RECONNAISSANCE LAKE INVENTORY OF LIMESTONE LAKE

Watershed Code: 190-265100-30600-81400
Waterbody Identifier: 00092HERR

Prepared for:

Lheidli T'enneh Band Fisheries Program
1041Whenun Road
Prince George, BC
V2K 5G5

Prepared by:

Richard Formosa
EDI ENVIRONMENTAL DYNAMICS INC.
Suite 301-1705 - 3rd Avenue
Prince George, BC
V2L 3G7

EDI Project No. 600-02

April, 2000

PROJECT REFERENCE INFORMATION

FRBC Activity Number	10212
FRBC Project Number	OPM98110
FDIS Project Code	1781
FRBC Region	Omineca-Peace
MELP Region	Sub-Region 7A (Omineca)
FW Management Unit	7-18
DFO Habitat Area	Upper Fraser
Forest Region	Prince George
Forest District	Prince George
Forest Licensee and Tenure #	Northwood; A18165

WATERSHED INFORMATION

Watershed Group	Herrick Creek
Watershed Code	190-265100-30600-81400
Waterbody Identifier	00092HERR
UTM at Lake Inlet	10.629900.6033220
Order at Lake Outlet	3
Number of Tributaries	13
Drainage Area of Lake	27.94 km^2
Magnitude of Lake	29
Elevation	1400 m
NTS Map	093I/6 and 093I/7
TRIM Map	93I.045 and 93I.046
BEC Zone	ESSF
Air Photo	30 BCB 96045 No. 64

LAKE SAMPLING SUMMARY

Lake Survey Type	Primary (1998 RIC Standards)
Water Surface Area	100.5 ha
Maximum Depth	35.4 m
Mean Depth	13.1 m
Secchi Depth	11.75 m
Volume	13 123 940 m^3
Area Above 6 m Contour	47.97 m^2
Shoreline Perimeter	6420 m
Number of Islands	0
Species Present in Lake	NFC
Lake Sample Dates	September 9 and 10, 1999

CONTRACTOR INFORMATION

Proponent:	Name:	Brian Toth, R.P.Bio.
	Address:	Lheidli T'enneh Band Fisheries Program 1041 Whenun Road Prince George B.C. V2K 5G5
	Phone:	(250) 963-8451
Project manager:	Name:	Dwight Hickey, R.P.Bio.
	Address:	Suite 301-1705 - 3rd Avenue Prince George, B.C. V2L 3G7
	Phone:	(250) 562-5412
Field crew:	Names:	Bill Cranston, Tim Newman
Data entry by:	Names:	Jocelyn Salton
Report prepared by:	Names:	Richard Formosa
Report edited by:	Names:	Robert M Van Schubert, R.P. Bio.
Maps prepared by:	Names:	Paul Walsh
GIS services by:	Company:	Environmental Dynamics Inc.
	Address:	Suite 301-1705 - 3rd Avenue Prince George, B.C. V2L 3G7
	Phone:	(250) 562-5412
Water chemistry conducted by:	Name:	Philip Analytical Services Corp.
	Address:	8577 Commerce Court, Burnaby,B.C., V5A4N5
	Phone:	(604) 444-4808
Aging sample analysis by:	Name:	N/A
Genetic sample analysis by:	Name:	N/A
Voucher species ID by:	Name:	N/A
QA/QC audit by:	Name:	David Hamilton, R.P.Bio.
Transportation	Name:	Pacific Western Helicopters Ltd.
	Address:	4214 Cowart Road, Prince George B.C.,
	Phone:	(250) 562-7911

ACKNOLWEDGEMENTS

Funding for this inventory was provided by Forest Renewal BC, a partnership of forest companies, workers, environmental groups, First Nations, communities and government. Forest Renewal BC funding from stumpage fees and royalties that forest companies pay for the right to harvest timber on Crown lands is reinvested in the forests, forest workers, and forest communities.

DISCLAIMER

This product has been accepted as being in accordance with approved standards within the limits of Ministry quality assurance procedures. Users are cautioned that interpreted information on this product developed for the purposes of the Forest Practices Code Act and Regulations, for example stream classifications, is subject to review by a statutory decision maker for the purposes of determining whether or not to approve an operational plan.

Report approved by: _____

Robert J. Redden, R.P.Bio

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ATTACHMENTS AVAILABLE AT MELP OFFICE

The following attachments to this report are available at the Ministry of Environment, Lands and Parks office in Prince George, B.C. The contact name, phone number, and address are presented below.

Ms. Lynn Blouw
Regional Fisheries Habitat/Inventory Specialist
Room 325, 1011-4th Avenue
Prince George, B.C.
V2L 3H9
(250) 565-6424

Attachments

I- Photo documentation

II- Digital data

III- Phase Completion Report

IV- Field Cards*

V- Aerial Photographs

VI- Fish Aging Structures

VII- Voucher Identification Forms

VIII- Planning Document

IX- FISS Data Forms and Maps

*** - see Attachment 2 of the 1999 Herrick Fish and Fish Habitat Stream Report**

1.0 INTRODUCTION

1.1 Project Scope and Objectives

The Reconnaissance Fish and Fish Habitat Inventory is a sample-based survey covering whole watersheds, (i.e., all lakes, stream reaches and connected wetlands within the watershed, as defined from air photos and 1:20,000 scale maps). This inventory is intended to provide information regarding fish species characteristics, distributions and relative abundance, as well as stream reach and lake biophysical data for interpretation of habitat sensitivity and capability for fish production (BC Ministry of Fisheries 1998). This lake was one of three lakes sampled during the 1999 Reconnaissance Fish and Fish Habitat Inventory within the Herrick Creek Watershed. Environmental Dynamics was retained by the Lheidli T'enneh Band to conduct fieldwork and reporting for the three lakes. However, all other contract requirements such as planning, logistics, and stream surveys, were conducted by the band. This primary lake survey provided baseline information on bathymetry, water quality, fisheries values and associated lake tributary fish habitat quality.

1.2 Location

The unnamed lake is located approximately 180 kilometers northeast of the town of Prince George, BC and situated at the northeast foot of Ice Mountain. The outlet drains into a stream known as Spakwaniko Creek, which eventually drains into the McGregor River (Figure 1). Table 1 presents the survey site location and description of lake 00092HERR.

Table 1. Survey Site Location and Description

WATERSHED CODE	UTM AT INLET	WBID	NTS / TRIM MAPS	BEC ZONE	LAKE AREA (HA)	AIR PHOTOS
190-265100-30600-81400	10.629900. 6033220	00092HERR	093I.045 093I.046	ESSF	100.5	30BCB96045 #64

1.2.1 Access

Leaving the city of Prince George, travel east on Highway 16 until the intersection of Upper Fraser Road is reached. Turn left on the Upper Fraser Road and proceed past the community of Upper Fraser until the McGregor camp is reached. Turn left at McGregor camp and travel down the Pass Lake Main Forest Service Road (FSR). Immediately after crossing the suspension bridge over the McGregor River, turn left down the Herrick Creek Road to the Herrick camp, where a helicopter landing site is available. There is no road access to this lake therefore a helicopter must be taken approximately 23 km northeast, following Spakwaniko Creek, to the west end of the Limestone Lakes chain. In addition a horse trail also leads to the Limestone Lakes chain.

2.0 RESOURCE INFORMATION

The study area lies within BC Environment's Herrick Creek Watershed Group, of which the northern portion is the Spakwaniko Watershed. This watershed falls within the boundaries of BC Environment's sub-region 7A (Omineca) and Management Unit 7-18 (BC Ministry of Environment, Lands and Parks 1993). The study area is within a third order watershed within the watershed group, delineated from TRIM base maps and inventoried under the Herrick Creek Watershed Group Reconnaissance Fish and Fish Habitat Inventory.

