

# YUKON RIVER WATER QUALITY STUDY



A Water Contaminants Evaluation

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# YUKON RIVER WATER QUALITY STUDY

A Water Contaminants Evaluation  
File 9590-2-7

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February 1998

**ABSTRACT**

The Whitehorse watershed is the most developed and impacted stretch of the Yukon River. Grab samples were collected and analyzed for asbestos, *Giardia*, chemical and physical parameters. The results show that the Yukon River is a high quality water source. A large spike of phosphorous and dissolved solids are introduced at the Wolf Creek input. This study provides a base line for water quality in the Yukon River, at this point in the watershed development, above and immediately below Whitehorse. Future development in the area will have to be managed to reduce the impact to the Whitehorse watershed.

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## INTRODUCTION

The area from the Marsh Lake Dam to the Lake Laberge outlet on the Yukon River is the most developed and impacted stretch of the Yukon. Historically, the Yukon River was used for navigation but today the river is used for hydroelectric power, domestic and agricultural use. It is this area that will see the most change and environmental impact within the next decade.

Many activities have been recognized as effecting the quality of water in the Yukon River. The Arctic Environmental Strategy documented the contamination of Lake Laberge fish and water. Modifications to the City of Whitehorse sewage lagoon system have potentially improved the quality of effluent, but it has yet to discharge into the Yukon River. The development of rural residential subdivisions, and industrial growth at McRae and Carcross Corners, will have impacts on ground and surface waters. In Whitehorse there are hydrocarbon discharges from storm sewers, sewage in the Kishwoot Island area, ice jamming and flooding in the Marwell and downtown areas, and potential industrial development. All these inputs need to be addressed and studied. However, before this can occur a base line of existing water quality must be recorded.

## OBJECTIVE

To determine the water quality, at the present stage of development, for the Yukon River in the Whitehorse watershed, and identify any point sources of contamination.

## METHODS

Samples of water were collected from 11 sites considered to be representative of major watershed inputs. These range from Nares Lake in the south, to the Thirty Mile River in the north. Grab samples were taken in the middle of the river channels during (July-August). (Table 1) (Photos A, B and C)

Samples were analysed for physical properties, asbestos, inorganic chemistry, and *Giardia*. No bacterial samples were collected as they were considered to have high daily variability.

### Physical Properties Methodology

Samples were analyzed using the procedure detailed in publications of the American Public Health Association, U.S. Environmental Protection Agency, AWWA Standard Methods.

Dissolved metals were determined in a filtered (0.45 um) and acidified sample aliquot by UNCIP-AES (EPA Method 200.15)

Total metals were determined in a sample aliquot which was acid digested in a closed Teflon vessel in a microwave oven (EPA Method 3015). The digest was analyzed by UNCIP-AES (EPA Method 200.15)

Asbestos concentration analysis was performed by analytical transmission electron microscopy. For full procedure refer to Appendix.

*Giardia* concentration analysis was performed by using AWWA Standard Methods, as described in Roach 1992.

## RESULTS

There are two major input sources to the river system in the area studied: the M'Clintock River and Wolf/Cowley Creek. The mean daily flow for the Yukon River was found to be 656.18 cms, Wolf Creek flow in August was 0.882 cms, and the M'Clintock River flow is historically at 11.0 cms.(Figure 1) during August.

### Physical Properties

The results of sample analysis are displayed in Table 2 and 3. As Whitehorse employs the Yukon River as a source of drinking water, and it is a fish bearing water, the Canadian Water Quality Guidelines (for Aquatic Life) were used as an acceptable standard of water quality (Health Canada, 1995). There was no significant difference found in the physical properties of the Yukon River water between the upper river and lower river. Yukon River water was found to within or below the standard level of inorganic parameters except for calcium. Calcium, total hardness of the water and total alkalinity are graphed in Figure 2. Dissolved solids and phosphorous levels were graphed in Figure 3 and Figure 4 respectively. There was a significant difference found in dissolved solids and phosphorous levels from upper and lower river sources ( Mann-Whitney Rank Sum Test,  $T=38.000$ ,  $p=0.006$  and t-test,  $t=-7.732$ ,  $df=9$ ,  $p<0.001$ , respectively). The mean pH level of the 11 sites samples is 7.04. This falls within the water guidelines standards. All the pH levels for the 11 sites are graphed in Figure 5.

### Asbestos and *Giardia*

Asbestos was found in 5 of 9 sites plus in Whitehorse tap water. All asbestos was found to be of the chrysotile type and below the USEAA water standard of  $7 \times 10^6$  asbestos fibres per litre, except at Wolf Creek, which was found to be  $13.41 \times 10^6$  asbestos fibres per litre. (Figure 6).

*Giardia* was found at two sites: M'Clintock River and Wolf Creek. (Table 4).

## DISCUSSION

The results of this study suggest that the water quality of the Yukon River between Nares Lake and Thirty Mile is of high quality. However there is some concern on asbestos levels in Wolf Creek and dissolved solids and phosphorous levels in the lower portion of the river (Wolf Creek to Thirty Mile).

Yukon River water is of a basic pH ranging from 7.6 to 8.0. (Fig.5). The Yukon river has a high calcium content (Fig. 2). The calcium is above what the Canadian Water guidelines suggests however this unlikely to be effecting aquatic life, as it reflects the parent rock in the area, and has probably not changed significantly since the River began flowing in this drainage. The M'Clintock River and Wolf Creek have a higher alkalinity and hardness then the Yukon River (Fig. 2). Dissolved solids and phosphorous levels increased significantly after the Yukon River met Wolf Creek and remained high into Thirty Mile River. (Fig. 3&4) The increase in dissolved solids is typical of small creeks flowing through lacustrine deposits. Silt banks along the Yukon River start at Wolf Creek and the sediment is easily eroded, causing suspended and dissolved solids to increase. The level of dissolved solids remains high through the downstream environment, into Schwatka Lake. The Yukon River flow crosses Lake Laberge on the east side and the Takhini and Yukon river's slit load flows into the Thirty Mile.

