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Golder Associates

REPORT ON

SHELL LEASE 13
WINTER AQUATICS FIELD PROGRAM

Submitted to:

Shell Canada Limited
400 - 4th Ave. SW
P.O. Box 100, Station M
Calgary, AB

December 1997

972-2221

Golder Associates Ltd.

10th Floor, 940 6th Avenue S.W.
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January 14, 1998

Proj. No. 972-2221

Dr. Doug Mead
Senior Environmental Scientist
Safety and Environmental Resources
Shell Canada Limited.
400 - 4th Avenue SW
P.O. Box 100, Station M
Calgary, AB T2P 2H5

RE: Lease 13 Winter Work Program - Final Report for Aquatics Field Program

Dear Doug:

Attached is the final report for the Shell Lease 13 Winter Aquatics Field Program. This report provides a review of the Aquatics Winter Work program completed for Shell in 1997. It includes details on: a) areas included in the winter field program; b) methodologies employed; and c) chemical and fish habitat evaluation results.

The data collected during the winter of 1996-1997 will provide valuable information to allow completion of the aquatics component of the Muskeg River Mine Project Environmental Impact Assessment.

Should you have any questions about this report, please contact me at 299-5640.

Yours very truly,

GOLDER ASSOCIATES LTD.

John R. Gulley
Oil Sands Project Director

attachment

cc. Judy Smith (Shell)
Ian Mackenzie (EIA Project Manager)

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EXECUTIVE SUMMARY

A winter sampling program was conducted in March 1997 to provide current winter baseline information, to determine the applicability of historical information and to provide information for an EIA. The scope of work included the collection of water samples from Jackpine, Muskeg and Shelley Creeks, Isadore's Lake and the Muskeg River, as well as aquatic habitat measurements to assess the potential for fish overwintering in the Shell Lease 13 study area.

Water quality in the Muskeg River watershed was generally similar at all sample locations. Findings at several stations closely matched reviewed historical data. The only exception was the Dissolved Oxygen (DO) levels measured in the Muskeg River, that were lower than suggested by historical data and tributary water chemistry.

Water from Isadore's Lake contained very high sulphur levels, as well as high chloride, calcium and magnesium concentrations. Water from this lake was toxic to bacteria, deficient in oxygen and contained high levels of biodegradable organic matter. A low flushing rate, combined with the productive nature of this lake, likely account for the observed water quality.

Historical records documented the use of the Muskeg River system by a number of fish species during the open-water season. However, the potential for large fish to overwinter in the system was described as poor. The present field data support these conclusions, as most of the small watercourses sampled in this study were frozen to near the bottom. The low DO levels may also limit some larger fish species from using these habitats over the winter. Although sampled pools in the Muskeg River and Jackpine Creek could potentially be used as overwintering areas, most large fish species likely vacate these regions for reaches further downstream in the Muskeg River and the Athabasca River. Observations at a fish fence installed in the fall, on the lower reaches of the Muskeg River, showed a large number of fish moving downstream at that time.

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1.0 INTRODUCTION

Shell Canada Limited (Shell) is proposing to develop an oil sands mine on Lease 13, about 75 km northeast of Fort McMurray. Lease 13 is located on the east side of the Athabasca River within the Muskeg River watershed (Figure 1-1). As part of the Environmental Impact Assessment (EIA) for a new oil sands development, Shell initiated an aquatic environmental baseline program in February 1997. The aquatic baseline program builds on previous studies within the watershed, namely the aquatic baseline study for Syncrude Canada Limited's (Syncrude) Aurora Mine (Golder 1996a, Golder 1996b), the OSLO studies from the late 1980s (Beak 1986, R.L.&L. 1989) and the Alsands Studies from the early 1980s (Webb 1981).

As part of the aquatic baseline program, Golder Associates Ltd. (Golder) was retained to conduct winter field sampling. The purpose of the sampling was to determine winter water quality and to evaluate the potential for fish to overwinter in the watershed. These data were compared with historical data for the study area (Webb 1981, Beak 1986, R.L.&L. 1989). The field program consisted of sampling in the Muskeg River and its tributaries on Lease 13 as well as in Isadore's Lake and Mills Creek (a small tributary of Isadore's Lake).

