Government of the Northwest Territories

TECHNICAL DATA SUMMARY

ARSENIC IN THE YELLOWKNIFE ENVIRONMENT

YELLOWKNIFE, NORTHWEST TERRITORIES

JANUARY, 1977

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Prepared by the Ad Hoc
Standing Committee
on Arsenic

D. Billing
Chairman

Yellowknife, Northwest Territories.

ABSTRACT

This report summarizes all of the available information on the level of arsenic in various segments of the Yellowknife, N.W.T., environment. The data were obtained from several studies conducted by a number of federal government departments (Fisheries and the Environment, Indian Affairs and Northern Development, National Health and Welfare), the Government of the Northwest Territories, and other agencies.

A summary of arsenic levels is presented below:

1. Concentrations in the air averaged 0.1 $\mu gm/m^3$ (microgram per cubic meter) in the city and 0.3 $\mu gm/m^3$ at Giant Mine.

2. Ambient arsenic levels in suspended particulates in the air over the city were, with few exceptions, always <(less than) 0.1 $\mu gm/m^3$.

3. Arsenic concentrations in the Yellowknife municipal water supply were, with very few exceptions, always <0.01 mg/ℓ (milligrams per litre), the desirable National Standard.

4. Arsenic concentrations in the potable mill water supply for Giant Mine ranged from <0.01 mg/ℓ to > (greater than) 1.0 mg/ℓ.

5. Sediments in Back Bay and within 500 meters of Giant Mine contain arsenic levels of 440 and 1300 mg/kg(milligrams per kilogram) respectively.

6. Arsenic levels in several Yellowknife area lakes exceed 0.1 mg/ℓ.

7. Arsenic concentrations in snow usually range from 0.5 to 10 mg/ℓ.

8. Soils in the city contain a highly variable amount of arsenic (1 - 600 ppm). High levels (>4000ppm) occur near Con and Giant Mines.

9. Locally grown vegetables contain 0.02 to 7.0 ppm (wet weight) of arsenic.

10. Fish in Yellowknife Bay contain 0.2 to 3.2 ppm arsenic in their flesh.

11. Aquatic biota are almost non-existent in Baker Creek below Giant Mine. Benthic invertebrates are scarce in Back Bay.

12. Arsenic in small wildlife ranged from <0.1 to 1.4 ppm.

13. Out of a total of 700 Yellowknife residents, 57 had arsenic levels >10ppm in hair. Of those 57 people, 6 had arsenic levels exceeding 100 ppm.

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1. INTRODUCTION

At the request of the Standing Committee on Arsenic Pollution in Yellowknife and its chairman, Mr. Dan Billing, a summary of data collected in the Yellowknife Environmental Survey (1975) has been prepared.

This summary document is a compilation of tabulated data of arsenic concentrations in the various segments of the Yellowknife and vicinity environment. Air, water, snow, soil, vegetation, fish and wildlife samples were analyzed during the Yellowknife Environmental Survey. Human hair sampling and analyses was undertaken by the Department of National Health and Welfare.

Included in this technical summary are data from the Food and Drug Act outlining allowable arsenic limits in food, standard limits for arsenic in water supplies, guidelines for allowable levels of arsenic in surface water, and the occurrence of arsenic in various water bodies. Standards on the arsenic level in soils in absence of a source of arsenic contamination, and available data on arsenic concentration in soils in other areas have been tabulated. National Air Quality Objectives for suspended particulate material in ambient air and arsenic concentrations in ambient air of some communities in North America is provided.

Yellowknife Bay Area

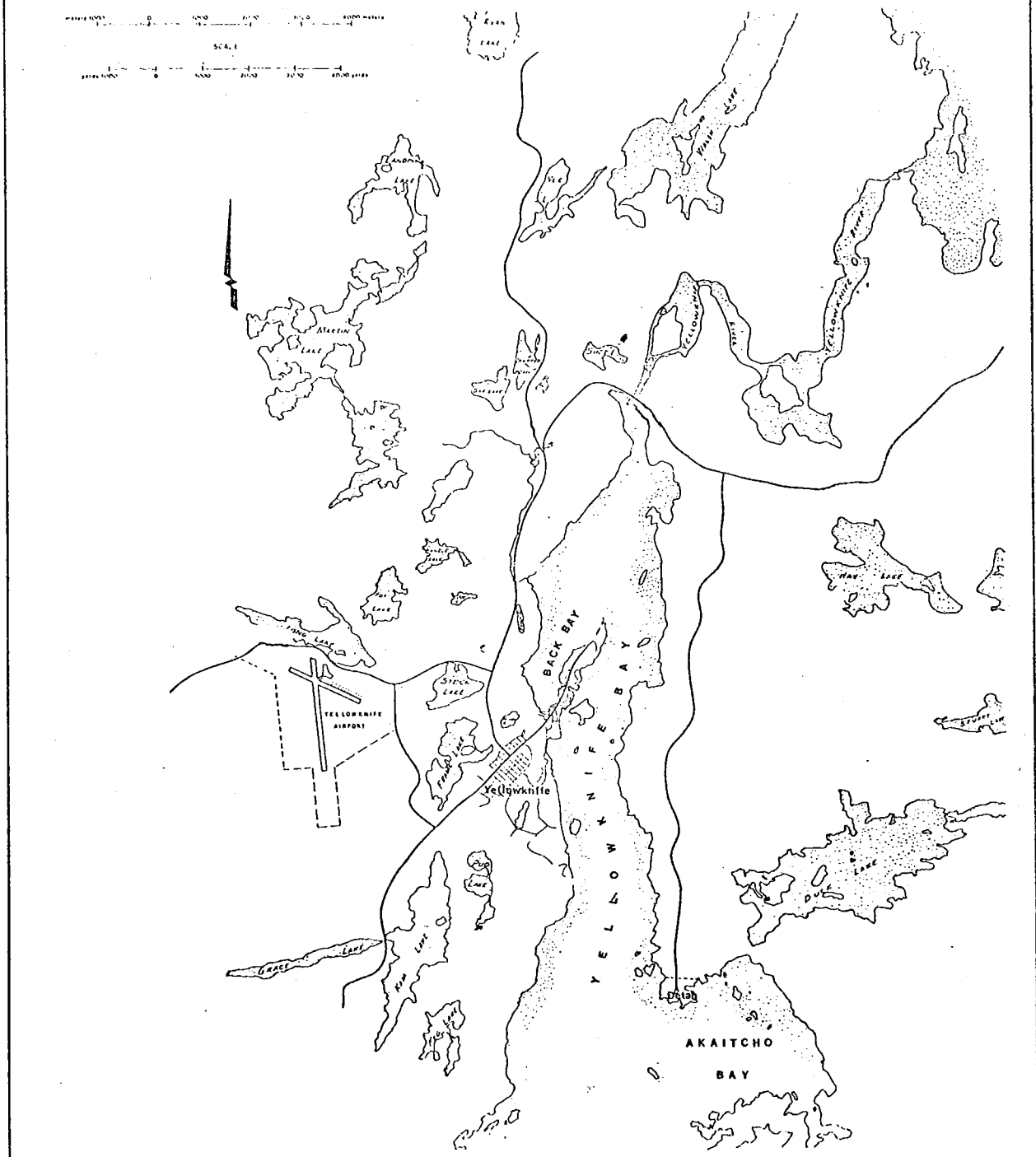

TABLE 1

Average Ore Processed and Arsenic

Released to Atmosphere

Cominco Con Mine

Yellowknife, N.W.T.

Year	Ore Processed (tons/day)	Arsenic Removed from Waste Gases (lbs/day)	Arsenic Released to Atmosphere (lbs/day)
1948		-	79
1949		72	139
1950		135	15
1951		170	16
1952		166	10
1953		197	10
1954		221	14
1955		232	14
1956		237	14
1957		262	13
1958	516	245	13
1959	524	243	14
1960	520	250	20
1961	528	237	24
1962	538	247	20
1963	525	230	16
1964	445	136	8
1965	412	165	12
1966	451	145	10
1967	430	120	11
1968	413	115	10
1969	400	84	11
1970	396	68	13
1971	425	0	0
1972	451	0	0
1973	462	0	0
1974	398	0	0
1975	404	0	0
1976		0	0
	TOTAL	21,780 tons	2,782 tons

TABLE 2

Average Ore Processed and Arsenic

Released to Atmosphere

Giant Yellowknife Mine

Yellowknife, N.W.T.