Fig 1
Goes here!

Figure 1. Overview Map of the Study Area within the Herrick Creek Watershed Group

OVERVIEW MAP
Herrick River Watershed

Scale 1:75,000

3km 2km 1km 0km 0.5km 1km

Project Code: 1781
Date: March, 2000
Inventory Company: Canadian Forest Product Ltd.

MONKMAN PROVINCIAL PARK

190-265100-30600-81400

Limestone Lakes

CAMP SITE

WEAVER PEAK

00092 HERR

093I.045

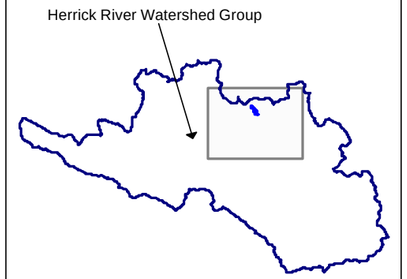
093I.046

ICE MTN

093I.035

093I.036

- Definite Stream
- Indefinite Stream
- Intermittent Stream
- Definite Lake
- Indefinite Lake
- Intermittent Lake
- Marsh
- Swamp
- Study Area



Position of Lake in Study Area

Position of Study Area in Province

Prepared by: Environmental Dynamics Inc.
Date: March, 2000

ENVIRONMENTAL DYNAMICS INC.
Natural Resource Consultants
Suite 301, 1705 - 3rd Avenue
Prince George, BC, V2L 3G7

Prepared for: Lheidli T'enneh Band Fisheries Program

Figure 1.

Linear development in the form of roads, within this Watershed Group and the study area, has remained relatively undeveloped prior to 1999. However, timber harvesting and road construction within the Herrick Creek Watershed is taking place at an accelerated rate in response to beetle infestation. The Herrick Creek FSR and Pass Lake Main FSR are primarily gravel routes providing access to logging areas within the watershed. With the exception of recently developed forest service roads, the northern section of the Herrick Creek Watershed Group has remained untapped.

According to a BC Ministry of Forests Recreation Map for the Prince George Forest District, there are six BC Forest Service recreation sites located within the Herrick Creek Watershed Group. All six recreation sites are located on the south side of the McGregor River with none of the sites located in the Spakwaniko Watershed. The recreation sites, from west to east, are known as Church Site, Amanita Lake, Pass Lake, McGregor River, Kittil Falls, and Walker Creek. All offer camping facilities, with Church Site offering canoeing facilities as well (BC Ministry of Forests 1994).

Reconnaissance stream inventories, in conjunction with the primary lake survey of the unnamed lake, were conducted within this basin in September of 1999 (Lheidli T'enneh 2000). These inventories found that fish were absent above the lake outlet.

In the prefield planning phase of the watershed based reconnaissance inventory, eleven inlet tributaries and a single outlet tributary were identified (Lheidli T'enneh 1999). During the fieldwork phase of the reconnaissance survey, one unmapped inlet tributary was discovered. During the lake survey an interesting phenomenon was discovered. At the time of survey the lake was found to be at a much lower level than found on the map. The resulting newly exposed land contained a channel acting as an outlet for the lake. This outlet eventually spirals in upon itself and disappears into an apparent aquifer. In addition, a number of smaller streams that would be inlets to the lake at higher water levels enter into the newly formed outlet. Approximately 200m northwest of where the outlet disappears, a massive amount of water emerges from the side of a steep cliff and forms a waterfall. It could be concluded that the 200m of subsurface flow along with the waterfall is the outlet for this lake. The structure of the outlet would serve as a barrier to fish and prevent entry into the lake.

Stream inventories were conducted according to the data collection methodologies outlined in the Resources Inventory Committee (RIC) Reconnaissance (1:20,000) Fish and Fish Habitat Inventory Standards and Procedures (BC Ministry of Fisheries 1998). The first reach of each lake tributary was surveyed to identify habitat that may be used by lake fish populations during various life stages. The main inlet and outlet tributaries (WSC 190-265100-30600-81400) are the main drainage corridors for the watershed basin. While the outlet had no fish habitat the inlet had excellent rearing habitat resulting from the cover provided by deep pools and boulders. Refer to section 4.8 and Appendix 4; FDIS stream summary printout, for specific data pertaining to inlet and outlet tributaries of the unnamed lake.

3.0 METHODS

Methodologies followed the Reconnaissance (1:20,000) Fish and Fish Habitat Inventory: Standards and Procedures (BC Ministry of Fisheries 1998) and Bathymetric Standards for Lake Inventories (BC Ministry of Fisheries 1999). Methodologies were also consistent with the approach outlined in Reconnaissance (1:20,000) Fish and Fish Habitat Inventory in the Herrick Creek Watershed (Lheidli T'enneh 1999). A summary of the methods and equipment used are outlined below.

Sampling Equipment and Methodologies

- 4 m Polaris inflatable boat powered by a 15 hp outboard motor
- Meridata Model 100 electronic depth sounder
- Trimble Pro-XL GPS (for georeferencing depth soundings)
- Contour interpolation was conducted using Vertical Mapper software in MapInfo
- MapInfo was run on a PC based computer platform
- Microsoft Excel was used to produce graphs from the spreadsheet calculations
- YSI Model 57 oxygen/temperature meter (measured oxygen/temperature profile of water column)
- pH (field) measurement: EM Science colored pH indicator strips
- Conductivity (field) measurement: Hand-held Oakton Model TDS-TESTR 3
- Van Dorn bottle type field water sampler
- Hach H_2S field sample kit for hydrogen sulphide detection
- Six-panel 91 m sinking monofilament gill net with mesh sizes ranging between 25 and 89 mm (BC Environment standard)
- Six Minnow traps (Gee-type)
- Camera (Pentax Zoom WR90 Date, 35 mm) (lens focal length 38 - 90 mm)

Bathymetric Mapping

Bathymetric surveys were conducted in accordance with the methodology outlined by RIC (1999). Depth soundings of the lake were conducted using a Meridata Model 100 electronic depth sounder and were georeferenced using a Trimble Pro-XL GPS (Global Positioning System). The lake depths, along with their associated positions, were recorded and stored in the GPS data layer and later corrected with base station files provided by Terra Pro GPS Surveys Ltd., Prince George, BC. The corrected georeferenced information files were imported into Vertical Mapper®, a grid-based contouring and display software system running under the MapInfo® GIS software. The software generates contour maps by triangulating the points provided by the GPS. Lake outlines, tributaries, roads and surrounding wetland locations are obtained from digital Terrain Resource Information Management (TRIM) mapsheets. The bathymetric information was placed over the existing digital TRIM contour grid as a separate layer in the GIS. The mapping software then calculates area, volume and depth statistics. Bathymetric maps were prepared according to the specifications and examples provided by RIC (1999).

Annotated Air Photo

The air photo was scanned on an HP ScanJet 6100C scanner and enlarged for presentation. The unregistered raster image was imported into MapInfo® or Corel Draw 7, where symbols and a legend were added. The annotated air photo was printed using an HP DeskJet 1120C colour printer.

Photodocumentation

Panoramic colour photographs of the surrounding area as well as photographs of shoreline conditions, benchmark, inlet and outlet tributaries and any other significant features are presented within this report as plates in Appendix 4 (tributaries) and Appendix 5 (lakes). However, some photos have been omitted from the report. These would include redundant, out-of-focus and personal photos. The only photos included in Appendix 5 of the report are those which best meet the photodocumentation requirements of the project.

