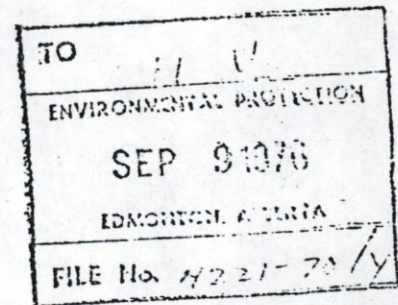
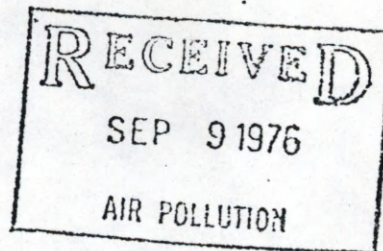


P. O. Box 2310,
Yellowknife, N.W.T.

August 4th, 1976.



Mr. Dan Billing,
Chairman,
Standing Committee on Arsenic,
Government of the N.W.T.,
Yellowknife, N.W.T.

Dear Mr. Billing:

I am pleased to submit this draft summary report of the Yellowknife Environmental Survey on behalf of the Environmental Protection Service for review by yourself and your committee. I have attempted to summarize the investigations which were carried out in 1975 and compare their findings with earlier studies conducted in this area and in other areas of the globe. The conclusions and recommendations given in the summary report are those of the various authors of the individual investigations.

I would be pleased to discuss this report with you and the committee at your convenience.

Yours truly,

David A. Garzill, P. Eng.,
Senior Project Engineer,
Environmental Protection Service,
Yellowknife, N.W.T.

c.c. H. Veldhuizen

SUMMARY REPORT

YELLOWKNIFE ENVIRONMENTAL SURVEY (Y.E.S.)

JULY, 1976

D. A. GEMMILL, P. ENG.
SENIOR PROJECT ENGINEER
ENVIRONMENTAL PROTECTION SERVICE
YELLOWKNIFE, N.W.T.

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SUMMARY REPORT

YELLOWKNIFE ENVIRONMENTAL SURVEY (Y.E.S.)

JULY, 1976

Abstract

During 1975, a comprehensive survey of Arsenic contamination in and around Yellowknife was carried out. This comprehensive survey has been called the Yellowknife Environmental Survey (Y.E.S.) and will be referred to as the Y.E.S. in this report.

As part of the overall study, a number of areas were investigated including air, snow, solids, vegetation, wildlife, water and human health. Final reports covering most of the study areas have recently been received. Other reports are still pending and will be made available as they are received.

This summary report has been prepared from the reports and data received to date. It attempts to arrange the data and information gathered from the various areas into a total "picture" of the arsenic levels in the Yellowknife area. Included is a look at the emissions from the Giant Mines Limited roaster stack.

Information collected during the 1975 survey is compared with results of earlier studies in the Yellowknife area as well as with information on arsenic concentrations in other areas of the world.

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Brief History of Previous Studies in the Yellowknife Area

a) de Villiers and Baker Study

Between 1950 and 1963, a study was conducted at the request of the Medical Service Branch of the Department of National Health and Welfare to determine the extent to which arsenic in the environment affects the health and well being of Yellowknife residents (1).

On the basis of data collected and included in the report, there was, on the average, a fall-out on the town of Yellowknife of about 3.5 pounds of arsenic per square mile per day (lbs As/mile²/day).^{*} Core samples of locally grown vegetables did not reveal significant amounts of arsenic. Over the 18 year period from 1952-1969, the water supply in Yellowknife showed an average reading of 0.04 ppm arsenic. This compares favorably with Canada's Drinking Water Standard (1968) of 0.05 ppm arsenic.

The report concluded that there was a "high incidence of acute respiratory disease (in Males) in the Yellowknife community together with a high prevalence of chronic non-specific respiratory disease. It is possible that the imitant action of inhaled arsenical dusts may have had a minor contributory role to play in the etiology of these conditions but this could be of less importance than other environmental factors. In example, the harsh climate in association with other insults on the respiratory system such as smoking". The study also concluded that it was possible that arsenic exposure may have contributed to the high incidence of chronic bronchitis.

b) Arsenic Survey of Yellowknife Bay

Grainge's survey in April, 1967 (23), indicated high levels of Arsenic in Yellowknife water supplies. A recommendation was made to construct a pipeline from the Yellowknife River to supply Yellowknife with a potable water supply and provide for discontinued use of Yellowknife Bay water for domestic purposes.

c) O'Toole, Clark, Malaby and Trauger Study

A survey of trace elements was conducted in the Yellowknife area in 1970 and 1971 (2). Samples of soil, water, snow, vegetation and human hair were collected. Arsenic, antimony and mercury levels "were very high in all environmental samples examined. Hair analyses showed arsenic and mercury levels higher than normal".

^{*} (106 lbs. arsenic/mile²/month)

d) Arsenic; A Bibliography of Recent Literature

Wallace's compilation of recent literature on Arsenic and its compounds contains over 1500 references (3). The references are indexed according to analytical methods, reviews, biological studies - including soils, sediments and aquatic studies - human health, air pollution and studies in the Yellowknife area.

e) Arsenic Levels in the Yellowknife Area

A July, 1975 report prepared by the Occupational Health Unit, Medical Services Branch, Health and Welfare Canada (4), studied arsenic exposure in work place areas at the two gold mines in Yellowknife. Although the report concluded that workers in the Yellowknife gold mines and milling operations were not unduly exposed to harmful arsenic concentrations in the air; it did recommend a number of preventive measures which should be implemented.