1.1 Study Area

The proposed Shell Lease 13 Oil Sands Project is located in the center of the Muskeg River watershed. Portions of several Muskeg River tributaries and the central portion of the Muskeg River are located within the lease boundaries (Figure 1-1). Muskeg River tributaries within the lease include Shelley, Jackpine and Muskeg Creeks and small portions of Blackfly, Green Stockings, Khahago and Wesukemina Creeks. As well, the study area includes Isadore's Lake, which is connected to the Athabasca River through an outlet at the west end of the lake. Also included in the lease are several unnamed ephemeral streams and approximately 28 unnamed ponds and wetlands (Webb 1981).

Jackpine Creek and the Muskeg River represent the most significant fish habitat in this region since they provide spawning habitat for Arctic grayling and northern pike (R.L.&L. 1989, Golder 1996b). Isadore's Lake is also significant since northern pike have been reported to reside and possibly spawn in the lake (Webb 1981).

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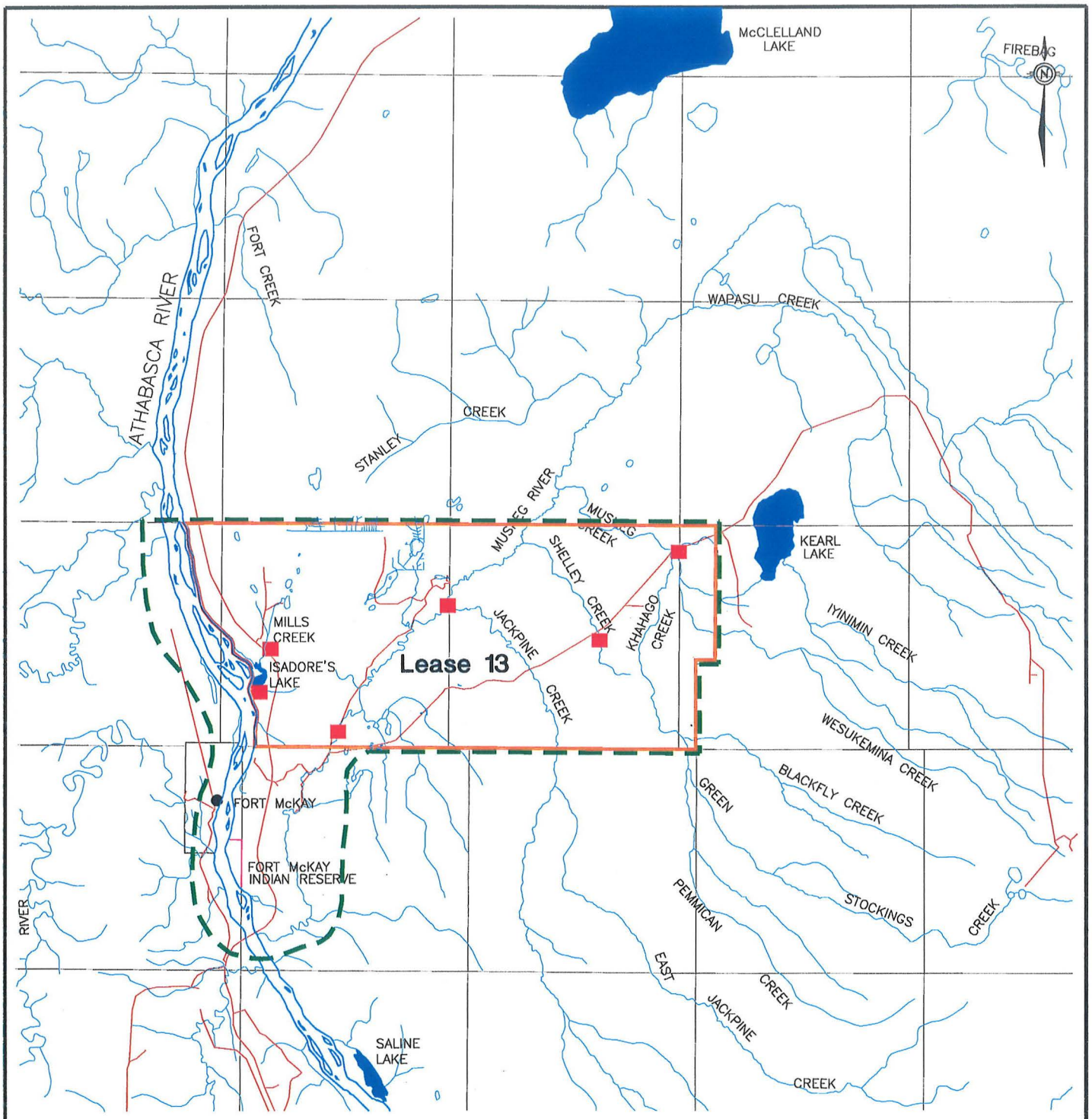


LEGEND

- WATER SAMPLING SITES
- LOCAL STUDY AREA
- LEASE 13 BOUNDARY
- ROAD

0 2.5 5 7.5 10 12.5km

SCALE 1:250,000

REFERENCE

DIGITAL DATA SETS 74D, 74E, 74I
84A AND 84H FROM RESOURCE DATA DIVISION
ALBERTA ENVIRONMENTAL PROTECTION, 1997.