Year	Ore Processed (tons/day)	Arsenic to Underground Storage (lbs/day)	Arsenic to Tailings Pond (lbs/day)	Arsenic Removed by Hot Cottrell (lbs/day)	Arsenic to Stack (lbs/day)	Baghouse Efficiency (%)
1948	250					
1949	232					
1950	346					
1951	416				2053	
1952	850				3941	
1953	673				7094	
1954	756				11,980	
1955	788				6392	
1956	813				5998	
1957	848				6544	
1958	782				3330	
1959	989				115	
1960	991				165	
1961	1003				330	
1962	1029				330	
1963	1063				330	
1964	1094		416		496	
1965	1082		509		372	
1966	1053	31,329	449	1014	247	99.2
1967	876	27,169	262	1168	124	99.6
1968	1024	30,941	54	576	256	99.2
1969	1095	30,552	56	551	466	98.5
1970	1164	28,793	76	588	485	98.3
1971	1106	26,393	91	701	1933	93.2
1972	1096	24,847	101	773	875	96.6
1973	1067	23,784	95	726	549	97.7
1974	899	19,643	99	728	485	97.6
1975	1074	19.338	106	858	479	97.6

(Data supplied by Giant Yellowknife Mine)

TABLE 3

Summary of Arsenic Concentrations in Air

Various Communities

(Arsenic Concentration in $\mu gm/m^3$)

(Reference 1)

Location	1964		1972		1973		1974	
	Max.	Yearly Ave.	Max.	Yearly Ave.	Max.	Yearly Ave.	Max.	Yearly Ave.
Ontario:								
Windsor			0.300	0.030	0.025	0.012		
Welland			2.313	0.696	0.610	0.271	4.256	0.730
Sault Ste. Marie			0.040	0.017	0.057	0.013		
South Porcupine			--	--	1.090	0.168		
Sudbury			0.153	0.026	0.058	0.013		
Yellowknife, N.W.T.:								
Airport					0.62	0.12	1.46	0.12
Townsite					0.42	0.14	0.75	0.098
Giant Mine					0.95	0.22	1.68	0.26
United States:								
Chicago	0.04	0.03						
Toledo, Ohio	0.18	0.09						
El Paso, Texas	1.40	0.75						
Dallas, Texas	0.03	0.02						
Seattle, Washington	0.14	0.08						
Charleston, W.Virginia	0.36	0.25						
Average of 133 U.S. Stations		0.02						

TABLE 4

Giant Yellowknife Mine Stack

Arsenic Emission Tests

(Conducted by EPS, Edmonton staff)
(Reference 2)

Date	Test Number	Arsenic Emission (lbs As/day)
August 14, 1975	1	150.3
August 15, 1975	2	238.3
August 16, 1975	3	155.8
August 17, 1975	4	175.1
August 18, 1975	5	157.3
August 19, 1975	6	127.6
(average)		(167.4)

TABLE 5

Continuous Air Sampling by Cominco Con Mine

Arsenic Concentration in the Air

Yellowknife, N.W.T.

(Arsenic Concentration in mg/m^3)

Sampling Date (1976)	Location	Arsenic Concentration
March 3-10	North side of Con Mill	0.05
March 10-17	"	0.07
March 17-24	"	0.03
March 24-31	"	0.07
March 31-April 7	"	0.03
April 7-14	"	0.06
April 14-21	"	0.08
April 21-28	"	0.04

Note: (1.) Samples obtained by Hi-Vol Sampler.

(2.) Chemical analysis at Cominco Laboratory, Trail, B.C.

TABLE 6

Ambient Air Monitoring Program

in the Yellowknife Area, 1975.

Arsenic Concentration in Suspended Particulates
(Reference 3)

Parameter	Date	Arsenic Concentration
Overall annual geometric mean suspended particulate	1973	0.08 µgms As./m^3
	1974	0.09 "
	1975	0.06 "
Individual 24-hour suspended particulate	1973-1975	<0.01 - 3.91 µgms As./m^3 range

Following are available data on standards for arsenic in air.

Extraneous Air Quality Limits: (µgm As./m^3)

Arsenic Concentrations in Suspended Particulates: 24-hour basis

B.C. Objective	-	1.0
USSR Standard	-	3.0
Czechoslovakia Standard	-	3.0

TABLE 7

Criteria and Guidelines for

Allowable Levels of Arsenic

in Surface Water

(Arsenic Concentration in ppm.)

	Water Quality Criteria U.S. Environmental Protection Agency	Maximum Arsenic Level N.W.T. and Y.T. Guidelines
Public Water Supplies (Raw water from rivers or lakes used for drinking)	0.1	0.05 maximum 0.01 acceptable
Recreation and Esthetics	not specified	not specified
Fresh Water Aquatic Life and Wildlife	not specified	not specified
Marine Aquatic Life and Wildlife	0.01 and 0.05	not specified
Agricultural Uses of Water	0.01 (continuous use)	
Water for livestock	2.0 (for up to 20 yrs)	0.05
Water for irrigation	not specified	2.0 maximum 0.1 desirable
Industrial Water Supplies	not specified	not specified

TABLE 8

Standard Limits for Arsenic in Water Supplies

(Arsenic concentration in ppm.)

1.	U.S.A. Public Health Service (1962)	
	a) Limit which should not be exceeded if an alternative water source can be made available	0.01
	b) Limit above which water source should be rejected	0.05
2.	Canada, Department of National Health & Welfare (1968)	
	a) Acceptable Limit	0.01
	b) Maximum permissible limit	0.05
3.	World Health Organization	
	International standard (1971)	0.05
4.	World Health Organization	
	European standard (1970)	0.05

TABLE 9

Arsenic Concentration of

Yellowknife Municipal Water Supply

(Arsenic Concentration in ppm.)

Date of Sampling	Tap Water	Schooldraw Pumphouse Yk. River Supply	Schooldraw Pumphouse Yk. Bay Supply
1975 Summary	0.01	0.01	
Feb. 18, 1975			0.011
June 18, 1975			0.020
Sept. 28, 1975			0.01
Oct. 28, 1975			0.01
Nov. - Dec., 1975			0.01
1976:			
January 6	<0.01		
January 13	<0.01		
January 19	<0.01		
January 26	<0.01		
February 9	0.0008		
February 11		0.0008	0.003
March 2	0.0029		
March 9	0.0006		
March 16	0.0241		
March 22	0.003		
March 30	0.0006		
April 5	0.0008		
April 13		0.0007	0.0045
April 27		0.0001	0.0009
May 11		0.0005	0.020
May 17	0.0020		
May 25	0.0068		
June 7	<0.0005		
June 11		0.0046	0.014
June 14	0.0010		
June 21	0.0008		

TABLE 9 (cont'd)

Date of Sampling	Tap Water	Schooldraw Pumphouse Yk. River Supply	Schooldraw Pumphouse Yk. Bay Supply
1976:			
July 5	0.0006		
July 12	0.0038		
July 19	0.0020		
July 29	0.0001		
August 2	0.0002		
August 10	<0.0005		
August 13		0.002	0.55
August 23	<0.0005		
August 30	0.0008		
September 14	<0.0005		
September 23	<0.0005		
September 27	<0.0005		
October 5	0.0018		
October 15		<0.0005	0.014
October 18	<0.0005		
November 8	<0.0005		
November 15	<0.0005		
November 29	<0.0005		
December 7	<0.0005		
December 14	<0.0005		
1977:			
January 4	<0.0005		
January 6		<0.0005	0.0093
January 11	0.0007		
January 18	0.0008		