Studies Outside the Yellowknife Area

a) Preliminary Air Pollution Survey of Arsenic and its Compounds

A report prepared by Sullivan (5) for the U.S. Department of Health, Education and Welfare (1969) provides a review of the effects of arsenic and its compounds on humans, on animals and on vegetation. It discusses the occurrence of arsenic, the production of the various compounds of arsenic as well as giving brief information on air standards and concentrations.

b) Ambient Air Sampling for Total Arsenic Near the Tacoma Copper Smelter

Early in 1975, a sampling program was conducted near the Tacoma, Washington copper smelter to determine total arsenic in the surrounding air (6). Six sampling methods were used to evaluate atmospheric concentrations of total arsenic and the penetration of arsenic vapor or small particles through filters. An evaluation of the results of the various sampling methods recommends suitable sampling equipment for arsenic testing.

Toxic Nature of Arsenic

A number of studies have been carried out on the toxic nature of arsenic and its compounds (5, 7, 8, 9, 10). As early as 1820, arsenical compounds were suspected of carcinogenic (cancer causing) action (5). Plambeds and Smith (11) state that "arsenic and its compounds have long been known to be hazardous". Plambede and Smith list a number of references that document the hazards to human health from smelter fume emissions containing arsenic compounds (*).

Recently, (July, 1975) the Saskatchewan Force on Arsenic in Ambient Air completed an extensive report (7) for HWC. The report outlines the characteristics of arsenic, details its toxic effects on man, and presents many of the problems encountered in analysing for its presence. Arsenic levels in various non-contaminated areas are presented in this summary report to provide comparisons to arsenic levels determined in the Y.E.S. The report states that "a body of evidence from clinical reports and epidemiological studies suggests that arsenic is indeed either a carcinogen or a cocarcinogen.

Many other studies (8, 9, 10) provide similar and significant evidence to suggest the possibility of carcinogenic effects of arsenic and its compounds.

The strongest arguments against arsenic as a carcinogen are the failure to show increased prevalence of cancer among industrial workers and failure to induce cancer in experimental animals (5).

Arsenic taken into the body is excreted mainly in the urine and to a minor extent in the bile, feces, hair and nails (5, 7). Highest concentration in the body are normally found in the liver, kidneys, hair and nails (7). It has been calculated recently that a normal 160 pound man contains, on the average, approximately 0.2 ppm arsenic (7) in his body.

(*) Grainge (23) has indicated that arsenic exhibits coacinogenic properties.

Gold Milling in the Yellowknife Area

Some of the reports in the Y.E.S. survey provide much detail on the mining and milling processes in the Yellowknife area. This report only summarizes some of the significant aspects of the operation.

There is an abundance of arsenopyrite (FeAsS) in the gold bearing ore found in the Yellowknife area. Full recovery of the gold requires wasting of the ore in the milling process. The fumes produced by the wasting process contain arsenic trioxide (As_2O_3) and sulfur dioxide (SO_2). It is these constituents in the gas stream that must be removed before the gas is emitted to the atmosphere.

Roasting of the ore began at Con Mine in 1941, stopped during the war years (1942), and started again in 1948. Con Mine installed a wet scrubber system in 1949 to try to stop the dispersion of arsenic into the environment. The resulting arsenic containing slurry was, and still is, held in tailings ponds near the Con Mine. Con Mine stopped roasting the ore in 1970 and now removes the arsenic by other means, storing it in tailings ponds. This arsenic cannot be considered permanently removed from the environment. Drying on the surface of the tailings ponds, and dust movement due to wind action, can cause arsenic mobilization around the area away from the mine.