Relevant photographs of the lake, presented in the report, are provided with a caption which includes plate number, description and photo orientation, along with the specific roll number and frame number

of the photograph. Photographs of the unnamed lake have been scanned and copied to CD with a file name conforming to the following seven character file naming convention: R586F24.tif, where:

- R = Roll number
- 586 = Film roll number
- F = Film frame
- 24 = the frame number (i.e. 1 through 25)
- .tif = computer file extension which is assigned when the photograph is scanned

4.0 RESULTS AND DISCUSSION

4.1 Logistics

Fieldwork was conducted between September 9 and 10, 1999. The lake was accessed by Jet Ranger helicopter due to lack of road access to the lake. From the staging area at the Herrick Creek Camp, crew and equipment were ferried approximately 23 km to a suitable landing site at the eastern shoreline of the lake. There were no problems encountered during the survey that impacted the study.

4.2 Immediate Shoreline

The lake perimeter was 95% low rocky and 5% cliffs with no visible land use development of the immediate shoreline or surrounding area at the time of survey. Rocks and small boulders bordered the immediate shoreline and there was evidence of avalanche chutes around the lake. Shoreline cover was very sparse due to the absence of large and small woody debris, overhanging vegetation and aquatic plants.

4.3 Terrain

The terrain surrounding the unnamed lake was mountainous, as the lake was situated in a hanging valley between two mountain ranges both running north to south. The dominant tree species were sub-alpine fir (*Abies lasiocarpa*) and lodgepole pine (*Pinus contorta*). The notable understory vegetation present was alder (*Alnus* sp.) and willow (*Salix* spp.).

4.4 Aquatic Flora

The unnamed lake has no aquatic vegetation. The absence of macrophytes limits the quality of shoreline cover available to aquatic organisms.

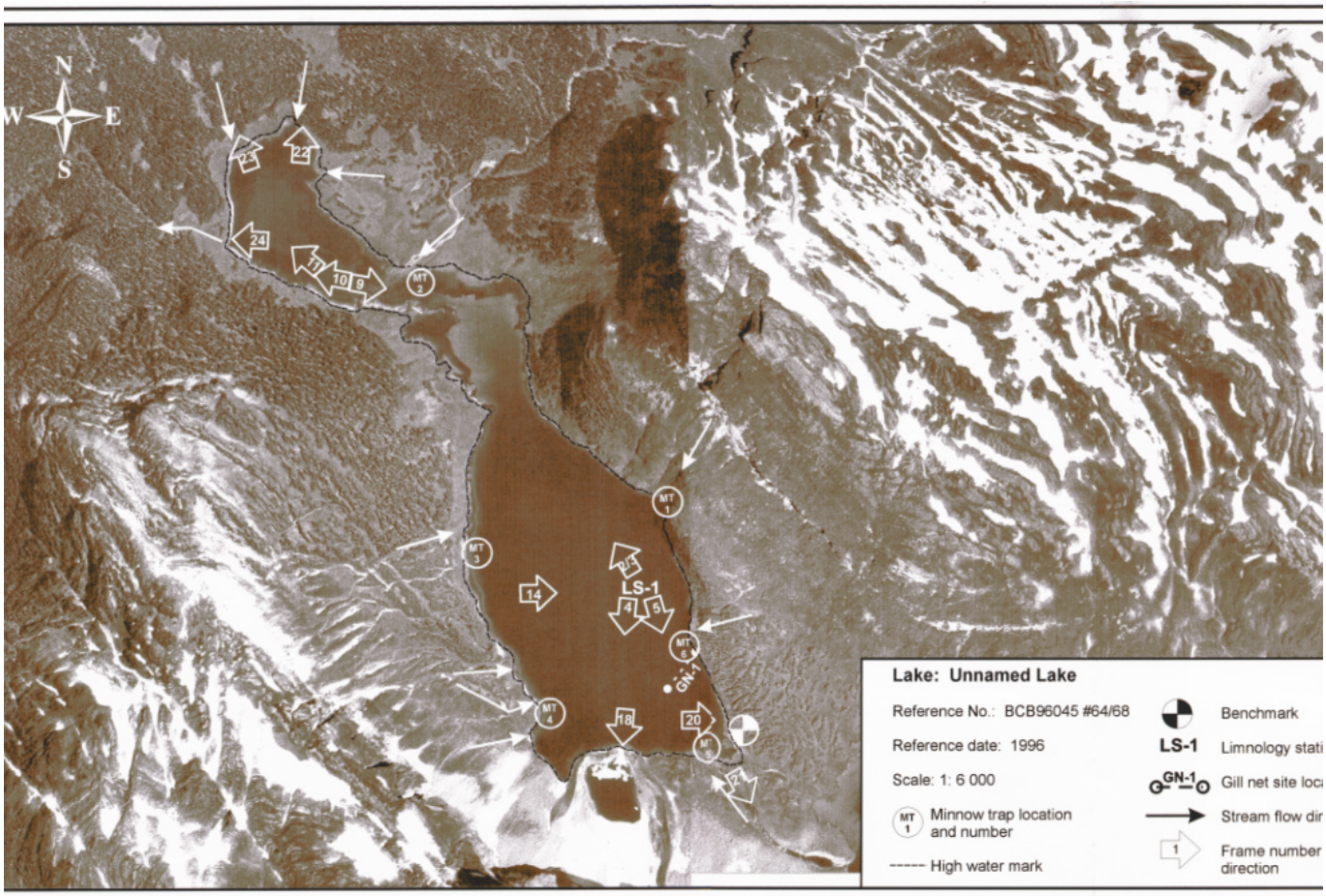
4.5 Site Summary

Figure 2 and Figure 3 illustrate the locations of the gill net and minnow traps, photograph numbers and directions, limnological station site location, benchmark location and streamflow direction.

