925	104	615
	Lac du Sauvage	2006, 2013	3.12	-5.23	36	0.8344	354	560
	Paul Lake	2013	2.96	-4.78	24	0.8708	355	514
	Duchess Lake	2013	3.09	-5.17	64	0.9931	104	509

Table 3.2-26 Length-Weight Relationships for Fish Species in the Baseline Study Area, 2006 to 2013

Species	Waterbody	Year	Slope	Intercept	n	(R^2)	Minimum Fork Length (mm)	Maximum Fork Length (mm)
	Lake Ad8	2013	3.50	-6.19	26	0.9815	358	615
	Lake E1	2013	3.15	-5.28	30	0.9972	134	565
Burbot	all waterbodies	2006, 2012, 2013	2.70	-4.55	21	0.8889	47	240
Longnose Sucker	all waterbodies	2013	2.88	-4.57	13	0.9826	198	469
	Paul Lake	2013	2.86	-4.51	11	0.9808	198	469
Ninespine Stickleback	all waterbodies	2013	2.60	-4.45	125	0.7901	26	68
	Lake Ac17	2013	2.93	-5.04	95	0.8015	30	68
	Lake E1	2013	2.71	-4.54	24	0.8400	34	57
Slimy Sculpin	all waterbodies	2007, 2012, 2013	3.07	-5.19	152	0.9209	41	93
	Lake D3 (Counts)	2007, 2012, 2013	2.92	-4.93	74	0.9192	41	85
		2007	2.66	-4.48	36	0.7820	41	75
		2012, 2013	3.17	-5.39	38	0.9794	45	85
	Lake B4 (Cujo)	2007, 2012, 2013	3.12	-5.28	47	0.9111	45	87
		2007	3.14	-5.34	20	0.9028	45	81
		2012, 2013	3.00	-5.04	27	0.9375	49	87

n = number of samples; (R^2) = coefficient of determination for regression; mm = millimetre.

For Lake Whitefish, the lowest reported slope was in Paul Lake (2.96) and the highest reported slope was in Lake Ad8 (3.50), approximately 20% higher than that in Paul Lake. For Lake Trout, slopes were typically above 3.0, with the exception of Lac du Sauvage (2.68). The highest reported slope for Lake Trout was in Lake D3 (Counts Lake = 3.1).

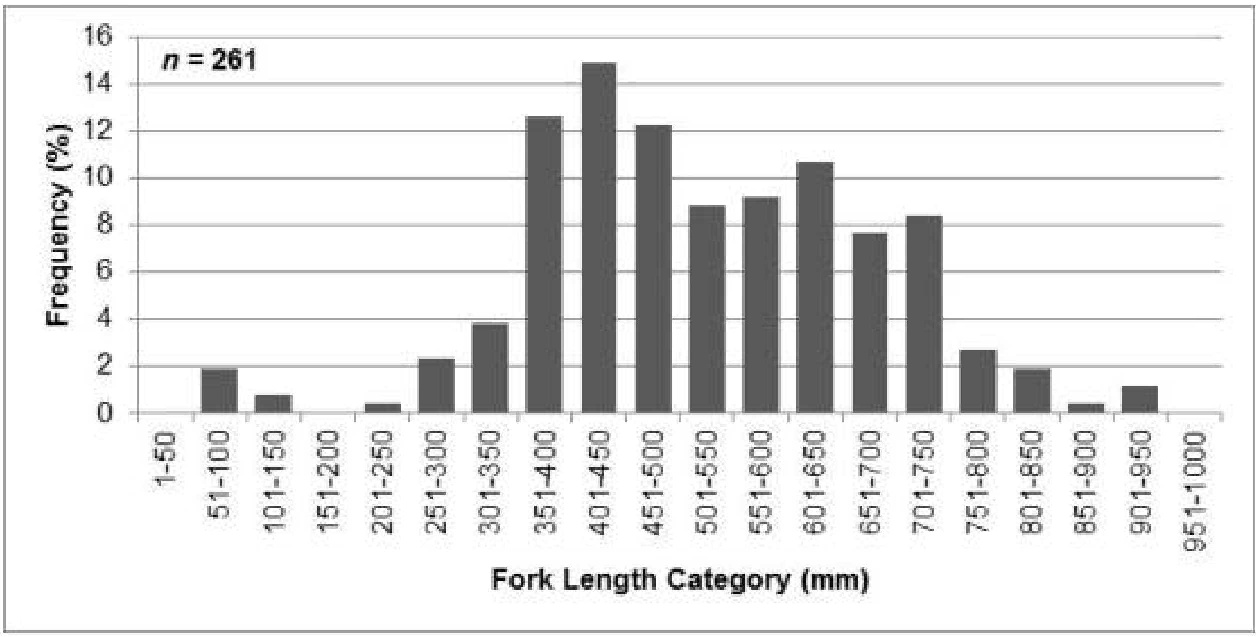
3.2.6.1.2 Length-Frequency Distributions

To describe size distribution of the captured species, length-frequency tabulations were compiled using 50-mm length intervals. Distributions were calculated by species and further described by lake and year if sample sizes were greater than 25. For length-frequency and length-at-age analyses, all capture methods were combined.

Lake Trout

Lake Trout in the BSA (n = 261) during the 2006 to 2013 field programs ranged from 57 to 947 mm in fork length. Mean fork length was 522 mm. Small-sized (less than 300 mm in fork length) Lake Trout were not well represented in the BSA (5%, n = 14). Large-sized Lake Trout (fork length greater than 301 mm) made up most of the fish captured (Figure 3.2-31). The low numbers of individuals in small size classes may be more of an artefact of sampling biases towards larger fish sizes, rather than low annual recruitment into the population. However, populations in Arctic lakes are often skewed towards adult fish because slow growth and low annual recruitment can characterize populations in Arctic ecosystems (Johnson 1976). Previous studies suggest that large adult fish can control recruitment by forcing juveniles into sub-optimal habitats, where foraging opportunities are reduced and growth is slow (McDonald et al. 1992, 1996). The largest Lake Trout had a fork length of 947 mm and was caught in Lake B4 (Cujo) in August 2007.

Figure 3.2-31 Overall Length-Frequency of Lake Trout Captured in the Baseline Study Area, 2006 to 2013

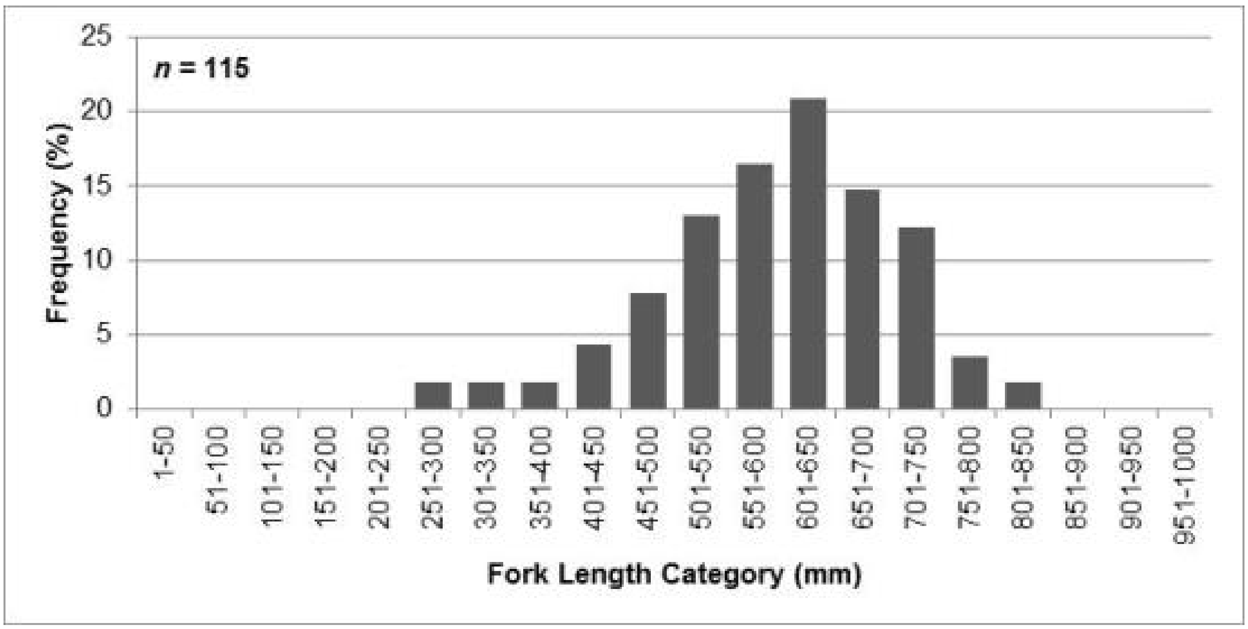


% = percent; n = number of samples; mm = millimetre.

From 2006 to 2013 in Lac du Sauvage, Lake Trout fork length ranged from 299 to 850 mm (n = 115), with over half of the fish (51%, n = 59) between 601 and 800 mm (Figure 3.2-32). The mean fork length of Lake Trout in Lac du Sauvage was 599 mm. The largest fork length was 850 mm, for a fish captured in 2011. Although there is evidence of recruitment into the population, as illustrated in the histogram, the overall distribution may reflect sampling biases towards larger fish sizes. Alternatively, the histogram may reflect an unbalanced population given that the histogram does not show a stable decline in fish numbers with increasing length.

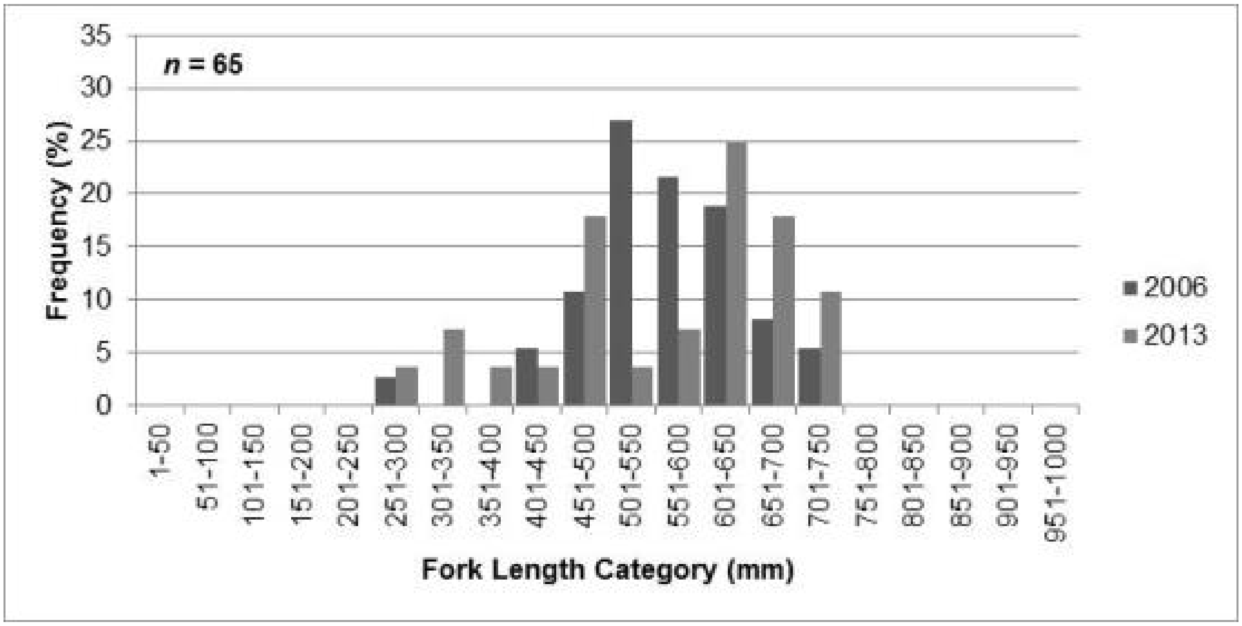
In 2006, fork length ranged from 299 to 727 mm (n = 37) with almost half of the fish (49%, n = 18) between 501 and 600 mm (Figure 3.2-33). Approximately seven years later, the size distribution remained similar. In 2013, fork length ranged from 300 to 735 mm (n = 28) with almost half (43%, n = 12) of the fish between 601 and 700 mm (Figure 3.2-33).

Figure 3.2-32 Length-Frequency of Lake Trout Caught in Lac du Sauvage, 2006 to 2013



% = percent; n = number of samples; mm = millimetre.

Figure 3.2-33 Length-Frequency of Lake Trout Caught in Lac du Sauvage, 2006 and 2013



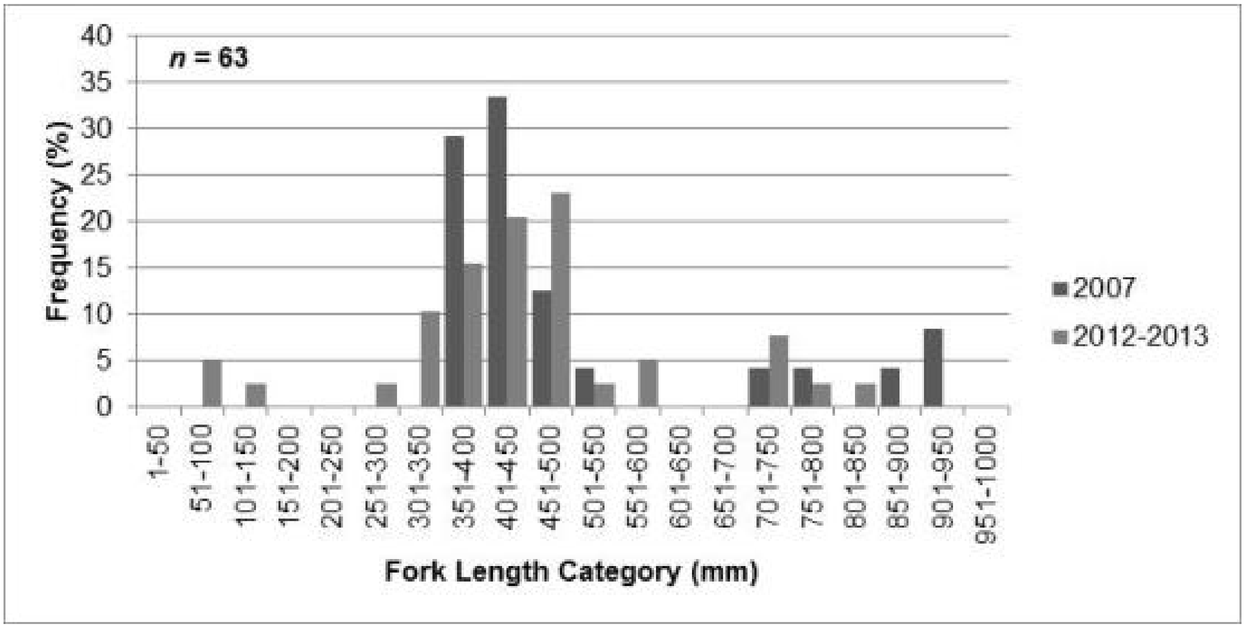
% = percent; n = number of samples; mm = millimetre.

In Lake B4 (Cujo) from 2007 to 2013, Lake Trout fork length ranged from 69 to 947 mm (n = 63), with almost half of the fish (44%, n = 28) between 401 and 500 mm (Figure 3.2-34). The mean fork length of Lake Trout in Lake B4 from 2007 to 2013 was 467 mm, approximately 22% smaller than in Lac du Sauvage. The largest Lake Trout had a fork length of 947 mm and was captured in 2007. Although there is evidence of recruitment into the population, as illustrated in the histogram, there was no stable decline in fish numbers with increasing length.

In 2007, fork length ranged from 355 to 947 mm (n = 24) with most of the fish (63%, n = 15) between 351 and 450 mm (Figure 3.2-34). In 2012, the size distribution shifted towards smaller fish and included small size classes that may represent YOY and yearling fish (i.e., evidence of recruitment). In 2012, fork length ranged from 69 to 741 mm (n = 25) and in 2013, fork length ranged from 360 to 819 mm (n = 14). In 2012 and 2013 combined, almost half (44%, n = 17) of the fish were between 401 and 500 mm (Figure 3.2-34).

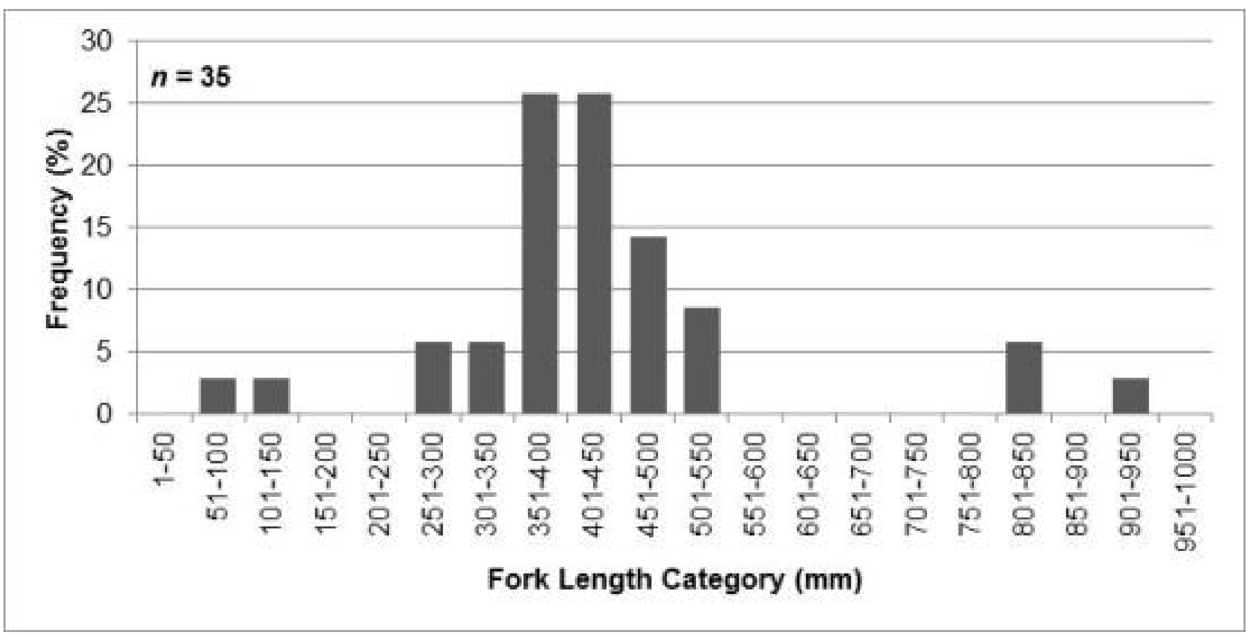
In Lake D3 (Counts) from 2007 to 2013, Lake Trout fork length ranged from 62 to 910 mm (n = 35), with over half of the fish (51%, n = 18) between 351 and 450 mm (Figure 3.2-35). The mean fork length of Lake Trout in Lake D3 (Counts) from 2007 to 2013 was 433 mm, approximately 7% smaller than Lake B4 (Cujo), and 28% smaller than Lac du Sauvage. The largest Lake Trout had a fork length of 910 mm and was captured in 2013. Small size classes of captured fish, although poorly represented in the dataset, provide evidence of recruitment into the population.

Figure 3.2-34 Length-Frequency of Lake Trout Caught in Lake B4 (Cujo), 2007 and 2012 to 2013



% = percent; n = number of samples; mm = millimetre.