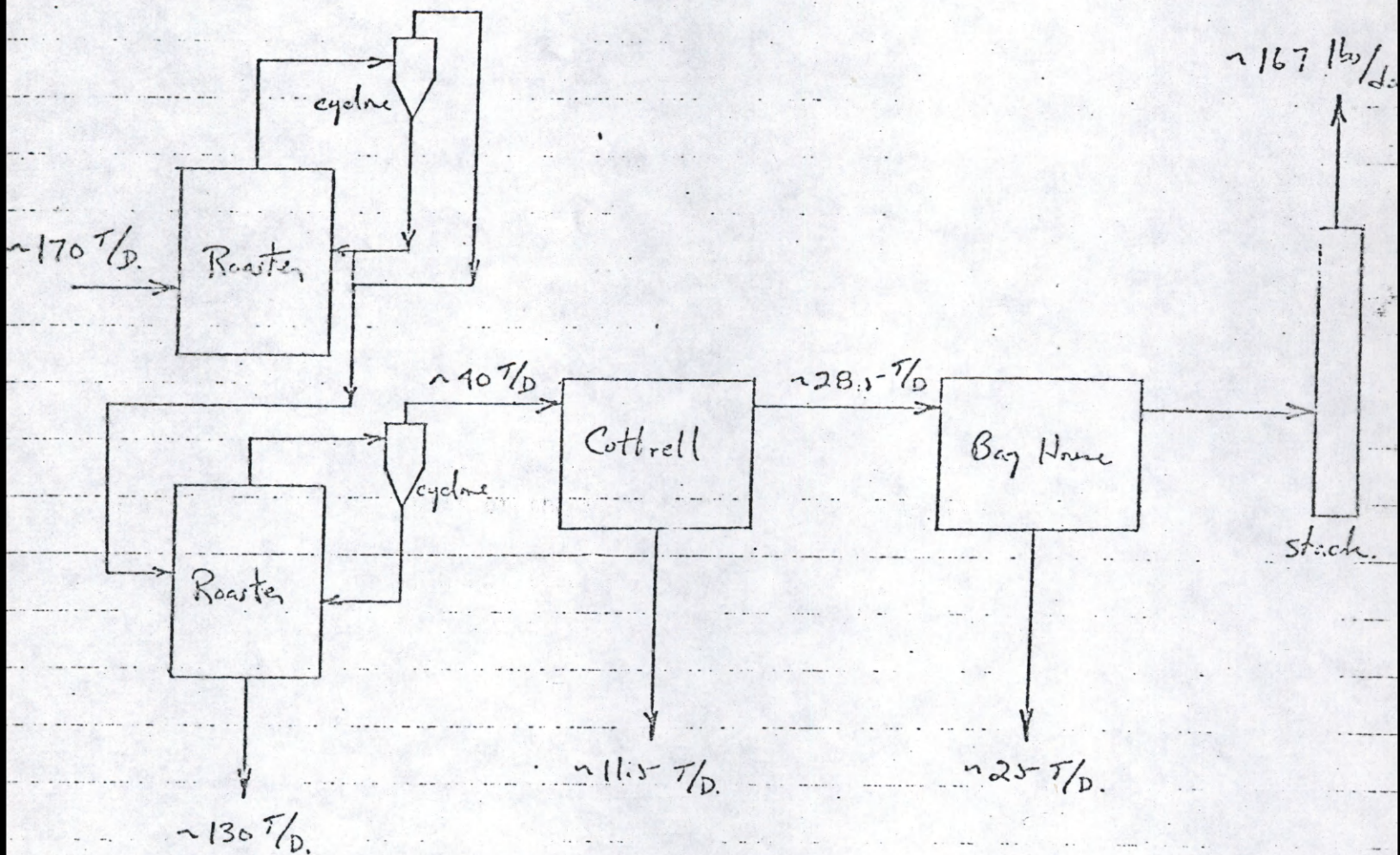
Giant began roasting ore in 1949; in 1951 the mine installed a Cottrell precipitation for collecting dust emitted from the roasting process. In 1955, Giant started a second Cottrell precipitation. In the fall of 1958, a bag-house dust collector was installed. Arsenic trioxide dust collected by the dust collection system is permanently stored in sealed stopes underground. The dust collection system has reduced greatly the arsenic emissions to the atmosphere. This is evidenced by the results of the stack testing program carried out as part of the Y.E.S. ().

The report prepared by Plambede and Smith (11) provides data on arsenic emissions to atmosphere from both milling operations during their years of operation.

A simplified illustration of the gas and dust treatment system at Giant Mines follows. Approximate tonnages and amounts of arsenic containing dust collected at various points in the system have been noted (12). Indications are that stack emissions could be higher than determined.

A simplified illustration of the gas and dust treatment system at Giant Mine follows. Approximate tonnages and amounts of arsenic-containing dust collected at various points in this system have been noted (12). Indications are that stack emissions could be higher than determined.

Figure 1 - Gas and Dust Treatment System, Giant Mine.



* from tests carried out (12).

Other quantities are approximate daily averages and may vary substantially.

The Yellowknife Environmental Survey Summary

a) Components of the Survey

A number of areas were investigated as part of the overall study. These included:

- 1) Previous studies and investigations into Arsenic contamination in the Yellowknife area
- 2) Ambient (surrounding) air survey to determine dust and SO₂ concentrations in the area.
- 3) Stack emission survey at Giant Mine to determine total stack emissions
- 4) Snow survey to determine snow quality with emphasis on possible aerial fallout, acidity of the snow and arsenic levels.
- 5) Soils and Vegetation study to determine arsenic and heavy metal concentrations in soils, vegetables and fruit in the Yellowknife area
- 6) Disturbed soils study to determine the amount of arsenic in soils of significant human activity (including street dust, playground soil and garden soil)
- 7) Wildlife study to determine arsenic concentrations in some of the typical small wildlife of the area (rabbits, ravens and ptarmigans)
- 8) Water survey to determine extent of arsenic concentrations in lakes and streams around Yellowknife

A summary of the various investigations is tabulated below.

TABLE 1 - SUMMARY OF Y.E.S. INVESTIGATIONS

Component	Study/Testwork (reference)	Conducted By	Dates	Reports Prepared
Air	a) Ambient air (13)	EPS Edmonton	mid 1973 to mid 1975	Yes - April 1976
	b) Stack survey (12)	EPS Edmonton	August, 1975	Yes - April, 1976
Water	a) Runoff (14)	DINA/Water Manage. (Yellowknife)	April, 1976	Yes - June 1976
	b) Water Supply	DINA/Water Manage. (Yellowknife)	Ongoing	Information available
Snow	a) Snow Survey (15)	EPS/Edmonton	March, 1975	Yes - April, 1976
Soil	a) Soils study (11)	U of A/Edmonton	June & Sept. 1975	Yes - April, 1976
	b) Disturbed Soils (16)	EPS/Yellowknife	May & Sept. 1975	Yes - June, 1976

Component	Study/Testwork (reference)	Conducted By	Dates	Reports Prepared
Vegetation	a) Soils Study (11)	U of A/Edmonton	June & Sept. 1975	Yes - April, 1976
	b) Plant Ecology Survey (17)	CFS/Edmonton	September, 1975	Draft only - March 1976
Wildlife	a) Local small game (18)	GNWT	April 1976	Memo received, June, 1976
Health	a) Human Hair (4)	NHW	1975	Yes - late 1975