Phosphorous levels is a indicator of nutrient content in the water. Similar to the dissolved solids in the Yukon River there is a spike seen at the input of Wolf Creek. There are agricultural activities along Cowley Creek, and this may be a source for the phosphorous observed. The increase could also be a result of soil and silt bank erosion along the Yukon River. The phosphorous level decrease in Lake Laberge and Thirty Mile River are probably due to biological uptake of this essential nutrient (Fig.4). The long term storage lagoons at the sewage treatment site in Whitehorse are not discharging at the present time. After the long term storage fills up and the treatment system begins discharging into the Yukon River, the downstream sampling should be repeated.

Asbestos levels in the Yukon River are below the United States Environmental Protection Agency standard (Fig.6) and there is no Canadian guideline for asbestos in drinking water. The M'Clintock River, Wolf Creek, and Whitehorse tap water, had elevated levels that were still below the EPA standard. This may be attributed to the creek and rivers flowing through asbestos laden silts and gravels, or the presence of asbestos containing rock in the headwaters.

*Giardia* was found at only two sources, the M'Clintock River and Wolf Creek, and were presumed to be from natural sources. *Giardia lamblia* is a micro-parasite which resides in the intestine of humans, domestic animals (dogs, cats, cattle, sheep) and wild animals (beaver, bear, fox, coyote). *Giardia* cysts are shed into the environment through faecal matter (Roach 1992). The M'Clintock River, Wolf Creek, and the Yukon River, all have high beaver populations. The presence of this parasite in low numbers is of limited concern, except for the Whitehorse water supply.

## SUMMARY

The Yukon River is a source of high quality water for Whitehorse and the downstream communities. However, any future increase in upstream development could have a negative impact on water quality. The effect of sewage on the Yukon River below Whitehorse is not represented in the sampling and should be included when the long term storage lagoons begin discharging. Further study of the Wolf/Cowley Creek system would be helpful to determine why

there is such a large spike in the levels of phosphorous, dissolved solids, and asbestos. This study represents a base line for water quality in the Yukon River at this stage in the watershed development. Any future development within the area will have to be managed to reduce the impact to the Yukon River watershed.

**TABLE 1: LOCATION OF YUKON RIVER WATER GRAB SAMPLES**

Sample Date	Location	Total Asbestos Concentration (fibres per litre)	Chrysotile Asbestos Concentration
July-96	Whitehorse tap water	6.37X10 <sup>5</sup>	6.37x10 <sup>5</sup>
August-97	Nares Lake upstream of 10 Mile Point (Nares Lake)	0	0
August-97	Windy Arm upstream of Bove Island (Windy Arm)	33.50x10 <sup>3</sup>	33.50x10 <sup>3</sup>
August-97	Taku Arm at Tagish Lake (Taku Arm)	0	0
August-97	Tagish River upstream of Tagish (Tagish Lake)	0	0
August-97	Tagish River downstream of Tagish (Marsh Lake)	0	0
August-97	M'Clintock River at Alaska Highway (M'Clintock River)	9.24x10 <sup>5</sup>	9.24x10 <sup>5</sup>
August-97	Lewes River at Alaska Highway (Lewes River)	0	0
August-97	Wolf Creek at Yukon River (Wolf Creek)	13.41x10 <sup>6</sup>	13.41x10 <sup>6</sup>
August-97	Yukon River at Schwatka Reservoir (Schwatka Lake)	1.34x10 <sup>5</sup>	1.34x10 <sup>5</sup>

**TABLE 2: PHYSICAL PROPERTIES OF YUKON RIVER WATER SAMPLES**

PROPERTIES	Canadian Water Guidelines	SITES										
		Nares Lake	Windy Arm	Taku Arm	Tagish Lake	Marsh Lake	M'Clintock River	Lewes River	Wolf Creek	Schwatka Lake	Lake Laberge	Thirty Mile River
<b>PHYSICAL PROPERTIES</b>												
<b>Alkalinity (mg/L)</b>												
Hydroxide CaCO3		< 5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Carbonate CaCO3		< 5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Bicarbonate CaCO3		< 5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	100	39	38	40
Total Alkalinity		30.0	29.0	34	33	38	98	30	100	39	38	40
<b>Acidity (mg/L)</b>												
Total Acid CaCO3		3.0	<1.0	<1.0	1	2	6	1	2	4	2	4
<b>Conductivity (uS/cm)</b>												
pH	8	7.6	7.6	7.7	7.9	7.5	8	7.8	8	7.5	7.9	8
<b>Solids (mg/l)</b>												
Suspended 105C		11.0	6.0	6	7	7	18	8	7	<1.0	<1.0	<1.0
Dissolved 105C		60.0	30.0	43	40	40	40	37	290	280	283	317
<b>Anions by IEC (mg/L)</b>												
Chloride		<0.2	<0.2	<0.2	0.2	<0.2	<0.2	0.4	0.321	0.16	0.13	0.16
Sulfate		6.9	6.8	5.9	5.7	5.7	6.4	59	12	5.7	5.1	5.7
<b>Nitrogen (mg/L)</b>												
Ammonia N	1.37-2.2	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Nitrite N	0.06	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
NO2 + NO3 N		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05				
Nitrate N									<0.05	<0.05	<0.05	<0.05
<b>Phosphorous (mg/L)</b>												
Total PO4-P		0.0	0.0	0.029	0.031	0.033	0.043	0.028	0.11	0.132	0.096	0.091
<b>Miscellaneous Ions (mg/L)</b>												
Fluoride H2O soln		0.2	0.19	<0.1	0	0.1	<0.1	0.12	0.1	0.09	0.12	0.13