Figure 3.2-35 Length-Frequency of Lake Trout Caught in Lake D3 (Counts), 2007, 2012 and 2013

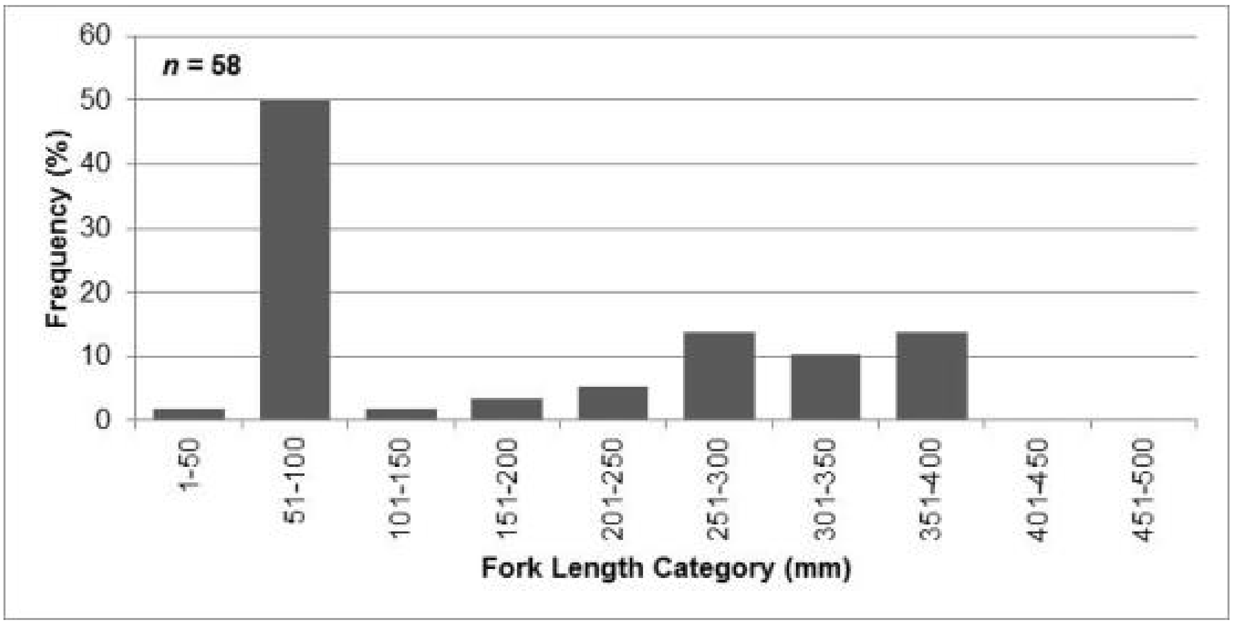


% = percent; n = number of samples; mm = millimetre.

Arctic Grayling

Arctic Grayling captured in 2012 (n = 7) and 2013 (n = 51) combined (n = 58) ranged from 50 to 385 mm in fork length (mean = 178 mm). Exactly half of the fish captured were within the size range of 51 to 100 mm (50%, n = 29), potentially representing YOY and yearling age classes (Figure 3.2-36). The largest Arctic Grayling was captured in 2013 in Lake D2 and had a fork length of 385 mm. The low fish numbers in medium-sized categories could reflect poor recruitment years or be an artefact of sampling biases.

Figure 3.2-36 Overall Length-Frequency of Arctic Grayling Caught in the Baseline Study Area, 2012 and 2013



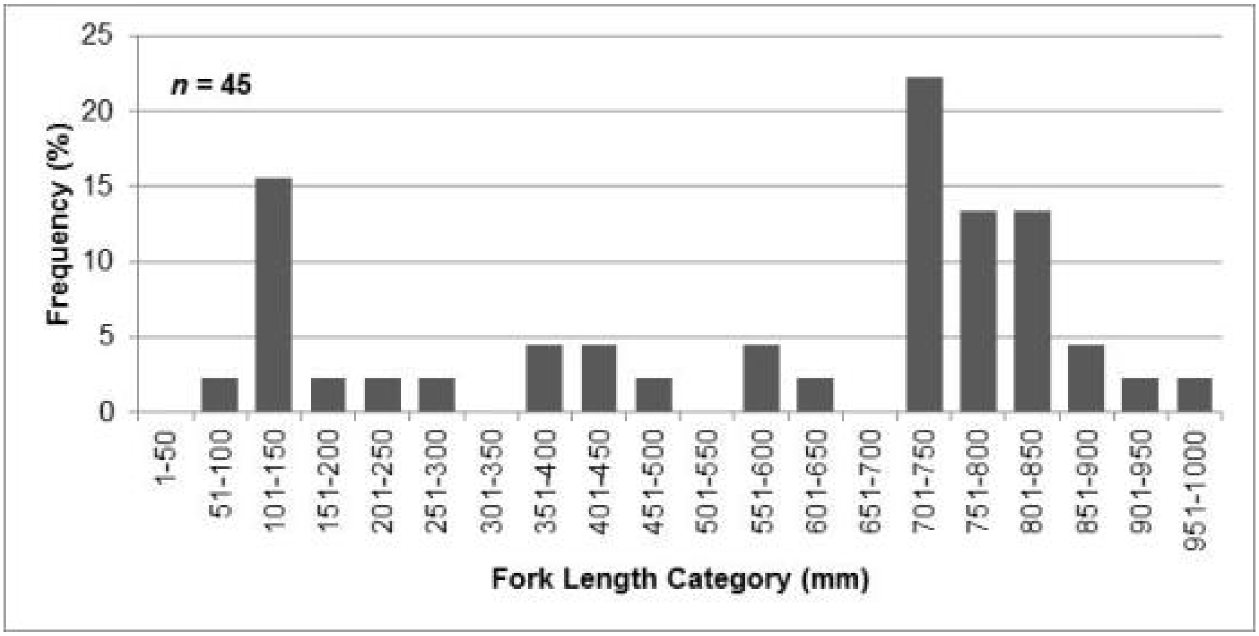
% = percent; n = number of samples; mm = millimetre.

Northern Pike

Northern Pike captured in 2013 (n = 45) ranged from 62 to 960 mm in fork length (mean = 582 mm). Over half of the fish in the BSA were in the 701 to 900 mm size range (53%, n = 24) and another substantial proportion was within the 101 to 300 mm size range (22%, n = 10) (Figure 3.2-37). However, there was no clear stable decline from shorter to longer length in the histogram. Although the histogram does not illustrate fast growth and strong recruitment into the population, small-sized fish were captured, potentially representing YOY and yearling age classes. The largest Northern Pike was captured in Paul Lake and had a fork length of 960 mm.

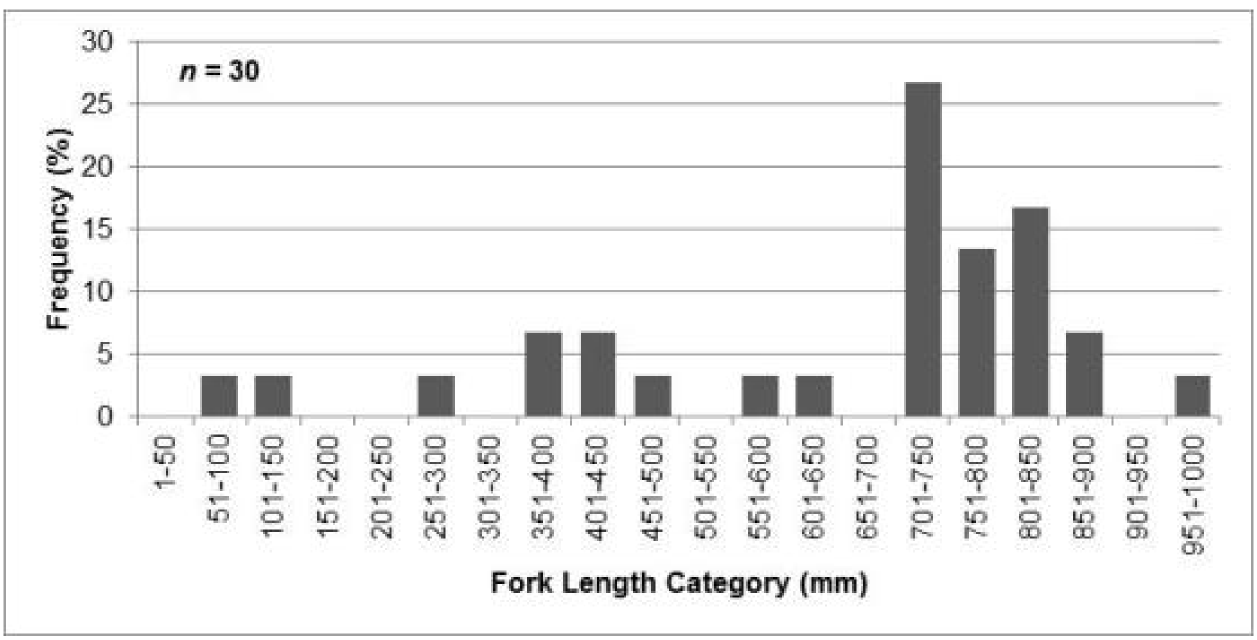
Most of the Northern Pike captured in 2013 were from Paul Lake (67%). In Paul Lake, Northern Pike also ranged from 62 to 960 mm in fork length (mean = 657 mm). Most of the Northern Pike in Paul Lake were large fish between 701 and 900 mm (63%, n = 19) (Figure 3.2-38).

Figure 3.2-37 Overall Length-Frequency of Northern Pike Caught in the Baseline Study Area, 2013



% = percent; n = number of samples; mm = millimetre.

Figure 3.2-38 Length-Frequency of Northern Pike Caught in Paul Lake, 2013



% = percent; n = number of samples; mm = millimetre.

Round Whitefish

Round Whitefish in the BSA (n = 194) during the 2006 to 2013 field programs ranged from 102 to 467 mm in fork length. The mean fork length was 308 mm. Large-sized (fork length between 301 to 500 mm) Round Whitefish made up most of the fish caught (61%, n = 118), while small-sized (fork length between 101 to 300 mm) fish represented 39% (n = 76) of the catch (Figure 3.2-39). The largest Round Whitefish was caught in Lake D3 (Counts) in August 2012 and had a fork length of 467 mm.

The histogram shows an increasing trend from shorter to longer length (101 to 350 mm) size classes, followed by a steep reduction in larger fish. Underlying mechanisms are unclear, but general trends may reflect sampling biases towards larger fish. An alternative hypothesis would be slow growth and low recruitment, which can characterize fish populations in Arctic ecosystems.

In Lac du Sauvage in 2006 and 2013 (combined), Round Whitefish fork length ranged from 102 to 378 mm (n = 26), with most of the fish (69%, n = 18) between 101 and 300 mm (Figure 3.2-40). The mean fork length of Round Whitefish in Lac du Sauvage from 2006 and 2013 (combined) was 235 mm. The smallest size class of captured fish in the histogram may represent a yearling age class. The largest Round Whitefish in Lac du Sauvage was captured in 2006 and had a fork length of 378 mm.

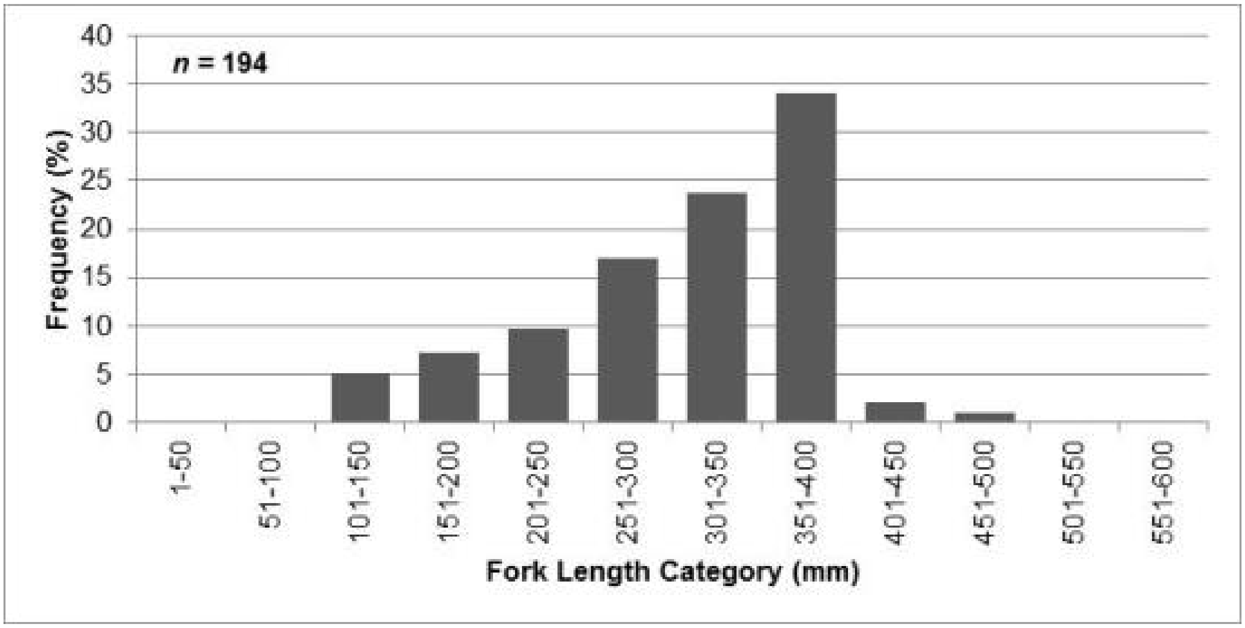
In Lake B4 (Cujo) from 2007 to 2013, fork length ranged from 192 to 421 mm (n = 54), with half of the fish (50%, n = 27) between 351 and 400 mm (Figure 3.2-41). The mean fork length of Round Whitefish in Lake B4 (Cujo) in 2007 to 2013 was 345 mm, approximately 47% larger than Lac du Sauvage. The largest Round Whitefish in Lake B4 (Cujo) was captured in 2012 and had a fork length of 421 mm.

In 2007, fork length ranged from 232 to 400 mm (n = 24) with over half (59%, n = 17) of the fish between 351 and 400 mm (Figure 3.2-41). A similar size distribution was observed five years later. In 2012, fork length ranged from 192 to 421 mm (n = 21) and in 2013, fork length ranged from 357 to 404 mm (n = 4). In 2012 and 2013 combined, over half of the fish (68%, n = 17) were between 301 and 400 mm.

In Lake D3 (Counts) from 2007 to 2013, fork length ranged from 125 to 467 mm (Figure 3.2-42). The mean fork length was 330 mm, and was similar to Lake B4 (only 4% smaller) but 40% larger than Lac du Sauvage. Most of the fish were between 301 and 350 mm (34%, n = 23) or 351 and 400 mm (35%, n = 24). The smallest size class of captured fish in the histogram may represent a yearling age class. The largest Round Whitefish in Lake D3 (Counts) was captured in 2012 and had a fork length of 467 mm.

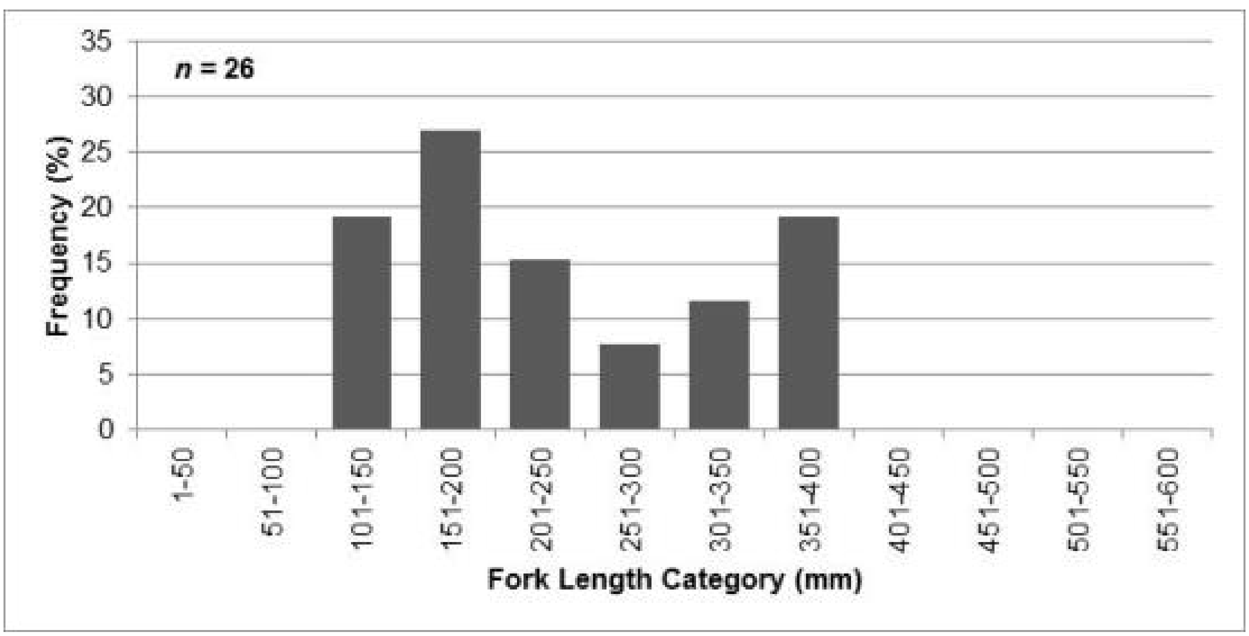
In 2007, fork length ranged from 244 to 392 mm (n = 32) with nearly half of the fish (47%, n = 15) between 301 and 350 mm (Figure 3.2-42). Approximately five years later, size distributions of the fish catch were more variable. In 2012, fork length ranged from 212 to 467 mm (n = 25) and in 2013, fork length ranged from 125 to 385 mm (n = 10). In 2012 and 2013 combined, almost half (46%, n = 16) of the fish were between 351 and 400 mm.

Figure 3.2-39 Overall Length-Frequency of Round Whitefish Caught in the Baseline Study Area, 2006 to 2013



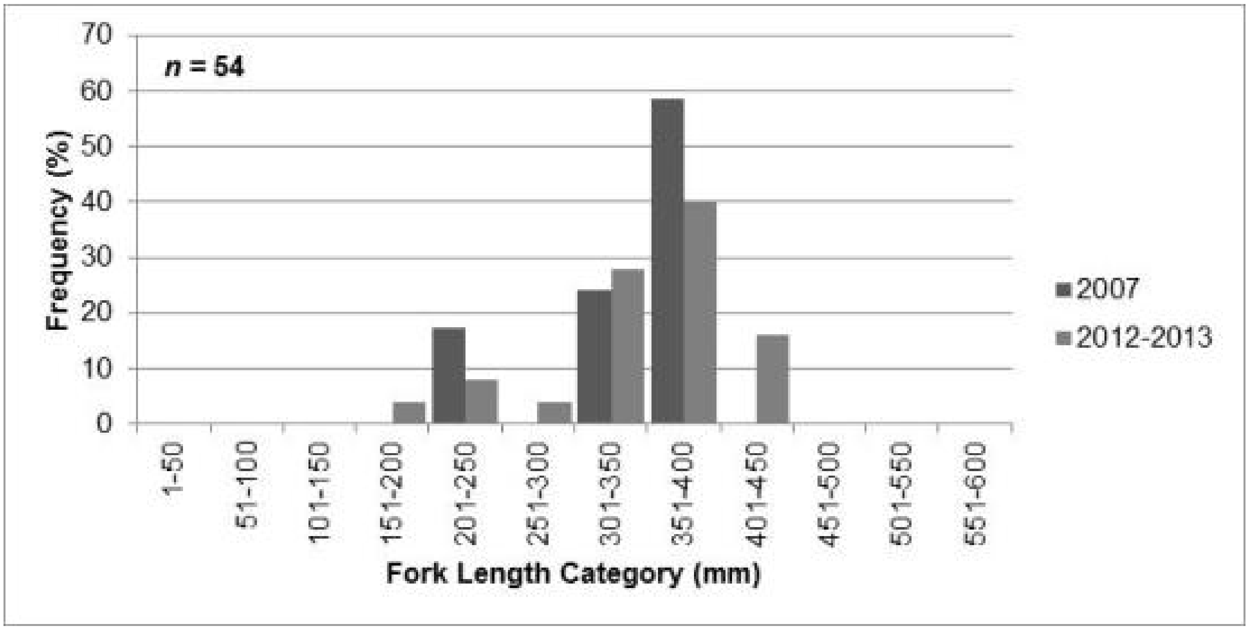
% = percent; n = number of samples; mm = millimetre.