Conclusions

Report/Reference

- it is not possible to define clearly whether the injury is due to SO_2 or to arsenic emissions.
- 10) Surface runoff sample analysis give a range of arsenic concentrations from 0.008 ppm (Yellowknife River) to 31.0 ppm (Giant tailings effluent entering Baker Creek). Results are tabulated in this report. Runoff Survey (14)
 - 11) The arsenic concentration of Yellowknife drinking water supply is within the acceptable Canadian Drinking Water Standard of 0.05 ppm. Water Supply data (tabulated in this report)
 - 12) Most of the melted snow samples tested are not suitable as a potable water source. The melted snow samples were to acidic and analysed higher than the 0.05 ppm limit for drinking water. The average arsenic concentration was determined to be 0.17 ppm. Snow Survey (15)
 - 13) Arsenic concentrations of disturbed soils samples collected vary from 755 ppm maximum to less than 1.0 ppm. Disturbed Soils
 - 14) Original soils (undisturbed) and mine wastes generally have the highest total arsenic concentration. Disturbed and recently excavated sites (clay, sand, gravel) generally have lower total arsenic concentrations. Disturbed Soils
 - 15) In general the bulk of the arsenic determined was in the insoluble form. Disturbed Soils
 - 16) There is a high degree of contamination by arsenic compounds in the soil and vegetation of the Yellowknife area. Values range from a few hundred ppm to a few thousand ppm. Preliminary results show that vegetables contain far less arsenic than the soil in which they grow. Soils and Vegetation Study (11)
 - 17) The pattern of arsenic contamination clearly indicates that it arises from the operations of Giant and Con Mines. Soils and Vegetation Study.
 - 18) There is a minor contamination by antimony and a trace contamination by mercury in the soil and vegetation of the Yellowknife area. Soils and Vegetation Study
 - 19) Arsenic levels in some small wildlife samples were:
 - ptarmigan (9 samples) - 0.45 ppm arsenic average
 - raven (5 samples) - 0.01 ppm arsenic average
 - snowshoe hare (1 sample) - 1.44 ppm arsenic averageLocal Small Game (18)
 - 20) Based on observations and air sampling results, it is not unduly exposed to harmful arsenic-in-air concentrations. Human Hair (4)

b) Summary of Conclusions from the Various Study Reports

<u>Conclusion</u>	<u>Report/Reference</u>
1) Hourly ambient (surrounding) air concentrations of SO ₂ rarely exceed maximum acceptable National Air Quality Objectives (NAQO).	Ambient Air (13)
2) On an annual basis, SO ₂ levels meet maximum acceptable NAQO.	Ambient Air (13)
3) Total settleable particulate (dust) levels measured are (generally) insignificant in comparison to levels measured in other Canadian cities. A deposition rate of 11.9 lbs of "dust" per square mile per month was determined. This included an arsenic deposition rate of 0.0048 lbs. of arsenic per square mile per month. Composition of collected dust samples indicated that the majority of arsenic is in the potentially hazardous arsenite form.	Ambient Air (13)
4) Calculated 1974/75 winter average arsenic deposition rate was 11 lbs. of arsenic per square mile per month, within a 10 mile radius of Giant mine. (This does not compare too well with the results of (3) above; possibly due to sampling procedure, time of testing, or analysis technique).	Snow Survey (15)
5) Measured total daily suspended particulate (dust) levels exceed maximum acceptable NAQO approximately 10% of the time.	Ambient Air (13)
6) Measured daily total suspended arsenic oxide particulate (dust) levels near Giant Mine are significantly above those measured in other parts of Yellowknife.	Ambient Air
7) The average arsenic emission rate was determined to be 167 lbs. of arsenic per day, with a range of 127 to 238 lbs. of arsenic per day. The majority of the arsenic was collected as a particulate in the sampling process.	Stack Survey (12)
8) Near the Giant and Con smelters there is deterioration of vegetation.	Plant Ecology Survey (17)
9) Within one mile of the Giant stack there is drastic deterioration of both forest and outcrop vegetation. Although vegetation exhibits symptoms of SO ₂ injury	Plant and Ecology Survey

c) Summary of Recommendations from the Various Study Reports

Recommendation

Report/Reference

- 1) If the arsenic is present in toxic form, levels found in the study could indicate high degree of hazard. Therefore, precautions should be taken to routinely monitor arsenic levels in the water supply and the public must be prohibited from using melted snow as a potable water supply. The public should be advised also not to consume Yellowknife Bay water, especially during spring runoff periods. Soils and Vegetation Study; Runoff Study; Snow Survey, (11, 14, 15)
- 2) Studies should be continued to provide better definition of the area and level of arsenic contamination in soils and vegetation as well as the forms of arsenic compounds present Soils and Vegetation Study; Disturbed Soils Study (11, 16); Ambient Air (13).
- 3) Future stack sampling surveys, if conducted, should include consideration of various alternatives in the sampling process. These are outlined. Stack Survey (12)
- 4) An approved standard laboratory reference method for the determination of arsenic and an approved reference method for the determination of arsenic concentrations in ambient air needs to be developed. Evidence quoted in references indicates that the Hi-Vol sampling technique for arsenic measurement used, actually underestimates the true concentrations of arsenic in the ambient condition. Subsequently, interpretation of overall or individually reported arsenic concentrations past or present may lead to erroneous conclusions. Ambient Air (13)
- 5) Further additional ambient air sampling by an approved standard reference method is required to ascertain the true ambient arsenic concentrations in the Yellowknife area. Ambient Air (13)
- 6) Overall total and arsenious deposition rate data collected for 1975 for the Yellowknife area indicates the prevalence of low deposition rates. Further monitoring is not required as data presented is most probably indicative of the air pollution burden attributed to settleable particulates. Ambient Air (13)
- 7) As the detected air quality levels for sulfur dioxide are Ambient Air (13)

within maximum acceptable National Air Quality Objectives, it is recommended that the sulfur dioxide monitoring program be terminated.