TABLE 10

Arsenic Concentration of
Giant Yellowknife Mine
Mill Potable Water Supply

Year	Month	Ave. Arsenic Content ppm.	Minimum ppm.	Maximum ppm.
1973	January	0.0077	N.D.	0.014
	February	0.0066	0.001	0.013
	March	0.0069	0.002	0.013
	April	0.0098	0.005	0.015
	May	0.0260	0.006	0.144
	June	0.0460	0.005	0.290
	July	0.0300	0.004	0.097
	August	0.0210	0.007	0.045
	September	0.0195	0.011	0.037
	October	--	--	--
	November	0.0220	N.D.	0.056
	December	0.0200	0.000	0.103
1974	January	0.0110	0.000	0.040
	February	--	--	--
	March	0.0120	0.003	0.024
	April	0.0100	0.005	0.019
	May	0.0090	0.005	0.016
	June	0.0070	0.003	0.013
	July	0.0270	0.003	0.093
	August	0.0190	0.005	0.048
	September	--	--	--
	October	0.0097	0.005	0.019
	November	0.0080	0.003	0.013
	December	0.0070	0.003	0.011
1975	January	0.0120	0.005	0.019
	February	0.0080	0.003	0.011
	March	0.0080	0.005	0.013
	April	0.0160	N.D.	0.035
	May	0.0470	<0.015	0.190
	June	0.0480	0.021	0.320
	July	0.0410	<0.015	0.186
	August	--	--	--
	September	0.0320	<0.015	0.073
	October	0.0260	<0.015	0.057
	November	--	--	--
	December	0.0200	<0.015	0.060
1976	January	0.0170	<0.015	0.059
	February	0.016	<0.015	0.027
	March	0.017	<0.015	0.042
	April	0.024	<0.015	0.058
	May	0.033	<0.015	0.100
	June	0.056	<0.015	0.189

N.D. = Not Determined

TABLE 11

Arsenic Content of Surface Water

Yellowknife, N.W.T. (1976)

(EPS, Yellowknife)

BAKER CREEK - above mine

	May 26	June 10	June 24	July 7	July 21	Aug. 12	Aug. 24	Sept. 3
mg/l	0.03	<0.02	<0.02	<0.02	0.10	<0.02	<0.02	0.03

YELLOWKNIFE BAY

Station 1

May 17	May 28	June 1	June 3	June 9	June 23	July 8	July 26	Aug. 5	Aug. 18	Oct. 6
<0.02	<0.02	0.74 0.03 <0.02	0.05 <0.02 <0.02	0.06	0.40	<0.02	<0.02	<0.02	<0.02	<0.02

Station 2

0.03	<0.02	No data	No data	<0.02	0.04	0.04	<0.02	<0.02	<0.02	<0.02

Station 3

<0.02	0.02	"	"	0.03	0.03	0.11	<0.02	<0.02	<0.02	<0.02

Station 4

0.03	No data	"	"	No data	No data	No data	<0.02	<0.02	<0.02	<0.02

YELLOWKNIFE RIVER

May 5	May 26	June 10	June 24	July 7	July 21	Aug. 24	Sept. 1
<0.02	<0.02	<0.02	<0.02	0.03	0.08	<0.02	<0.02

TABLE 12

Sediments, Yellowknife Bay (1974)

Yellowknife, N.W.T.

(EPS, Yellowknife)

(readings in mg/kg, dry weight)

a) Near Yellowknife River

Mean	Range	95% Confidence Limit	Number of Samples
138	6-515	83	14

b) Back Bay

441	33-1332	254	11

c) 0-500m from Mine

1316	385-2400	480	6

d) Near Latham and Jolliffe Island

130	34-427	75	11

e) Between Con Mine and Detah

63	8-227	47	9

f) Wool Bay

11	10-12	--	3

TABLE 13

Arsenic Levels in Yellowknife Area Lakes

(arsenic concentration in ppm)

Lake/Location	Arsenic (soluble)	Remarks
"Lake 2; 1.9 miles S.W."	3.90	Data from O'Toole
"Lake 7; 0.3 miles S.W."	12.40	Reference 4
"Lake 9; 1.9 miles S.W."	0.19	Summer, 1970
"Lake 13; 1.8 miles N.W."	0.56	
"Lake ; 10 miles"	0.20	
"Lake ; 20 miles"	0.001	
Yellowknife Bay:		
near Latham Island	0.010	Data from Cominco Ltd.,
near Mosher Island	<0.005	survey (1970). Wadey, R.H.
near Detah village	<0.005	Supervisor, Waste Control,
3000 ft. from Kam Point	<0.005	Cominco, Trail, B.C.
Stock Lake	0.005	
Frame Lake	0.055	
Pud Lake (discharge)	0.030	
Kam Lake	3.0	
Yellowknife Bay:		
near Latham Island	0.020	Cominco, Ltd. survey
near Mosher Island	0.022	(1971)
near Detah Village	0.005	
3000 ft. from Kam Point	0.029	
Stock Lake	0.130	
Frame Lake	0.250	
Pud Lake (discharge)	5.600	
Kam Lake	2.800	
Kam Lake	1.0 - 5.0	Data from memo Brunskill
Grace Lake	0.001- 0.10	to Hamilton Feb. 6/75
Frame Lake	0.150- 0.180	"Arsenic in Yk. Waters"
Lakes 16 miles N.E.	n/d	(Tests carried out over
Lakes 12-15 miles N. & N.E.	0.0005 - 0.007	1972-1974()n/d=non detectal

TABLE 13 (cont'd)

Lake/Location	Arsenic (soluble)	Remarks
Long Lake	3.0 - 8.0	G. Brunskill; preliminary findings, 1975
Long Lake - beach	0.135	Feb. 25/75; G. Brunskill
Long Lake - center	0.105	"
Stock Lake	0.112	"
Range Lake	1.296	Feb. 26/75; G. Brunskill
Fault Lake	0.270	"
Rat Lake	0.471	"
Kam Lake	2.850	"
Frame Lake	0.562	Feb. 7/75; G. Brunskill
Grace Lake	0.026	"
Yellowknife Bay:		
near Latham Island	0.01	Cominco, Ltd. survey (1975)
near Mosher Island	0.01	Brown, R.L., Supervisor,
near Detah Village	0.01	Waste Control, Cominco,
3000 ft. from Kam Point	0.01	Trail, B.C.
Arden Bay	0.01	
Stock Lake	0.06	
Frame Lake	0.21	
Kam Lake	2.55	
Long Lake	0.09	
Kam Lake:		
North basin	2.04	Data collected May 25/76
Central	1.08	by Dr. J. Moore, EPS,
South basin	2.06	Yellowknife. Internal correspondence.

TABLE 14

Occurrence of Arsenic in Various Water Bodies

Arsenic in Water (conc. in ppm)

(Reference 1)

Occurrence	Level or Range of Levels
Sea Water	0.006 - 0.30
River water, United States	mean 0.0004; maximum 0.230
Natural levels, Canadian rivers; 1968 - 1974	0.005 - 0.13
Lakes Superior, Ontario, Huron, Erie	0.00025 - 0.001
River; Sweden (upstream from industrial site)	0.002
Surface water; United States	mean 0.064; range 0.005 - 0.336
Tap Water; United States	0.100 in some samples tested
Spring water - California, Rumania USSR; New Zealand	0.400 - 1.300 (high in bicarbonate)
Near Yellowknife, 1973 - 1974	0.070 - 1.00
Great Slave Lake	0.004 - 0.500 total 0.001 - 0.030 dissolved
Taiwan (artesian wells)	0.010 - 1.82 (most 0.40 - 0.60)
Cobalt Lake (Ottawa River Basin) 1970 - 1971	1.00 - 2.50
Argentina, Cordoba province	approximately 1.50
New Zealand (fresh water)	approximately 20.0
Searles Lake, California (high salinity water)	over 200.0

TABLE 15

Summary of Arsenic Deposition Rates, Yellowknife, N.W.T.

Survey Date	Survey	Arsenic Deposition ($lbs/mile^2/mth$)		Details of Survey
1950-1963	de Villiers & Baker (Reference 5)	low:	17	Survey in town of Yellowknife.
		high:	469	
		average:	106	
1950-1956	Cominco Con Mine	low:	27	6 sample points; ¼ to 2 miles from stack.
		high:	267	
1955-1956	Giant Mine	low:	27	15 sample points; 1, 2, and 3 miles from stack.
		high:	613	
1974-1975	E.P.S. Snow Survey (Reference 6)	low:	1.2	52 sample points; 'low' was obtained 4 miles south of Giant; 'high' was obtained inside Giant property.
		high:	564	
		calculated winter mean:	11.0	
1975	E.P.S. Ambient Air (Reference 3)	low:	0.0033	'average' is based on results of 22 stations over period June to October, 1975.
		high:	0.00714	
		average:	0.0048	

TABLE 16

Arsenic Concentrations in Snow in Yellowknife Area

(Arsenic Conc. in ppm.)