Figure 3.2-40 Length-Frequency of Round Whitefish Caught in Lac du Sauvage, 2006 and 2013



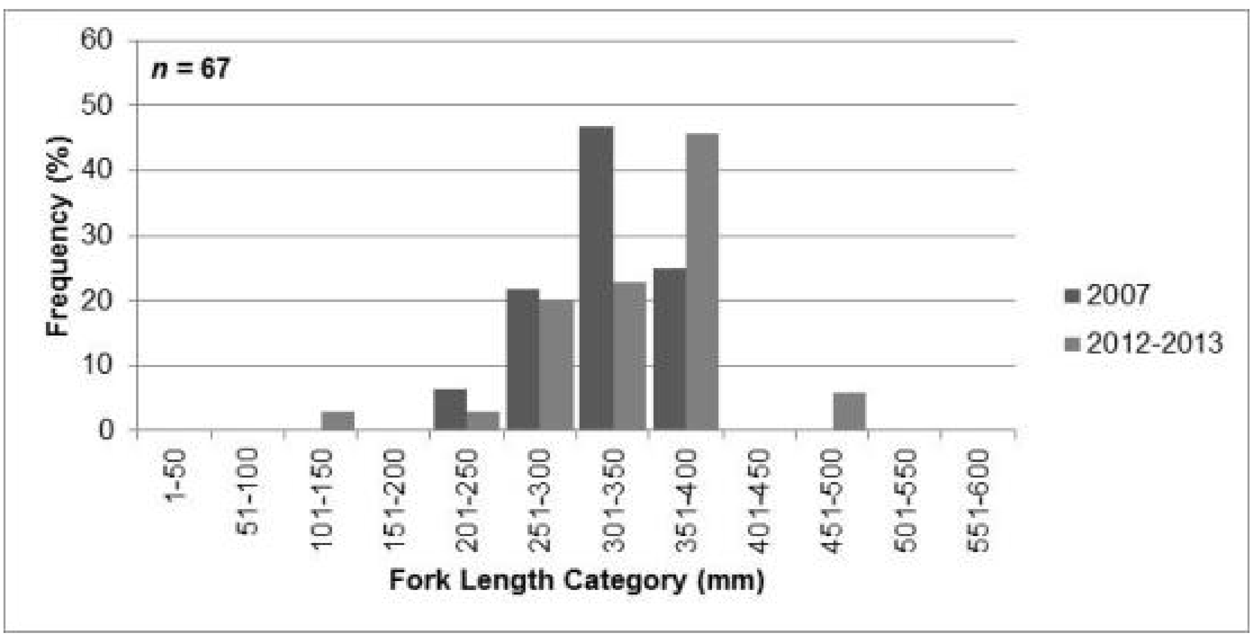
% = percent; n = number of samples; mm = millimetre.

Figure 3.2-41 Length-Frequency of Round Whitefish Caught in Lake B4 (Cujo), 2007 to 2013



% = percent; n = number of samples; mm = millimetre.

Figure 3.2-42 Length-Frequency of Round Whitefish Caught in Lake D3 (Counts), 2007 to 2013



% = percent; n = number of samples; mm = millimetre.

Lake Whitefish

Lake Whitefish in the BSA (n = 202) during the 2006 and 2013 field programs ranged from 104 to 615 mm in fork length. The mean fork length was 376 mm. Medium-sized Lake Whitefish (fork length between 301 to 500 mm) made up half of the fish caught (51%, n = 103), while small-sized (fork length between 101 to 300 mm) fish represented 32% (n = 63) of the species catch. Large-sized Lake Whitefish (fork length between 501 to 650 mm) made up 18% (n = 36) of the catch (Figure 3.2-43). As noted for other species, underlying mechanisms of trends in the histogram are unclear. Sampling biases likely have a large role, but the histogram may also represent an unbalanced population (e.g., slow growth, low annual recruitment). The largest Lake Whitefish was caught in Lake Ad8 in August 2013 and had a fork length of 615 mm.

In Lac du Sauvage in 2006 and 2013 (combined), Lake Whitefish fork length ranged from 354 to 560 mm (n = 39), with almost half of the fish (43%, n = 17) in the 451 to 500 mm size class (Figure 3.2-44). The mean fork length of Lake Whitefish in Lac du Sauvage from 2006 and 2013 (combined) was 477 mm. The largest Lake Whitefish captured in Lac du Sauvage was from 2006 and had a fork length of 560 mm. There were no small size classes of fish potentially representing YOY and yearlings in the catch.

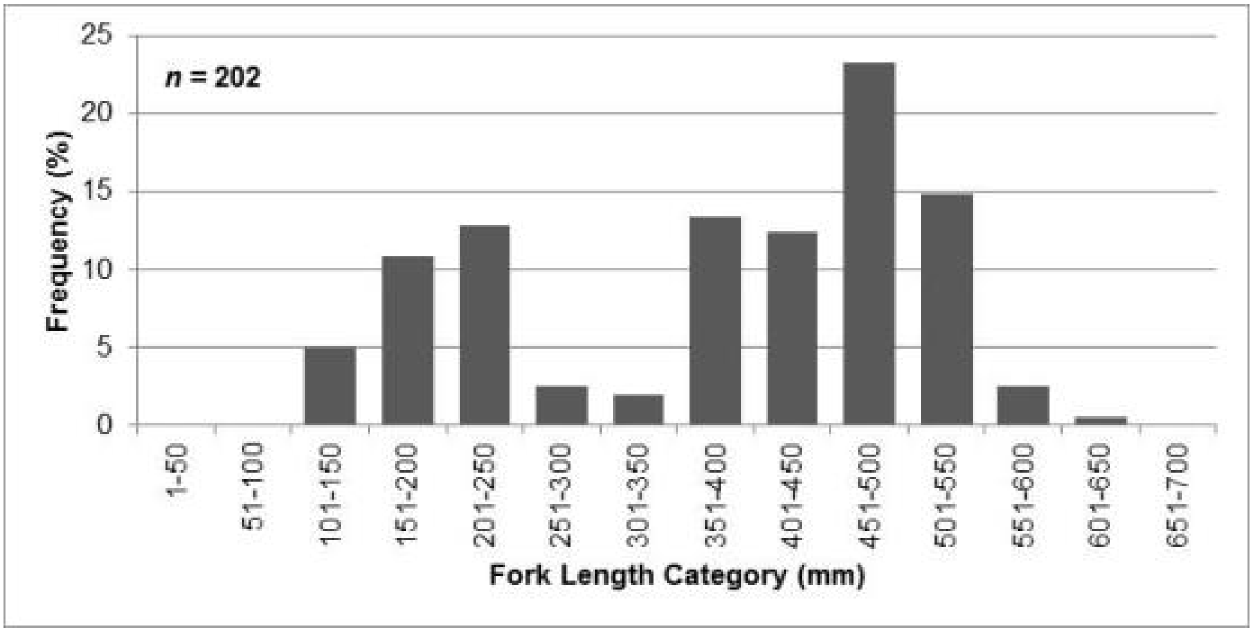
In Duchess Lake in 2013, Lake Whitefish fork length ranged from 104 to 509 mm (n = 39), with most of the fish (72%, n = 46) in the 101 to 300 mm size class (Figure 3.2-45). The mean fork length of Lake Whitefish in Duchess Lake in 2013 was 252 mm, approximately 47% smaller than in Lac du Sauvage. Included in the catch were small size classes of fish potentially representing yearlings.

In Lake E1 in 2013, Lake Whitefish fork length ranged from 134 to 565 mm (n = 39), with a large proportion of the fish (39%, n = 15) between 451 and 500 mm in length. No fish were in the 351 to 400 mm size range (Figure 3.2-46). The mean fork length of Lake Whitefish in Lake E1 from 2013 was 379 mm, approximately 21% smaller than in Lac du Sauvage, but 50% larger than in Duchess Lake. Included in the catch were small size classes of fish potentially representing yearlings.

In Lake Ad8 in 2013, Lake Whitefish fork length ranged from 358 to 615 mm (n = 26), with the largest proportion of fish (38%, n = 10) between 400 and 450 mm (Figure 3.2-47). Another large (27%, n = 7) proportion was between 501 and 550 mm fork length. The mean fork length of Lake Whitefish in Lake Ad8 from 2013 was 467 mm and was similar to the mean length in Lac du Sauvage (only 2% smaller). There were no small size classes of fish potentially representing YOY and yearlings in the catch.

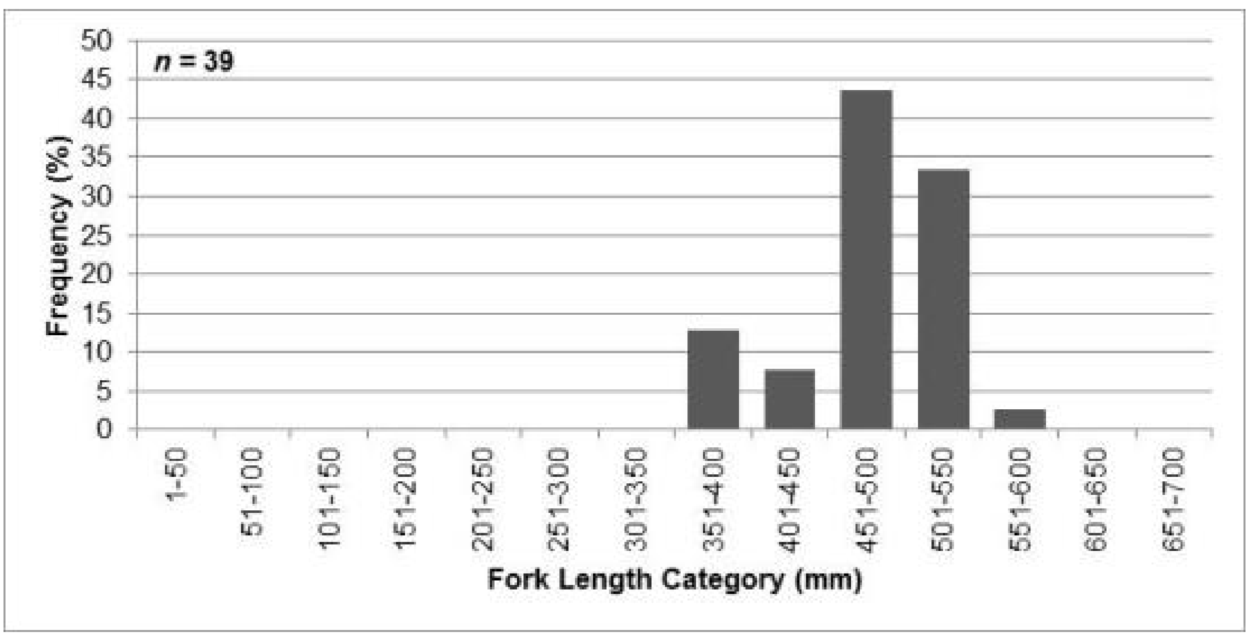
In Paul Lake in 2013, Lake Whitefish fork length ranged from 297 to 514 mm (n = 26). Half of the fish (50%, n = 13) were in the 351 to 400 mm and 401 to 450 mm size range bins combined, and a large proportion of fish (38%, n = 10) were between 451 and 500 mm (Figure 3.2-48). The mean fork length of Lake Whitefish in Paul Lake from 2013 was 437 mm, approximately 8% smaller than in Lac du Sauvage. There were no small size classes of fish potentially representing YOY and yearlings in the catch.

Figure 3.2-43 Overall Length-Frequency of Lake Whitefish Caught in the Baseline Study Area, 2006 and 2013



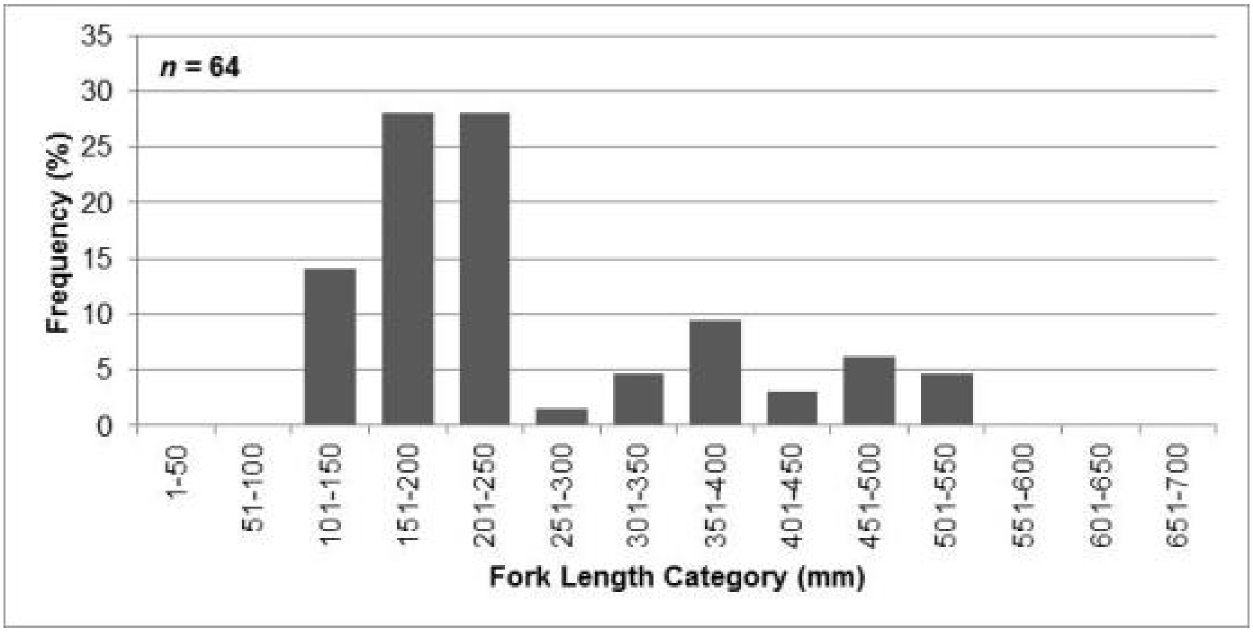
% = percent; n = number of samples; mm = millimetre.

Figure 3.2-44 Length-Frequency of Lake Whitefish Caught in Lac du Sauvage, 2006 and 2013



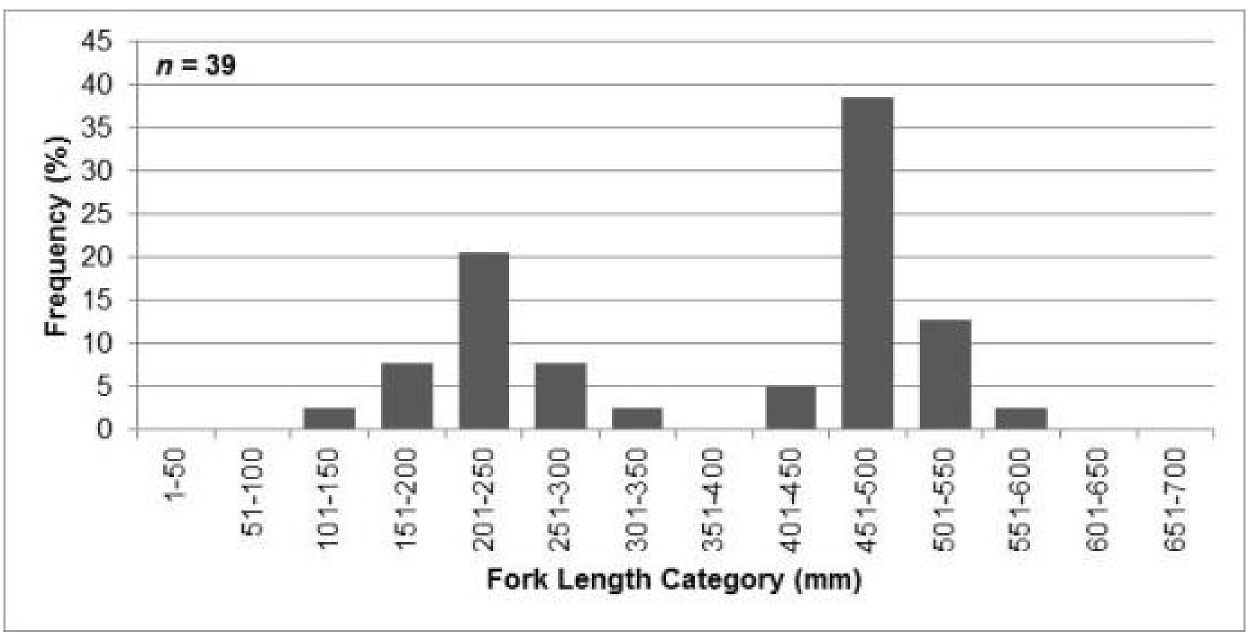
% = percent; n = number of samples; mm = millimetre.

Figure 3.2-45 Length-Frequency of Lake Whitefish Caught in Duchess Lake, 2013



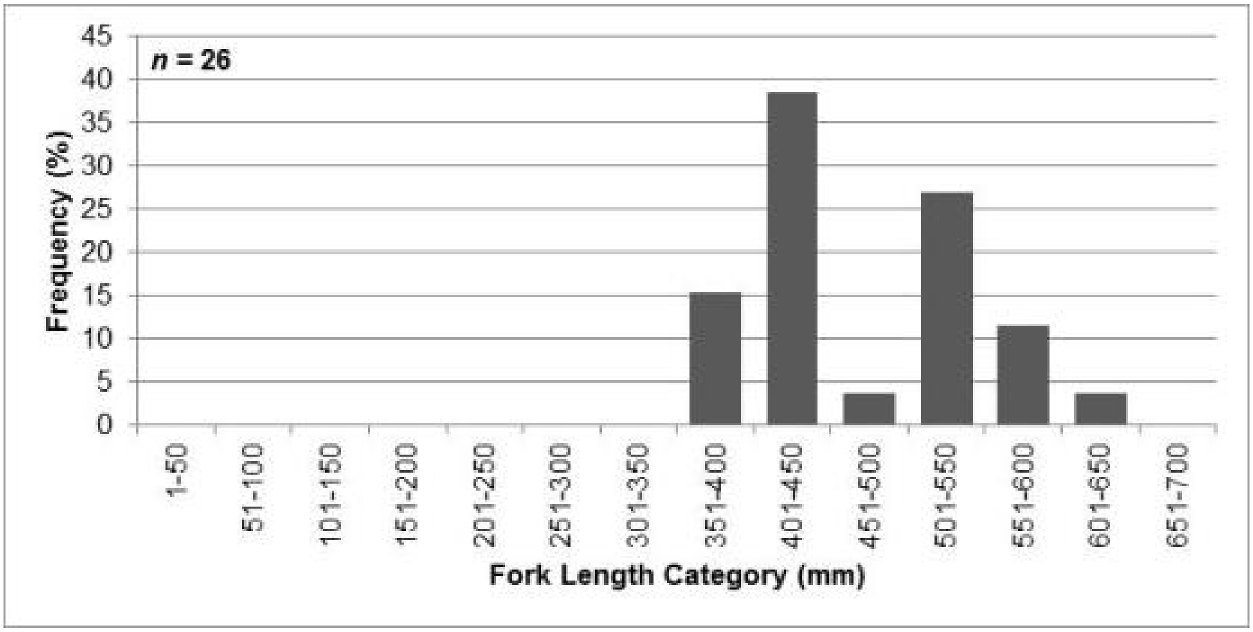
% = percent; n = number of samples; mm = millimetre.