- 8) To further define the problem of vegetation injury due to air emissions, further field and test work is required at many more sites. Plant Ecology Survey (17)
- 9) The level of hazard of the various forms of arsenic compounds should be evaluated by a medical toxicologist with particular competence in this area. Soils and Vegetation Study
- 10) To completely prevent remobilization of arsenic compounds from Con Mine tailin-s ponds, these ponds should be permanently sealed with an impermeable cover. Soils and Vegetation Study
- 11) Arsenic exposures in the working environment at Giant Mine should be monitored annually. Emphasis should be on workplace areas in roasting and gas treatment processes Human Hair (4)
- 12) Certain preventative measures should be implented at Giant Mine, including: Human Hair
 - regular medical exams (every 2 years)
 - posting of proper safety procedures in high dust level areas with the intent of minimizing exposure to arsenic oxides.
 - provision of proper safety equipment and facilities for employees who work in high dust level areas

Information is sparse concerning the amount of arsenic present in the air of Canadian communities. Some available data is presented for Ontario, Yellowknife, and a variety of United States' locations (7). A summary of some of that data follows (arsenic concentration is in $\mu\text{gm As/m}^3$).

TABLE 2 - SUMMARY OF ARSENIC IN AIR, VARIOUS COMMUNITIES

LOCATION	-YEARLY AVERAGE-			
	1964	1972	1973	1974
Windsor, Ontario		0.030	0.012	
Welland		0.696	0.271	
Sault Ste. Marie		0.017	0.013	
South Porcupine			0.168	
Sudbury		0.026	0.013	
Yellowknife, N.W.T.				
- airport			0.12	0.12
- townsite			0.14	0.098
- Giant mine			0.22	0.26
Chicago	0.04			
Toledo, Ohio	0.09			
El Paso, Texas	0.75			
Seattle, Washington	0.08			
Charleston, W. Virginia	0.25			
average of 133 U.S. stations	0.02			

Guidelines for acceptable arsenic-in-air concentrations are unsettled and not well defined presently; however, it has been recommended that concentrations of arsenic be kept below $0.05 \mu\text{gm}/\text{m}^3$.

b) Arsenic Deposition Rate

Measurements of settleable particulates (dustfall or fallout) are usually expressed in terms of pounds per square mile per month (lbs./mile²/mth). The following table presents the results of the dust fall tests and compares them to calculated values from the Snow Survey (15) and to values obtained by National Health and Welfare (1).

TABLE 3 - DUSTFALL DETERMINATIONS, YELLOWKNIFE

SURVEY	DATE	DUSTFALL (lbs/mile ² /mth)	DUSTFALL (lbs As/mile ² /mth)	REMARKS
Air	June, 1975	17.6	0.0034	
	July, 1975	26.2	0.00714	
	August, 1975	14.5	0.0069	
	September, 1975	9.7	0.0043	
	October, 1975	4.3	0.0033	
	(average)	(11.9)	(0.0048)	average of 22 stations over period June to October
Snow	74/75 Winter		1.2	4 miles S. of Giant
			564.0	Inside Giant property
			11.0	Calculated winter mean deposition rate
NHW	1950-1963		106	Reference 1

c) Sulfur Dioxide Concentration in the Air

Three sites were used to monitor SO₂ concentrations in the air. Results indicated that, on the average, SO₂ concentrations do not exceed maximum acceptable NAQO. As a result, SO₂ monitoring has been terminated.

Stack Survey

The stack survey carried out at Giant Mine was an attempt to validate a proposed stack sampling method for arsenic as well as gather data for the Y.E.S. The test method is outlined in the report (12).

August 14 to 19, 1975, was the test period. The test equipment was assembled on the platform at the 75 foot level of the stack. The average emission rate was determined to be 167 lbs of arsenic per day. Most of the arsenic collected was contained on the glass- fibre filter - that is, it was in the form of a fine solid particulate (arsenic oxide - As_2O_3). Results of the stack tests are summarized below.

TABLE 4 - GIANT STACK ARSENIC EMISSION TESTS

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)

Sulfur dioxide emission was also measured during this stack survey. The rate was determined to be 41.5 tons of SO_2 per day discharged to atmosphere.

b) Water

1) Runoff

During the 1976 spring melt and runoff period, water samples were obtained from a number of sources around Yellowknife. These samples were analyzed for arsenic concentration, the analyses being carried out at the Yellowknife Water Laboratory. The purpose of this program was to measure arsenic levels when they are at their highest. It is during the short spring melt and runoff period that the entire winter accumulation of arsenic "fallout" is suddenly released to the aquatic environment.

The Yellowknife Environmental Survey - Component Details

a) Air

1) Ambient (Surrounding) Air Study

This study was to provide data on the quality of air within the city of Yellowknife. The following constituents were determined in the surrounding air:

- a) total suspended particulates (dust) in the air;
- b) arsenic deposition (fallout) rate;
- c) sulfur dioxide (SO_2) gas concentration in the air.

The testing was carried out between June and October, 1975. No standard reference method for determining arsenic concentrations in ambient air existed during the sampling program and as a result, the total suspended dust sample collected was analyzed for arsenic content.

A Hi-Vol sampler is situated in Yellowknife on the roof of the Hudson's Bay store and has operated for $3\frac{1}{2}$ years. Results obtained from this sampler provides data on total dust fallout for 1973, 1974 and 1975.

b) Total Suspended Particulates in the Air

Generally, suspended particulate levels in 1973, 1974 and 1975 did not exceed maximum desirable National Air Quality Objectives (NAQO). The major constituent of the dust in the air in the vicinity of Giant Mine was arsenite (As_2O_3), the potentially hazardous arsenic compound. Values measured were in the range from a low of 0.09 to a high of 2.75 micrograms of arsenite per cubic meter ($\mu\text{gm As}_2\text{O}_3/\text{m}^3$).