**TABLE 3: LEVELS OF DISSOLVED METALS IN YUKON RIVER WATER SAMPLES**

PROPERTIES	SITES											
	Canadian Water Guidelines	Nares Lake	Windy Arm	Taku Arm	Tagish Lake	Marsh Lake	M'Clintock River	Lewes River	Wolf Creek	Schwatka Lake	Lake Laberge	Thirty Mile River
<b>Total Hardness</b>												
Total Hard CaCO3		36.1	37.9	38.9	49.4	47.1	121	44.6	103	39.6	40.4	42
Aluminum (mg/L)	<0.1	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Antimony		<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Arsenic	0.05	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Barium		0.0169	0.0169	0.0246	0.0271	0.0264	0.0547	0.0254	0.0537	0.0241	0.0224	0.0235
Beryllium		<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	0.0002	<0.002
Bismuth		<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Cadium	0.0002-0.0018	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.005
Calcium	0.00006	11.9	12.4	12.2	15.4	14.7	35.2	13.9	30.2	12.4	12.6	13.1
Chromium	0.002-0.02	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper	0.002-0.004	<0.002	<0.002	<0.002	<0.002	0.003	0.003	<0.002	0.006	<0.002	<0.001	<0.002
Iron	0.3	0.025	0.024	<0.003	0.008	<0.003	0.046	0.007	0.044	0.005	0.005	0.008
Lead	0.001-0.007	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Lithium		<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Magnesium		1.53	1.66	2.05	2.65	2.52	7.92	2.38	6.72	2.11	2.19	2.29
Manganese		0.0023	0.0014	0.0014	0.0021	0.0031	0.0073	0.0024	0.0127	0.0021	0.002	0.0021
Molybdenum		<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Nickel	0.025-0.15	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Phosphorus		<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06
Potassium		<0.2	0.5	<0.2	0.6	0.8	0.8	0.9	0.8	0.6	0.4	0.2
Selenium	0.001	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Silicon		1.2	0.8	0.4	1.1	1.12	3.45	1	4.69	1.1	1.37	1.45
Silver	0.0001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Sodium		1.28	1.29	0.9	1.1	1.1	2.55	1.25	3.86	1	1.16	1.24
Strontium		0.083	0.084	0.063	0.083	0.083	0.141	0.075	0.234	0.067	0.07	0.072
Sulfur		2.4	2.4	2	2.5	2.3	2.3	2.1	4	1.9	1.7	1.9
Thorium		<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Tin		0.006	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Titanium		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Uranium		<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06
Vanadium		<0.002	<0.002	0.002	<0.003	<0.002	0.003	<0.002	0.002	<0.002	<0.002	<0.002
Zinc	0.03	0.005	<0.002	0.004	0.002	0.007	0.003	0.003	<0.001	<0.001	<0.001	<0.001
Zirconium		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

**TABLE 4: PH, HARDNESS AND LEVELS OF *GIARDIA* CYSTS IN YUKON RIVER WATER SAMPLES**

Location	pH	Hardness in ppm	Giardia Cysts per 100 liters
Canadian Water Guidelines	6.5-9.0		
Whitehorse Tap Water			
Nares Lake	7.6	36	0
Windy Arm	7.6	38	0
Taku Arm	7.7	39	0
Tagish Lake	7.9	50	0
Marsh Lake	7.5	47	0
M'Clintock River	8.0	121	5
Lewes River	7.8	45	0
Wolf Creek	8.0	103	13
Schwatka Lake	7.5	40	0
Lake Laberge	7.9	40	0
Thirty Mile River	8.0	420	0