Figure 3.2-46 Length-Frequency of Lake Whitefish Caught in Lake E1, 2013



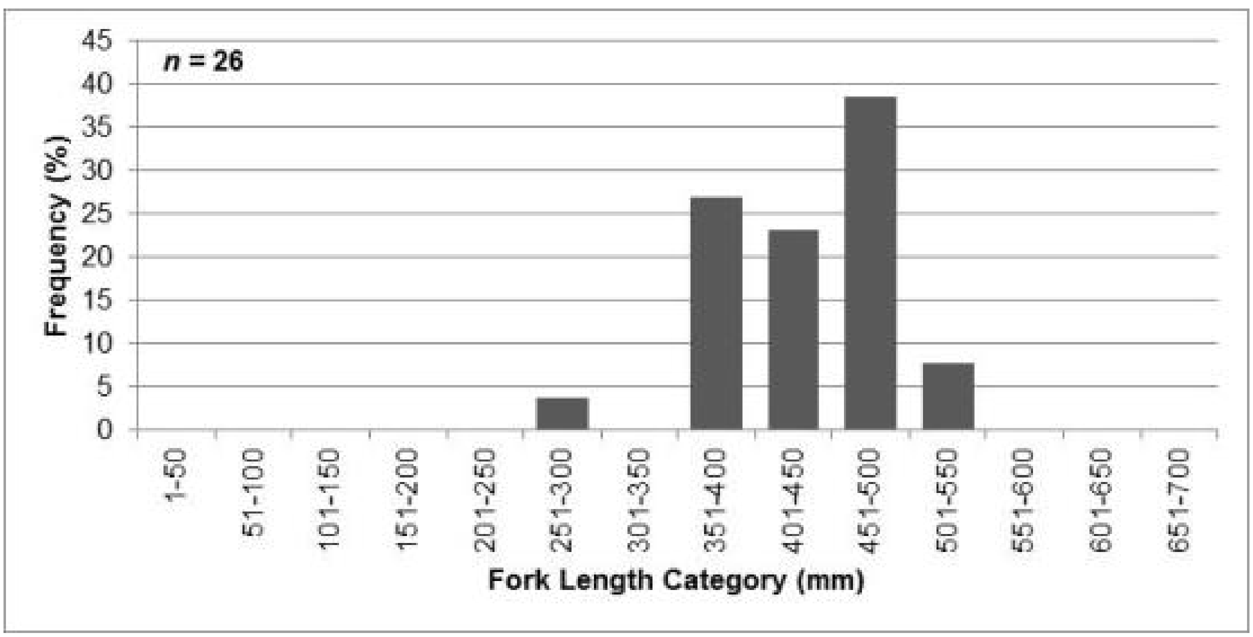
% = percent; n = number of samples; mm = millimetre.

Figure 3.2-47 Length-Frequency of Lake Whitefish Caught in Lake Ad8, 2013



% = percent; n = number of samples; mm = millimetre.

Figure 3.2-48 Length-Frequency of Lake Whitefish Caught in Paul Lake, 2013



% = percent; n = number of samples; mm = millimetre.

Cisco

Cisco were captured in the BSA (n = 19) during the 2013 field program. In Lac du Sauvage (n = 7), fork length ranged from 163 to 255 mm with a mean fork length of 210 mm (Table 3.2-25). In Duchess Lake (n = 12), fork length ranged from 105 to 143 with a mean fork length of 210 mm.

Longnose Sucker

Longnose Sucker were captured in the BSA (n = 13) during the 2013 field program. In Paul Lake (n = 11), fork length ranged from 198 to 469 mm with a mean fork length of 376 mm (Table 3.2-25). In Duchess Lake (n = 2), fork length ranged from 201 to 385 mm.

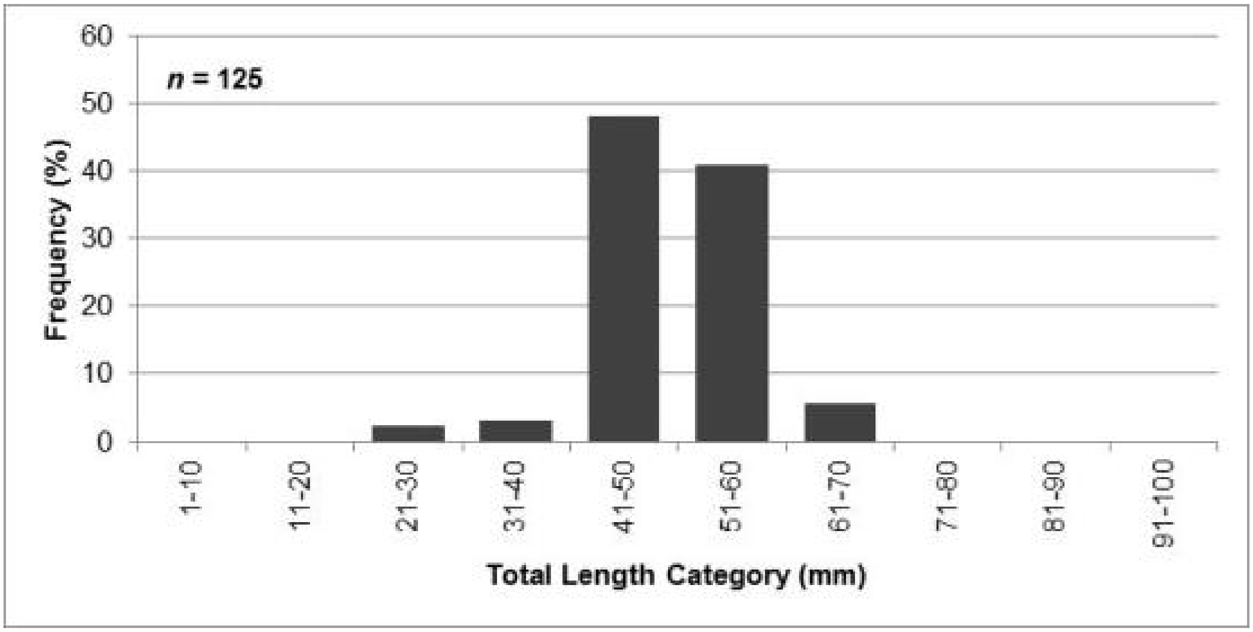
Burbot

Burbot were captured in the BSA (n = 21) during the 2006, 2012, and 2013 field programs (Table 3.2-25). In 2006, Burbot were caught in Lac du Sauvage (n = 3). Fork length ranged from 61 to 64 mm. In 2012, Burbot were caught in Lake D3 (Counts) (n = 3). Fork length was smaller than observed in Lac du Sauvage and ranged from 47 to 56 mm. In 2013, Burbot were caught in Duchess Lake, Lake E1, Lake B1 (Christine), Lake B15, Lake D2, Hammer Lake, and Lynx Lake (combined n = 15). Fork length ranged from 48 to 240 mm, with a mean fork length of 79 mm.

Ninespine Stickleback

Ninespine Stickleback were captured in Lac du Sauvage, Lake E1, Lake Ac17, and Stream D1 in the BSA (n = 125) during the 2013 field programs. Most of the fish were captured in Lake Ac17 in 2013 (n = 95). Fish total length ranged from 26 to 68 mm. The mean total length was 50 mm. Most of the Ninespine Stickleback were within the 41 to 50 mm size range (48%, n = 60) and the 51 to 60 mm size range (41%, n = 51) (Figure 3.2-49). The largest Ninespine Stickleback was caught in Lake Ac17 in August 2013 and had a total length of 68 mm.

Figure 3.2-49 Overall Length-Frequency of Ninespine Stickleback Caught in the Baseline Study Area, 2013



% = percent; n = number of samples; mm = millimetre.

Lake Chub

Lake Chub were captured in two lakes in the BSA (n = 8) during the 2013 field program. In Lake B1 (Christine) (n = 5), fork length ranged from 29 to 139 mm with a mean fork length of 86 mm (Table 3.2-25). In Hammer Lake (n = 3), fork length ranged from 32 to 132 mm, with a mean fork length of 66 mm.

Slimy Sculpin

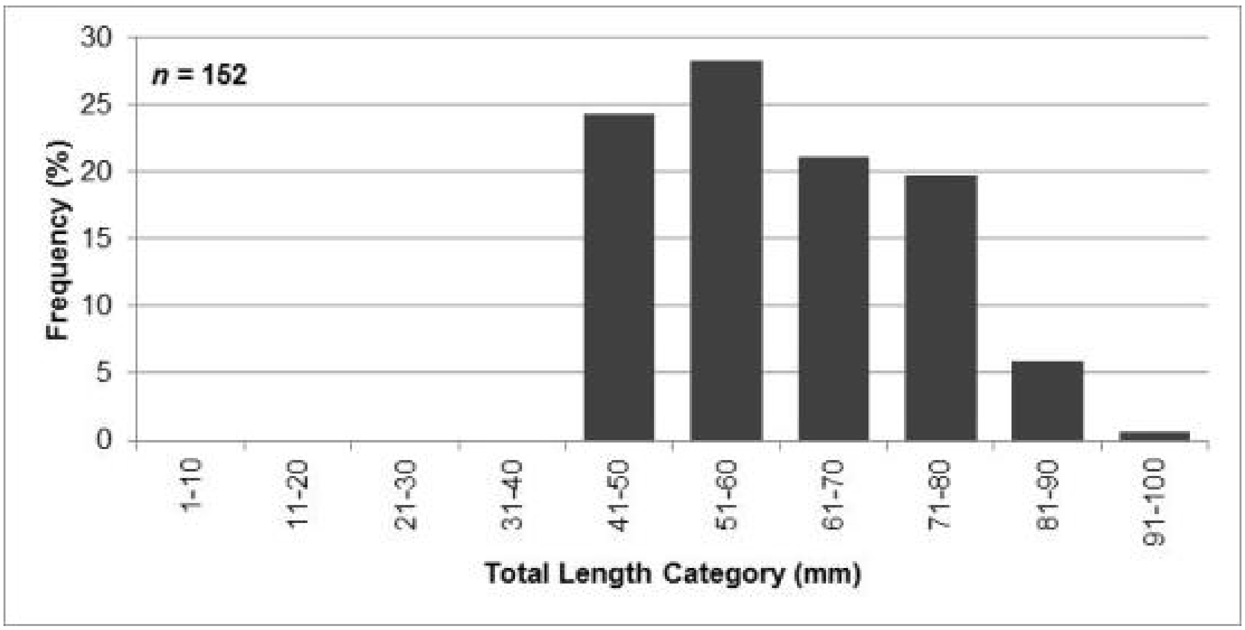
Slimy Sculpin were captured in the BSA (n = 152) during the 2006 and 2013 field programs, and ranged from 41 to 93 mm in total length. The mean total length was 61 mm. Most of the Slimy Sculpin were within the 51 to 60 mm size range (28%, n = 43) and the 41 to 50 mm size range (24%, n = 37) (Figure 3.2-50). The largest Slimy Sculpin was caught in Lake D2 in September 2013 and had a total length of 93 mm. The histogram suggests a stable decline from shorter to longer length, and therefore, a stable population.

Slimy Sculpin in Lake B4 (Cujo) (n = 47) were captured during the 2007 to 2013 field programs and ranged from 45 to 87 mm in total length. The mean total length was 62 mm. Most of the Slimy Sculpin were within the 51 to 60 mm size range (34%, n = 16) and the 61 to 70 mm size range (32%, n = 15) (Figure 3.2-51).

Slimy Sculpin in Lake D3 (Counts) (n = 74) were captured during the 2007 to 2013 field programs and ranged from 41 to 85 mm in total length. The mean total length was 58 mm, which was similar to the mean length observed in Lake B4 (Cujo). Most of the Slimy Sculpin were within the 41 to 50 mm size range (38%, n = 28), and the 51 to 60 mm size range (26%, n = 19) (Figure 3.2-52).

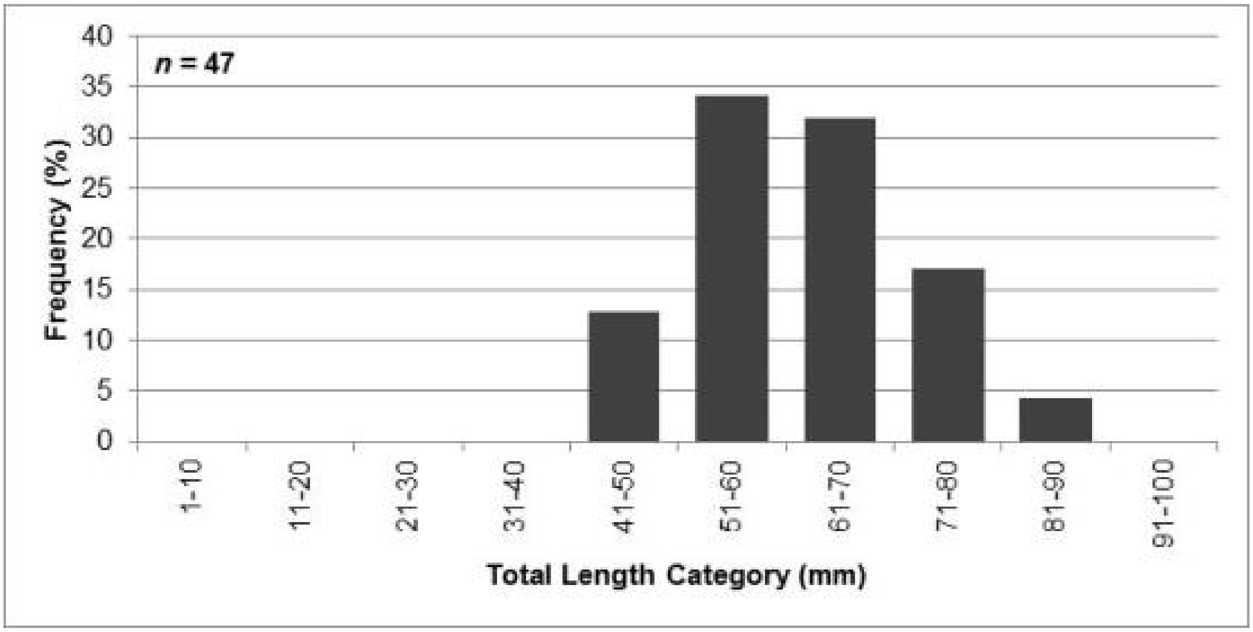
Slimy Sculpin in Lake D3 (Counts) in 2007 (n = 36) ranged from 41 to 75 mm in total length. The mean total length was 52 mm. Most of the Slimy Sculpin were within the 41 to 50 mm size range (61%, n = 22) (Figure 3.2-52). The histogram of fish sizes moved towards larger fish from 2007 to 2012/2013. In 2012, total length ranged from 45 to 85 mm (n = 31); in 2013, total length ranged from 45 to 79 mm (n = 7). In 2012 and 2013 combined (n = 38), most fish were within the 51 to 60 mm size range (32%, n = 12) and the 71 to 80 mm size range (32%, n = 12) (Figure 3.2-52).

Figure 3.2-50 Overall Length-Frequency of Slimy Sculpin Caught in the Baseline Study Area, 2007 to 2013



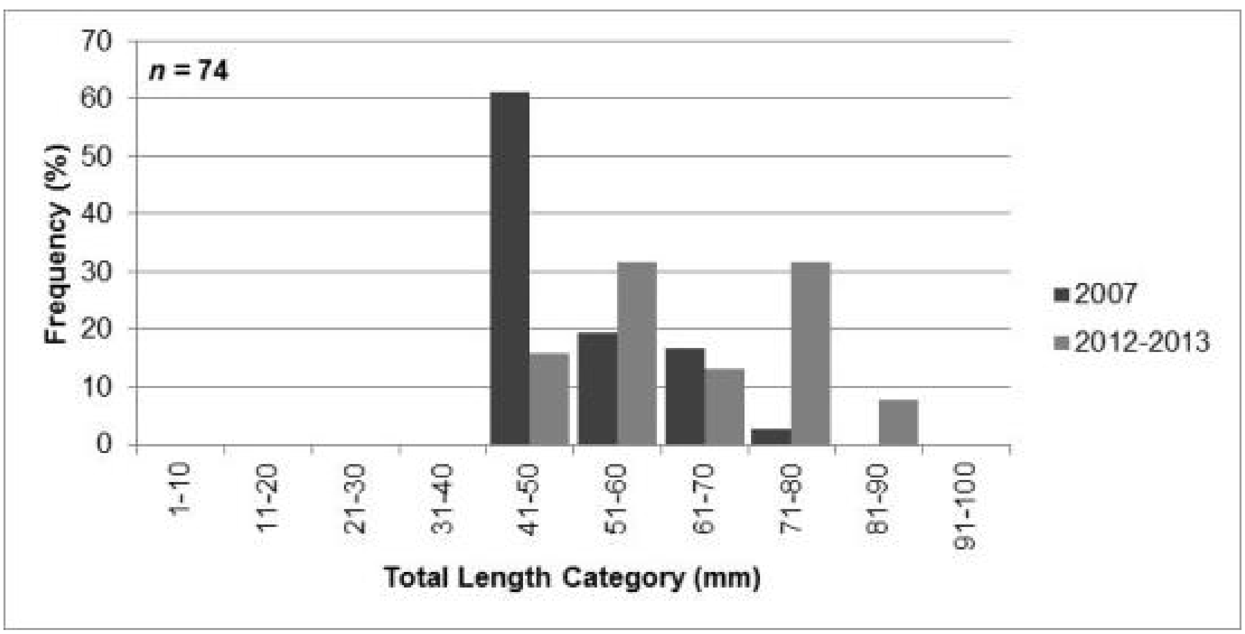
% = percent; n = number of samples; mm = millimetre.

Figure 3.2-51 Length-Frequency of Slimy Sculpin Caught in Lake B4 (Cujo), 2007 to 2013



% = percent; n = number of samples; mm = millimetre.

Figure 3.2-52 Length-Frequency of Slimy Sculpin Caught in Lake D3 (Counts), 2007 to 2013



% = percent; n = number of samples; mm = millimetre.