Golder Associates

SHELL CANADA LIMITED

SHELL LOCAL STUDY AREA AND SAMPLING SITES FOR WINTER BASELINE WORK

14 Jan 1998	Figure 1.1	DRAWN BY: CG

The local study area includes Lease 13 and all watercourses/waterbodies within it (Figure 1-1). Since changes in aquatic habitat, water quality or water quantity could affect the lower reaches of the Muskeg River and the Athabasca River immediately downstream of the Muskeg River, these reaches are also included in the local study area.

1.2 Objectives

The objectives of this study were to provide current winter baseline information, to determine the applicability of historical information and to provide information for an EIA. To satisfy these objectives the following activities took place:

- confirmation of flow in tributaries and verification that any existing flow was groundwater related;
- assessment of the potential of different sections of waterbodies/watercourses for fish overwintering; and
- collection of water quality samples for basic and detailed chemical analyses.

2.0 METHODS

Water quality sampling and habitat measurements to assess the potential for fish overwintering were conducted from March 15 to 19, 1997. Sampling conducted at each station is identified in Table 2-1. A GeoExplorer® Global Positioning System (GPS) unit was used to record the position of all sampling locations. Sampling sites (Figure 1-1) included:

- Muskeg River at the south boundary of Lease 13;
- Jackpine Creek (at the mouth);
- Shelley Creek at the Canterra Road crossing;
- Muskeg Creek at the Canterra Road crossing;
- Isadore's Lake; and
- Mills Creek at the Highway 63 crossing.

Table 2-1 Summary of sampling stations for the aquatics winter work program.

Watercourse	Site	UTM E	UTM N	Discharge Measurement	Water Quality*
Muskeg River	WQ1	471649	6346448	yes	F + L
Jackpine Creek	WQ2	471657	6346354	yes	F + L
Shelley Creek	WQ3	477978	6345474	yes	F + L
Muskeg Creek	WQ4	481036	6348848	yes	F + L
Isadore's Lake	WQ5	463378	6342927	no	F + L
Mills Creek	WQ6	463829	6344743	yes	F

*F = field measurements, L = lab samples collected

2.1 Water Quality Sampling

Field measurements, including dissolved oxygen (DO), pH, conductivity and temperature, were taken at all six sample sites (Table 2-1), following Golder Technical Procedure 8-3-1. A dissolved oxygen profile was also generated for Isadore's Lake, using a YSI 57 DO meter.

Water samples were collected at five of the six sites (Jackpine, Muskeg and Shelley Creeks, Isadore's Lake and the Muskeg River). They were preserved in accordance with Golder Technical Procedure 8.3-1 and shipped to Enviro-Test Laboratories (ETL) in Edmonton for analysis. Samples were analyzed for conventional parameters (including total dissolved solids, major ions and nutrients), naphthenic acids and total metals (Table 3-1). Water samples taken

from the Muskeg River were also analyzed for polycyclic aromatic hydrocarbons (PAHs) and alkylated PAHs.

2.2 Aquatic Habitat Measurements

Aquatic habitat measurements at each sample site consisted of ice thickness, water depth, discharge rates and water velocity. Velocity was measured with a Marsh-McBirney Flo-Mate 2000 velocity meter and a top-setting wading rod. Stream discharge rates were determined for the Jackpine, Shelley, Muskeg and Mills Creeks and the Muskeg River. All measurements were made following Golder Technical Procedure 8.3-1.

3.0 RESULTS

3.1 Water Quality

The following section summarizes water quality sampling results. Site-specific data are compared with results from other sites and with available historical records. Similarities and notable differences were highlighted, while keeping data interpretation to a minimum. Isadore's Lake and Mills Creek were discussed separately from the other four sample sites, since these two waterbodies lie outside of the Muskeg River watershed.

Muskeg River Watershed

Waters collected from Jackpine Creek, Shelley Creek, Muskeg River and Muskeg Creek were generally quite similar (Table 3-1). These four streams were found to be non-toxic to bacteria. PAHs were non-detectable in the Muskeg River. Recoverable hydrocarbons were low or non-detectable at all sites in the watershed. Low Biochemical Oxygen Demand (BOD) numbers indicate that these waters also contained little biodegradable organic matter. Despite these similarities, there were several distinct differences within the watershed, as discussed below.