Survey	Sample	Location	Arsenic	Acidity (pH)	Remarks
O'Toole (Reference 4)	'Snow 5'	0.35 mile N.E.	0.68		
	'Snow 9'	1.30 mile N.E.	1.20		
	'Snow 10'	0.22 mile N.W.	8.75		
	'Snow 21'	2.0 miles N.E.	0.47		
EPS, Yellowknife district office (Feb. 17, 1975)	1	(Sample locations on attached map; figure 2).	0.46	3.4	
	2		0.44	3.7	
	3		0.48	3.9	
	4		0.81	3.6	
	5		11.40	6.6	
	6		0.71	6.7	
	7		9.10	4.4	
	8		1.30	4.4	
	9		8.60	4.2	
	10		0.50	4.2	
	11		0.027	4.2	
	12		2.30	3.6	
March, 1975 survey (6)	(Refer to report, reference # 6)		0.17	4.6	average; 52 samples.
		0.1 mile W. of Giant	8.80	7.7	maximum
			0.02	2.7	minimum

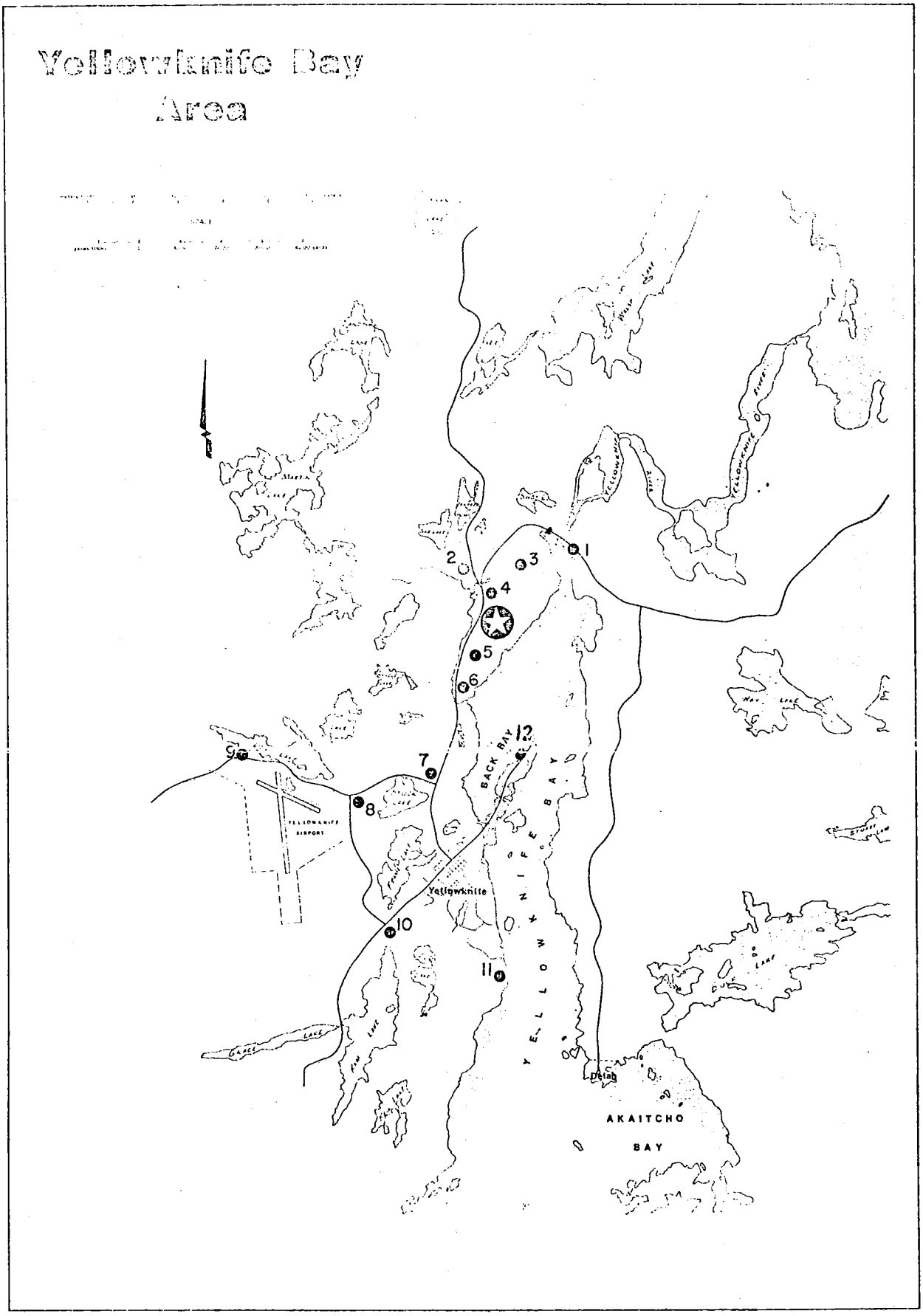

FIGURE 2 MAP OF SNOW SAMPLING STATIONS; FEBRUARY 17, 1975, ENVIRONMENTAL PROTECTION SERVICE YELLOWKNIFE, NWT.

TABLE 17

Spring Runoff Sampling Conditions
Yellowknife, N.W.T.

	Sampling Date	Conditions
1)	April 13, 1976	Spring melt in the early stage; minimal flows; ice cover on all lakes and rivers.
2)	April 27, 1976	Melting rate near its maximum; Yellowknife River was flowing; surface runoff flows peaking; most lakes were melting around edges.
3)	May 11, 1976	Melt was nearing completion; surface runoff was beginning to decrease; most lakes had only patches of ice remaining.
4)	June 11, 1976	Several drainage ditches and surface melt; water pools were dry.

TABLE 18

1976 Spring Runoff Analyses

Yellowknife, N.W.T.

(Arsenic Concentration, ppm.)

Sampling Site	1 April 13	2 April 27	3 May 11	4 June 11	Remarks
Yellowknife River	0.09	0.001	0.0009	0.008	At bridge on Ingraham Trail; (April 13, meltwater on ice surface)
Giant Tailings Pond	13.9	2.8	5.7	6.0	April 13 - meltwater at edge of tailings area; 2, 3 & 4 - seepage from pond.
Giant Surface Meltwater	0.023	0.23	0.30	dry	Shallow pool near road at tailings pond.
Giant Tailings Effluent	31.0	4.20	14.4	9.5	Entering Baker Creek.
Baker Creek	1.20	1.20	0.70	0.80	Represent As levels after tailings effluent diluted with Baker Creek.
Mouth of Baker Creek	1.50	1.00	0.73	1.32	Discharge to Yellowknife Bay.
Junction of Giant Road and Airport Road	0.036	0.28	0.068	0.17	Slough on N.E. side.
Runoff to Stock Lake	0.075	0.184	0.160	0.096	1 - pool near Bristol monument; 2 & 3 - flow into Stock Lake; 4 - Stock Lake water.

TABLE 18 (cont'd)

(Arsenic Concentration, ppm.)

Sampling Site	1 April 13	2 April 27	3 May 11	4 June 11	Remarks
Long Lake	0.030	0.048	0.074	0.122	1 - near boat ramp/picnic area; 2 & 3 - edge of lake; 4 - in lake.
Surface Meltwater near Northland Trailer Court	0.014	0.056	0.035	1.45	1, 2, 3 - S.E. side of junction Franklin Avenue & Correctional Institute road; 4 - Kam Lake.
Yellowknife Bay at Con Mine Pumphouse	0.032	0.015	0.016	0.22	1 & 4 - inside pumphouse; 2 & 3 - from bay outside pumphouse; (water used only for industrial purposes).
Back Bay/Rainbow Valley	0.177	0.08	0.016	0.36	1 - meltwater on surface of ice; 2 & 3 - near shoreline.
Rat Lake	0.16	0.45	0.40	0.56	1, 2 & 3 - small stream entering Rat Lake; 4 - from Rat Lake (stream dry).
Con Mine Tailings	4.0	4.2	7.4	3.6	1 - meltwater near dam in Pud Lake; 2 & 3 - control dam outflow; 4 - inside tailings pond.
Meltwater near City Snow dump area	0.044	0.056	0.035	0.058	From ditch near snow dump; ½ mile N. of Niven Lake; east side of highway.