3.2.6.1.3 Growth in Length

To describe trends in growth, length-at-age plots were derived per captured species. Ages were determined from otoliths for sacrificed fish, whereas for non-sacrificed fish, ages were determined from fin rays and a regression model predicting fish age, developed from a subset of individual fish with both otolith and fin ray ageing structures (Equations 3.1-1, 3.1-2, and 3.1-3).

For species and lakes with sufficient sample sizes in Lac du Sauvage and other study lakes (n >25), von Bertalanffy equations were developed to quantify growth parameters. Equations were developed for Northern Pike, Lake Trout, Lake Whitefish, and Round Whitefish. Parameters of interest for these species were length at time zero (t0), asymptotic length (L∞), and a growth coefficient (K) (Table 3.2-27).

Table 3.2-27 von Bertalanffy Model Parameters for Fish Species in the Baseline Study Area, 2006 to 2013

Species	Lake	Parameters				Length (mm)	
		L∞	t0	K	n	Min.	Max.
Northern Pike	Paul Lake	889.592	93.3156	0.19035	29	133	960
Lake Trout	Lac du Sauvage	686.363	-517.71	0.18968	92	299	850
	Lake D3 (Counts)	7601.06	236.926	0.00208	33	281	910
	Lake B4 (Cujo)	19990.4	247.508	0.00089	47	300	947
Lake Whitefish	Duchess Lake	508.132	27.3005	0.16259	47	166	509
	Lac du Sauvage	569.919	265.765	0.07872	26	354	560
	Lake E1	505.192	33.6128	0.17236	39	134	565
	Paul Lake	490.171	-114.86	0.24262	25	297	514
	Lake Ad8	618.356	172.665	0.12250	26	358	615
Round Whitefish	Lake D3 (Counts)	417.040	187.203	0.10734	66	212	467
	Lake B4 (Cujo)	421.336	119.770	0.15349	40	192	421

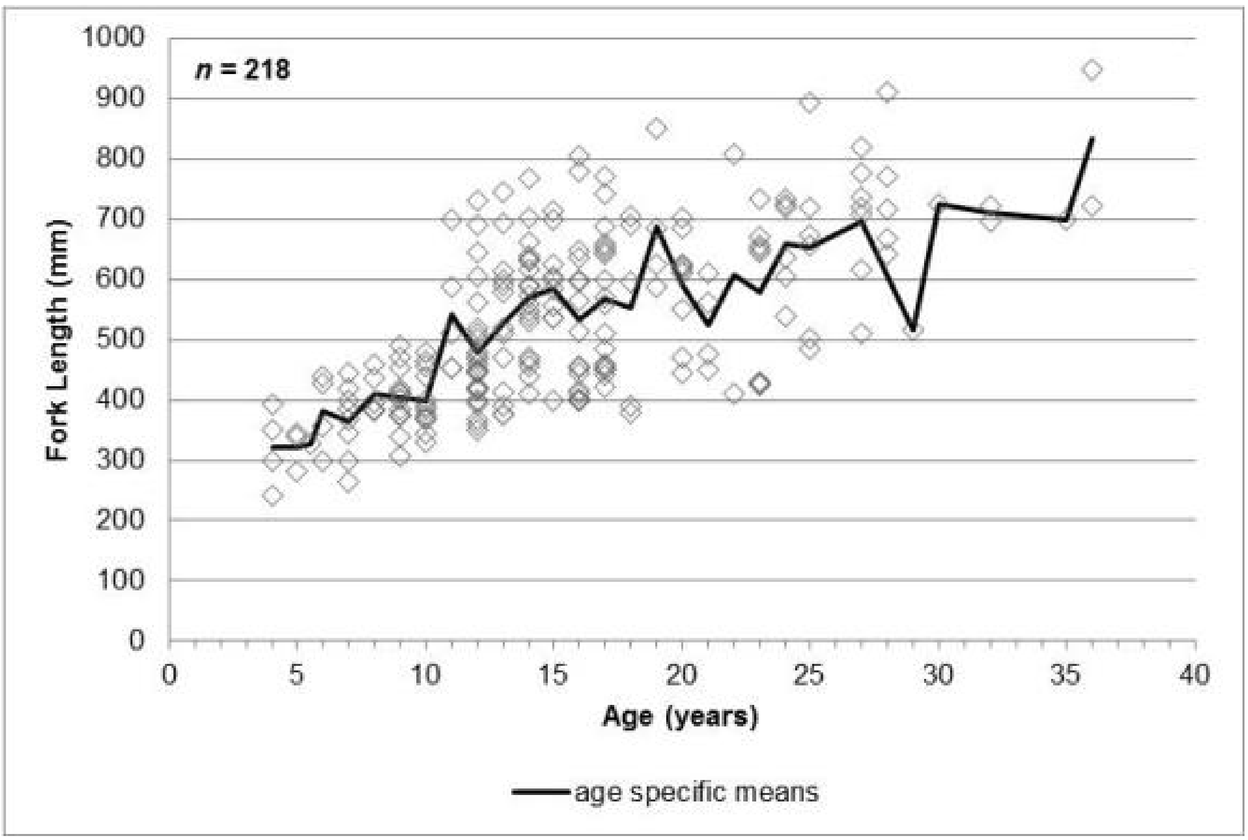
t0 = time zero; L∞ = asymptotic length or theoretical maximum length, K =growth coefficient and often used to evaluate the approximate rate at which fish reach the mature adult stage; n = sample number; Min = minimum; Max = maximum.

Lake Trout

From 2006 to 2013 sampling, age determined for 218 Lake Trout ranged from 4 to 36 years (n = 218, mean = 16 years, standard deviation [SD] ± 6.6) (Figure 3.2-53; Appendix F). The oldest fish (36 years old) was caught in Lake B4 (Cujo) in 2007. Of the four youngest fish (4 years old), three were caught in Lake B4 (Cujo) in 2013, and one was caught in Duchess Lake in 2013.

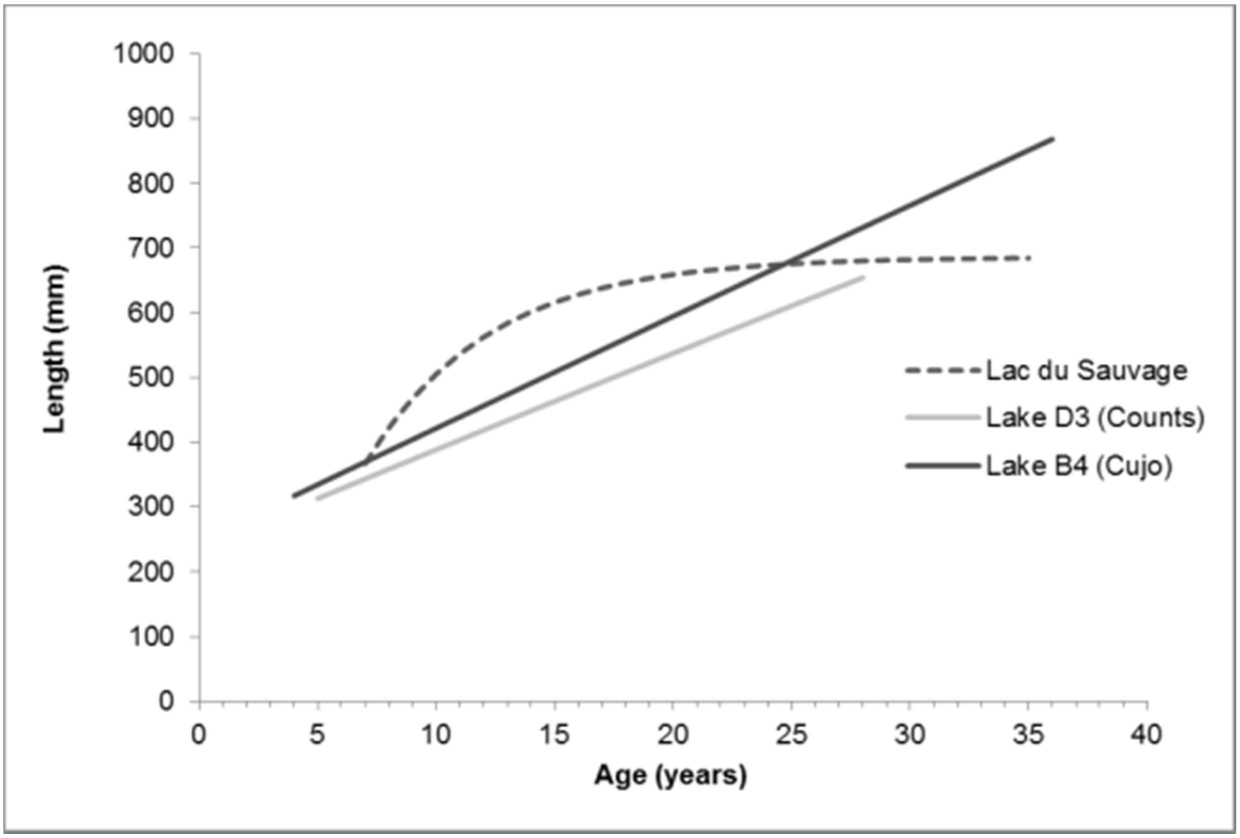
Growth, as determined by von Bertalanffy equations, varied between Lac du Sauvage versus Lakes D3 (Counts) and B4 (Cujo) (Figure 3.2-54; Table 3.2-27). For example, the theoretical maximum length of fish appeared to be much larger in Lakes D3 (Counts) and B4 (Cujo), versus Lac du Sauvage. In addition, the growth constant (K) is larger in Lac du Sauvage suggesting that it takes less time to produce a mature adult Lake Trout, compared to Lakes D3 (Counts) and B4 (Cujo). However, trends in growth rate in Lakes D3 (Counts) and B4 (Cujo) could be an artefact of mortalities as part of previous monitoring programs for the Ekati Mine.

Figure 3.2-53 Overall Age-Length Relationship for Lake Trout Caught in the Baseline Study Area, 2006 to 2013



n = number of samples; mm = millimetre.

Figure 3.2-54 von Bertalanffy Relationships for Lake Trout Caught in Lac du Sauvage, Lake D3 (Counts), and Lake B4 (Cujo), 2006 to 2013

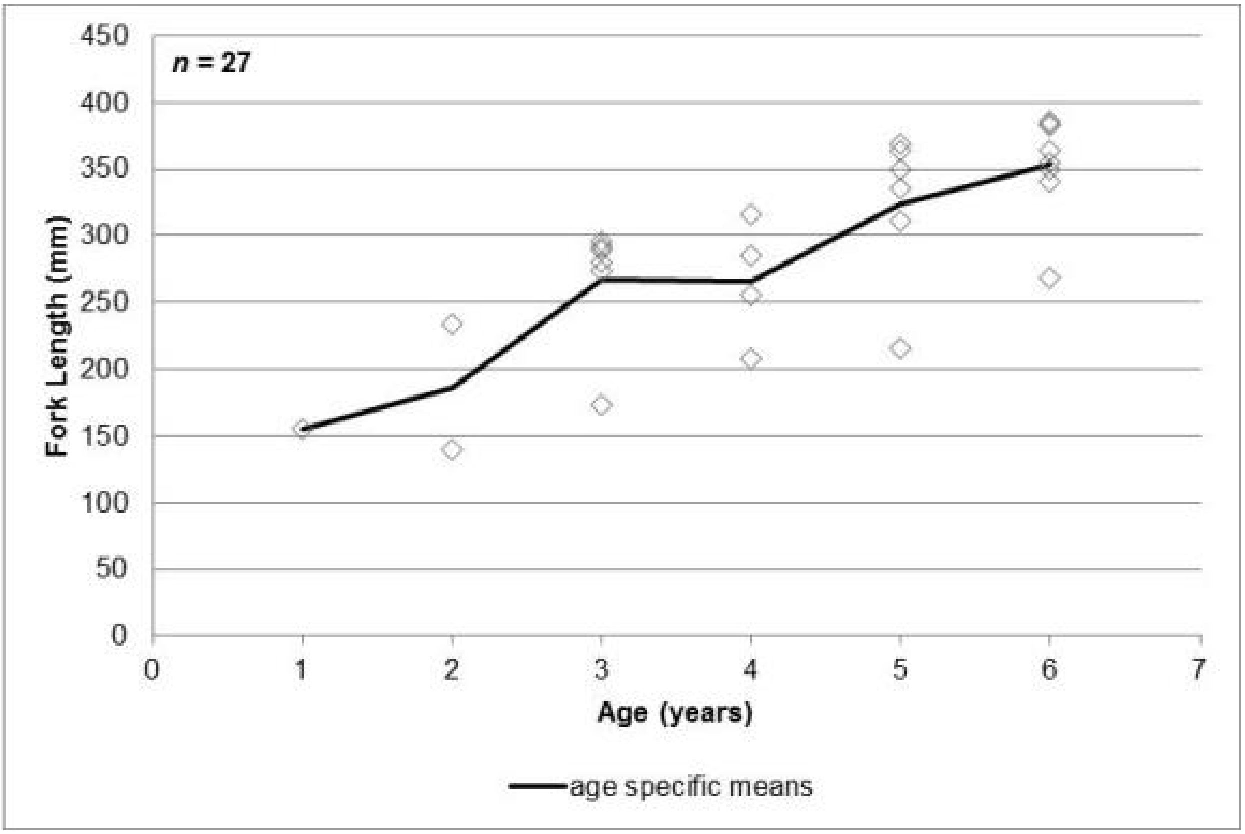


mm = millimetre.

Arctic Grayling

In 2013, Arctic Grayling ages ranged from 1 to 6 years (n = 27, mean = 4 years, SD ± 1.5) (Figure 3.2-55; Appendix F). Most of the fish were aged 3 years and up (n = 24). The youngest fish (1 year old) was caught in Paul Lake and was approximately 150 mm in length. Most of the fish were captured in Lake B4 (Cujo) (n = 9) and Lake D2 (n = 8).

Figure 3.2-55 Overall Age-Length Relationship for Arctic Grayling Caught in the Baseline Study Area, 2013

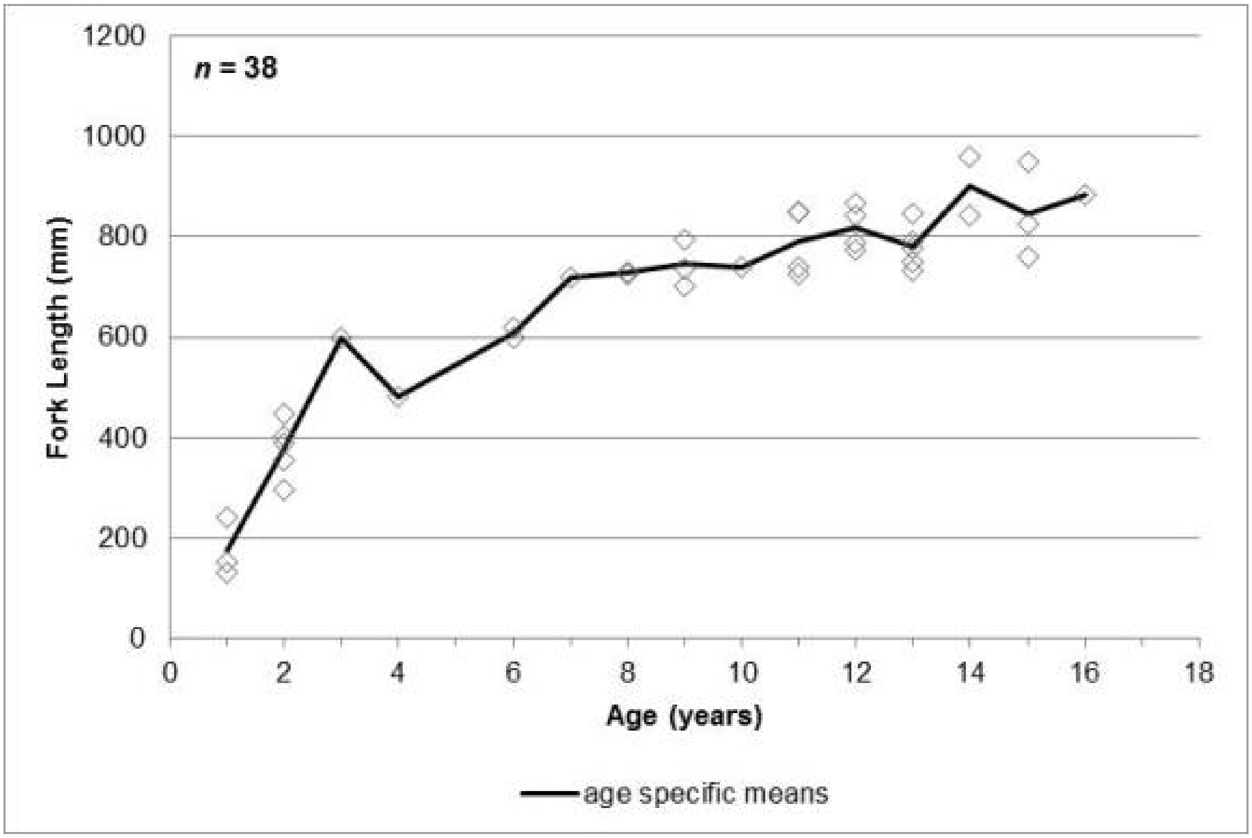


n = number of samples; mm = millimetre.

Northern Pike

In 2013, age was determined for 38 Northern Pike and ranged from 1 to 16 years (n = 218, mean = 9 years, SD ± 4.83) (Figure 3.2-56; Appendix F). The oldest fish (16 years old) was caught in Paul Lake and had a fork length of 882 mm. The three youngest fish (1 year old) were caught in Stream E2, Paul Lake, and Lake E1. Most of the fish were captured in Paul Lake (n = 29). The theoretical maximum length of Northern Pike in Paul Lake was 890 mm (Table 3.2-27).

Figure 3.2-56 Overall Age-Length Relationship for Northern Pike Caught in the Baseline Study Area, 2013

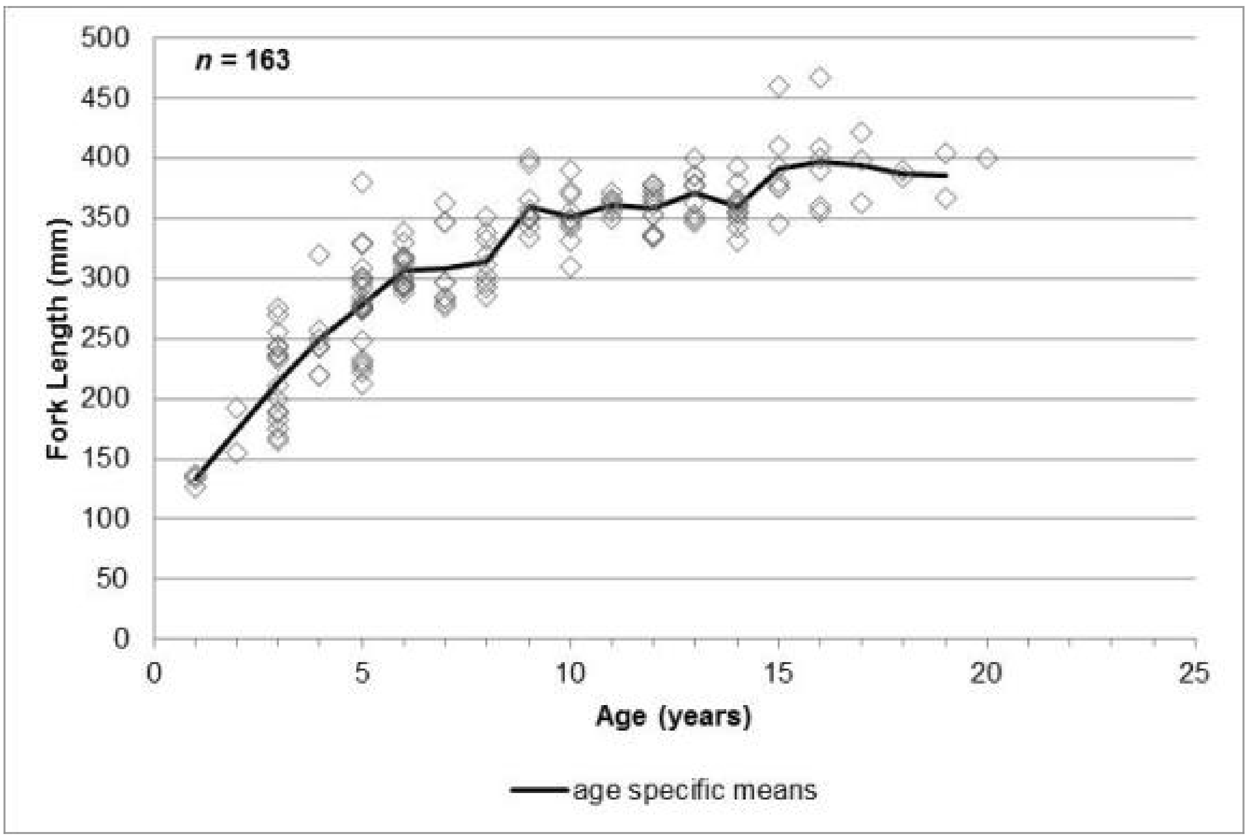


n = number of samples; mm = millimetre.