4.6 Bathymetry

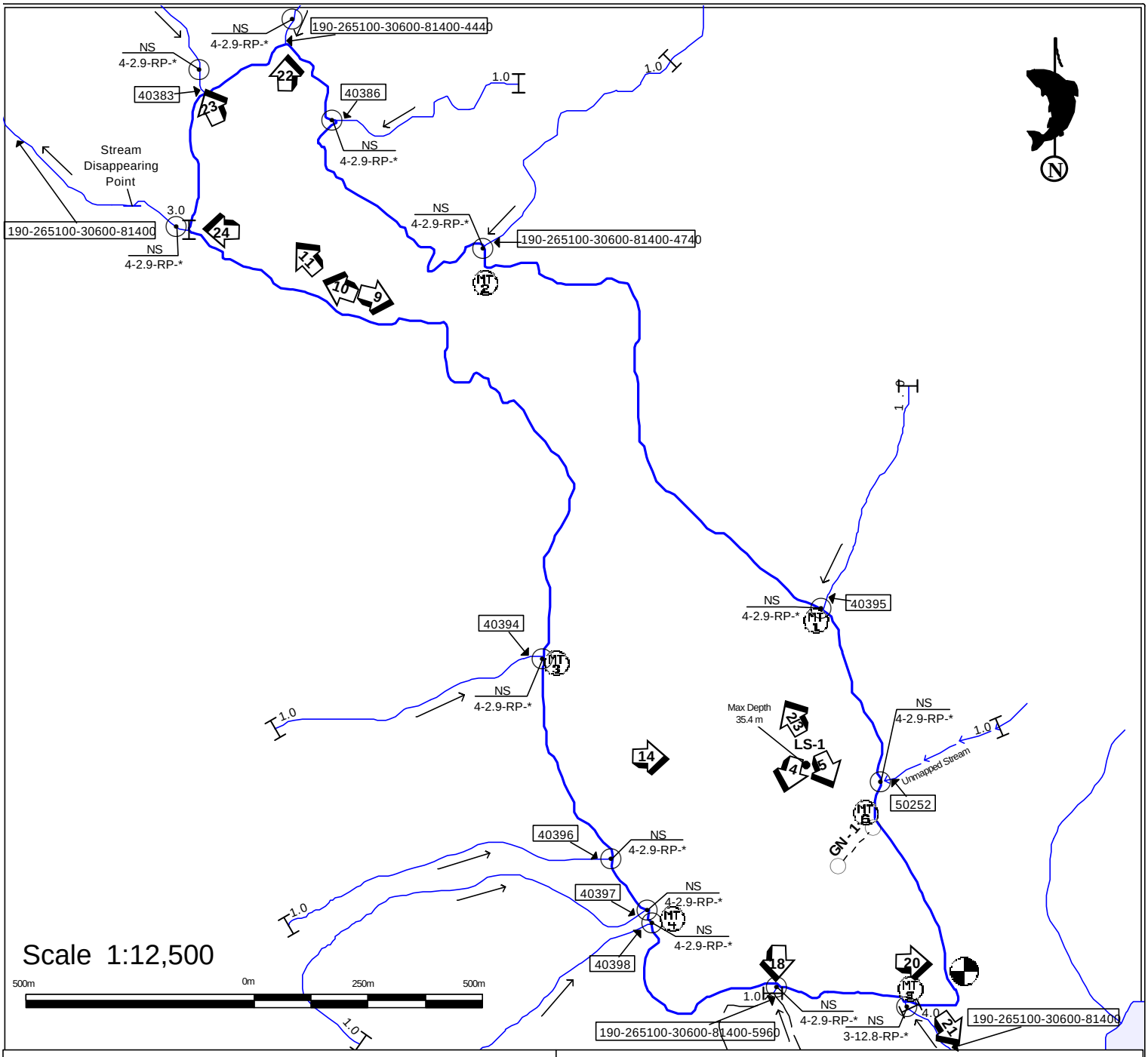
Table 2 presents the bathymetric statistics at the time of survey for the unnamed lake. Figure 4 presents the bathymetric sounding transect locations for the unnamed lake. Bathymetric maps are provided in Figure 6 (8.5" × 11" format) and Appendix 6 (E - size format).

Figure 2 Annotated Air Photo



ure 2. Annotated Air Photo

Figure 3 Location of Sampling Sites



Unnamed Lake

Figure 3. Location of Sampling Sites

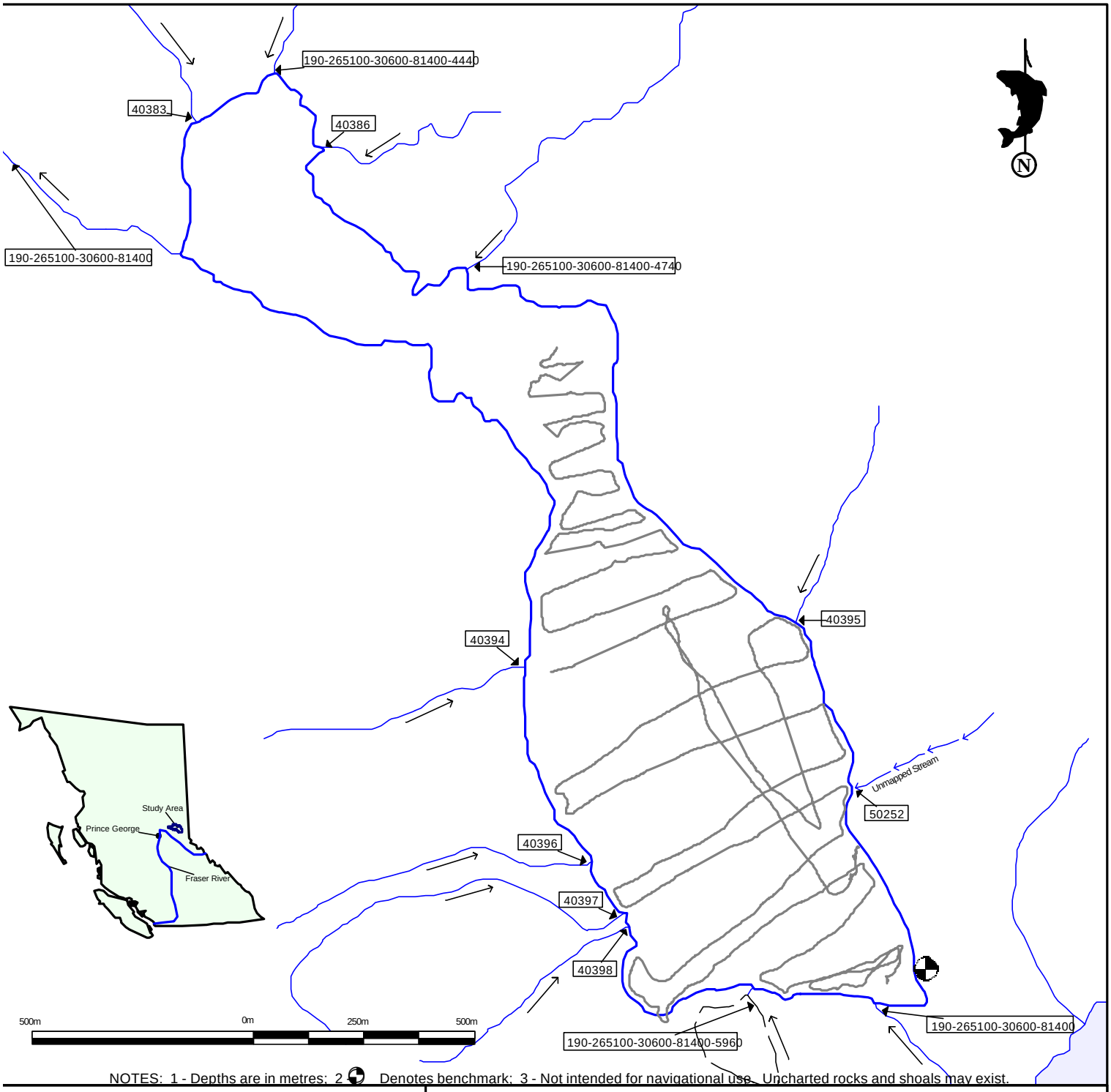
Benchmark	Permanent stream direction
GN-1 Gill net sampling site	Seasonal stream direction
MT 1 Minnow trap number	Swamp
LS-1 Limnology station number	Marsh
2 Frame number and direction	Road
2.1 Upper reach break and number	Stream disappearing point
	Tributary sample site

Map features based on digital Terrain Resource Information Management, digital forest harvest information, and/or field survey information.

Produced by: Environmental Dynamics Inc., March 2000

Figure 4 Sounding Transects

1999 Primary Lake Reconnaissance Survey of Unnamed Lake (Waterbody ID: 00092 HERR)



NOTES: 1 - Depths are in metres; 2 ⊕ Denotes benchmark; 3 - Not intended for navigational use. Uncharted rocks and shoals may exist.