TABLE 18 (cont'd)

Sampling Site	(Arsenic Concentration, ppm.) 1 April 13	2 April 27	3 May 11	4 June 11	Remarks
Yellowknife Bay at Schooldraw Culvert	0.012	0.052	0.024	0.067	Runoff under Schooldraw Road into Yellowknife Bay.
Detah Water Hole	0.0043	0.0070	0.0050	0.0034	Just offshore from Detah Village.
Yellowknife Water Supply	0.0007	0.0001	0.0005	0.0046	Schooldraw Road pumphouse; water from Yellowknife River.
Yellowknife Emergency Water Supply	0.0045	0.0090	0.020	0.014	Yellowknife Bay; wetwell in schooldraw pumphouse.
Causeway to Latham Island	0.0036	0.007	0.017	0.036	Northside of causeway.
Yellowknife tapwater	0.0005	0.0008	0.0005	0.0005	Tapwater normally sampled weekly. Canadian Drinking Water Standard - 0.01 ppm.
McNiven Beach slough	---	0.012	0.015	0.011 (0.27)	1 - frozen solid, no sample; 2 & 3 - slough draining to Frame Lake; 4 - slough outflow minimal (Frame Lake sampled also).

TABLE 19

Yellowknife Arsenic Survey, 1970 (Soils)

Cominco, Ltd., Trail, B.C.

(Arsenic Concentration in dry weight, ppm.)

Location	Depth in Soil, Inches 0-1	1-7	7-13	0-6	0-13
Undisturbed Soil:					
1) 0.75 mile S.W. of Giant stack.				58	
2) 2 miles S. of Giant stack.	205	50	14		
3) East end, Frame Lake.	101	45	26		
4) Con residential area.	147	33			
5) East of Negus mine.				96	
6) West of Con head-frame.				2980	
Cultivated Soil:					
7) Garden, Con residential area.				21	40

Standard

Arsenic level in soils in the absence of a source of contamination... $\leq$5.0 ppm.

TABLE 20

Arsenic Content of Soil Samples, Disturbed Soils Study, 1975
(Reference 7)

Sample	Location	Total Arsenic (ppm)	Insoluble Arsenic (ppm)
M-1	Con Mine	192	191
M-2	Con Mine	342	341
M-3	Con Mine	58	57
M-4	Con Mine	115	114
M-5	Con Mine	115	115
M-6	Con Mine	490	484
S-1	Town	36	25
S-2	Town	27	8
S-3	Town	39	27
S-4	Town	10	10
S-5	Town	75	47
S-6	Town	138	138
S-7	Town	19	4
S-8	Town	10	5
S-9	Town	605	46
S-10	Town	23	17
S-11	Town	83	81
S-12	Town	43	23
S-13	Town	1	1
S-14	Town	26	1
S-15	Town	42	42
S-16	Town	8	1
S-17	Town	18	8
S-18	Town	21	7
S-19	Town	5	4
S-20	Town	5	5
S-21	Con Mine	313	313
S-22	Con Mine	129	129
S-23	Con Mine	755	755
S-24	Con Mine	10	10
S-25	Con Mine	605	605
S-26	Giant Mine	261	105
S-27	Giant Mine	38	36
S-28	Giant Mine	33	33
S-29	Giant Mine	79	70
S-30	Giant Mine	75	66