Round Whitefish

From 2006 to 2013, age was determined for 160 Round Whitefish, ranging from 1 to 20 years (n = 163, mean = 9 years, SD ± 4.6) (Figure 3.2-57; Appendix F). The oldest fish (20 years old) was caught in Lake B4 (Cujo) in 2007 and had a fork length of 400 mm. Of the three youngest fish (1 year old), two were caught in Lake B15, and one was caught in Stream B1 (Christine Creek). Most of the fish were captured in Lake D3 (Counts) (n = 66) and Lake B4 (Cujo) (n = 40). Round Whitefish growth was similar in Lakes D3 (Counts) and B4 (Cujo) (Table 3.2-27).

Figure 3.2-57 Overall Age-Length Relationship for Round Whitefish Caught in the Baseline Study Area, 2006 to 2013



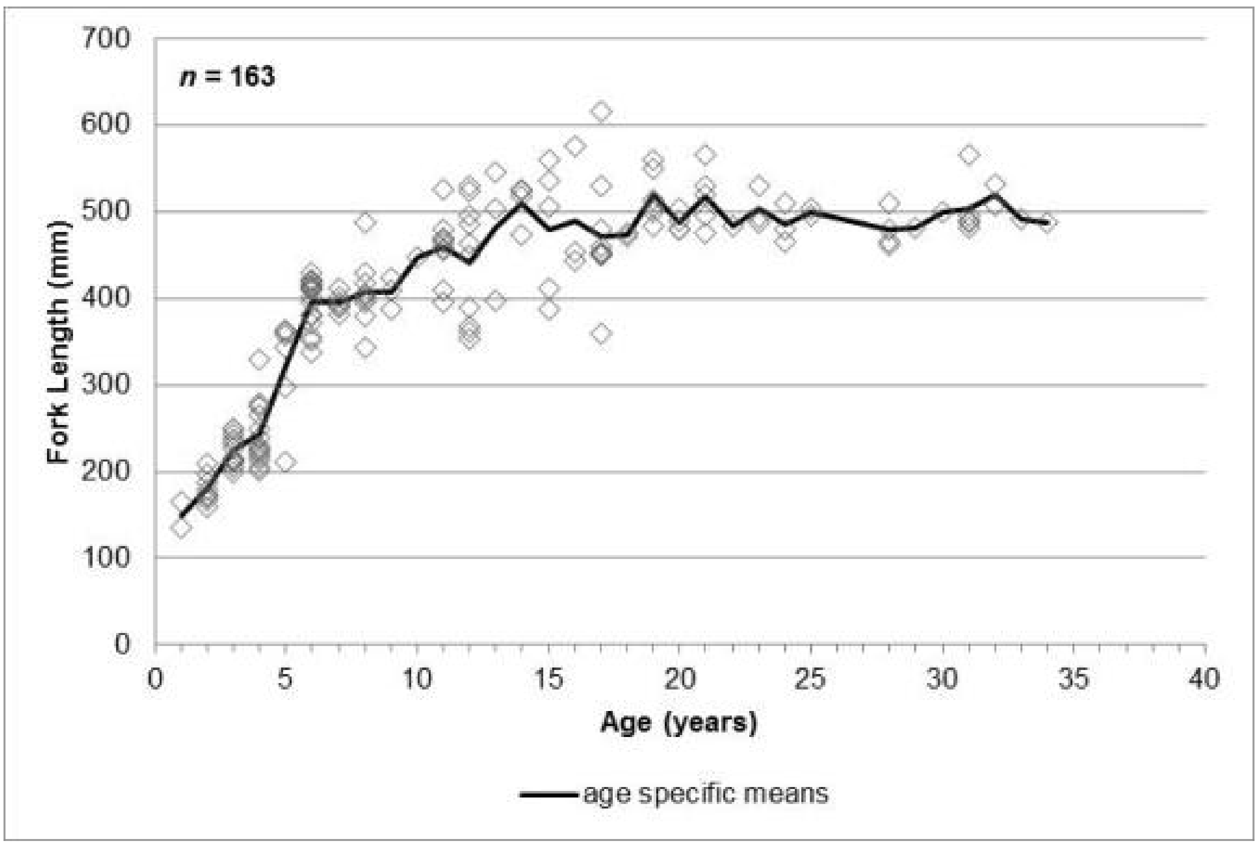
n = number of samples; mm = millimetre.

Lake Whitefish

In 2013, age was determined for 163 Lake Whitefish and ranged from 1 to 34 years (n = 163, mean = 12 years, SD ± 8.6) (Figure 3.2-58; Appendix F). The oldest fish (34 years old) was caught in Paul Lake in 2013 and had a fork length of 487 mm. The two youngest fish (1 year old) were caught in Lake E1 and Hammer Lake. Most of the fish were captured in Duchess Lake and Lake E1 (both n = 39).

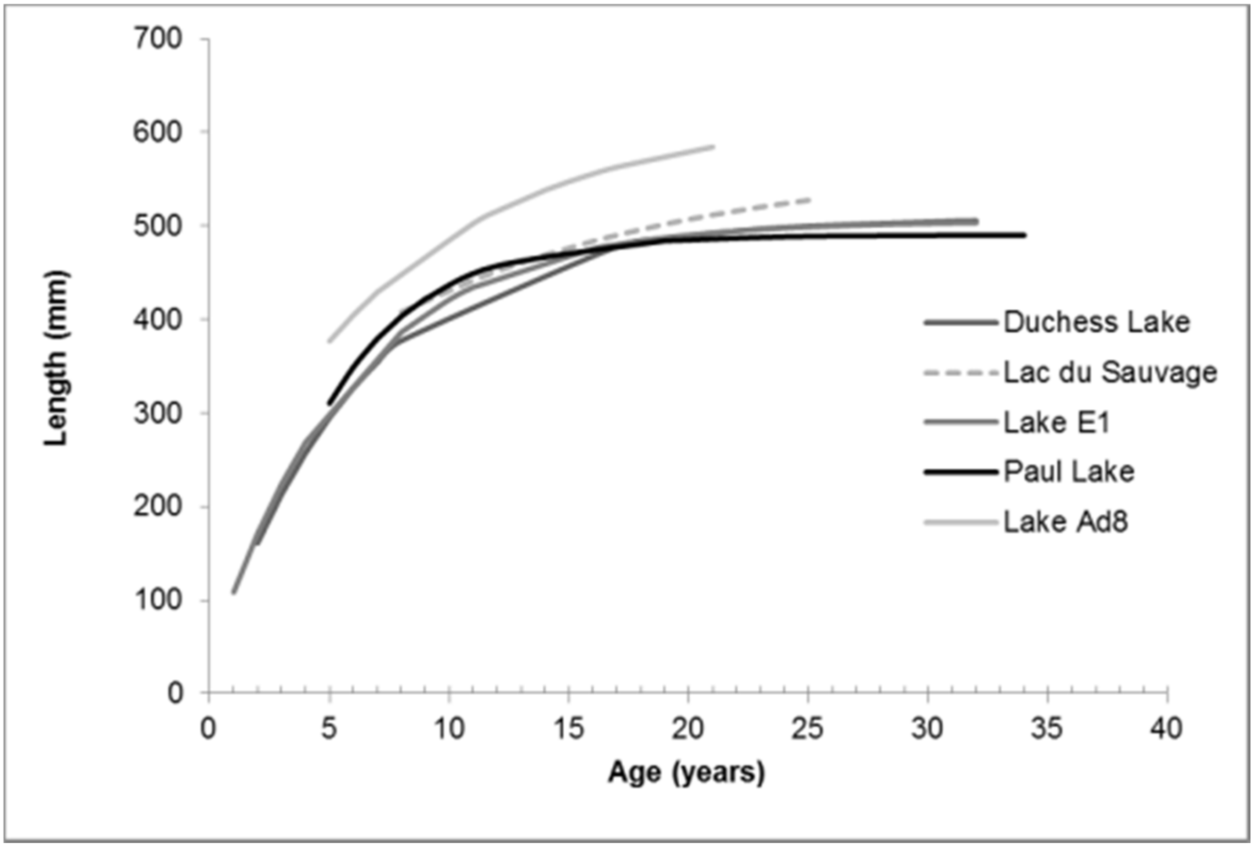
Lake Whitefish growth, as determined by von Bertalanffy equations, varied between Lake Ad8 versus other lakes in the BSA (Figure 3.2-59; Table 3.2-27). For example, the theoretical maximum length of fish appeared to be much larger in Ad8, versus Lac du Sauvage, Lake E1, Paul Lake, and Duchess Lake. In addition, the growth constant (K) was largest in Paul Lake and smallest in Lac du Sauvage. In other words, it may take more time to produce a mature adult Lake Whitefish in Lac du Sauvage, compared to other lakes in the BSA.

Figure 3.2-58 Overall Age-Length Relationship for Lake Whitefish Caught in the Baseline Study Area, 2013



n = number of samples; mm = millimetre.

Figure 3.2-59 von Bertalanffy Relationships for Lake Whitefish Caught in Lac du Sauvage, Duchess, E1, Paul, and Ad8 lakes, 2006 to 2013



mm = millimetre.

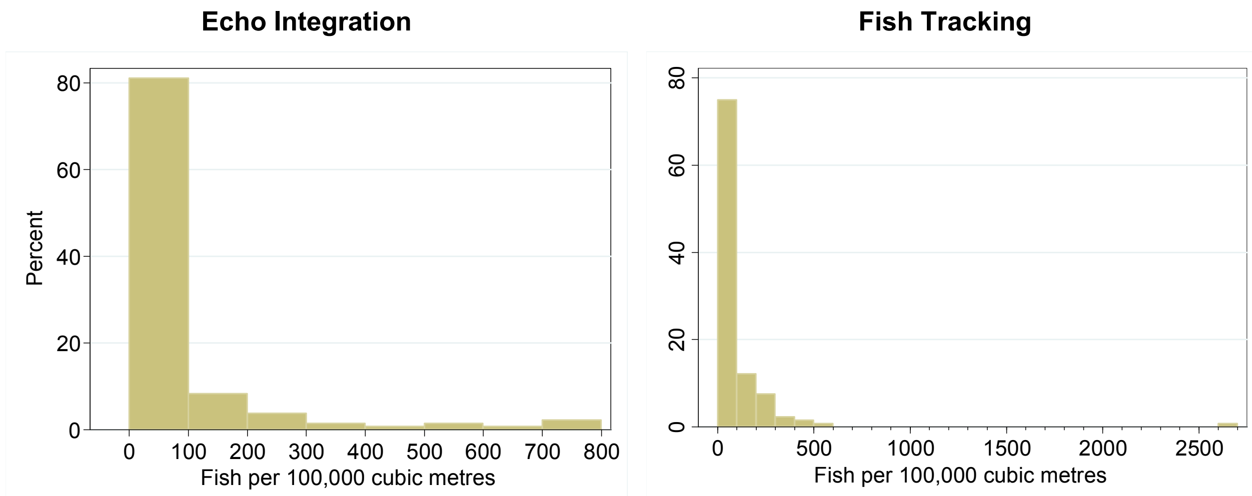
3.2.7 Lac du Sauvage Population Estimation

3.2.7.1 Fish Densities

Fish densities were calculated for transects using two analytical methods: echo integration and fish tracking. The statistical distributions of fish densities from both datasets were suggestive of highly skewed distributions (Figure 3.2-60). Most transects had densities of less than 100 fish per 100,000 m^3 and, in general, higher densities of fish were typically recorded at internal basins Aa, Ab, and Ac in Lac du Sauvage (Table 3.2-28; Table 3.2-29).

Echo integration and fish tracking methods yielded different results for transects, in part, because echo integration considers total acoustic energy in the sampling beam, whereas fish tracking only includes targets or echoes that meet the criteria of a chosen algorithm (Table 3.2-28; Table 3.2-29; also see Section 3.5.1).

Figure 3.2-60 Statistical Distribution of Volumetric Fish Density Values of Combined Horizontal and Vertical Beaming Data Collected in Lac du Sauvage, August 2013



Note that the evaluation of the hydroacoustic data for Lac du Sauvage in Echoview suggested that the occurrence of schooling behavior was uncommon over the 132 km of transects covered during both surveys combined. Only five small schools of fish were visually identified during survey one and four small schools during survey two, all of which were recorded in the horizontal beam in the upper parts of the water column in internal basins Ac, Ad, and Ae of Lac du Sauvage. The length of the schools ranged from approximately 4 to 26 m, and the height of the schools in the water column ranged from 3 to 8 m, as identified in Echoview.

Reporting of results considered outputs from both echo integration and fish tracking analyses because echo integration is a commonly used approach for quantifying abundance and biomass, whereas fish tracking methods are reliable for quantifying abundance where schooling behaviour is uncommon and for describing population structure. Furthermore, consideration of multiple methods may reduce underlying uncertainties in the analysis of hydroacoustic data.

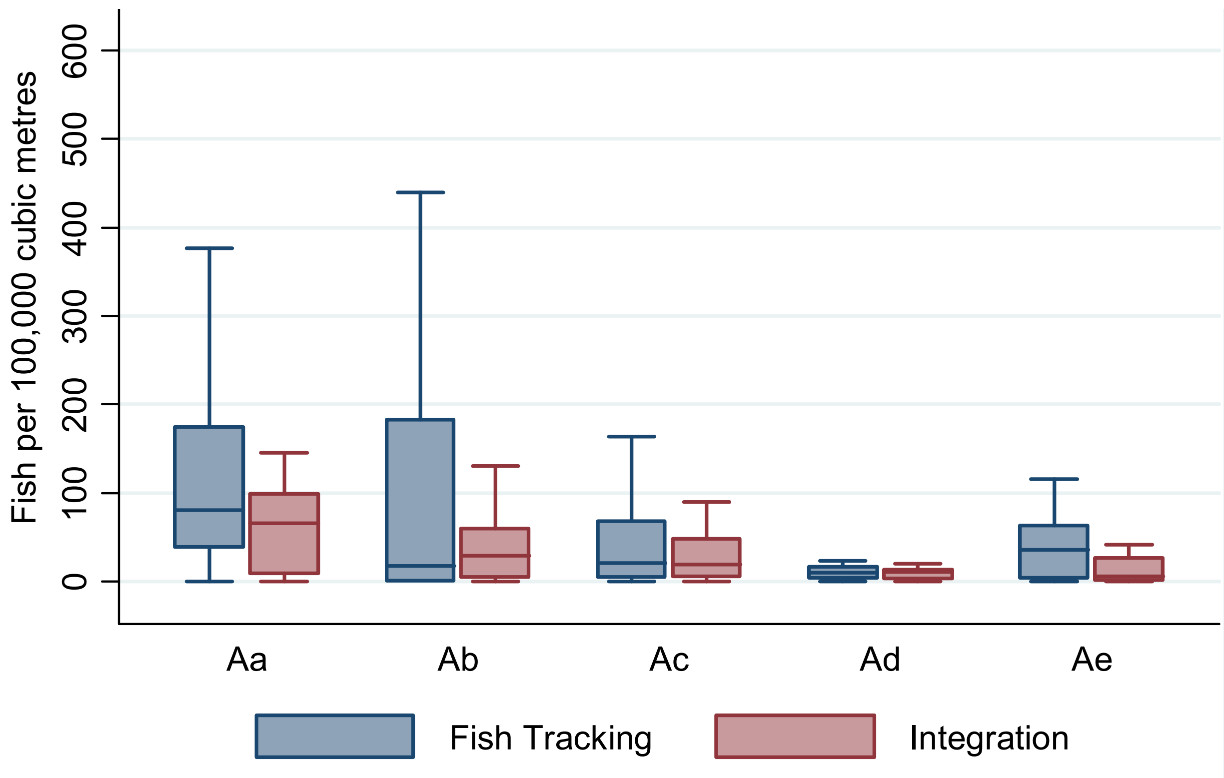
3.2.7.2 Echo Integration Results

Echo integration generated fish densities for most of the transects surveyed with the exception of no fish recorded at the following transects: Aa 1.4, Ab 1.3, Ac 1.2, Ac 1.7, and Ae 1.1 in the vertical beam during survey one, Ab 1.7 and Ac 1.2 in the vertical beam during survey two, Ac 1.12 in the horizontal beam during survey one, and Ab 1.7 in the horizontal beam during survey two (Table 3.2-28). No fish were recorded at Ac 1.2 in the vertical beam (i.e., deep water locations) during either survey. This transect is positioned within internal basin Ac.

Echo integration densities were typically higher in the vertical beam (greater than 5 m stratum) than in the horizontal beam (0 to 5 m stratum) (Figure 3.2-61). Highest densities were observed at transect Ab 1.10 during survey two when 362.3 fish per 100,000 m^3 were recorded in the vertical beam and 731.3 fish per 100,000 m^3 in the horizontal beam. The next highest density of fish was at Aa 1.1 where 329.8 fish per 100,000 m^3 were noted during survey two in the vertical beam. Transects Aa 1.1 and Ab 1.10 were in close proximity to each other, separated by a distance of only 1 to 2 km (Map 3.1-3).

More fish were detected during the second survey versus the first survey; for example, on average, the difference from the first to second survey was 58.2 fish in the vertical beam and 30.0 fish in the horizontal beam (Table 3.2-28). Thus, results reporting for echo integration herein emphasize the second survey. For survey pass two, the median density of fish was approximately 41.6 fish per 100,000 m^3 in the vertical beam, and 17.9 fish per 100,000 m^3 in the horizontal beam for the second survey.

Figure 3.2-61 Boxplot of Fish Densities from Echo Integration and Fish Tracking for Vertical and Horizontal Beams per Internal Basin (Aa to Ae)



Note: Boxplot includes quartiles with 10% and 90% percentiles.