**PHOTO A: WATER QUALITY GRAB SAMPLES**

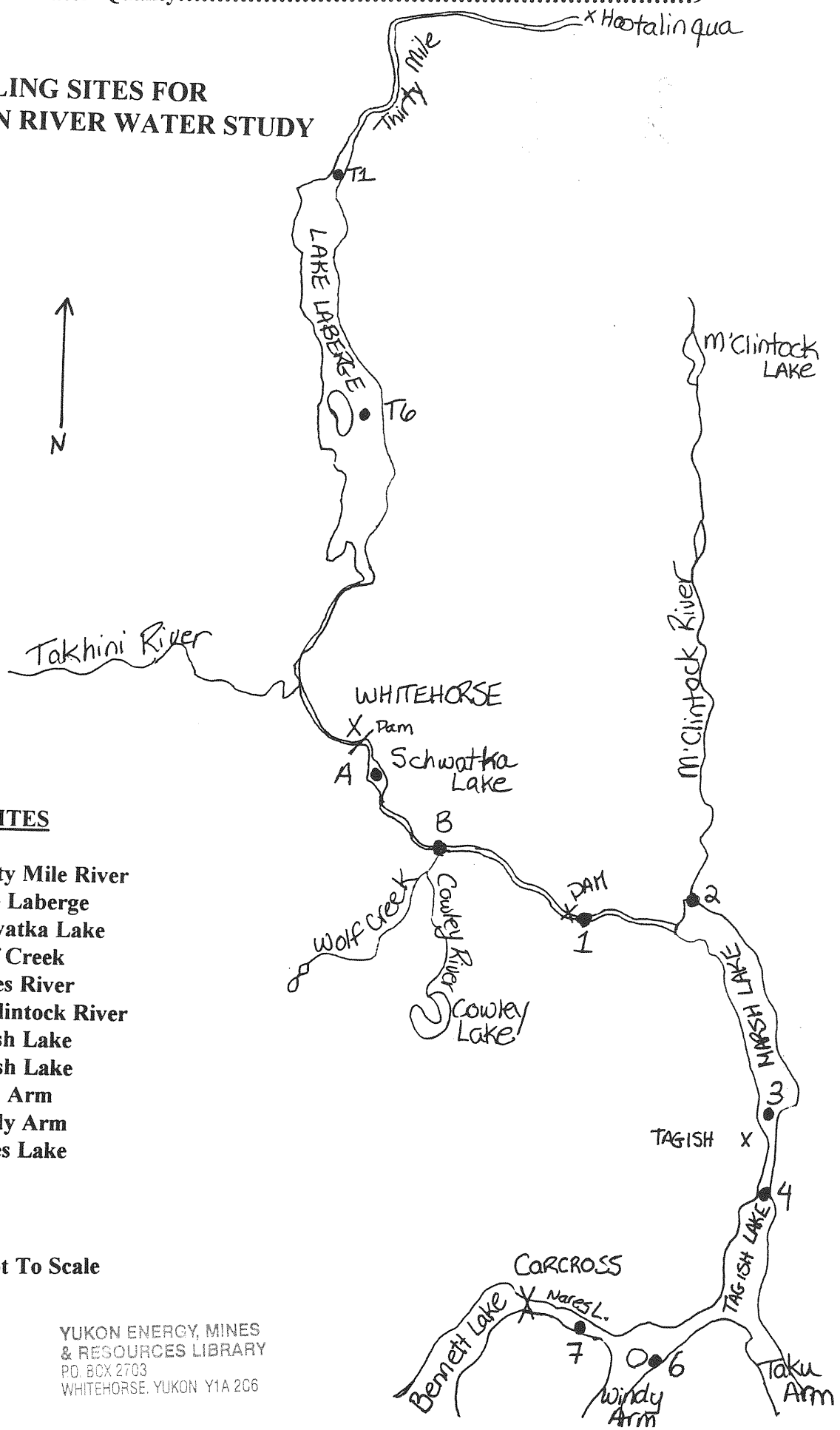


**PHOTO B: WATER QUALITY SAMPLE SET**



**PHOTO C: GIARDIA SAMPLING AT WINDY ARM**

**MAP 1: SAMPLING SITES FOR YUKON RIVER WATER STUDY**



**SITES**

- T1 Thirty Mile River
- T6 Lake Laberge
- A Schwatka Lake
- B Wolf Creek
- 1 Lewes River
- 2 M'Clintock River
- 3 Marsh Lake
- 4 Tagish Lake
- 5 Taku Arm
- 6 Windy Arm
- 7 Nares Lake