SURVEYED BY: B. Cranston / T. Newman
OUTLINE SOURCE: 93I.045 / 93I.046 Digital TRIM Mapsheet
DATE: September 9-10, 1999

Unnamed Lake

Elevation	1 400 m
Surface Area	1 005 000 m²
Area Above 6 m Contour	479 700 m²
Volume	13 123 940 m³
Mean Depth	13.1 m
Maximum Depth	35.4 m
Perimeter, Main Shore	6 834 m
Perimeter, Islands	0 m
Benchmark	3.5 m

Prepared for: Lheidli T'enneh Band

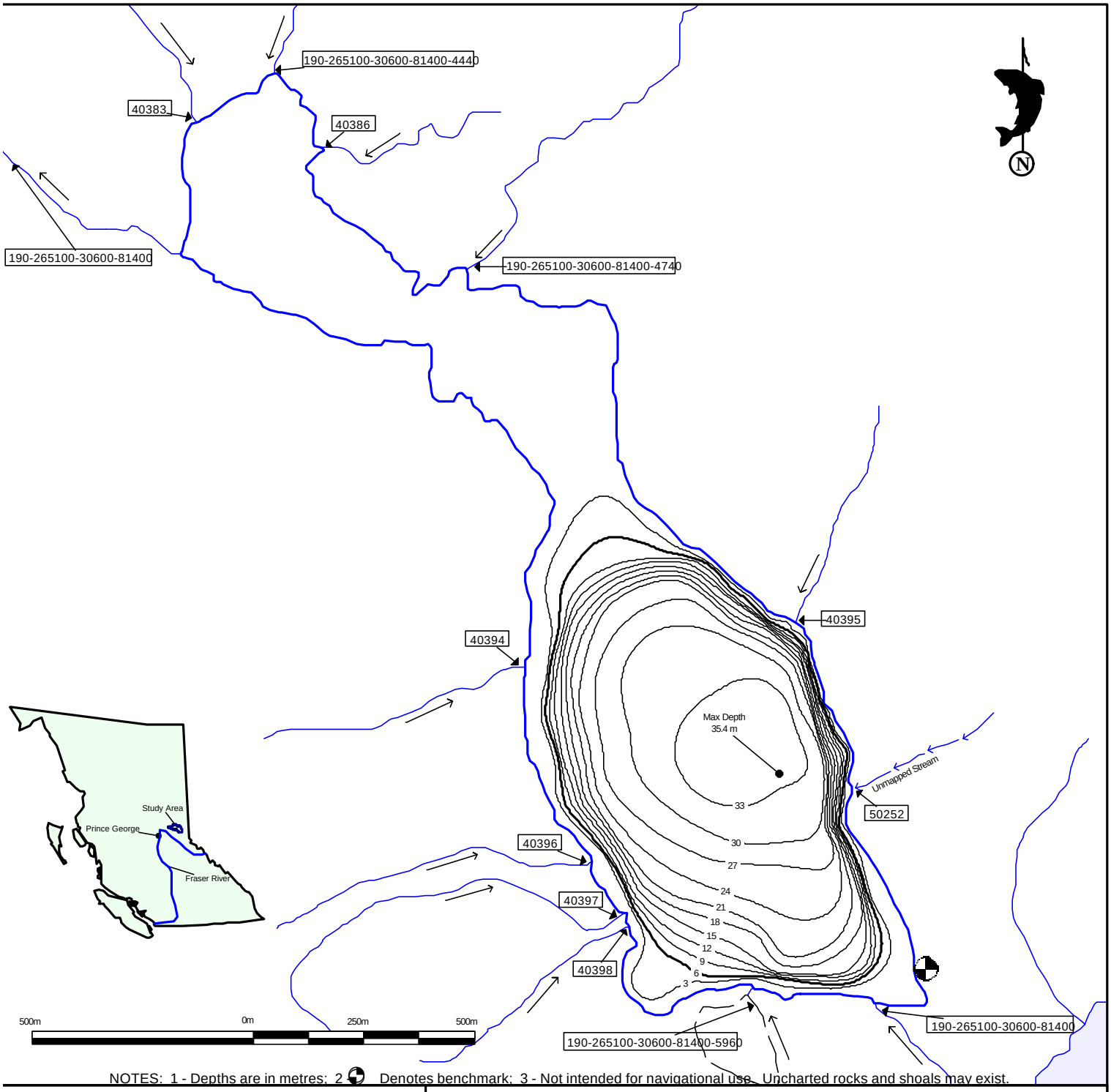
By: Environmental Dynamics Inc.
Suite 301, 1705 - 3rd Ave., Prince George, BC
Phone: (250)-562-5412 Fax: (250)-562-5413

WATERSHED CODE: 190-265100-30600-81400		UTM COORDINATE: 10.623460.6034780	
WATERBODY ID: 00092 HERR	DATE: March, 2000	REVISION DATE:	SCALE: 1:12,500
DIGITIZED: MapInfo	REACH NO: 4.0	APPROVED:	
CONTOURS: Vertical Mapper	MU: 7-18		NTS NO: 93I/6
TECH. CHECK: PJW	ESTIMATED ANNUAL FLUCTUATION: 2.9m		

Figure 4. Sounding Transects

Figure 5 Bathymetric Map

1999 Primary Lake Reconnaissance Survey of Unnamed Lake (Waterbody ID: 00092 HERR)



NOTES: 1 - Depths are in metres; 2 ⊕ Denotes benchmark; 3 - Not intended for navigational use. Uncharted rocks and shoals may exist.

SURVEYED BY: B. Cranston / T. Newman
OUTLINE SOURCE: 93I.045 / 93I.046 Digital TRIM Mapsheet
DATE: September 9-10, 1999

Unnamed Lake

Elevation	1 400 m
Surface Area	1 005 000 m²
Area Above 6 m Contour	479 700 m²
Volume	13 123 940 m³
Mean Depth	13.1 m
Maximum Depth	35.4 m
Perimeter, Main Shore	6 834 m
Perimeter, Islands	0 m
Benchmark	3.5 m

Prepared for: **Lheidli T'enneh Band**

By: **Environmental Dynamics Inc.**
Suite 301, 1705 - 3rd Ave., Prince George, BC
Phone: (250)-562-5412 Fax: (250)-562-5413

WATERSHED CODE: 190-265100-30600-81400		UTM COORDINATE: 10.623460.6034780	
WATERBODY ID: 00092 HERR	DATE: March, 2000	REVISION DATE:	SCALE: 1:12,500
DIGITIZED: MapInfo	REACH NO: 4.0	APPROVED:	
CONTOURS: Vertical Mapper	MU: 7-18		NTS NO: 93I/6
TECH. CHECK: PJW	ESTIMATED ANNUAL FLUCTUATION: 2.9m		

Figure 5. Bathymetric Map

Table 2. Bathymetric Statistics Summary

Bathymetric Statistics at Time of Survey								
Elevation (m)	**Surface Area (m^2)**	**Area Above 6 m contour (m^2)**	**Volume (m^3)**	**Mean Depth (m)**	**Max Depth (m)**	**Shoreline Perimeter (m)**	**Island Perimeter (m)**	**Benchmark Height (m)**
1 400	1 005 000	479 700	13 123 940	13.1	35.4	6 420	0	3.5

4.7 Limnological Sampling

A water sampling station was established at the deepest point of the lake (35.4 meters). Two water samples were taken, one at a depth of 1.0m and the other at a depth of 34.0m. Three major groups of water chemistry parameters were measured during the lake inventory: physical, general inorganics and nutrients (nitrogen and phosphorus). In addition to the water quality data from the survey of this lake and associated tributaries in the study area, temperature, conductivity and pH readings are available from the stream fish and fish habitat surveys conducted in this watershed (Lheidli T'enneh 2000).