Table 3.2-28 Calculated Fish Densities from Echo Integration for Horizontal Beaming and Vertical Beaming per Transect and Survey Pass

Basin ID	Transect ID	Vertical Beam Fish Per 100,000 m^3 (>5 m depth)			Horizontal Beam Fish Per 100,000 m^3 (0 to 5 m depth)		
		Pass 1	Pass 2	Unit Change	Pass 1	Pass 2	Unit Change
Aa	Aa1.1	278.44	329.83	51.39	78.13	99.34	21.21
	Aa1.2	71.23	145.56	74.33	59.47	89.78	30.31
	Aa1.3	98.58	99.57	0.98	67.35	10.88	-56.47
	Aa1.4	0	64.07	64.07	1.69	2.76	1.07
	Aa1.5	0.98	55.37	54.39	7.29	17.92	10.63
Ab	Ab1.1	122.08	199.92	77.84	30.05	115.61	85.56
	Ab1.10[(a)]	60.64	362.25	301.60	37.87	731.33	693.47
	Ab1.2	0.06	130.38	130.32	26.50	82.02	55.52
	Ab1.3	0	4.12	4.12	0.17	0.09	-0.08
	Ab1.4	2.91	33.64	30.73	13.65	0.23	-13.41
	Ab1.5	13.86	30.44	16.59	27.65	9.94	-17.70
	Ab1.6	53.73	41.57	-12.16	56.02	4.23	-51.79
	Ab1.7	12.74	0	-12.74	39.93	0	-39.93
	Ab1.8	17.07	94.62	77.55	18.33	0.05	-18.28
	Ab1.9	58.11	154.03	95.92	16.83	49.96	33.13
Ac	Ac1.1	11.77	9.56	-2.22	2.97	3.68	0.71
	Ac1.10	46.13	18.83	-27.30	121.14	11.10	-110.04
	Ac1.11	11.82	38.49	26.68	21.38	51.65	30.28
	Ac1.12	6.95	17.42	10.47	0	0.30	0.29
	Ac1.2	0	0	0.00	3.69	27.75	24.06
	Ac1.3	0.12	59.25	59.13	3.04	13.63	10.59
	Ac1.4	6.75	32.52	25.77	21.71	6.87	-14.84
	Ac1.5	11.13	16.28	5.15	20.43	89.49	69.07
	Ac1.6	31.32	208.40	177.08	21.50	50.44	28.94
	Ac1.7	0	318.18	318.18	0.31	67.37	67.07
	Ac1.8	51.75	261.06	209.30	1.93	70.19	68.27
	Ac1.9	26.40	59.66	33.25	24.44	19.10	-5.34
Ad	Ad1.1	4.02	10.79	6.78	4.63	10.83	6.20
	Ad1.2	0.28	39.31	39.03	0.37	20.15	19.78
	Ad1.3	11.52	11.51	-0.01	0.78	14.08	13.30
Ae	Ae1.1	0	5.58	5.58	0.70	5.24	4.54
	Ae1.2	0.08	41.75	41.67	10.36	27.28	16.91
	Ae1.3	2.71	39.51	36.79	0.26	25.98	25.72

Note: Average change from survey 1 to 2 for vertical beam was +58.2 fish / 100,000 m^3, and for horizontal beam was +30.0 fish / 100,000 m^3.

a) Highest densities were recorded at Ab1.10 during survey 2.

ID = identification m^3 = cubic metre; > = greater than; m = metre.

3.2.7.3 Fish Tracking Results

Approximately 5,338 fish tracks were detected along survey transects where total volume of sampled water was approximately 9,258,220 m^3. Using transect as the sampling unit, the statistical distribution of densities was highly skewed (Figure 3.2-62), with the tail end of the distribution including Ab 1.10 where 2,628.8 fish per 100,000 m^3 were recorded in the horizontal beam (0-5 m stratum) during the second survey (Table 3.2-29).

Densities varied across Lac du Sauvage and between survey periods. The Ab 1.10 density in the 0 to 5 m stratum was an extreme outlier in the dataset with the next highest densities of fish at much smaller values; the second highest density included 519.3 fish per 100,000 m^3 at Aa 1.1 during pass one in the horizontal beam, followed by 515.8 fish per 100,000 m^3 at Ab 1.10 during pass two in the vertical beam. Transects Aa 1.1 and Ab 1.10 were in close proximity to each other, separated by a distance of 1 to 2 km (Map 3.1-3).

More fish were recorded during the second survey than the first survey, as reported for echo integration. Differences in densities per transect, on average, were higher during the second survey by 70.7 fish in the vertical beam and by 100.1 fish in the horizontal beam (Table 3.2-29). Thus, results reporting for fish tracking densities herein emphasize the second survey. During the second survey, the median density of fish was approximately 41.5 fish per 100,000 m^3 in the vertical beam and 22.0 fish per 100,000 m^3 in the horizontal beam.

Table 3.2-29 Calculated Fish Densities from Target Tracking for Horizontal Beaming and Vertical Beaming per Transect and Survey Pass

Basin ID	Transect ID	Vertical Beam Fish Per 100,000 m^3 (>5 m depth)			Horizontal Beam Fish Per 100,000 m^3 (0 to 5 m depth)		
		Pass 1	Pass 2	Unit Change	Pass 1	Pass 2	Unit Change
Aa	Aa1.1	376.14	245.86	-130.28	519.25	281.03	-238.22
	Aa1.2	67.41	121.58	54.17	117.00	229.66	112.66
	Aa1.3	42.19	81.95	39.76	203.15	42.03	-161.12
	Aa1.4	0	80.63	80.63	3.33	12.27	8.94
	Aa1.5	7.03	36.41	29.38	27.23	27.40	0.18
Ab	Ab1.1	94.97	179.14	84.17	60.30	439.56	379.26
	Ab1.10[(a)]	29.70	515.78	486.08	184.75	2,628.83	2,444.07
	Ab1.2	0	213.30	213.30	7.43	277.00	269.57
	Ab1.3	0	5.68	5.68	1.55	0	-1.55
	Ab1.4	0	6.30	6.30	27.06	0.81	-26.25
	Ab1.5	9.21	29.54	20.33	87.13	3.87	-83.26
	Ab1.6	25.73	52.89	27.17	105.33	5.11	-100.22
	Ab1.7	50.90	0	-50.90	69.30	0	-69.30
	Ab1.8	0	0	0	47.63	0	-47.63
	Ab1.9	0	343.60	343.60	130.01	424.09	294.09

Table 3.2-29 Calculated Fish Densities from Target Tracking for Horizontal Beaming and Vertical Beaming per Transect and Survey Pass

Basin ID	Transect ID	Vertical Beam Fish Per 100,000 m^3 (>5 m depth)			Horizontal Beam Fish Per 100,000 m^3 (0 to 5 m depth)		
		Pass 1	Pass 2	Unit Change	Pass 1	Pass 2	Unit Change
Ac	Ac1.1	0	7.55	7.55	0.91	3.38	2.46
	Ac1.10	19.61	41.48	21.87	10.73	22.40	11.67
	Ac1.11	26.08	22.42	-3.66	85.66	10.91	-74.75
	Ac1.12	0	4.41	4.41	0	0	0.00
	Ac1.2	0	0	0	2.93	6.89	3.97
	Ac1.3	0	135.00	135.00	2.92	27.61	24.69
	Ac1.4	13.00	40.58	27.58	64.62	12.53	-52.10
	Ac1.5	0	0	0	162.65	11.30	-151.35
	Ac1.6	17.31	250.05	232.74	72.40	163.41	91.01
	Ac1.7	0	383.76	383.76	2.00	278.12	276.12
	Ac1.8	32.08	127.63	95.55	5.21	100.89	95.68
	Ac1.9	8.11	71.72	63.61	28.05	54.31	26.26
Ad	Ad1.1	0	9.38	9.38	1.11	9.53	8.42
	Ad1.2	0	22.80	22.80	0	9.32	9.32
	Ad1.3	0	11.69	11.69	0.45	22.00	21.55
Ae	Ae1.1	0	5.99	5.99	1.21	20.33	19.11
	Ae1.2	0	65.99	65.99	8.29	103.65	95.36
	Ae1.3	12.36	50.87	38.51	0.89	115.13	114.24

Note: The average net unit change from pass 1 to pass 2 for vertical beam was +70.7 fish / 100,000 m^3, and for horizontal beam was +100.1 fish / 100,000 m^3.

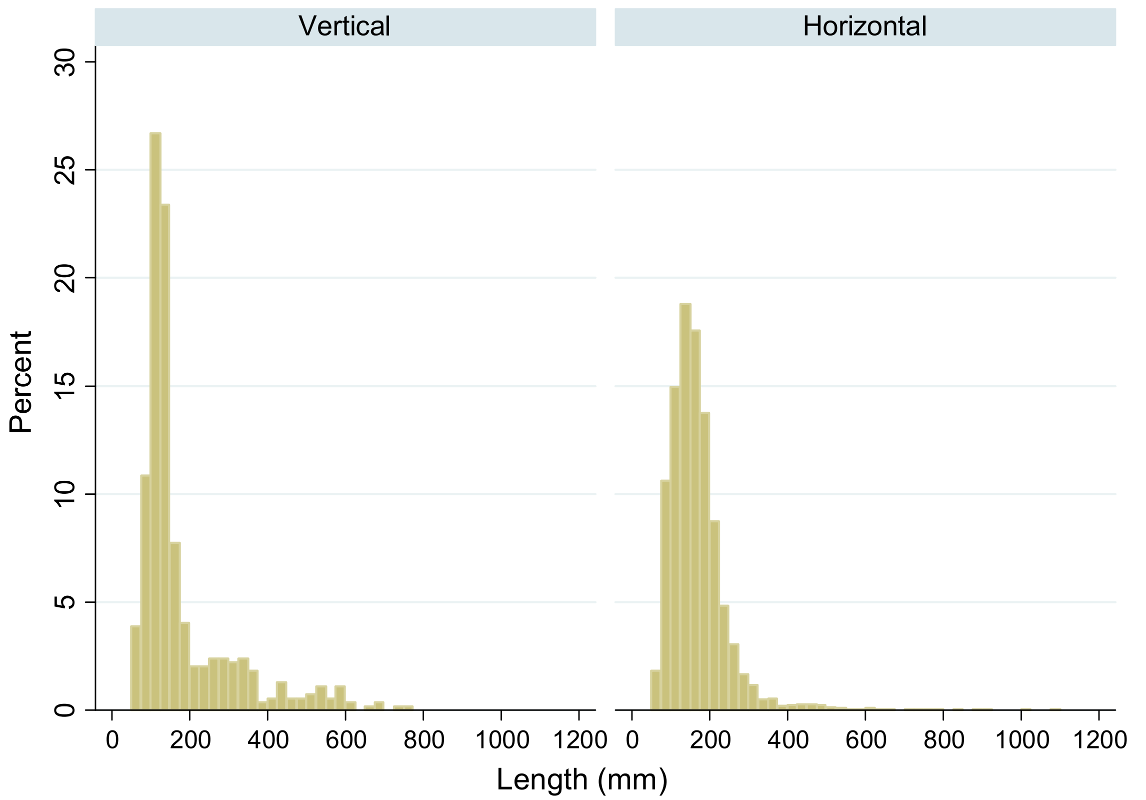
a) Highest densities recorded on Ab1.10 during second survey.

ID = identification; m^3 = cubic metre; > = greater than; m = metre.

3.2.7.4 Target Strength Distribution

Echoview's fish tracking module identified 7,603 fish tracks in transects and between transects (as incidental observations) in total. Of these, 5,338 fish tracks were detected along transects. Using maximum TS per horizontal fish track and mean TS per vertical fish track combined with TS equations to calculate fish length, the mean length of fish in Lac du Sauvage was approximately 166 mm. As expected, fish identified in the second survey were slightly longer (by almost 3 mm) than those recorded during the first survey (because they were older fish in the second survey). Approximately 5% of all fish tracks were greater than 300 mm in length and, of these, 25 individuals were longer than 1.0 m (23 large fish were located in deep water locations, and two large fish were near the surface) (Figure 3.2-62). In the west section of Lac du Sauvage (i.e., internal basins Ac, Ad, and Ae), approximately 7% of the fish tracks were greater than 300 mm in length; in the east section of Lac du Sauvage (i.e., internal basins Aa and Ab), only 3.6% of the fish tracks were greater than 300 mm.

Figure 3.2-62 Length Distribution Derived from Target Strengths of Fish Recorded from Vertical and Horizontal Beaming



mm = millimetre.

Fish sizes varied within the water column and across internal basins of Lac du Sauvage (Table 3.2-30). In the water column, mean sizes of fish in the vertical beam (greater than 5 m stratum) were, on average, 13 mm longer than those recorded in the horizontal beam (0 to 5 m stratum). Of the five internal basins, fish were on average largest in Basin Ad (247 mm), followed by Basin Ae (178 mm) and Basin Ac (172 mm). Fish were smallest in length in Basin Aa (160 mm) and Ab (161 mm).

Table 3.2-30 Statistics for Fish Length Derived from Target Strengths of Fish Estimated from Hydroacoustic Transects per Internal Basin

Internal Basin	Vertical Beam			Horizontal Beam			Strata Combined		
	Mean (mm)	SD	Count	Mean (mm)	SD	Count	Mean (mm)	SD	Total Count
Aa	162.2	104.3	63	159.7	63.5	1,044	159.8	66.4	1,107
Ab	184.6	128.1	139	160.0	62.9	2,418	161.4	68.2	2,557
Ac	177.0	117.4	175	171.5	74.9	1,116	172.3	81.9	1,291
Ad	255.5	161.5	9	245.4	166.9	78	246.5	165.5	87
Ae	162.5	82.0	18	178.9	84.2	278	177.9	84.0	296
Aa/b	177.6	121.3	202	159.9	63.1	3,462	160.9	67.7	3,664
Ac/d/e	179.2	117.6	202	176.8	85.5	1,472	177.1	90.0	1,674
LDS	178.4	119.3	404	165.0	70.9	4,934	166.0	75.8	5,338

mm = millimetre; SD = standard deviation; LDS = Lac du Sauvage.

3.2.7.5 Population Estimation

Abundances of yearling and older fish were generated using fish densities and water volumes for the 0 to 5 m stratum and greater than 5 m depth stratum per the west region (internal basin Ac/d/e) and east region (internal basin Aa/b) of Lac du Sauvage (Table 3.2-31). Predicted fish abundances were nearly identical between east and west regions of the lake (difference of less than 1,000 fish) when considering echo integration values; whereas, an additional 11,000 fish were predicted for the east versus west region when considering fish tracking values.

For all of Lac du Sauvage, median total abundance was similar for echo integration (approximately 194,000) versus fish tracking methods (approximately 197,000). Concordance in predictions highlights the reliability of the analyses used to predict the abundance of fish in Lac du Sauvage. However, the advantage of fish tracking methods includes additional outputs on fish sizes and distributions.

The predicted population estimate using 75th percentiles, as part of an environmentally conservative approach for this baseline study, was determined to be approximately 828,000 fish for Lac du Sauvage. However, the actual population estimate for fish (including Cisco, Lake Trout, Lake Whitefish, Round Whitefish, and Arctic Grayling) in Lac du Sauvage may be much lower and closer to the median values reported in Table 3.2-31 (e.g., approximately 197,000 individuals based on fish tracking).

Table 3.2-31 Percentile (Including Quartile) Statistics for Density and Abundance of Fish Estimated from Hydroacoustic Surveys

Percentile Statistics	Internal Basin Aa/b			Internal Basin Ac/d/e			Total Abundance
	Fish/100,000 m^3		Abundance	Fish/100,000 m^3		Abundance	
	>5 m	0 to 5 m		>5 m	0 to 5 m		
Echo Integration							
10%	4.12	0.05	3,767	5.58	3.68	16,339	20,106
25%	33.64	0.23	30,506	11.51	10.83	39,872	70,377
50%	94.62	10.88	97,608	35.51	19.63	96,791	194,399
75%	154.03	89.78	242,100	59.25	50.44	195,155	437,255
90%	329.83	115.61	429,937	261.06	70.19	570,686	1,000,623
Fish Tracking							
10%	0.00	0.00	0	0.00	3.38	6,420	6,420
25%	6.30	0.81	6,592	7.55	9.53	30,761	37,352
50%	80.63	27.40	104,106	31.69	21.16	93,316	197,422
75%	213.30	281.03	516,164	71.72	100.89	311,988	828,153
90%	343.60	439.56	816,291	250.05	163.41	729,544	1,545,835

Note: Abundance derived for Aa/b basins using a volume of 89,883,788 m^3 at depths >5m, and 115,446,534 m^3 at depths 0 to 5 m, and for Ac/d/e/ basins using a volume of 167,468,165 m^3 at depths >5 m and 190,191,703 m^3 at depths 0 to 5 m.

% = percent; m^3 = cubic metre; > = greater than; m = metre.

4 SUMMARY

A review of historical baseline information identified general trends in species abundance and distributions, and life history. The primary sources of information were baseline evaluations and environmental monitoring reports related to diamond mining activities by BHP (Ekati Mine) and DDMI in the BSA. A total of 38 documents were reviewed. Standard investigations of fish populations and habitat at 17 lakes were summarized, including Lac du Sauvage, Paul Lake, Duchess Lake, and Lake E1 during the open-water season in 2013. In addition to lakes, the summary involved standard fish sampling at 6 streams and collection of habitat information at 17 streams (typically ephemeral streams with minimal to no flows). Habitat descriptions involved aerial photographs of habitat, surface water quality, vertical lake profiles, lake bathymetry, and stream discharge. Included in the analyses were fish and fish habitat data from recently completed fish programs in the Fish and Fish Habitat BSA: 2006 Jay Pipe Aquatic Baseline Report, the Ekati Mine 2007 and 2012 AEMP reports, and two reports in support of the Diavik Mine 2008 and 2011 AEMPs.

Fish Habitat

Of lakes sampled in 2013, Lac du Sauvage was the largest with a total surface area of 8,550 ha and a total volume of 630,320,529 m^3, with a maximum depth recorded of approximately 40 m (in the western internal basins). For comparison, Lac de Gras is almost seven times larger in area than Lac du Sauvage with a total surface area of 57,223 ha and a total volume of 6,155,786,146 m^3, with a maximum depth of approximately 50 m. Lac du Sauvage is almost eight times larger than the next biggest lake sampled in the BSA (i.e., Duchess Lake = 1,016 ha, with maximum depth of 16 m). Paul Lake has a surface area of 964 ha, and a maximum depth of 19 m. The remaining study lakes were relatively small and included Lake E1 with a surface area of 169 ha, and a maximum depth of 12 m. The other 13 lakes are in the Ab, Ac, B, C, and D basins that drain into Lac du Sauvage, and range in size from 6 ha (Lake D2) to 163 ha (Lake C1).

In 2013, habitats of representative shoreline sections were characterized in all study lakes. Detailed shoreline habitat maps were created for major lakes, including Lac du Sauvage. Through examination of aerial orthophotographs and ground-truthed surveys, the Lac du Sauvage shoreline (0 to 5 m depths) was found to consist mostly of fines (70%), followed by boulder/cobble (23%) and other coarse substrate types. The substrate at both deep and shallow locations in Lac du Sauvage was described with hydroacoustics data and using three broad categories of substrate: fines, mixed (coarse and fine substrates), and coarse substrates (e.g., bedrock, boulder, cobble). Overall, the dominant substrate type was fines, followed by mixed and coarse substrates. As noted in the historical reports, coarse substrates were dominant (52.3%) at shallower depths (0 to 2 m), followed by fines (45.1%) and mixed (2.6%). Fines (56.7%) represented most of the substrate found between 2 and 6 m, with coarse and mixed substrate types comprising 34.1% and 9.2%, respectively. Substrates identified as cobble in the field often included small areas of gravel as potential spawning locations for Lake Trout, Cisco, and Whitefish species. For depths ranging from 6 to 10 m, fines were the dominant substrate type, followed by mixed and coarse. Depths greater than 10 m were assigned 100% fines because of assumed effect of deposition.