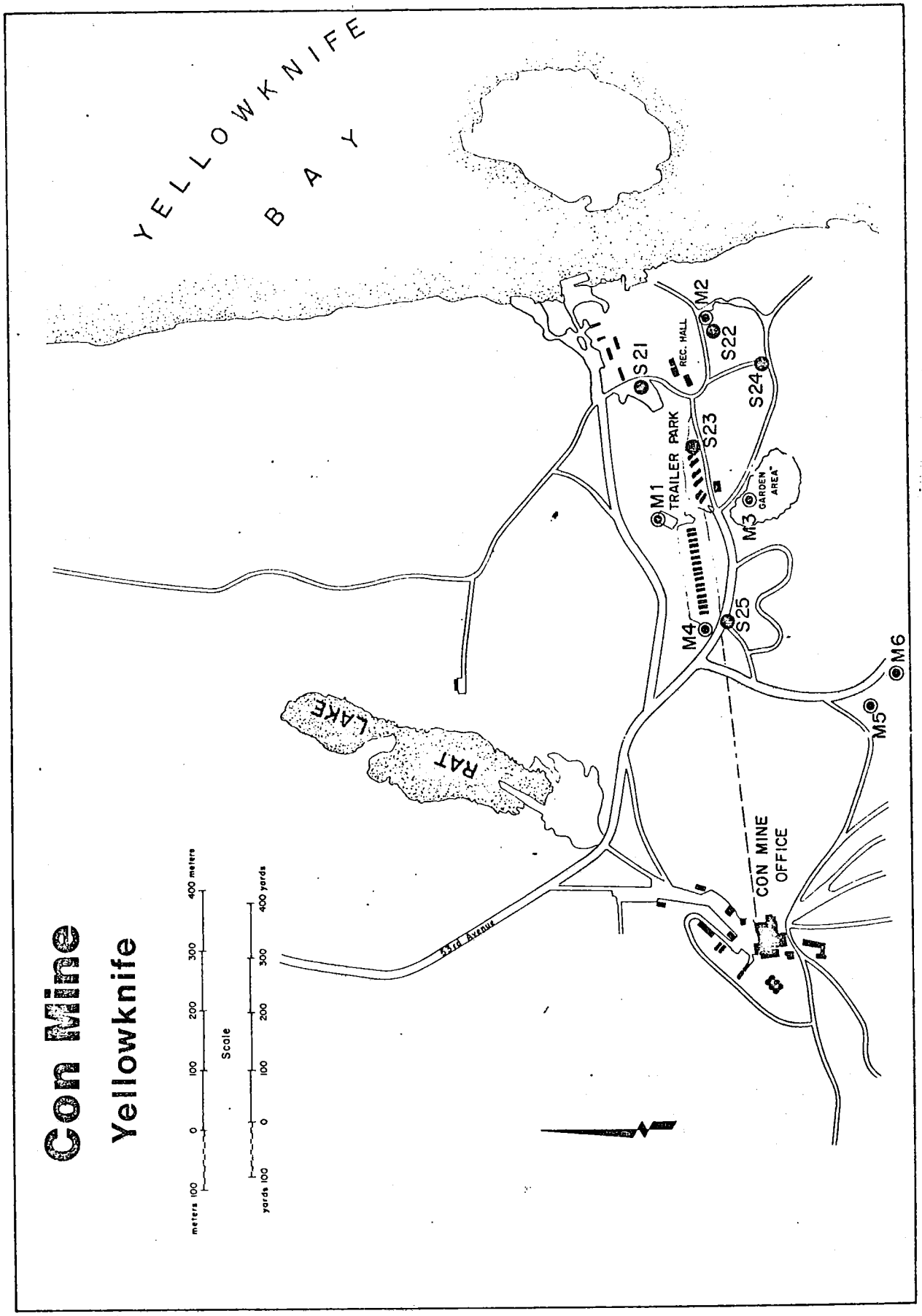

FIGURE 3 LOCATION OF SOIL SAMPLE SITES; CON MINE DISTURBED SOILS STUDY; 1975

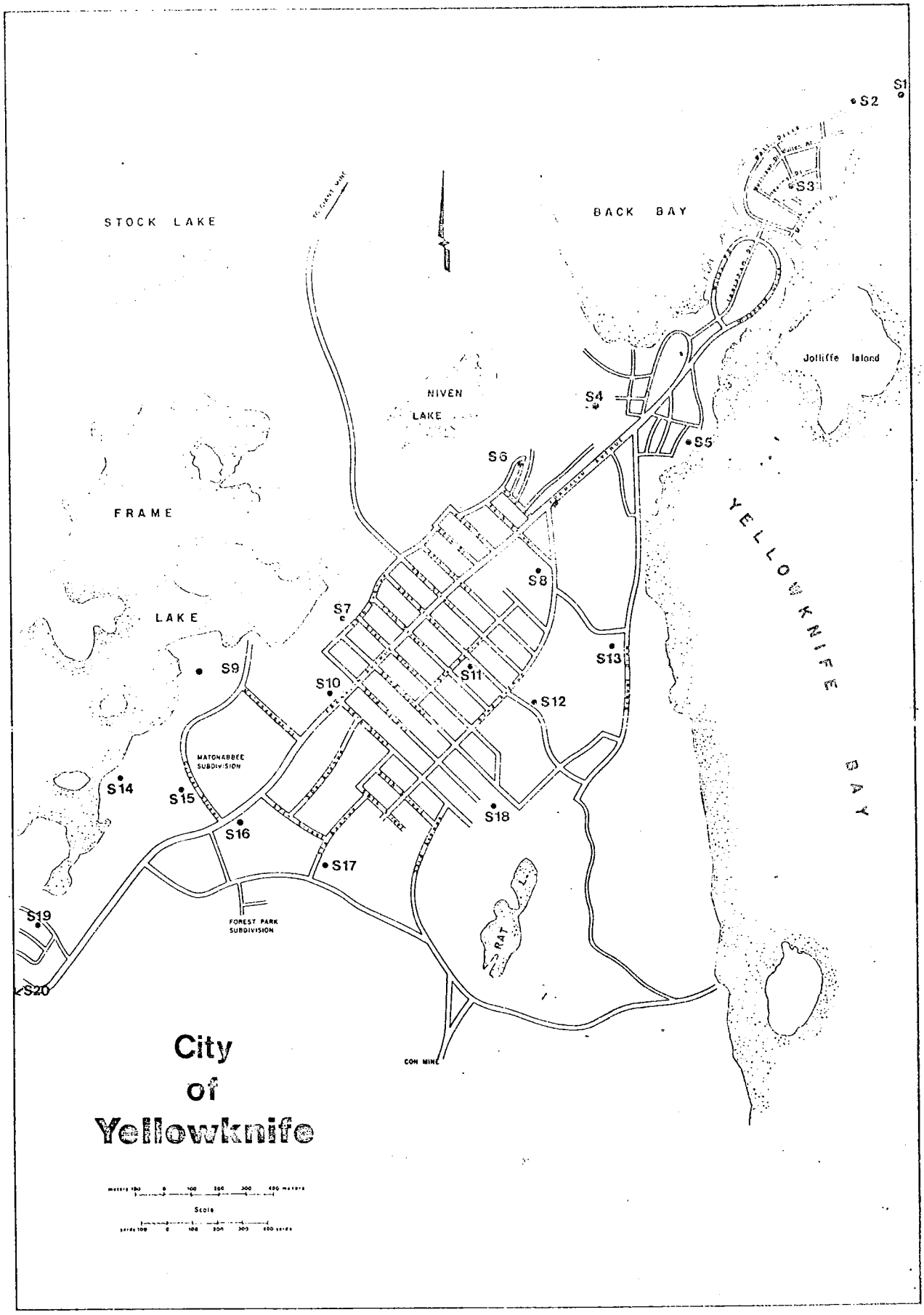

FIGURE 4 SOIL SAMPLE SITES; YELLOWKNIFE, NWT.
DISTURBED SOILS STUDY; 1975

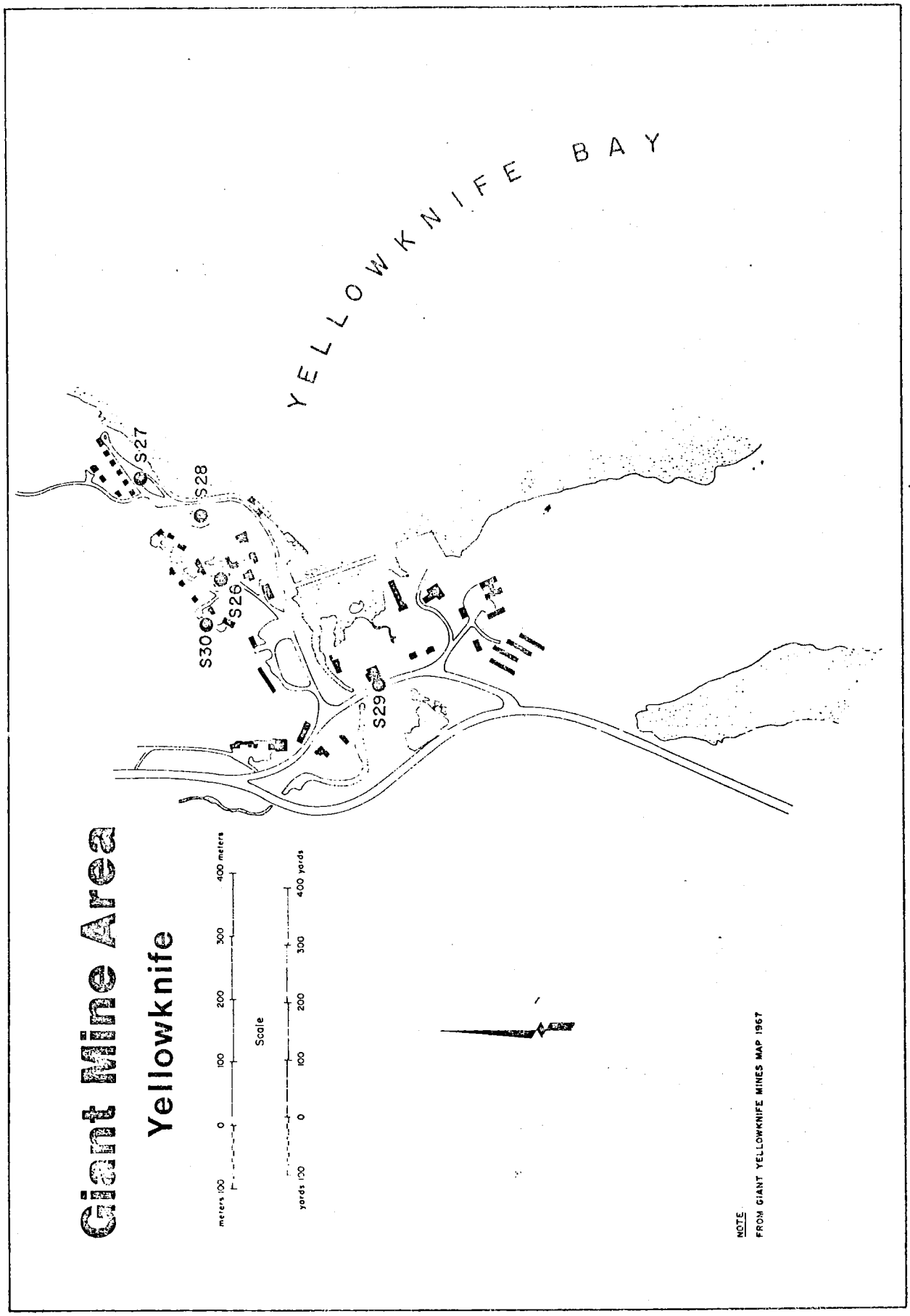

FIGURE 5 SOIL SAMPLE SITES; GIANT MINE DISTURBED SOILS STUDY; 1975

TABLE 21

Arsenic Content in Road Dust Samples, Disturbed Soils Study
(Reference 7)

Gravel Samples			Dust from Pavement		
Sample	Total Arsenic (ppm)	Insoluble Arsenic (ppm)	Sample	Total Arsenic (ppm)	Insoluble Arsenic (ppm)
G-1	74	74	P-1	33	21
G-2	31	25	P-2	128	128
G-3	30	30	P-3	58	58
G-4	21	20	P-4	216	206
G-5	38	38	P-5	94	94
G-6	49	49	P-6	58	58
G-7	29	28	P-7	161	155
G-8	21	21	P-8	38	38
G-9	16	16	P-9	45	45
G-10	42	34	P-10	36	31