Muskeg River

Dissolved oxygen levels in the Muskeg River, although comparable to those in Shelley Creek, were considerably lower than those observed in Jackpine and Muskeg Creeks (Table 3-1). Historically, the Muskeg River generally contains higher DO levels than those observed in this study. The cause of this low DO reading is unclear.

Aside from DO levels, water chemistry in the Muskeg River closely resembled findings from the rest of the watershed, except for Muskeg Creek (Table 3-1). River water quality also closely matched historical records. There were slight differences, including higher Total Organic Carbon (TOC), total phosphorus, aluminum and zinc readings, plus lower Total Dissolved Solids (TDS) levels in 1997 than in earlier records (Table 3-1). However, on the whole, water quality in the Muskeg River was consistent with past data.

TABLE 3-1
WINTER WATER QUALITY IN THE MUSKEG RIVER WATERSHED
(Page 1 of 2)

Parameter	Units	Muskeg River			Jackpine Creek		Muskeg Creek			Shelley Creek	Isadore's Lake	Mills Creek
		Golder	Historical*		Golder	Shell	Golder	Historical**				
		1997	mean	range	1997	1974	1997	mean	range			
Field measurements												
Temperature	°C	**0.3**	0.1	-0.1 - 0.5	**0.4**	0.0	**0.4**	0.3	0 - 0.5	**0.9**	**1.3**	**0.2**
pH		**7.7**	-	-	**7.9**	-	**7.6**	-	-	**7.7**	**6.9**	**7.9**
Conductance (EC)	µS/cm	**470**	-	-	**537**	-	**282**	-	-	**501**	**716**	**842**
Dissolved Oxygen	mg/L	**3.2**	8.7	5.7 - 11.2	**10.3**	6.8	**10.5**	9.1	7.3 - 10.9	**3.7**	***	**10.8**
Conventional Parameters and Major Ions												
Bicarbonate (HCO_3)	mg/L	**313**	330	312 - 350	**349**	404	**169**	202	176 - 229	**351**	**430**	-
Dissolved Organic Carbon	mg/L	**27**	24	22 - 27	**14**	-	**21**	-	-	**15**	**10**	-
Carbonate (CO_3)	mg/L	**<5**	-	-	**<5**	-	**<5**	5	-	**<5**	**<5**	-
True Colour	T.C.U.	**50**	72	61 - 96	**35**	-	**100**	-	-	**60**	**35**	-
Conductance (EC)	µS/cm	**510**	490	461 - 523	**593**	-	**292**	365	330 - 400	**542**	**812**	-
Hardness	mg/L	**241**	258	237 - 271	**265**	229	**126**	140	122 - 158	**277**	**455**	-
pH		**7.3**	7.3	6.8 - 7.6	**7.8**	8.1	**7.2**	7.3	-	**7.2**	**7.5**	-
Total Alkalinity	mg/L	**256**	268	256 - 286	**286**	-	**139**	166	144 - 188	**287**	**352**	-
Total Dissolved Solids	mg/L	**270**	367	267 - 476	**340**	551	**150**	-	-	**290**	**590**	-
Total Organic Carbon	mg/L	**36**	22	19 - 26	**19**	-	**31**	34	32 - 37	**21**	**12**	-
Total Suspended Solids	mg/L	**5**	4	2 - 8	**3**	9	**3**	-	-	**24**	**4**	-
Calcium	mg/L	**67**	73	67 - 77	**74**	82	**33**	36	31 - 42	**76**	**119**	-
Chloride	mg/L	**5.5**	5.4	3.6 - 8.0	**12.9**	12	**1.9**	2	1.3 - 3.4	**1.2**	**12.9**	-
Magnesium	mg/L	**18**	19	17 - 21	**20**	13	**11**	12	11.2 - 13	**21**	**38**	-
Potassium	mg/L	**1.6**	1.5	1.3 - 1.6	**1.6**	-	**1.6**	2	1.8 - 1.9	**0.8**	**2.7**	-
Sodium	mg/L	**14**	15	13 - 17	**28**	-	**14**	18	16.7 - 18.5	**10**	**8**	-
Sulphate	mg/L	**6**	5	3 - 8	**7**	5	**6**	5	5.3 - 5.5	**6**	**102**	-
Sulphide	mg/L	**<0.002**	0.006	0.001 - 0.01	**<0.002**	< 0.01	**<0.002**	-	-	**<0.002**	**20**	-
Nutrients						-						-
Ammonia-N	mg/L	**0.6**	0.5	0.2 - 1.6	**<0.05**	1.6	**0.2**	0.6	0.6 - 0.7	**0.5**	**1.0**	-
Nitrate+Nitrite-N	mg/L	**<0.05**	0.20	0.02 - 0.3	**0.19**	0.80	**0.10**	0.06	0.03 - 0.10	**<0.05**	**<0.05**	-
Total Kjeldahl Nitrogen	mg/L	**0.8**	1.0	0.8 - 1.3	**0.5**	-	**0.6**	2.3	1.4 - 3.2	**0.8**	**1.5**	-
Phosphorus, Total	mg/L	**0.08**	0.03	0.02 - 0.04	**0.03**	-	**<0.02**	0.28	0.05 - 0.5	**0.14**	**<0.02**	-
Phosphorus,Total Dissolved	mg/L	**<0.02**	0.01	0.01 - 0.02	**<0.02**	-	**<0.02**	-	-	**<0.02**	**<0.02**	-
Total Metals						-						-
Aluminum (Al)	mg/L	**0.20**	0.01	-	**0.09**	-	**0.13**	0.07	0.03 - 0.1	**0.37**	**0.04**	-
Antimony (Sb)	mg/L	**<0.0004**	-	-	**<0.0004**	-	**<0.0004**	-	-	**<0.0004**	**<0.0004**	-
Arsenic (As)	mg/L	**<0.0004**	0.0002	0.0001 - 0.0006	**<0.0004**	-	**0.0004**	0.0004	0.0003 - 0.0005	**0.0011**	**<0.0004**	-
Barium (Ba)	mg/L	**0.07**	0.05	0.01 - 0.07	**0.11**	-	**0.03**	-	-	**0.06**	**0.18**	-
Beryllium (Be)	mg/L	**<0.001**	< 0.001	-	**<0.001**	-	**<0.001**	-	-	**<0.001**	**<0.001**	-