Historical surveys in Lac du Sauvage identified substantial areas of suitable habitat for spawning by Lake Trout, Cisco, and Whitefish species. While 43% of the 21 shoals identified in Lac du Sauvage could provide spawning habitat for Lake Trout and Cisco, only 10% were found to be suitable for Round Whitefish. Shoals in Lac de Gras were generally more deep and numerous, providing better quality spawning habitat for Lake Trout, Cisco, and Round Whitefish. Arctic Grayling were not observed spawning along shorelines, but were observed spawning in tributary streams flowing into either Lac de Gras or Lac du Sauvage.

Several lakes, including Lac du Sauvage, Paul Lake, Duchess Lake, Lake E1, and Lake C3 had steep drop offs from shore. Cover was provided by substrates (boulder) and depth in the majority of the lakes. Other types of cover were overhanging vegetation (shrubs) in Duchess Lake, Lake E1, Lake B4, Lake Ab2, Lake Ac17, Lake Ad8, undercut banks in Lake B4 and Lake B15, submergent vegetation (Paul Lake, Lake C1, Lake D2, and Lake Ad8) and emergent vegetation. Emergent vegetation included sedge (e.g., *Carex aquatilis* var. *aquatilis*) wetlands, which were present in Duchess Lake, Paul Lake, Lake E1, Lake B1, Lake B4, Lake B15, Lake D3, Lake D4, Lake Ac17, and Lake Ad8.

Habitat was considered at 17 streams (including ephemeral streams). Cumulative watershed areas of the study streams were relatively small (ranging from 104 ha for Stream Ad8 to 1,458 ha for Stream B1), with the exception of Stream E2 (15,972 ha) and E1 (20,650 ha). Streams with a cumulative watershed area of less than 300 ha were typically dry in August and lacked a defined bed and banks (i.e., ephemeral). On-the-ground habitat evaluations were performed for all watercourses with defined bed and banks and typically near lake outlets for lakes where fish were sampled. Most surveyed streams were narrow (approximately 2 m) with shallow to moderately deep runs (maximum depths 0.5 to 2.0 m) bordered by thick willows and substrate cover dominated by organics or fines. However, for certain streams the substrate was comprised mostly of gravel/cobble and boulder/bedrock (i.e., Streams C3 and Ab2, respectively). Arctic Grayling spawning habitat (gravel/cobble) was identified in Streams B1, C3, and D1, with juvenile and YOY captured in Streams B1, B15, C1, C3, and D1. Connectivity between Lac du Sauvage and the B, C, and D sub-basins is maintained by Streams B1 and C1 (into internal basin Ac), and D1 (into internal basin Ad), respectively.

Potential barriers to fish movement (extensive boulder gardens) were identified in Streams Ab2, B1, C1, and C3. Stream E2 differed from other streams in the BSA as it was a long (7.7 km), wide (approximately 19.2 m) entrenched, meandering watercourse consisting of deep runs. Riffle habitat was observed at upstream locations of Stream E2 from aerial photographs. Stream gradients were low to moderate with the steepest mean gradient (2.4%) recorded at Lynx Creek; however, most streams were less than 1% in slope. Streams with very low gradient (0.1% or lower) included Lac du Sauvage, Duchess, C3, and E2 lake outlets. Lac du Sauvage Creek is a relatively wide (minimum bankfull width of approximately 45 m) and short (210 m in length) outlet stream. Similarly, Duchess Creek, is a wide stream (minimum bankfull width of approximately 125 m) characterized by a reach length of 1,371 m.

Fish Community Composition

Based on previously completed reports and sampling performed in 2013, 11 fish species were identified in the BSA: Lake Trout, Arctic Grayling, Northern Pike, Cisco, Round Whitefish, Lake Whitefish, Burbot, Longnose Sucker, Ninespine Stickleback, Lake Chub, and Slimy Sculpin. It is expected that all 11 species occur in Lac du Sauvage. Historically, Lake Trout have been the most abundant species captured in Lac du Sauvage (59%). Lake Whitefish and Round Whitefish were the next most abundant species, followed by Cisco. All other species appeared to be much less abundant, but this may have been a reflection of capture methods because gill netting, which targets larger bodied species, was the most extensively used gear type.

The primary methods deployed during baseline studies were gill nets and minnow traps, with backpack electrofishing used along lake shorelines. Angling supplemented sampling in lakes. In streams, backpack electrofishing was the primary method to collect fish, with minnow traps set in one large stream (Stream E2) in 2013. Based on all methods and sampling years (2006 to 2013) combined, baseline data included a total catch of 1,390 fish, and included data for five species in the Salmonidae family (Lake Trout, Arctic Grayling, Round Whitefish, Lake Whitefish, and Cisco). Overall, Lake Trout (24%) and Lake Whitefish (22%) were most prevalent, followed by Round Whitefish (17%), Slimy Sculpin (13%), Ninespine Stickleback (9%), Arctic Grayling (7%), and Northern Pike (4%). Burbot (2%), Cisco (2%), Longnose Sucker (1%), and Lake Chub (1%) made up only a small portion of the total fish catch.

Fish were captured in all sampled lakes and streams, except for Lake Ab2. In lakes, the total catch (n = 1,322) was dominated by Lake Trout (25%) and Lake Whitefish (23%). The remainder of the catch in lakes included Round Whitefish (17%), Slimy Sculpin (13%), Ninespine Stickleback (9%), and smaller contributions from Arctic Grayling, Northern Pike, Burbot, Cisco, Longnose Sucker, and Lake Chub (all less than 5% each). In streams, the majority of the catch (n = 68) consisted of Arctic Grayling (60%), followed by Slimy Sculpin (16%), Ninespine Stickleback (9%), Northern Pike, and Round Whitefish (7% each).

Fish community assemblages varied across the study area. Lake Trout, Arctic Grayling, Round Whitefish, and Slimy Sculpin were the dominant species found in waterbodies and watercourses in the B, C, and D sub-basins. Lake Trout and Round Whitefish were the dominant species caught by gill net in lakes in the B, C, and D sub-basins. Lake Whitefish were not captured in the B, C, and D sub-basins, but were captured in the Lac de Gras sub-basin, Lac du Sauvage, Lake Ad8, Duchess Lake, and Lake E1. Most lakes had a gill net catch characterized by Lake Whitefish and Lake Trout. In Lac du Sauvage, gill netting resulted in the capture of a large number of three salmonids: Lake Trout, Round Whitefish, and Lake Whitefish.

Very few Arctic Grayling were captured outside of the B, C, and D sub-basins. Using a backpack electrofisher, Arctic Grayling were only captured in Lac du Sauvage and in lakes and streams of the B, C, and D sub-basins. The majority of the backpack electrofishing catch in Lac du Sauvage was Slimy Sculpin. Electrofishing in Duchess Lake and Stream E2 captured Northern Pike only. One Northern Pike was caught in Duchess Lake and five were caught in Stream E2.

Lac du Sauvage Hydroacoustic Data

Mobile hydroacoustic surveys targeted numerically abundant, pelagic species, such as Cisco, as well as other species that may be demersal and only occasionally pelagic, such as Lake Trout, Arctic Grayling, Lake Whitefish, and Round Whitefish. The surveys were also designed to detect larger fish, such as yearling and older fish in deep-water locations. The study design included two surveys completed in late July to mid-August where each survey spanned 66 km across 33 transects evenly spaced across Lac du Sauvage. Results emphasized those from the second survey, as densities were noticeably higher later in the season. Weather conditions may have affected fish movements, improving fish detection during the second survey.

Fish densities were calculated using two analytical methods in Echoview: echo integration and fish tracking, both of which yielded similar estimates and showed similar trends across Lac du Sauvage. Highest densities were recorded in the eastern half of Lac du Sauvage in internal basins Aa and Ab.

Echoview's fish tracking module identified 7,603 fish tracks in transects and between transects (as incidental observations). Of these, 5,338 fish tracks were detected along transects. Using target strength (TS) per horizontal and vertical fish tracks combined with the respective TS equations to calculate fish length the mean length of fish in Lac du Sauvage was approximately 166 mm. Approximately 5% of all fish tracks were greater than 300 mm in length. In the west section of Lac du Sauvage (i.e., internal basins Ac, Ad, and Ae), approximately 7% of the fish tracks were greater than 300 mm in length; in the east section of Lac du Sauvage (i.e., internal basins Aa and Ab), only 3.6% of the fish tracks were greater than 300 mm. Of the five internal basins, fish were largest, on average, in Basin Ad (247 mm), followed by Basin Ae (178 mm), and Basin Ac (172 mm). Fish were smallest in length in Basin Aa (160 mm) and Ab (161 mm).

The projected population estimate, using 75th percentiles as part of an environmentally conservative approach for this baseline study, was approximately 828,000 fish for Lac du Sauvage. However, the actual population estimate for fish (including Cisco, Lake Trout, Lake Whitefish, Round Whitefish, and Arctic Grayling) may be much lower and closer to the median values (e.g., approximately 197,000 fish).

Species Life History

Life history data were collected for 1,037 fish between 2006 and 2013, including Lake Trout (n = 261, length range 57 to 947 mm), Arctic Grayling (n = 58, length range 50 to 385 mm), Northern Pike (n = 45, length range 62 to 960 mm), Round Whitefish (n = 194, length range 102 to 467 mm), Lake Whitefish (n = 202, length range 104 to 615 mm), Ninespine Stickleback (n =125, length range 26 to 68 mm), and Slimy Sculpin (n = 152, length range 41 to 93 mm). There was a general lack of YOY and juvenile large-bodied fish captured per species in the study area, with the exception of YOY and juvenile Arctic Grayling captured in several streams, and Lake Whitefish and Round Whitefish captured in Duchess Lake.

Lake Trout had the widest ranging and most evenly distributed ages and were, on average, older than all other species. Age classes between 4 to 36 years were represented in the aged sample from 2013 (n = 218). Females were on average slightly younger than males, and first reached sexual maturity (4 years) earlier than males (10 years), but sexual maturity of all fish was reached at the same time for both males and females (11 years). Between 2006 and 2013, Lake Trout were represented by a wide range of size-classes (57 to 947 mm in fork length); however, most were adults larger than 300 mm.

Young-of-year Lake Trout (fork length less than 150 mm) were captured in Lake B1 (Christine) and Lake D4 in 2013, and in Lake D3 (Counts) and Lake B4 (Cujo) in 2012. Juvenile Lake Trout (fork length between 150 and 299 mm) were captured in Lac du Sauvage in 2006, Duchess Lake in 2013, and Lake D3 (Counts) in 2007 and 2012. The heaviest Lake Trout (9,750 grams [g]) was captured in Lake D3 (Counts) in 2013. The theoretical maximum length of fish appeared to be much larger in D3 (Counts) and B4 (Cujo) lakes, versus Lac du Sauvage. The von Bertalanffy growth constant (*K*) was larger in Lac du Sauvage suggesting that it takes less time to produce a mature adult Lake Trout, compared to B4 (Cujo) and D3 (Counts) lakes.

Lake Whitefish were composed mostly of medium-sized fish between 301 and 500 mm in fork length. Lake Whitefish were captured in Paul Lake, Duchess Lake, Lake Ad8, Lac du Sauvage, Lynx Lake, and Hammer Lake in 2013. The longest and heaviest Lake Whitefish was captured in Lake Ad8 in 2013 and was 615 mm in fork length and weighed 3,199 g. Age classes between 1 to 34 years were represented in the aged sample (n = 163). The theoretical maximum length of fish appeared to be much larger in Duchess Lake, versus Lac du Sauvage, Lake E1, Paul Lake, and Lake Ad8. In addition, the von Bertalanffy growth constant (*K*) was largest in Paul Lake and smallest in Lac du Sauvage.

Arctic Grayling ranged from 50 to 385 mm in length and approximately half of the catch comprised YOY and yearling age classes. Most of the YOY Arctic Grayling (fork length less than 100 mm) were captured in streams B1 (Christine), B15, C1, C3, D1, but were also found in Lake C1, Lake D2, and Lake D3 (Counts). Juvenile Arctic Grayling (fork length between 101 and 385 mm) were typically found in Paul Lake, Lake D2, and Lake B4 (Cujo), with a few captured in streams (C1 and D1). Age classes between 1 to 6 years were represented in the aged sample from 2013 sampling (n = 27).

Northern Pike ranged from 62 to 960 mm in fork length. Only one YOY (fork length less than 100 mm) Northern Pike was captured, in Paul Lake. Juvenile Northern Pike (fork length between 101 and 300 mm) were typically found in lakes (Paul Lake, Duchess Lake, and Lake E1), but were also captured in Stream E2. Age classes between 1 and 16 years were represented in the aged sample (n = 38).

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6 GLOSSARY

Term	Definition
Angle	To fish with a hook.
Aquatic macrophytes	Aquatic plants that are large enough to be seen by the naked eye. May include submergent (grow underwater) or emergent (grow above the waterline) varieties.
Back scattering cross-section	A measure of the reflectivity of a target. Target strength (TS) is equal to 10 log10(bs/4) of the backscattering cross section bs, which is defined by the relationship: bs = 4R2Ib/Ii where R = range to target; Ii = intensity at the midpoint of the incident wave at the target; Ib = intensity at the midpoint of the backscattering pulse.
Basin	A geographic area in which all water running off the land drains into a single point at lower elevation, such as a river or lake.
Bathymetry	Measurement of water depths in a lake.
Bedrock substrate	Substrate defined by unbroken, solid rock.
Body condition	A measurement of overall health of a fish by comparing its weight to the typical weight of another fish of the same length.
Boulder substrate	Substrates with a particle size greater than 256 mm in diameter.
Boulder garden	An area of a stream with exposed, large boulders providing instream cover, and potentially a barrier to upstream passage of fish at low flows.
Braided	Flowing in an interconnected network of channels that divide and reunite.
Calibration	Method of defining and setting characteristics of the electronic/mechanical equipment which allows repeatability of results. Measuring or adjusting the performance of a system to a specified standard is very important in quantitative hydroacoustic work.
Cascade habitat	A succession of steep, small falls where water falls over a vertical drop.
Catch-per-unit effort	The total catch divided by the total amount of effort used to capture the fish.
Cobble substrate	Substrates with a particle size between 64 and 256 mm in diameter.
Conductivity	A measure of the resistance of a solution to electrical flow; an indirect measure of the salinity of the water.
Demersal	Fish or other aquatic organisms found or living near the lake bottom.
Detection threshold	Signal power in the receiver bandwidth relative to the noise power in a 1 Hz band which permits the detection of a target against specified criteria (unit: dB).
Dissolved Oxygen	Oxygen dissolved within the water column.
Echo Integration	The processing technique that determines the average squared echosounder output voltage for selected range intervals and average times. The integrator output is proportional to fish density or biomass.
Ephemeral	Lasting for a short time or part of a complete cycle. In reference to water, typically describes a stream that flows for only part of the open-water period.
Fin ray	Splintlike supporting structures to the fin membranes, includes both soft-rays and spines.
Fine/organic substrate	Substrates with a particle size less than 2 mm in diameter.
Fish community	A group or assemblage of fish species inhabiting the same location at the same point in time.
Fork length	Fork length (FL) refers to the length of a fish measured from the tip of the snout to the end of the middle caudal fin rays and is used in fishes in which it is difficult to tell where the vertebral column ends.
Fish target strength	Acoustic size of target in dB (see backscattering cross section). The ability of a given target to reflect acoustic signals; usually given in terms of negative dB's.
Fish tracking	Raw acoustic tag echoes which have been selected and assigned a tag ID through an auto-tracking method. Also referred as auto-tracked.

Term	Definition
Flat habitat	An area of stream where the water velocity is slow, channel depth is uniform and lacks direct riffle/run association.
Freshet	The period of increased stream flow in spring caused by the melting snow pack.
Gradient	The slope of a stream channel or lake shoreline.
Gravel substrate	Substrates with a particle size between 2 and 4 mm in diameter.
Headwater	The source of water at the top of a watershed, typically a lake or marsh.
Hydroacoustics	The study or use of sound in water to remotely obtain information related to the physical characteristics of the waterbody, its bathymetry, or biotic populations.
Hydrology	The study of flowing water and effects of flowing water on the Earth's surface, in the soil and underlying rocks, and in the atmosphere.
Length-Weight Equation	A regression model that describes patterns of growth and can be used to calculate relative weights.
Life history	The full range of changes, habits, and behaviors of an individual over the course of its life.
Littoral	The shallow, shoreline area of a lake.
Meandering	Following a winding or intricate course.
Otolith	A calcium carbonate structure found in the chambers (sacculus, utriculus, and lagena) of the inner ear of fishes. Usually the one in the sacculus is the largest and it can often be used to tell the age or identity of the fish.
Pelagic	Relating to fish or other aquatic organisms that live offshore in the middle or lower part of the water column.
Population	A group of individuals of one species in one area; it often means the group of organisms that is convenient and practical to count. A population is also defined as individuals of a species that are close enough to each other for there to be at least occasional mating between them.
pH	A measure of the acidity or alkalinity of water.
Pool habitat	An area of stream where the water velocity is slow and stream depths are relatively deep.
R^2	This is a coefficient of determination, a statistical measure of how well a regression line approximates the real data points.
Riffle habitat	An area of stream where the water velocity is fast and stream depths are relatively shallow causing broken water.
Riparian	Relating to the banks or shoreline area of a stream or lake often referring to nearshore vegetation.
Run habitat	An area of stream where the water velocity is moderate, depths are greater than a riffle and most of the surface is not broken.
Shoal	A shallow, offshore reef in a lake.
Sonar	Commonly referred to as the transmission of sound waves and measuring the time it takes for their echo to return after reaching an object.
Sub-basin	A smaller scale basin within a larger basin. The sub-basin contributes runoff to the drainage system of the larger basin.
Substrate	The bottom of a waterbody, usually consisting of sediments of various particle sizes (e.g., sand, silt, clay, gravel, cobble, boulder) and organic material (e.g., living or dead plant material).
Thermal stratification	Horizontal layers of differing densities produced in a lake by temperature changes at different depths.
Thermocline	The depth in a lake where temperatures most sharply decline causing a separation of higher density water below the thermocline (hypolimnion) and lower density water above the thermocline (epilimnion).
Total length	Total length refers to the length of a fish measured from the tip of the snout to the tip of the longer lobe of the caudal fin, usually measured with the lobes compressed along the midline. It is a straight-line measure, not measured over the curve of the body.

Term	Definition
Transducer	Electro-mechanical device which translates electrical energy to sound energy to produce the hydroacoustic signal, and converts returning echoes back into electrical signals.
Tributary	A stream that flows into a larger stream or lake.
Turbidity	A measure of light penetration dependent on the concentration of suspended solids.
von Bertalanffy growth	A widely used growth curve used in fisheries studies to predict and calculate length-at-age.
Watershed	The upstream land area drained by a river network.