Daily levels of arsenic in the dust in the air ranged from less than 0.01 to $3.91 \mu\text{gm As}/\text{m}^3$ for the 1973 to 1975 test period.

Yearly average suspended arsenic levels, measured by the Hi-Vol method were 0.08 for 1973, 0.09 for 1974, and 0.06 for 1975. All values are in $\mu\text{gm As}/\text{m}^3$.

Supporting evidence indicates that the arsenic concentrations measured by the Hi-Vol method are lower than what might be considered "true concentrations" of arsenic in the surrounding air by as much as a factor of 10. As the task force on arsenic state (7) = Accuracy of traditional sampling techniques (Hi-Vol method) is compromised by the physical properties of arsenic compounds found in ambient conditions. Particulate arsenic compounds, such as As_2O_3 , are appreciably volatile. Therefore, losses may be suspected during and after collection....".

TABLE 5: SPRING RUNOFF SAMPLING CONDITIONS

<u>Sampling Date</u>	<u>Conditions</u>
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 6: 1976 RUNOFF ANALYSES

Sampling Site	Arsenic Concentration, ppm				Remarks
	1 April 13	2 April 27	3 May 11	4 June 11	
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 YK. Bay
Junction of Giant Road & Airport Road	0.036	0.28	0.068	0.17	Slough on N.E. side
Runoff to Stack Lake	0.075	0.184	0.160	0.096	1 - pool near Bristol monument; 2 & 3 - flow into Stack Lake; 4 - Stack Lake water
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

TABLE 6: 1976 RUNOFF ANALYSES CONT'D

Sampling Site	Arsenic Concentration, ppm				Remarks
	1 April 13	2 April 27	3 May 11	4 June 11	
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 Mile 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
Yellowknife Bay at schooldraw Culvert	0.012	0.052	0.024	0.067	Runoff under School-draw Road into Yk. 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 pump-house; water from Yk. River.
Yellowknife Emergency Water Supply	0.0045	0.0090	0.020	0.014	Yk. 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).

● A report detailing the runoff survey carried out by DINA/Water Management is included in the appendix. Also included is a map illustrating the sampling sites.

Yellowknife citizens have been informed by announcements in the various news media and by signs posted in key area, not be drink melted water or use snow in the area for a source of drinking water. Residents have also been advised not to consume Yellowknife Bay water.

2) Water Supply

This section of the summary report outlines arsenic concentrations in the Yellowknife municipal water supply (drinking water); in lakes and streams in the Yellowknife area (the aquatic environment); and provides some comparable arsenic concentrations in water bodies around the world.

a) Yellowknife Municipal Water Supply

Arsenic concentration in the Yellowknife municipal water supply is monitored weekly throughout the year by DINA/Water Management. Considerable data is on file. A summary follows. (Canadian Drinking Water Standard is 0.05 ppm arsenic maximum).

TABLE 7:
YELLOWKNIFE MUNICIPAL WATER SUPPLY (arsenic conc in ppm)

Date	Tap Water	Yellowknife River Water	Yellowknife Bay Water	Back Bay	
1975 Summary	0.01	0.01			
Feb. 18/75				0.011	
June 18/75			0.018	0.022	
Sept. 28/75			0.01	0.01	
Oct. 28/75			0.01	0.01	
Nov-Dec/75			0.01	0.01	
Jan. 76	0.01				
Feb. 76	0.008	0.0008	0.0030	0.0057	improved analytical technique.
March 2/76	0.0029				
March 9/76	0.0006				
March 16/76	0.0241				
March 22/76	0.0030				
March 30/76	0.006				
April 5/76	0.008				

TABLE 8: ARSENIC LEVELS IN YELLOWKNIFE AREA LAKES

b) Yellowknife Area Lakes (arsenic conc. in ppm)

Lake/Location	Arsenic	Remarks
"Lake 2; 1.9 miles S.W."	3.90	Data from O'Toole, etal.
"Lake 7; 0.3 miles S.W."	12.40	Reference 2
"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	
Kam Lake	1.0 - 5.0	Data from memo Brunskill to Hamilton
Grace Lake	0.001 - 0.10	Feb. 6, 1975 "Arsenic in Yk. Waters"
Frame Lake	0.150 - 0.180	(Tests carried out over 1972-1974)
Lakes 16 miles N.E.	n/d	(n/d = non detectable)
Lakes 12-15 miles N. & N.E.	0.0005 - 0.007	
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	" "
"Small Lakes" include Long, Stock, Frame and Kam.	"elevated arsenic concentrations; Kam Lake highest.	Cominco Ltd. Yellowknife Arsenic Survey Aug. 1975. (no numbers provided in memo)
Kam Lake:		
- North basin	2.04	Data collected May 25, 1976 by
- Central	1.08	Dr. J. Moore, Environmental Protection
- South basin	2.06	Service, Yellowknife. Internal correspondence.

c) Occurrence of Arsenic in Various Water Bodies

The report of the task force on arsenic (7) presents information on the occurrence of arsenic in various water bodies. Some of this is tabulated below.