TABLE 3-1
WINTER WATER QUALITY IN THE MUSKEG RIVER WATERSHED
(Page 2 of 2)

Parameter	Units	Muskeg River			Jackpine Creek		Muskeg Creek			Shelley Creek	Isadore's Lake	Mills Creek
		Golder 1997	Historical*		Golder 1997	Shell 1974	Golder 1997	Historical**				
			mean	range				mean	range			
Boron (B)	mg/L	**0.06**	-	-	**0.09**	-	**0.06**	0.08	0.06 - 0.1	**0.02**	**0.04**	-
Cadmium (Cd)	mg/L	**<0.0002**	0.001	0.001 - 0.002	**<0.0002**	<0.001	**<0.0002**	<0.001	-	**<0.0002**	**<0.0002**	-
Calcium (Ca)	mg/L	**72.5**	-	-	**77.8**	-	**35.4**	-	-	**77.5**	**118.0**	-
Chromium (Cr)	mg/L	**<0.0004**	0.005	0.003 - 0.01	**<0.0004**	<0.01	**<0.0004**	<0.001	-	**<0.0004**	**<0.0004**	-
Cobalt (Co)	mg/L	**0.001**	0.001	0.001 - 0.001	**0.001**	-	**<0.0005**	-	-	**0.003**	**<0.0005**	-
Copper (Cu)	mg/L	**0.002**	0.001	<0.001 - 0.003	**0.001**	-	**<0.0004**	0.001	-	**0.001**	**0.001**	-
Iron (Fe)	mg/L	**2.0**	1.7	1.0 - 2.9	**2.3**	2.4	**0.9**	1.2	1.1 - 1.3	**7.9**	**0.2**	-
Lead (Pb)	mg/L	**0.0005**	0.003	<0.002 - 0.007	**0.0004**	0.005	**0.0002**	0.002	-	**0.0004**	**0.0004**	-
Lithium (Li)	mg/L	**0.012**	-	-	**0.022**	-	**0.009**	-	-	**0.007**	**0.011**	-
Magnesium (Mg)	mg/L	**16.9**	-	-	**18.5**	-	**10.6**	-	-	**19.7**	**34.6**	-
Manganese (Mn)	mg/L	**0.43**	0.30	0.04 - 0.66	**0.07**	0.08	**0.11**	0.39	0.24 - 0.54	**2.29**	**0.33**	-
Mercury, (Hg)	mg/L	**<0.0002**	0.0002	-	**<0.0002**	0.0005	**<0.0002**	0.0005	-	**<0.0002**	**<0.0002**	-
Molybdenum (Mo)	mg/L	**<0.0001**	0.0010	<0.001 - 0.001	**0.0001**	-	**<0.0001**	-	-	**<0.0001**	**<0.0001**	-
Nickel (Ni)	mg/L	**0.001**	0.003	0.002 - 0.004	**0.001**	-	**0.001**	0.001	-	**0.002**	**0.002**	-
Potassium (K)	mg/L	**1.5**	-	-	**1.5**	-	**1.5**	-	-	**0.8**	**3.0**	-
Selenium (Se)	mg/L	**<0.0004**	0.0001	-	**<0.0004**	-	**<0.0004**	0.0003	-	**<0.0004**	**<0.0004**	-
Silicon (Si)	mg/L	**6.5**	-	-	**6.7**	8.0	**5.1**	-	-	**7.2**	**7.9**	-
Silver (Ag)	mg/L	**<0.001**	-	-	**<0.001**	-	**<0.001**	-	-	**<0.001**	**<0.001**	-
Sodium (Na)	mg/L	**13.4**	-	-	**28.4**	-	**14.5**	-	-	**9.9**	**6.5**	-
Strontium (Sr)	mg/L	**0.2**	-	-	**0.3**	-	**0.1**	-	-	**0.2**	**0.4**	-
Sulphur (S)	mg/L	**2.9**	-	-	**3.1**	-	**2.7**	-	-	**2.8**	**44.9**	-
Titanium (Ti)	mg/L	**0.004**	-	-	**0.002**	-	**0.003**	-	-	**0.006**	**0.002**	-