The Secchi depth was 11.75 meters and the water colour, as viewed through the Van Dorn water sampler, was a blue green. Hydrogen sulphide odour was not detected in the bottom water sample. Dissolved oxygen levels did not drop below 8.2 mg/L throughout the entire water column. Table 3 presents the summary of water quality sampling measurements of the unnamed lake. Refer to Appendix 2 for the detailed water chemistry analyses conducted by the Philip Analytical laboratory.

In northern temperate climates, lakes typically experience temperature stratification in the summer months because of daytime heating of the water column. The result is a distinct formation of a thermocline zone where temperature drops at least 1^oC with each 1 m increase in depth (Cole 1994). The data presented in Figure 6 indicate that a weak thermocline zone does exist between 15 and 22 m. The presence of a weak thermocline is supported by the D.O. profile which shows a reduction in D.O. concentrations below the level of the thermocline.

Table 3. Water Chemistry Summary

Group	Parameter Measured	Surface Ions (0.5 m)	Bottom Ions (30.0 m)
Physical	pH (field)	6.5	6.5
	pH (lab)	8.1	8.0
	Specific Conductance	122 uS/cm	133 uS/cm
	Residue Filterable (TDS)	70 mg/L	74 mg/L
General Inorganics	Acidity pH 4.5	< 0.5 mg/L	< 0.5 mg/L
	Acidity pH 8.3	0.7 mg/L	1.1 mg/L
	Alkalinity Total as $CaCO_3$	62.4 mg/L	68.1 mg/L
Nitrogen	Nitrogen: Ammonia	< 0.005 mg/L	0.006 mg/L
	Nitrogen: Nitrate	< 0.20 mg/L	0.03 mg/L
	Nitrogen: Nitrite	< 0.005 mg/L	< 0.005 mg/L
	Total Nitrogen	0.11 mg/L	0.34 mg/L
Phosphorus	Ortho-Phosphorus Phosphorus Total	< 0.005 mg/L < 0.005 mg/L	< 0.005 mg/L < 0.005 mg/L

Dissolved oxygen and temperature are important factors influencing the suitability of a lake to support various fish species and can dictate the amount of available habitat to resident fish populations. While cypriniforms tend to be more tolerant, salmonids have narrow tolerance ranges for these two parameters. If salmonids are subjected to prolonged dissolved oxygen (DO) concentrations below 5.0 mg/L, growth and survival will be reduced (Piper et al. 1982). For optimal survival, salmonids require DO concentrations greater than 6.5 mg/L. Figure 6 illustrates dissolved oxygen concentrations within acceptable ranges throughout the entire water column.

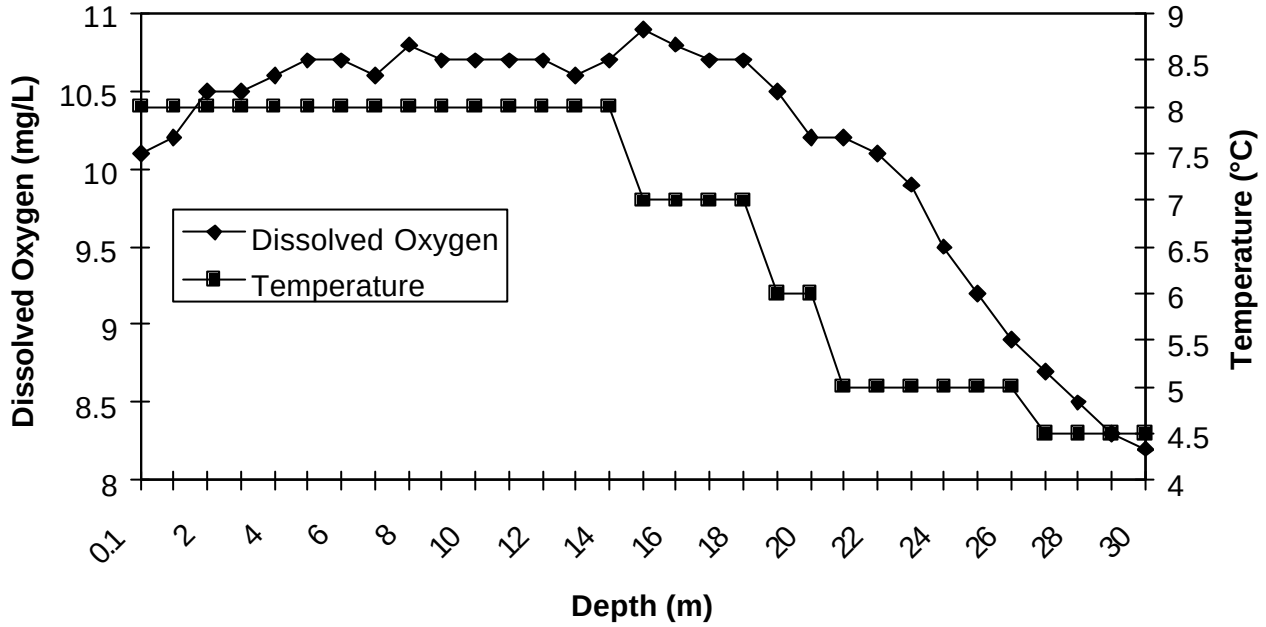


Figure 6. Dissolved Oxygen and Temperature Profiles of Unnamed Lake Taken on September 10, 1999

Nitrogen (N) and phosphorus (P) are the principal nutrients limiting primary production in fresh waters and can be related to the trophic status of a lake (Cole 1994). Quantification of nutrient levels not only describes the productivity potential of the lake, but can also determine which nutrient is limiting the system. N:P ratios, (total nitrogen and total phosphorus, respectively) can be used to assess nutrient limitations (Nordin 1985). Nordin concluded the following regarding N:P ratios:

N:P < 5	Nitrogen limitation
5 < N:P < 15	No limitation or co-limitation
N:P > 15	Phosphorus limitation

According to the laboratory analyses (Appendix 2) the average N:P ratio of the lake was 45, suggesting that an increase in the concentration of phosphorus will result in an increase in primary productivity.

There are two fundamental types of lakes to consider when assessing lake productivity. These are oligotrophic, or nutrient-poor, and eutrophic, or nutrient-rich. Often lakes possess characteristics of both fundamental types (Cole 1994). Features of the study lake, such as having deep and steep banks, limited or no littoral plant production, marked transparency of the water column and green water suggest the study lake is oligotrophic.

4.8 Inlets and Outlets

Lake 00092HERR has twelve inlets and one subsurface outlet (Figures 2 and 3). A summary of the habitat conditions in each of the tributary streams is provided in Table 4 as well as in the following paragraphs.

Table 4. Lake Inlet and Outlet Stream Summary

Watershed Code or ILP	Reach	Channel		Fisheries Habitat		
		Width (meters)	Gradient (%)	Spawning	Rearing	Overwintering
190-265100-30600-81400	3.0	0.4	10.5	Poor	Poor	Poor
190-265100-30600-81400	5.0	12.8	3	Poor	Fair	Fair
190-265100-30600-81400-4440	1.0	2.3	7	Good	Good	Poor
190-265100-30600-81400-4740	1.0	1.0[1]	N/A[2]	Poor	Poor	Poor
190-265100-30600-81400-5960	1.0	2.9	3.5	Poor	Poor	Poor
40383	1.0	0.8	15.8	Fair	Good	Poor
40386	1.0	N/A[2]	1[1]	Poor	Poor	Poor
40394	1.0	1.5[1]	N/A[2]	Fair	Fair	Poor
40395	1.0	N/A[2]	N/A[2]	Poor	Poor	Poor
40396	1.0	1.0[1]	N/A[2]	Poor	Poor	Poor
40397	1.0	3.0-5.0[1]	N/A[2]	Fair	Poor	Poor
40398	1.0	0.5[1]	N/A[2]	Poor	Fair	Poor
50252	1.0	1.5-2.0[1]	N/A[2]	Poor	Poor	Poor

[1] This value is a ground estimate due to an incomplete survey.
[2] This value could not be determined due to an incomplete survey.