TABLE 9: OCCURRENCE OF ARSENIC IN VARIOUS WATER BODIES

ARSENIC IN WATER (conc in ppm)

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 - 0.013
Lakes Superior, Ontario, Huron, Erie River; Sweden	0.00025 - 0.001 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 Zeland	0.400 - 1.300 (high in bicarbonate)
Near Yellowknife, 1973-74	0.070 - 1.00
Great Slave Lake	0.004 - 0.500 total 0.001 - 0.030 dissolved
Taiwan	0.010 - 1.82 (most 0.40 - 0.60)
Cobalt Lake (Ottawa River Basin) 1970-1971	1.00 - 2.50
Argentina	approximately 1.50
New Zealand (fresh water)	approximately 20.0
Searles Lake, California (high salinity water)	over 200.0

c) Snow

The snow survey was carried out in March, 1975. The intention was to provide information on the level of heavy metal contamination from the gold mines in snow in the Yellowknife area. The sampling technique and methods of analysis and sample handling are detailed in the report (15).

Consideringeing the various substances present in the snow, 2 parameters - the concentration of arsenic and athe acidity (pH) of the snow water - were found to exceed the Canadian Drinking Water standards of 0.05 ppm As and 6.0 - 8.0 pH.

In the following tabulation, results of the March, 1975 survey are compared to earlier snow surveys conducted in the area.

TABLE 10: SNOW SURVEYS IN YELLOWKNIFE AREA (arsenic conc. in ppm)

Survey	Sample	Location	Arsenic	Acidity (pH)	Remarks
O'Toole et al	'Snow 5'	0.35 mile N.E.	0.68		
Reference 2	'Snow 9'	1.30 mile N.E.	1.20		
	'Snow 10'	0.22 mile N.W.	8.75		
	'Snow 21'	2.0 mile N.E.	0.47		
E.P.S.	1	(Sample	0.46	3.4	
Yellowknife	2	Locations on	0.44	3.7	
Dist. Office	3	attached map	0.48	3.9	
Feb. 17, 1975	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	(Refer		0.17	4.6	average of 52 samples
Survey (15)	to	0.1 mile W. of	8.80	7.7	maximum
	report)	Giant	0.02	2.7	minimum

Figure 2 shows the snow sampling stations for the February 17, 1975 survey. Figures 3 and 4 illustrate sample site locations and arsenic levels for the March, 1975 snow survey.

Other snow surveys have been carried out: NHW, 1959 - 1963; and E.P.S., Yellowknife District office staff, March/April, 1975 (during which approximately 120 sites were sampled). Results of both survey indicated higher arsenic deposition rates and, thereby, higher arsenic concentrations in the snow.

Differences in concentrations between surveys may be accounted for by site location, equipment used and method of sampling, time of season sampled, and possibly the analysis technique used for determining the arsenic concentration.

Figure 2.