Uranium (U)	mg/L	**<0.0001**	-	-	**0.0001**	-	**<0.0001**	-	-	**0.0001**	**<0.0001**	-
Vanadium (V)	mg/L	**0.001**	0.003	0.002 - 0.004	**0.0004**	-	**0.0004**	0.001	-	**0.001**	**<0.0002**	-
Zinc (Zn)	mg/L	**0.030**	0.006	0.002 - 0.013	**0.025**	0.011	**0.010**	0.004	0.004 - 0.004	**0.027**	**0.048**	-
Organic Compounds and Toxicity						-						-
Hydrocarbons,Recoverable	mg/L	**2**	-	-	**<1**	-	**<1**	-	-	**<1**	**<1**	-
PAHs and Alkylated PAHs	µg/L	**N.D.**	-	-	**-**	-	**-**	-	-	**-**	**N.D.**	-
Biochemical Oxygen Demand	mg/L	**2**	2	0.6 - 4	**2**	4	**3**	5	2 - 8	**5**	**25**	-
Naphthenic Acids	mg/L	**<1**	-	-	**<1**	-	**1**	-	-	**1**	**<1**	-
Microtox (EC50 @ 15 min)	%	**> 99**	-	-	**> 99**	-	**> 99**	-	-	**> 99**	**27.8**	-

* values generated from Shell (1975), Noton and Shaw (1989), Noton and Saffran (1995)

** values generated from R.L.& L. (1989)

*** see Figure 3-1

Jackpine Creek

In addition to high DO concentrations, Jackpine Creek was rich in sodium, chloride and nitrate/nitrite-bound nitrogen, relative to the other three streams in the Muskeg River watershed (Table 3-1). Historical data describing winter water quality in Jackpine Creek are limited to an earlier Shell-sponsored project (Shell 1975). Their findings matched reasonably well with the current data, with some variation in TDS, Total Suspended Solids (TSS), ammonia and nitrate/nitrite levels (Table 3-1).

Muskeg Creek

Muskeg Creek contained relatively low calcium, magnesium and bicarbonate concentrations, compared to the Muskeg River and Jackpine and Shelley Creeks (Table 3-1), hence the lower TDS, alkalinity, hardness and conductivity readings associated with this site. Most of these results fall within historical limits, indicating that water chemistry for Muskeg Creek is normally different from other streams in this watershed. Notable exceptions include lower iron, nitrogen and manganese content and higher aluminum levels than previously observed (Table 3-1).

Shelley Creek

No historical winter water quality data are available to describe this stream. In contrast to the other sampled streams, Shelley Creek contained high concentrations of TSS, total phosphorus, aluminum, iron and manganese (Table 3-1). This creek was also almost completely frozen, with little flow (Table 3-2) and low DO levels (Table 3-1).