Map Not To Scale

**FIGURE 1: Mean River Flow of the Yukon River in August**

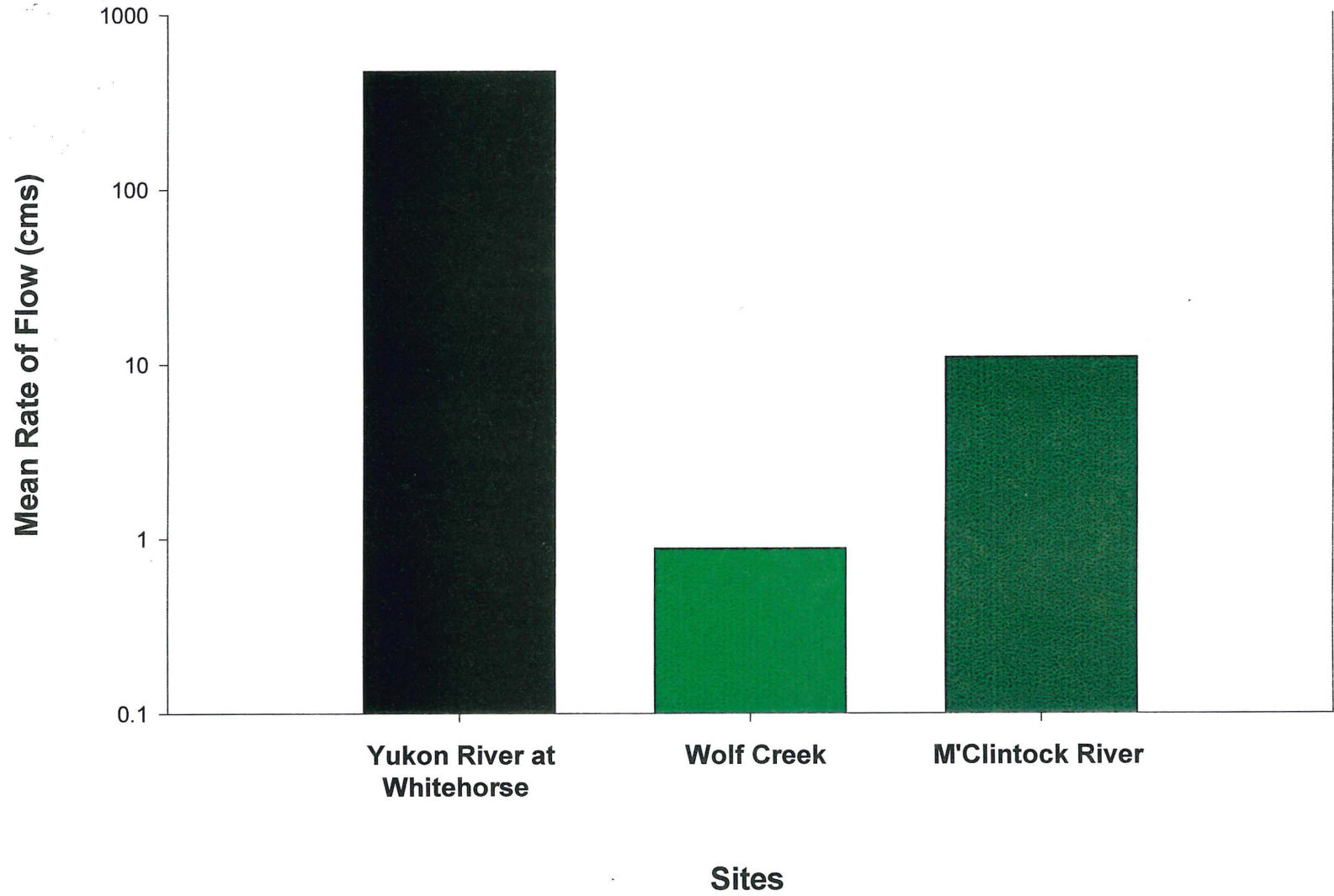
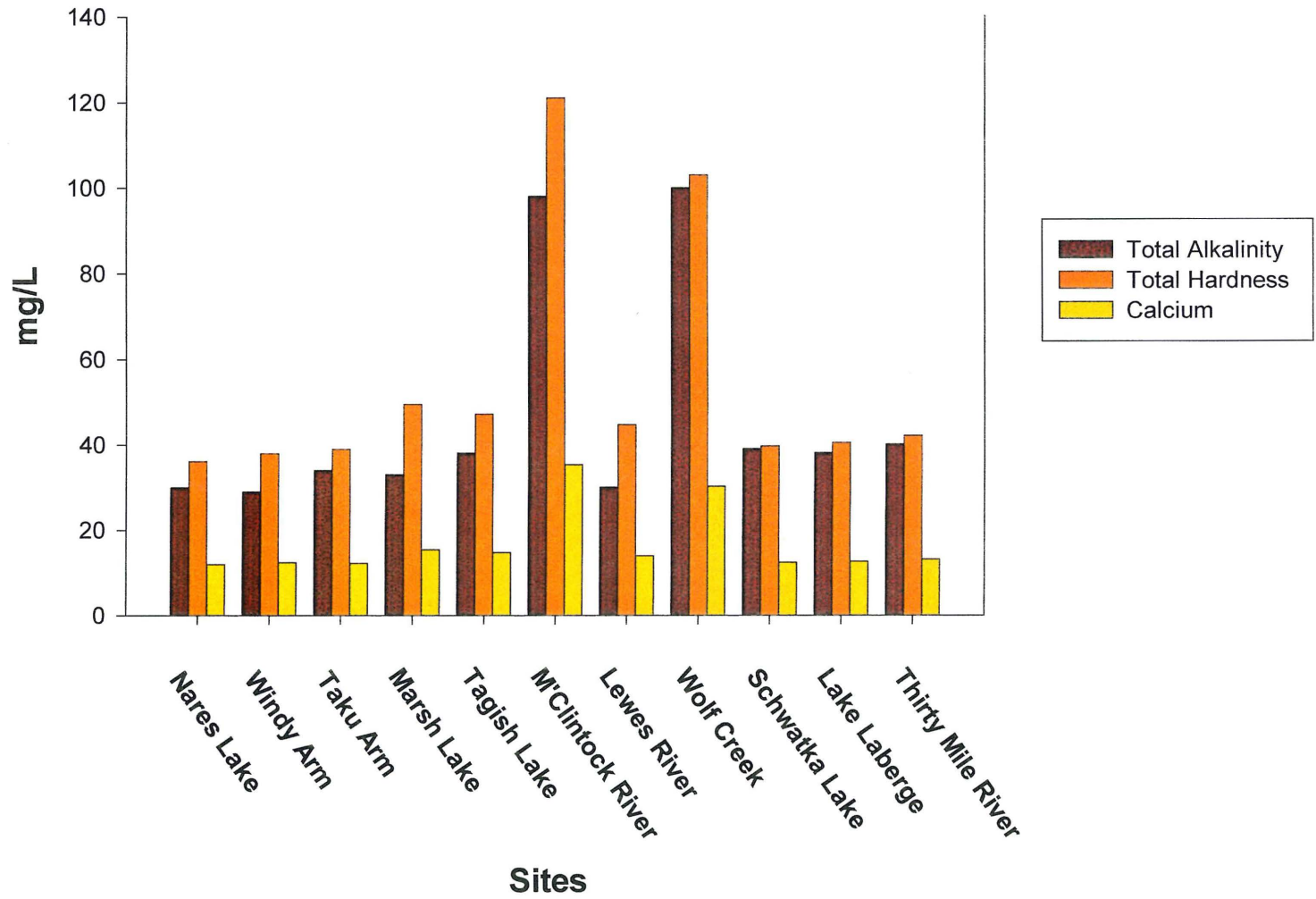
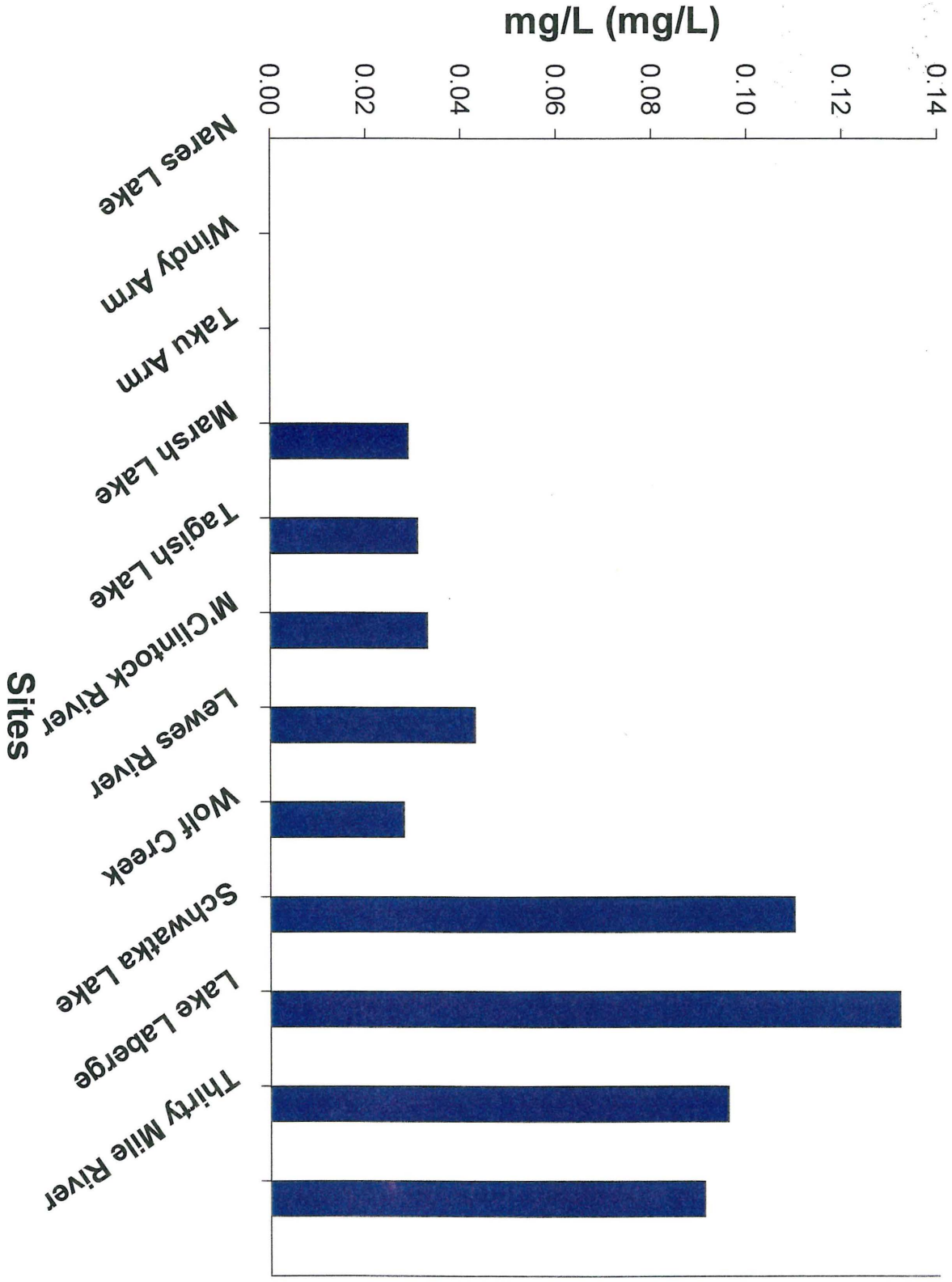