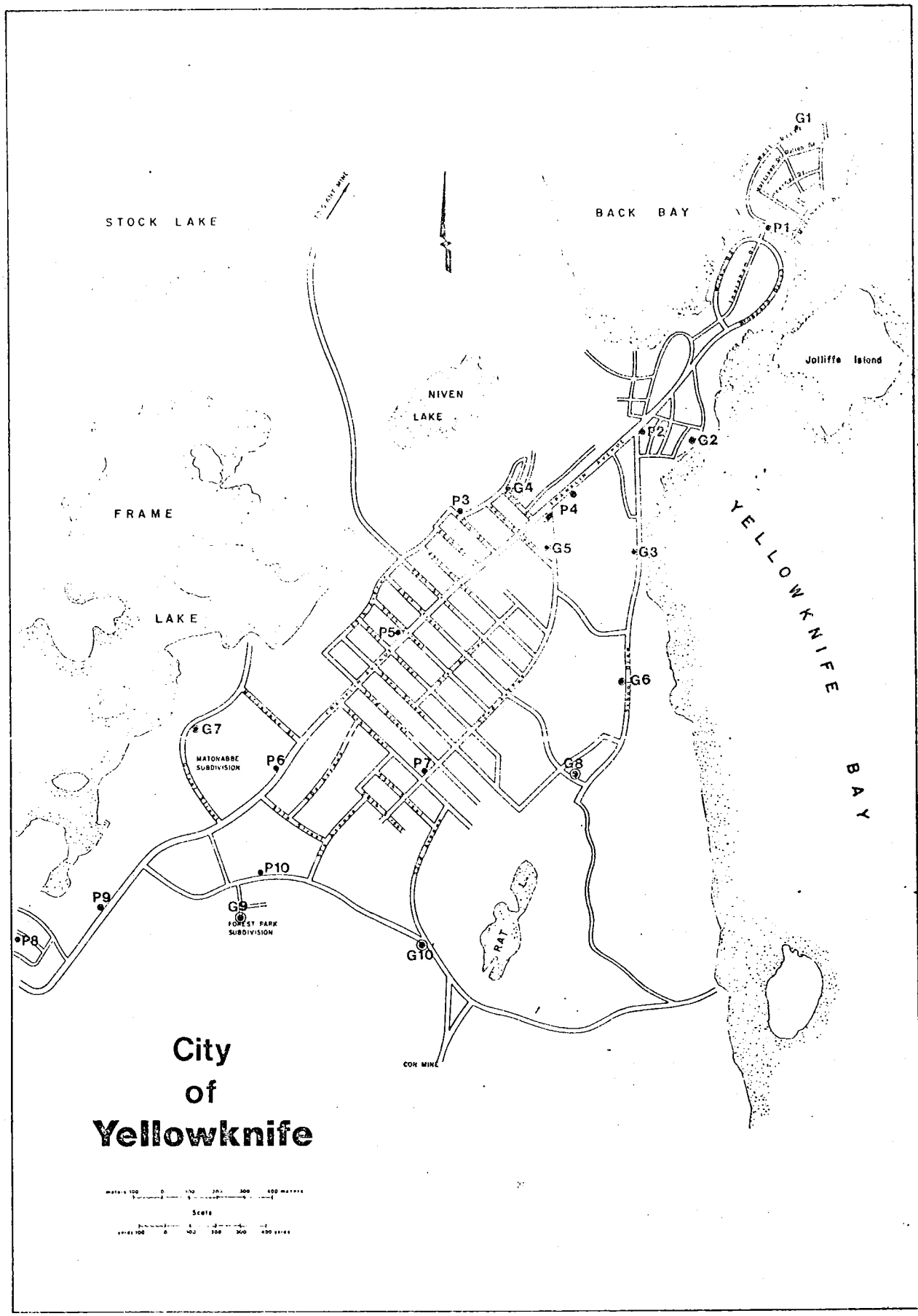

FIGURE 6 ROAD DUST SAMPLE SITES ; YELLOWKNIFE DISTURBED SOIL STUDY; 1975

TABLE 22

Various Soil Studies and Available Arsenic Data

Study	Date	Location	Arsenic (ppm)	Remarks
O'Toole (4)	Summer, 1970	Yellowknife area	low: 34 high: 7598	Concentrations for the various samples are presented in the following table.
Temple (8)	1974	Ontario	107	Average of over 50 samples near smelter 'A'.
			35	Average of over 50 samples near smelter 'B'.
			10	Urban area, remote from smelters.
Cominco (9)	July, 1975	Yellowknife area	low: 12 high: 4280	Nine sample locations; 4 soil depths; outlined in Cominco report.
Toft (1)		Agricultural soils	0.1 to 40 range	Health Protection Branch report.
Toft (1)		Orchard soils	100	Health Protection Branch report.
Plambeck & Smith (10)	June - Sept. 1975	Yellowknife - Con	82	Garden 'A'
		Yellowknife - town	52	Garden 'B'
		Yellowknife - town	36	Garden 'C'
		Yellowknife - Giant	287	Garden 'D'

TABLE 23

Arsenic Concentrations in Yellowknife Area

O'Toole, Clark, Malaby and Trauger

1970
(Reference 4)

Sample	Distance from Smelter (miles)	As (ppm)	Remarks
1	2.7 S.W.	219	Samples 1, 2, 4, 5, 6 and 7 are mineralized type soils
1A		199	
2	1.9 S.W.	115	
2A		164	Samples 1A, 2A, 4A, 5A, 6A, 7B are of high organic, mossy-type soils.
4	1.2 S.E.	601	
4A		814	
5	0.4 N.E.	602	
5A		852	
6	0.3 N.E.	3108	
6A		2641	
7	0.2 S.W.	6852	
7A		2449	
7B		7598	
8	0.8 N.E.	269	
9	1.3 S.W.	153	
12	1.8 N.W.	163	
13	1.8 N.W.	110	
14	0.7 N.W.	45	
TOWNSITES		119	Garden soil samples from Yellowknife
		34	
		178	

TABLE 24

Allowable Arsenic Limits in Food
Food and Drug Act Regulations
Health Protection Branch
Dept. of National Health & Welfare

Food	Arsenic, ppm.
Marine and Freshwater animal products	5.0
Liver	1.0
Fresh Fruits	2.0
Fresh Vegetables	1.0
Apple juice, cider, wine, beer	0.2
Other fruit juice, except apple juice	0.1
Beverages, as consumed and bottled water	0.1
Tea	1.0
Fish protein	3.5

TABLE 25

Arsenic Concentrations in Vegetables (ppm, natural weight)

Summary of Surveys in Yellowknife Area

including

Location of Garden and Test Laboratory

Vegetable	Con Mine Residences			Yellowknife Residences			Giant Mine Residences
	Food & Drug Lab, Ottawa 1970	Cominco Lab Trail 1970	Cominco Lab Trail 1975	Food & Drug Lab, Ottawa 1971	Cominco Lab Trail 1975	Cominco Lab Trail 1970	Cominco Lab, Trail 1975
Lettuce	2.65	0.64	0.26		2.25	0.28	0.16
	2.00	1.28	0.28		1.10		
	1.32						
	1.07						
	1.42						
	1.55						
Rhubarb		0.05	0.10	0.12		0.13	0.25
		0.10	0.13	0.04			
Carrots		0.05	0.45	0.39		0.17	0.22
			0.17	0.07			
				0.11			
				0.07			
Potatoes		0.20	0.31	0.07		0.25	0.24
		0.03	0.25	0.02			
				0.08			
				0.06			
Beets		0.42	0.20	0.51	0.61	0.26	0.36
		0.09	0.26	0.27			
Turnips		0.16	0.27				
Swiss Chard	1.05						
	3.15						
Small carrots	4.15				2.20		
(leaves & roots)	3.10				1.15		
	1.15						
	1.36						
Beets (leaves)	0.52						
Kohlrabi					0.67		
Cabbage					0.48		
Green pea pods					0.14		
Peas & Pods				0.08			
				0.11			
				0.06			
Tomatoes				0.13			
Onions				0.49			
				0.77			
Green Beans				0.25			

TABLE 26

Arsenic Content of Vegetation (ppm.)