Table 3-2 Discharge rates observed in the Muskeg River watershed.

Site	Discharge Rates (m^3/s)
Muskeg River	0.218
Jackpine Creek	0.003
Shelley Creek	0.000
Muskeg Creek	0.148
Mills Creek	0.031

Isadore's Lake and Mills Creek

Isadore's Lake and Mills Creek are not part of the Muskeg River watershed and very little previous water quality data has been reported. As a result, discussions are limited to across-site comparisons.

Mills Creek

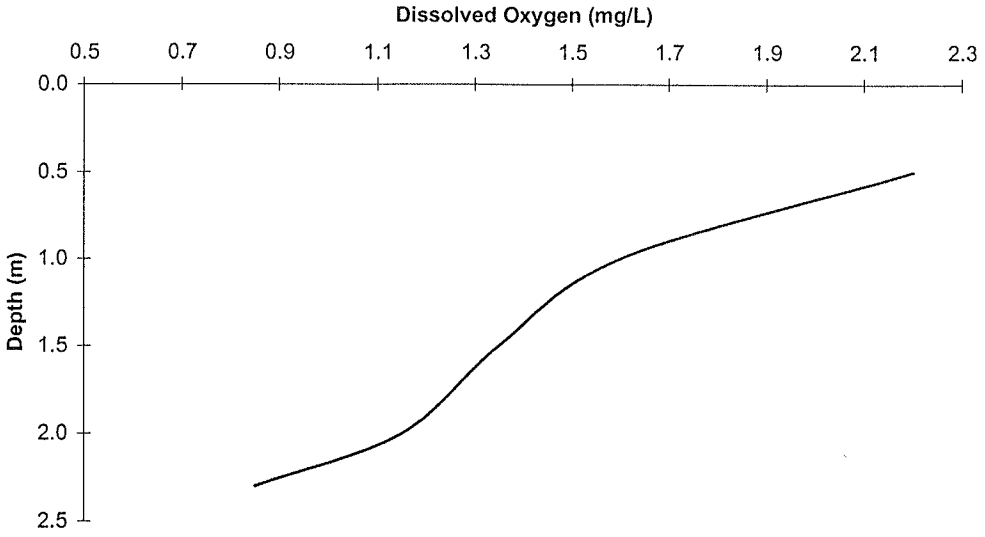
Data describing Mills Creek were limited to field measurements (i.e., pH, conductivity, DO and temperature). Conductivity, temperature and pH readings in Mills Creek were slightly different from those observed in Isadore's Lake (Table 3-1). Mills Creek waters were rich in DO, compared to the low DO levels observed in Isadore's Lake. Aside from conductivity, measurements taken from this creek closely resembled those from several creeks within the Muskeg River watershed (Table 3-1).

Isadore's Lake

Unlike Mills Creek, water quality in Isadore's Lake was very different from sample sites in the Muskeg River watershed. It contained much higher TDS, bicarbonate, sulphate, sulphide, chloride, calcium and magnesium concentrations than any of the other sampled waterbodies (Table 3-1). These waters were also oxygen poor, rich in biodegradable organic matter (hence high BOD values) and moderately toxic (Figure 3-1 and Table 3-1).

Isadore's Lake is a highly productive lake. Aquatic vegetation produced in the lake during the growing season dies off at the onset of winter, and becomes available for biodegradation. Biodegradation initially proceeds aerobically, with aerobic organisms consuming oxygen as they feed on the dead organic matter. DO concentrations in the lake subsequently drop to observed levels, and anaerobic bacteria replace aerobic bacteria. Biodegradation under anaerobic conditions likely produced sulphide compounds detected during sampling. These compounds may have been the cause of elevated toxicity readings observed in lake waters.

Figure 3-1 Dissolved Oxygen Profile for Isadore's Lake



3.2 Aquatic Habitat Measurements

Water depth and velocity, thickness of ice and wetted width of the stream were measured for the Muskeg River and all creeks sampled. Flowing water was observed at all watercourses sampled except Shelley Creek, which was almost frozen to the bottom. Calculated stream discharge rates were relatively low for all sites sampled (Table 3-2).

Muskeg River

The sampling site in the Muskeg River was one of two sites sampled with water depths exceeding 1 m (maximum depth of 1.6 m), hence exhibiting potential for fish overwintering. However, it was characterized by low water flow (0.22 m^3/s) and low DO level (3.2 mg/L) (Table 3-1). Although this area could be used by low oxygen-tolerant species, such as northern pike (*Esox lucius*) (Inskip 1982) and Arctic grayling (*Thymallus arcticus*) (Hubert et al. 1985) most large fish, including northern pike, likely vacate the upstream habitats in favor of areas farther downstream in the Muskeg River or the Athabasca River (R.L.&L. 1989).