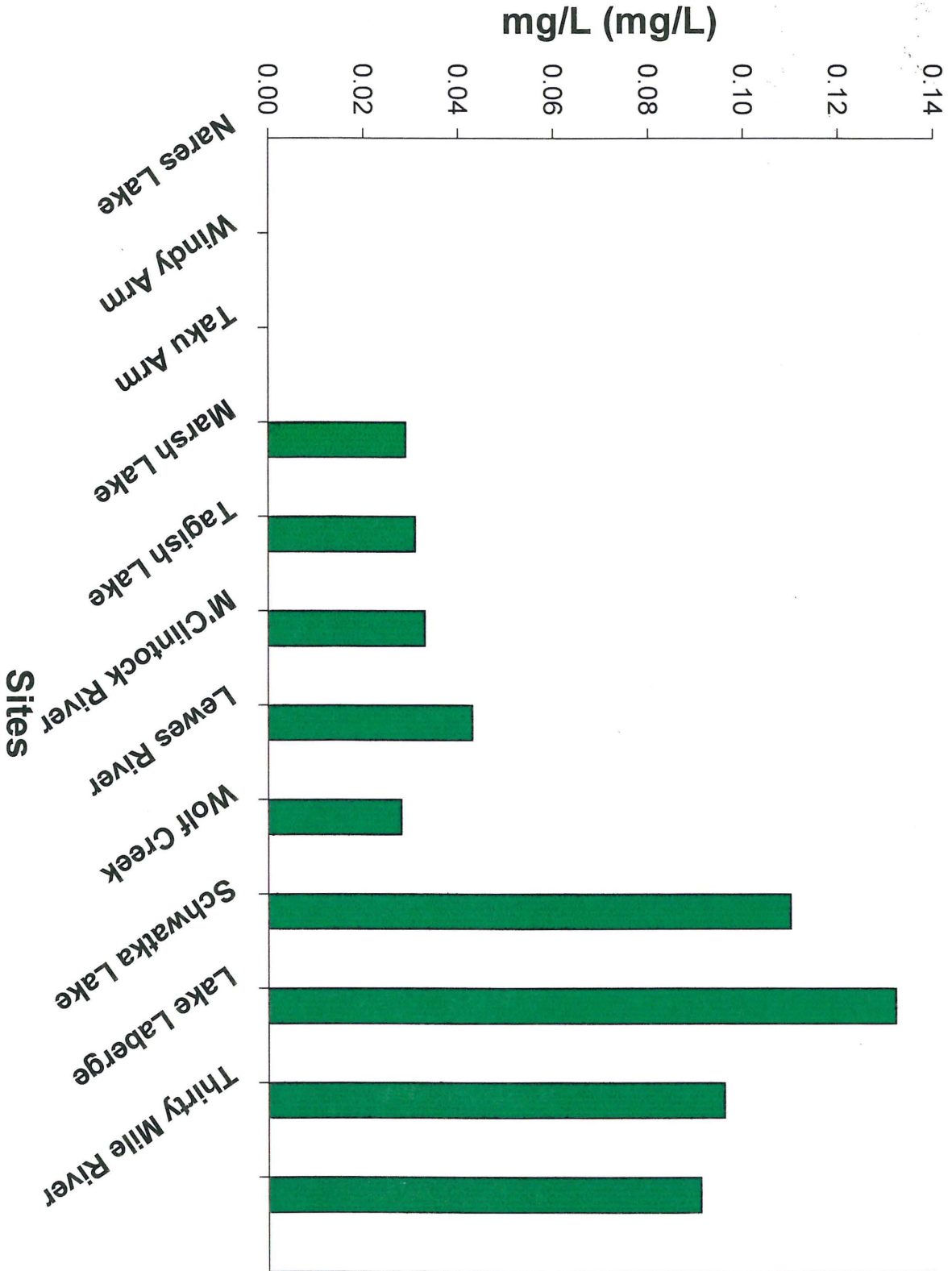
FIGURE 2 : Total Alkalinity, Hardness and Calcium in Yukon River Water Samples