Tributary 1 (WSC 190-265100-30600-81400 - outlet) flowed northwesterly. At the time of survey the lake was found to be at a much lower level than found on the map. The resulting lacustrine deposits contained a channel acting as the outlet for the lake. This outlet eventually spirals in upon itself and disappears into an apparent aquifer. Approximately 200m northwest of where the outlet disappears, a massive amount of water emerges from the side of a steep cliff and forms a waterfall. It could be concluded that the 200m of subsurface flow along with the waterfall is the outlet for this lake. No fish were captured in this tributary.

Tributary 2 (WSC 190-265100-30600-81400 - inlet) flowed in a northwesterly direction into the southern end of Limestone Lake through a low gradient area of deciduous shrubs and sub-alpine fir. The channel is continuous and joins this lake to two other lakes further upstream. Cover is provided primarily by deep pools and boulders. Spawning habitat was poor, as the dominant substrates were boulders and cobbles. Although there was only a moderate amount of cover the quality of rearing and overwintering was fair as the stream was deep and fast flowing. No fish were captured in this tributary.

Tributary 3 (WSC 190-265100-30600-81400-4440 - inlet) flowed in a southerly direction through an alpine area into the northernmost tip of Limestone Lake. At the time of survey, the discharge and water velocity of the inlet was high. Since there were small patches of gravels throughout a dominant substrate of cobbles, spawning habitat was considered good. Rearing habitat was also good, as the flow was adequate while the high water level and cobbles provide cover. Overwintering was poor due to a lack of deep pools and the likelihood that the stream will freeze. Although the water level is high for

this channel, it is unlikely to prevent the stream from freezing through during the water. No fish were captured in this tributary.

Tributary 4 (WSC 190-265100-30600-81400-4740 - inlet) flowed in a southwesterly direction into the northeastern shoreline of Limestone Lake. The channel was very small and shallow. It had a very low gradient near the confluence, but climbed quickly 40 m upstream from the lake. The dominant substrate was fines but intermittent sections of gravel exist. With no deep pools or holding pools there was very little cover in this tributary. Spawning, rearing and overwintering habitat were all poor within this reach. The tributary was only surveyed for fisheries habitat values as part of the 1999 Reconnaissance Lake Inventory for Limestone Lake.

Tributary 5 (WSC 190-265100-30600-81400-5960 – inlet) flowed in a northerly direction into the southern section of Limestone Lake. This tributary joins the study lake to a glacial pool 35 m upstream from the lake. The stream was small and had a substrate dominated by gravels, with boulders and cobbles subdominant. A few pools and some boulders provided a very small amount of cover. Although gravels were present, spawning habitat was poor as the stream was small and provided little cover. Rearing habitat was poor as the stream had only a few deep pools for cover. Overwintering habitat was poor, as this stream is likely to freeze in the winter. As this stream was only 35 m in length, no fish sampling was conducted.

Tributary 6 (ILP 40383 – inlet) flowed in a southeasterly direction into the northwestern point of the Limestone Lake. The stream flowed through an alpine meadow, at a high gradient, and over a substrate of moss-covered cobbles. Deep pools and boulders provided moderate cover. Spawning habitat was fair as some gravel pockets and holding pools exist, while access from the lake was unobstructed. Rearing habitat was good as the pools and cobbles provided cover. Overwintering was poor, as this tributary will likely freeze due to its alpine location. No fish were captured in this tributary.

Tributary 7 (ILP 40386 – inlet) flowed west, through a low gradient meadow, and entered the lake at the northern end of the east shore. The dominant substrate was fines surrounded by subdominant gravels. At the time of survey, the tributary had a very low flow. Spawning habitat was poor, due to a lack of holding pools for adults and a lack of suitable spawning gravels. Rearing habitat was poor due to a lack of cover for rearing juveniles. Overwintering habitat was poor as the water was shallow and will freeze to the bottom. The tributary was only surveyed for fisheries habitat values as part of the 1999 Reconnaissance Lake Inventory for Limestone Lake.

Tributary 8 (ILP 40394 – inlet) flowed east into the western shore of Limestone Lake and was a dry channel at the time of survey. The substrates were predominantly gravels and cobbles with some boulders. The majority of gravels were very angular and not suitable for spawning, however, occasional pockets of suitable gravels existed. Spawning habitat quality would be fair at times of flow. Rearing habitat would be fair during the spring freshet, as some pools close to the lake would be created. At times of higher flow, a greater availability of habitat cover would be provided by small woody debris and undercut banks. Overwintering was poor, as there would be no water in the channel during late summer and early fall. The tributary was only surveyed for fisheries habitat values as part of the 1999 Reconnaissance Lake Inventory for Limestone Lake.

Tributary 9 (ILP 40395 – inlet) flowed south-southwest through an avalanche chute to drain into the study lake at the southern portion of the east shore. Boulders were the dominant substrate in this tributary. There was very little water present and no fish habitat. Spawning, rearing and overwintering habitat were poor. The tributary was only surveyed for fisheries habitat values as part of the 1999 Reconnaissance Lake Inventory for Limestone Lake.

Tributary 10 (ILP 40396 – inlet) flowed east, through an alpine meadow, into the southern section of the west shore. At the time of survey, this tributary had very low flow and could not be sampled for fish. Within close proximity of the lake, the gradient was low, but approximately 50 m upstream from the lake the gradient rose quickly to form a step-pool morphology. The dominant substrate was gravels; however, most were angular and unsuitable for spawning. Spawning habitat quality was poor due to the unsuitable gravels and a lack of holding pools. Rearing habitat was sparse, although a few small holding pools were available due to the step-pool morphology. Overwintering habitat was poor as the pools were shallow and likely to freeze to the bottom. The tributary was only surveyed for fisheries habitat values as part of the 1999 Reconnaissance Lake Inventory for Limestone Lake.

Tributary 11 (ILP 40397 – inlet) flowed east, through an alpine meadow, into the southern section of the west shore entering the lake approximately 120 m south of tributary 10. Within the first 40 m of entering the lake, the tributary had a riffle-pool morphology, which changed to step-pool morphology with the corresponding increase in gradient. The dominant substrate near the lake is gravels but becomes cobbles and boulders with the change to step-pool morphology. Spawning habitat quality was fair, but most of the gravels were angular and unsuitable for spawning. Although there were some pools, rearing habitat was poor as there was very little cover. Overwintering habitat was poor. The tributary was only surveyed for fisheries habitat values as part of the 1999 Reconnaissance Lake Inventory for Limestone Lake.

Tributary 12 (ILP 40398 – inlet) flowed northeast and then turned east for 100 m before entering the lake at the southwestern end, approximately 100 m south of tributary 11. Water was present at the time of survey, but the water level was very low as the tributary was quite shallow. Pools were present throughout the first 100 m and were the only cover available for fish. The dominant substrates were gravels but some cobbles were present. Spawning habitat was poor as there were no holding pools, or cover, for spawning adult fish. With a few pools and the overall lack of cover, rearing habitat was fair. Overwintering habitat was poor as the stream was likely to freeze to the bottom or dry up completely. The tributary was only surveyed for fisheries habitat values as part of the 1999 Reconnaissance Lake Inventory for Limestone Lake.