Muskeg Creek

The stream discharge rate in Muskeg Creek was 0.15 m^3/s. Although DO was in the appropriate range (10.45 mg/L) to sustain sportfish species, the pool that was sampled was judged too shallow (less than 0.5 m) to provide a suitable overwintering habitat for fish.

Jackpine Creek

The discharge rate for Jackpine Creek was very low (0.003 m^3/s). The dissolved oxygen (10.3 mg/L) (Table 3-1) and the water depth (0.76 m) measured at this site were adequate to sustain sportfish species. Although Arctic grayling are thought to use certain portions of Jackpine Creek during the spring migration period (O'Neil et al. 1982) and for juvenile rearing and adult feeding in mid-summer, this species is believed to overwinter in the lower reaches of the Muskeg River or the Athabasca River (O'Neil et al. 1982). Large fish species also probably vacate tributaries such as Jackpine Creek and migrate downstream in the Muskeg River. Observations at a fish fence installed in the fall, on the lower reaches of the Muskeg River, showed a large number of fish moving downstream (Golder 1996a). Therefore, although there could be potential areas for fish overwintering in Jackpine Creek, it is believed that most fish species move downstream of this watercourse for the winter period.

Shelley Creek

Water was found at the sampling site in Shelley Creek, though there was no detectable flow. Due to the lack of flow and the low DO level (3.7 mg/L) (Table 3-1), there is a low potential for fish to overwinter in this stream.

Mills Creek

The discharge rate for Mills Creek was 0.03 m^3/s. Although the DO level was adequate (10.8 mg/L) to sustain sportfish species, water depth was relatively shallow, with a maximum depth of 0.24 m, hence, not likely deep enough to provide a suitable habitat over winter.

Isadore's Lake

Isadore's Lake was found to be deep enough to provide overwintering habitat for fish (depth of 2.36 m), but DO levels were very low (between 0.85 and 2.2 mg/L) (Figure 3-1), which may limit its capability to sustain sportfish species over the winter. Fish tolerant of anoxic (i.e., low oxygen) conditions (such as stickleback) could possibly overwinter in this lake (Scott and Crossman 1973).

4.0 CONCLUSIONS

4.1 Water Quality

Water quality across the Muskeg River watershed was generally quite similar from one sample location to another. Study findings at several stations also matched reasonably well with historical winter water quality records available for this area. There were some exceptions. Of particular note, DO levels were far lower in the Muskeg River than suggested by historical data and tributary water chemistry. The cause of this result remains unclear.

Water collected from Isadore's Lake was unique. It contained very high sulphur levels, together with high chloride, calcium and magnesium concentrations. Water from this lake was also toxic to bacteria, oxygen deficient and contained high levels of biodegradable organic matter. These differences were likely due to the fact that Isadore's Lake experienced much lower flushing rates than the sampled rivers and creeks. Slower flow rates, combined with the productive nature of this lake, likely triggered the anoxic conditions.

4.2 Potential for Fish Overwintering

Previous studies have documented the use of the Muskeg River system by a number of fish species during the open-water season (R.L.&L. 1989, Golder 1996a, 1996b). In particular, Arctic grayling, northern pike, longnose (*Catostomus catostomus*) and white suckers (*Catostomus commersoni*) are reported to spawn in the Muskeg River and Jackpine Creek in the spring and to remain in the watershed throughout the summer. However, the potential for large fish to overwinter in the system has been described as poor by R.L.&L. (1989), who assessed winter water quality in the Muskeg River and several tributaries.

The 1997 winter field data support these conclusions as most of the small watercourses sampled in the Muskeg River system were frozen to near the bottom. The low DO levels may also limit some larger fish species from using these habitats over the winter. Although pools sampled in the Muskeg River and Jackpine Creek could potentially be used as overwintering areas, it is believed that most large fish species vacate these regions for reaches further downstream in the Muskeg River and the Athabasca River. Observations at a fish fence installed in the fall, on the lower reaches of the Muskeg River, showed a large number of fish moving downstream at that time

(Golder 1996a). Therefore, due to low water flow and low levels of dissolved oxygen at most of the locations sampled, the potential for fish overwintering is limited.

5.0 CLOSURE

We trust that this report presents the information you require. Should any portion of the report require clarification, please contact the undersigned.

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