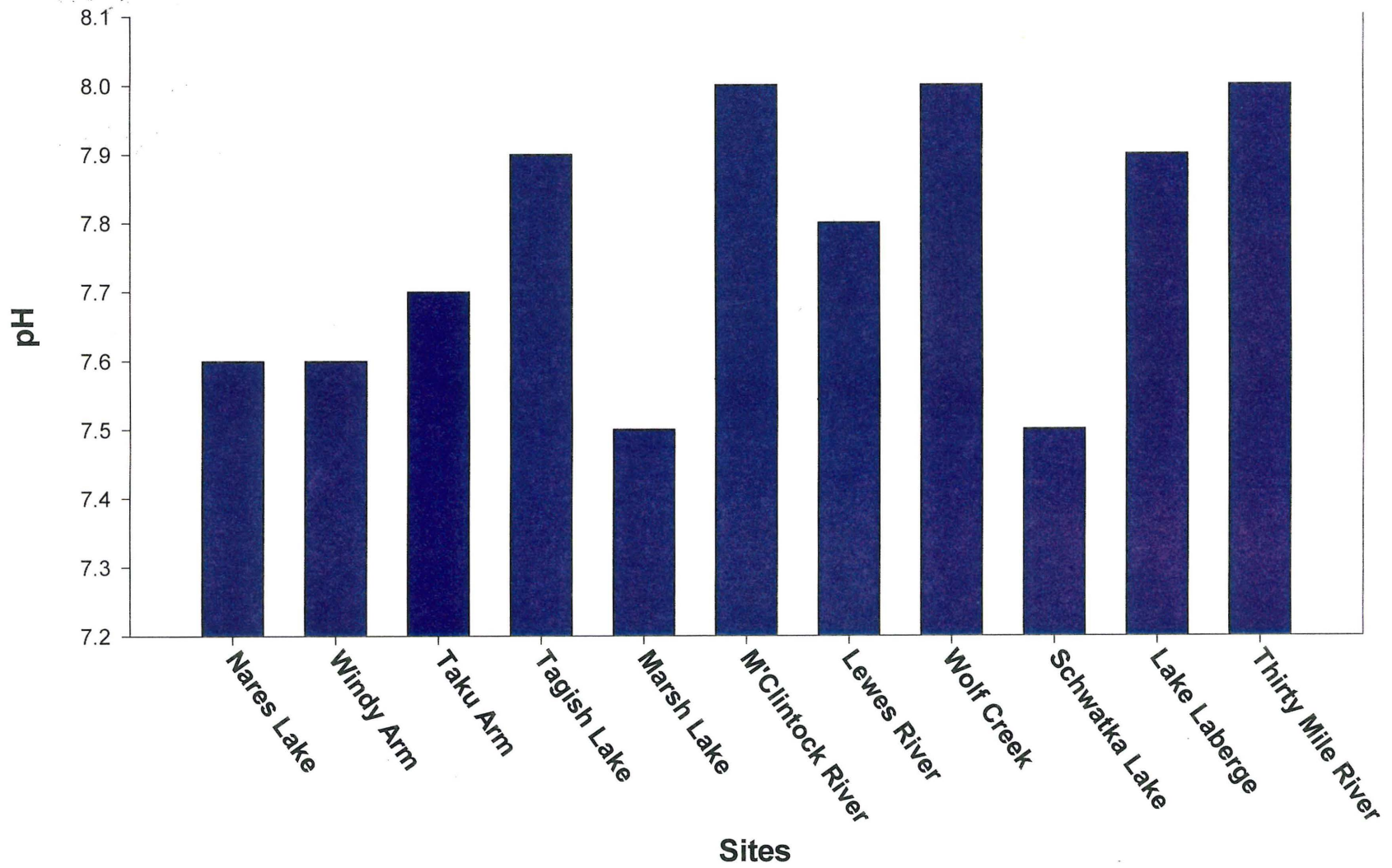
**FIGURE 3 :** Dissolved Solids in Yukon River Water Samples