Tributary 13 (ILP 50252) flowed southwesterly into the southern bank of the east shore. The stream flowed through steep ground and consequently had a cascade-pool morphology. There was no spawning, rearing, or overwintering habitat present in this tributary. Fish sampling was not conducted.

4.9 Fish Age, Size, and Life History

4.9.1 Fish Sampling Summary

A multi-panel sinking gill net with mesh sizes ranging between 25 and 89 mm and six baited Gee type minnow traps were set overnight. No fish were captured or visually observed within Limestone Lake or within any of the tributaries to the lake. Please refer to the comments section of the FDIS Lake Survey summary, and Tables 5 and 6 for the individual fish collection methods, sampling times and individual fish data.

4.9.2 Individual Fish Data Results

Although the lake and associated tributaries appeared to provide adequate habitat to support fish, sampling efforts failed to capture fish. Inventory surveys conducted within the basin in 1999 above the aquifer waterfall also failed to capture fish. This waterfall appears to preclude fish populations from accessing the habitat within the lake and the tributaries of this basin.

Table 5. Summary of Fish Sampling in Lake

NET / TRAP SUMMARY						
Site No.	Method	Set		Pulled		Species Captured*
		Date	Time	Date	Time	
Site 1	Sinking Gill Net	September 9	14:12	September 10	16:05	NFC
Site 1	Minnow Trap #1	September 9	13:10	September 10	15:05	NFC
Site 1	Minnow Trap #2	September 9	13:20	September 10	15:10	NFC
Site 1	Minnow Trap #3	September 9	13:30	September 10	15:17	NFC
Site 1	Minnow Trap #4	September 9	13:35	September 10	15:22	NFC
Site 1	Minnow Trap #5	September 9	13:45	September 10	15:35	NFC
Site 1	Minnow Trap #6	September 9	13:55	September 10	15:50	NFC

* NFC = no fish captured

Table 6. Summary of Fish Sampling in Tributaries of Lake

LAKE TRIBUTARY SAMPLING SUMMARY						
Watershed Code / ILP	Reach #	Site #	Inlet / Outlet	Length surveyed	Stream Order	Species Captured*
190-265100-30600-81400	5.0	81886	Inlet	100m	2nd	NFC
190-265100-30600-81400	3.0	81885	Inlet	300m	2nd	-***
190-265100-30600-81400-4440	1.0	81896	Inlet	145m	2nd	NFC
190-265100-30600-81400-4740	1.0	1	Inlet	100m	3rd	-***
190-265100-30600-81400-5960	1.0	81912	Inlet	100m	1st	-**
40383	1.0	81895	Inlet	210m	1st	NFC
40386	1.0	1	Inlet	100m	1st	-***
40394	1.0	1	Inlet	100m	1st	-***
40395	1.0	1	Inlet	100m	1st	-***
40396	1.0	1	Inlet	100m	1st	-***
40397	1.0	1	Inlet	100m	1st	-***
40398	1.0	1	Inlet	100m	1st	-***

* NFC = no fish captured

** This channel is 35 meters long and therefore was not sampled.

*** The tributary was only surveyed for fisheries habitat values as part of the 1999 Reconnaissance Lake Inventory for the unnamed lake.

Table 7. Fish Capture Summary

FISH CAPTURE SUMMARY							
Species*	# Fish Captured				# Sampled	# Preserved	Range of Fork Lengths (mm)
	Net Site No. 1	Minnow Traps	Angling	Total			
NFC	0	0	-	0	0	0	-
Totals	**0**	**0**	**-**	**0**	**0**	**0**	

* NFC = no fish captured

4.10 Significant Features and Fisheries Observations

4.10.1 Fish and Fish Habitat

No fish were captured within the unnamed lake or its tributaries. Habitat quality in the lake was considered good and several tributaries contained fair to good fish habitat. However, the outlet functions as a barrier, preventing movement of fish into this basin. The outlet appears to be an aquifer, which emerges as a waterfall out of a rock face some distance from the lake itself.

4.10.2 Habitat Concerns

Evaluation of physical and chemical characteristics of the lake indicated that a suitable environment exists for sport fish populations. For optimal survival, salmonids require DO concentrations greater than 6.5 mg/L. As illustrated by Figure 7, the dissolved oxygen concentrations were within acceptable ranges to a depth of 30 m at the time of survey. If fish were introduced into this basin they likely would be secluded from fish populations below the basin as the outlet is not a passable waterway for fish. No other habitat concerns were identified in the study area.

4.10.2.1 Restoration and Rehabilitation Opportunities

No potential restoration or rehabilitation opportunities were identified for this unnamed lake.

4.11 Wildlife Observations

The habitat of the unnamed lake and the surrounding wetland marshes within the study area is ideal for local ungulate and bird populations. Fifteen Canada Geese (*Branta canadensis*) were observed during the survey of the lake. As well, five goldeneyes (*Bucephala clangula*) were observed. No other significant or unusual wildlife observations were noted during the survey.

5.0 REFERENCES CITED

BC Ministry of Environment, Lands and Parks. 1993. British Columbia Recreational Atlas. B.C. Ministry of Environment. Lands and Parks, Victoria, B.C. 143 pp.

BC Ministry of Fisheries. 1998. **(errata 1999 included).** Reconnaissance (1:20,000) Fish and Fish Habitat Inventory Standards and Procedures (April, 1998). B.C. Ministry of Fisheries, Victoria, B.C. 111 pp.

BC Ministry of Fisheries. 1999. Bathymetric Standards for Lake Inventories – Version 2.0. Prepared by BC Ministry of Fisheries, Fisheries Inventory Section. Prepared for the Resources Inventory Committee. BC Ministry of Fisheries, Victoria, BC. January 1999. 65 pp.

BC Ministry of Forests. 1994. Prince George Forest District Recreation Map (1:400 000 scale). B.C. Ministry of Forests, Prince George, B.C.

Cole, G.A. 1994. Textbook of Limnology, 4th ed. Waveland Press, Inc. Prospect Heights, Illinois.

Lheidli T'enneh. 1999. Reconnaissance (1:20,000) Fish and Fish Habitat Inventory Planning in the Herrick Creek Watershed. Phases 1-3 Planning Report. Prepared for Northwood Inc. Prepared by Brian Toth, R.P.Bio.. Project Manager Lheidli T'enneh. 12 pp.

Lheidli T'enneh. 2000. Reconnaissance (1:20,000) Fish and Fish Habitat Inventory in the Herrick Creek Watershed. Phases 1-3 Report. In preparation for Canadian Forest Products. Prepared by Brian Toth, R.P.Bio.. Project Manager Lheidli T'enneh. 12pp.

Nordin, R. 1985. Water Quality Criteria for Nutrients and Algae: Technical Appendix. Water Quality Branch, B.C. Ministry of Environment, Victoria, B.C.

Piper, R. G., McElwain, I. B., Orme, L. E., McCraren, J. P., Fowler, L. G. and Leonard, J.R. 1982. Fish Hatchery Management. Department of the Interior U.S. Fish and Wildlife Service, Washington, D.C.

6.0 APPENDICES

APPENDIX 1

Lakes Survey Form

APPENDIX 2

Water Chemistry Analysis

APPENDIX 3

Fish Data Collection Form

APPENDIX 4

Reach/Site Summary Report for Lake

APPENDIX 5

Photographs

APPENDIX 6

Bathymetric Map