Vegetable	Fruit	Grass, Shrubs	Remarks (reference)
1.0	2.0		Federal maximum acceptable limits.
0.1			Level for vegetables grown in uncontaminated areas.
		12-138 range	O'Toole (4) 1970
<0.02	0.02-0.10		National Health and Welfare data (1).
	0.0 -5.0		Canadian apples, 1962-1964; higher results possibly due to use of arsenic compounds as pesticides on fruit crops.
<1.0	<1.0	1.0-62.0	Temple (8). Near smelters (1974).
$\leq$10.0	$\leq$10.0		Flambeck and Smith (10); 10 ppm was the detection limit of which the investigators were confident given the apparatus and technique used (XRF).

TABLE 27

Arsenic Content in Yellowknife Fruits and Vegetables Collected August, 1971
(Reference 1)

		Location	Arsenic (ppm) As Received	Arsenic (ppm) Washed & Dried	Arsenic (ppm) Cleaned as in Kitchen
1.	High Bush Cranberry	Con Mine	0.15		
2.	Gooseberry	Con Mine	0.48	0.19	
3.	Black Currant	Con Mine	0.63	0.18	
4.	Low Bush Cranberry	Airport	0.32		
5,	High Bush Cranberry	Airport	0.43		
6.	Vegetables, leaves	Mr. Bugg (204B; Giant Mine)	6.80	2.7	
7.	Vegetables, leaves	Mrs. Richardson-Con Mine	1.70	0.53	
8.	Vegetables, leaves	Mr. A.P. Morris	1.40	0.54	
9.	Vegetables, leaves	Correctional Camp	0.32	0.12	
10.	Vegetables, leaves	Mr. Christensen-Old Town	1.10	0.41	
11.	Vegetables, leaves	5018-54 Street, Yellowknife	0.30	0.10	
12.	Carrots	Mrs. Bugg (204B; Giant Mine)	0.61		0.39
	Beets	"	1.60		0.51
	Rhubarb	"			0.12
	Potatoes	"	0.96		0.07
13.	Carrots	Mrs. Richardson-Con Mine	0.25		0.07
	Beets	"	0.49		0.27
	Peas and Pods	"	0.16		0.08
	Potatoes	"	0.45		0.02

TABLE 27 (cont'd)

		Location	Arsenic (ppm) As Received	Arsenic (ppm) Washed & Dried	Arsenic (ppm) Cleaned As In Kitchen
14.	Carrots	Mr. A. P. Morris	0.61		0.11
	Peas and Pods	"	0.15		0.11
	Rhubarb	"			0.04
	Potatoes	"	0.54		0.08
	Tomatoes	"	0.23		0.13
15.	Beets	Correctional Camp			0.02
	Potatoes	"	0.32		0.01
	Radishes	"			0.09
	Onions	"			0.01
	Peas and Pods	"	0.25		0.03
16.	Carrots	Mr. Christensen-Old Town	0.49		0.07
	Potatoes	"	0.34		0.06
	Onions	"			0.49
	Peas and Pods	"	0.11		0.06
17.	Onions	5018-54 Street, Yellowknife	0.73		0.77
	Beans, green	"	0.07		0.25

TABLE 28

Arsenic in Fish Livers and Fish Muscles

Falk (11)

1973

Location	Fish Type	Number of Fish Sampled	Average Arsenic Concentration (ppm wet weight)	
			Liver	Muscle
Near mouth of Baker Creek	Sucker	4	--	0.28
	Whitefish	1	0.87	0.22
	Northern Pike	4	0.70	0.31
Back Bay, west of Latham Island.	Whitefish	2	<0.20	<0.20
	Northern Pike	1	0.73	--
Martin Lake (headwater of Baker Creek)	Northern Pike	5	0.96	1.69
	Walleye	4	1.62	0.29
	Whitefish	4	0.53	0.28
Kam Lake	Whitefish	5	0.80	0.28
	Northern Pike	5	2.23	3.22
Yellowknife Bay, sub-island region.	Northern Pike	5	0.32	0.31
	White fish	3	0.24	<0.20

Location	Animal	Arsenic Concentration, ppm
Keg Lake	Snails	79.7
Kam Lake	Snails	48.6
Vee Lake	Snails	4.8
Madeline Lake	Snails	3.1
Near Latham Island	Snails	5.4
Graham Lake	Water Beetles, amphipods	3.5

TABLE 29

Arsenic in Fish Muscle

Fisheries & Marine Service,

Yellowknife, N.W.T. (12)

1975

Location	Fish Type	Number of Fish Sampled	Arsenic Concentration (ppm)
Back Bay, north of Baker Creek.	Northern Pike	6	<0.20
	Whitefish	2	<0.20
Back Bay, south of Baker Creek.	Whitefish	3	<0.20
	Maria	2	<0.20
East Mirage Islands, Yellowknife Bay.	Whitefish	4	<0.20
	Maria	1	<0.20

TABLE 30

Number of Organisms

In Yellowknife Area Lakes and Rivers

Baker Creek

Average summer densities (±95% confidence limits)

	Above Mine	Below Mine
Phytoplankton	$0.8 \pm 0.1 \times 10^8$ $\mu m^3/L$	0.003×10^8
Epiphyton	$2.5 \pm 0.2 \times 10^8$ $\mu m^3/cm^2$	0.0009×10^8
Rotiferan zooplankton	500 animals/m^3	0
Crustacean zooplankton	12/m^3	0
Zoobenthos	5500/m^2	<100/m^2

Yellowknife Bay

(a) Transect directly out from Giant Mine into Yellowknife Bay

Distance from wharf (m)	Animals/m^2
0	0.00
200	550
400	200
600	1100
800	3600) *
1000	6600)
1200	4500)
1400	1100
1600	3900
1800	900

* recovery in numbers occurs in an area where the bottom is elevated and therefore protected from tailings.

(b) From Giant Mine into Back Bay

0	0
200	2300
400	1500
600	200
800	250
1000	200
1200	400
1400	200
1600	900
1800	1600
2000	3100
2200	6700

TABLE 31

Arsenic Content of Small Wildlife

Game Management Branch,

Government of the Northwest Territories

April, 1976
(values are in ppm arsenic)
(whole body analysed)
(Reference 13)

Specimen Number	Specimen	Collection Date	Water Content (%)	Arsenic Concentration	Collection Location
1	Willow Ptarmigan	Feb. 18/76	71.38	0.75	on road at Vee Lake
2	"	"	71.07	0.72	"
3	"	"	71.84	0.45	"
4	"	"	71.20	0.59	"
5	Snowshoe Hare	Feb. 19/76	75.53	1.44	Giant Mine dump.
6	Raven	"	69.79	<0.1	Bow-Springer kennels.
7	"	"	69.23	<0.1	"
8	"	"	69.42	<0.1	"
9	"	"	70.07	<0.1	"
10	"	"	67.52	<0.1	"
11	Willow Ptarmigan	Feb. 20/76	71.01	0.34	on road at Vee Lake
12	"	"	71.45	0.35	"
13	"	"	71.01	0.44	"
14	"	"	70.79	0.32	"
15	"	Nov. 12/75	69.31	<0.1	Highway 2; 26 miles west of Yellowknife.

TABLE 32

Arsenic in Human Hair Samples

Yellowknife, N.W.T.
(Reference 14)
1975

Early in 1975, 700 Yellowknife residents volunteered to have their hair sampled and tested for arsenic content.

Number of Persons with Arsenic Concentration

	Under 5 ppm	5-10 ppm	Over 10 ppm	Total
Mine & Mill Workers	61	30	44	135
Other Residents	516	30	19	565
All persons tested	577	60	63	700

Fifty-seven people from the "over 10 ppm" group received a thorough medical examination. Arsenic content of hair samples of this group were:

Arsenic in Hair (ppm)	Number of Persons	Arsenic in Hair mean value, ppm
10	10	7.1
10 - 49	34	21.2
50 - 99	7	66.7
Greater than 100	6	203.0
	57	43.5

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