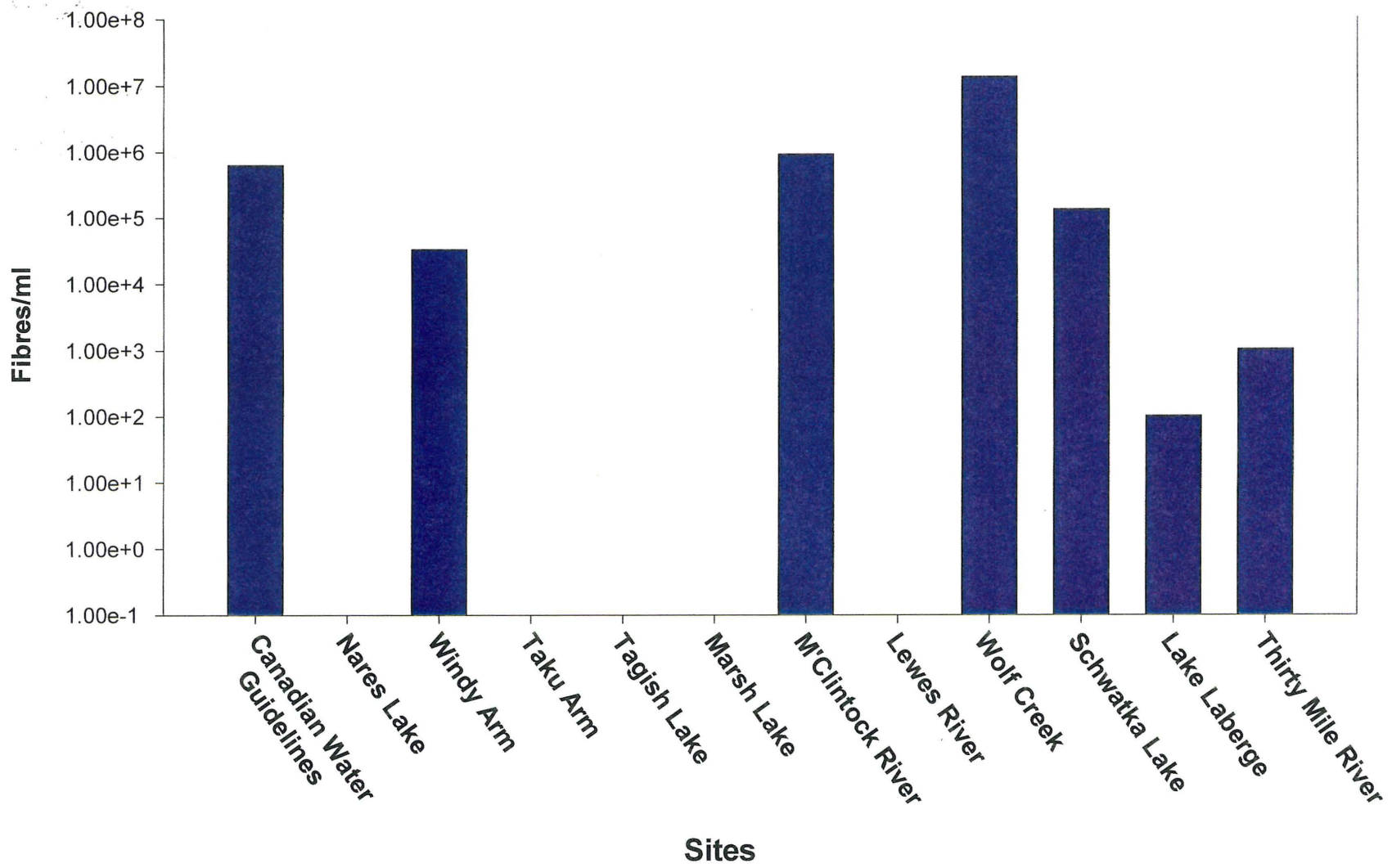
**FIGURE 4 :** Phosphorous Levels in Yukon River Water Samples



**FIGURE 5: pH Levels of Yukon River Water Samples**



**FIGURE 6: Total Asbestos Concentration in Yukon River Water Samples**



**APPENDIX A**

## *Appendix I*

### *Method*

Each sample was agitated prior to filtration through a 0.1  $\mu\text{m}$  pore size 47 mm diameter mixed cellulose ester filter (VC filter). Aliquots ranging from 1 ml to 200 ml were filtered for each sample. Two of the filters for each sample were processed further. The two chosen depended upon the sample loading (filtration time and visible material on the filter). Double deionized, distilled water was filtered through a VC filter and used for all sample preparation. Five hundred (500) ml of the same water was filtered through a VC filter and used as a laboratory blank. No asbestos fibres were found on the blank sample.

The filters were ashed in a low temperature plasma asher overnight to remove organic matter from the samples. The ash was suspended in filtered, double deionized, distilled water and sonicated in a low power sonicator. The suspension was then suction filtered through a VC filter. The filters were allowed to dry overnight at ambient temperatures.

The two samples plus the blank were processed in the following manner:

The filters were divided into eight equal wedges. Four of these were randomly selected for analytical transmission electron microscope (ATEM) analysis.

The wedges were affixed to a clean glass microscope slide with transparent tape and the filter matrix was collapsed with acetone vapour. The samples were then coated with a 20 to 30 nanometer thick layer of carbon using an Edwards vacuum evaporator. The filter was dissolved away with acetone in a condensation washer depositing the sample onto a 200 mesh nickel finder's grid.

The first two grids with at least seventy-five percent of the carbon film intact were used for the analyses. Ten grid openings on each grid were randomly selected and photographed at approximately 1000X magnification using a JEOL 1200EX ATEM. A contact print was made of each negative.

Each negative was scanned at approximately 27X magnification with a Jena microfilm reader. The final magnification of the negatives was 25,920X. Every fibre was measured with respect to its length and diameter and its position marked on the contact print.

X-ray analysis was performed on every fibre providing an elemental analysis<sup>2</sup>. With this method, possible fibre identifications were: chrysotile, amosite, crocidolite and other.

### *Reference*

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2. Clark, N.E., D.K. Verma, J.A. Julian. Determination of the Variability in Elemental Composition of Asbestos Fibres by Analytical Transmission Electron Microscopy. *Ann. Occup. Hyg.* 30(1): 79-88 (1995).

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