Map of Snow Sampling Stations

Feb. 17, 1975

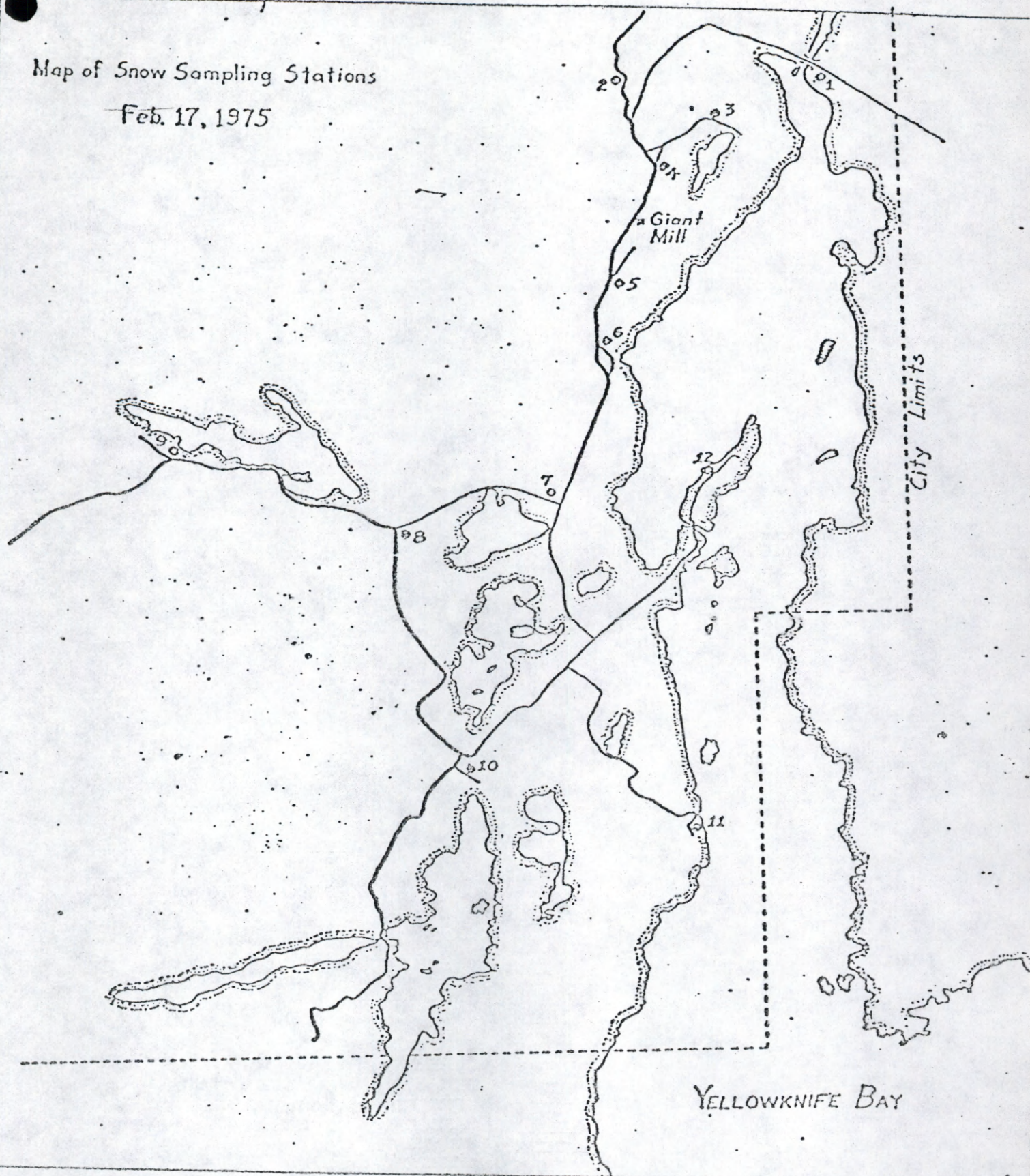
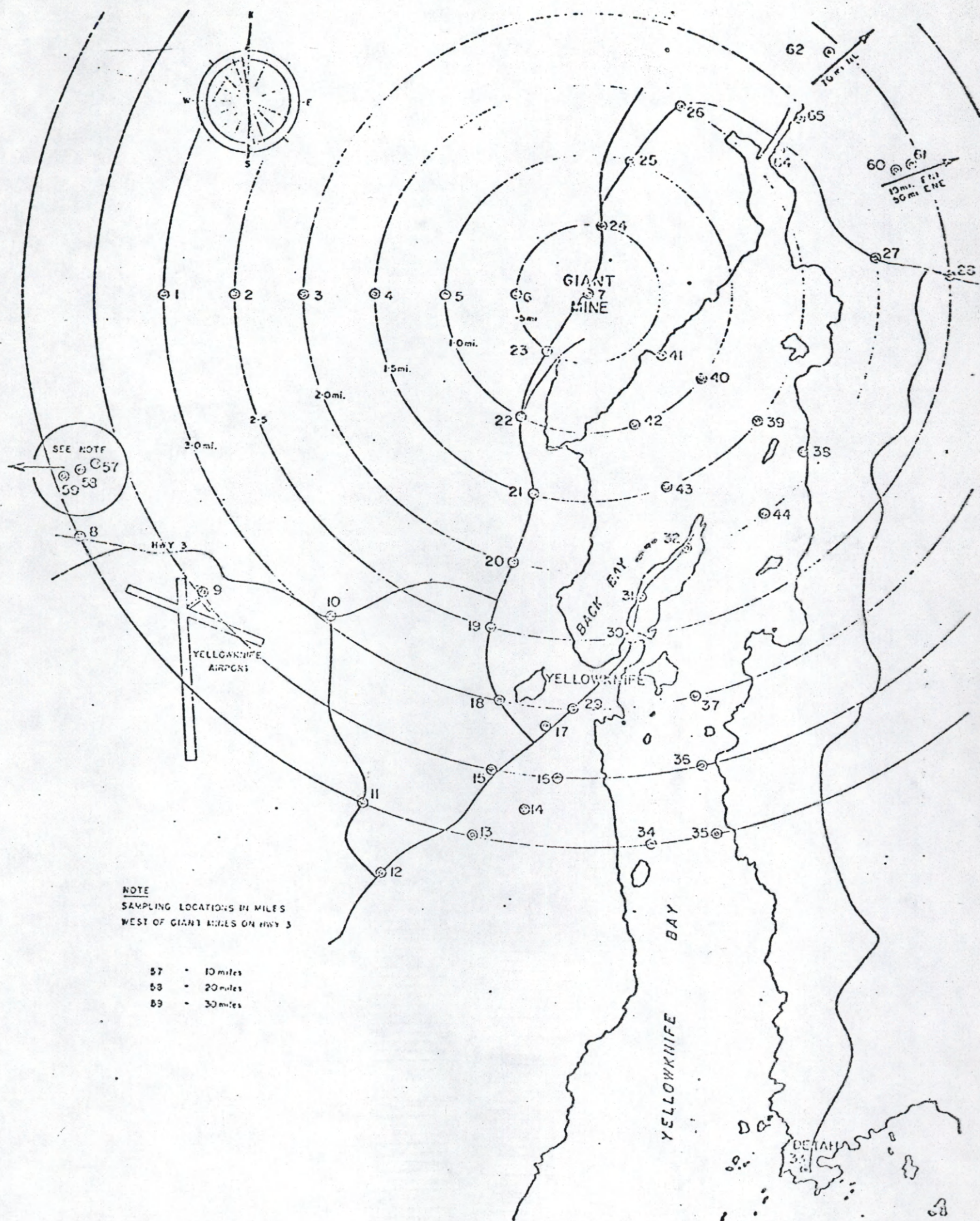


FIGURE 3 SAMPLE SITE LOCATION



d) Soil

1) Soils Study

The University of Alberta, under contract to the Environmental Protection Service, conducted a Soils (and Vegetation) survey in the Yellowknife area in June and September of 1975 (11). In June, 53 sites were used. Samples were taken of four soil levels as well as four types of vegetation. (In September, garden vegetables and wild fruit were sampled).

According to the authors, arsenic levels in soils are below 5 ppm in the absence of a source of contamination. This is confirmed by Toft et al (7).

From results obtained, the authors conclude that arsenic is present in "very high concentration" in the Yellowknife area exceeding the 5 ppm level by factors of from 100 to 2000. Figure 5 illustrates the degree of arsenic concentrations throughout the area in soil lichens and surface (horizon) soil.

As part of the study, garden soils in the Yellowknife area were analyzed for arsenic.

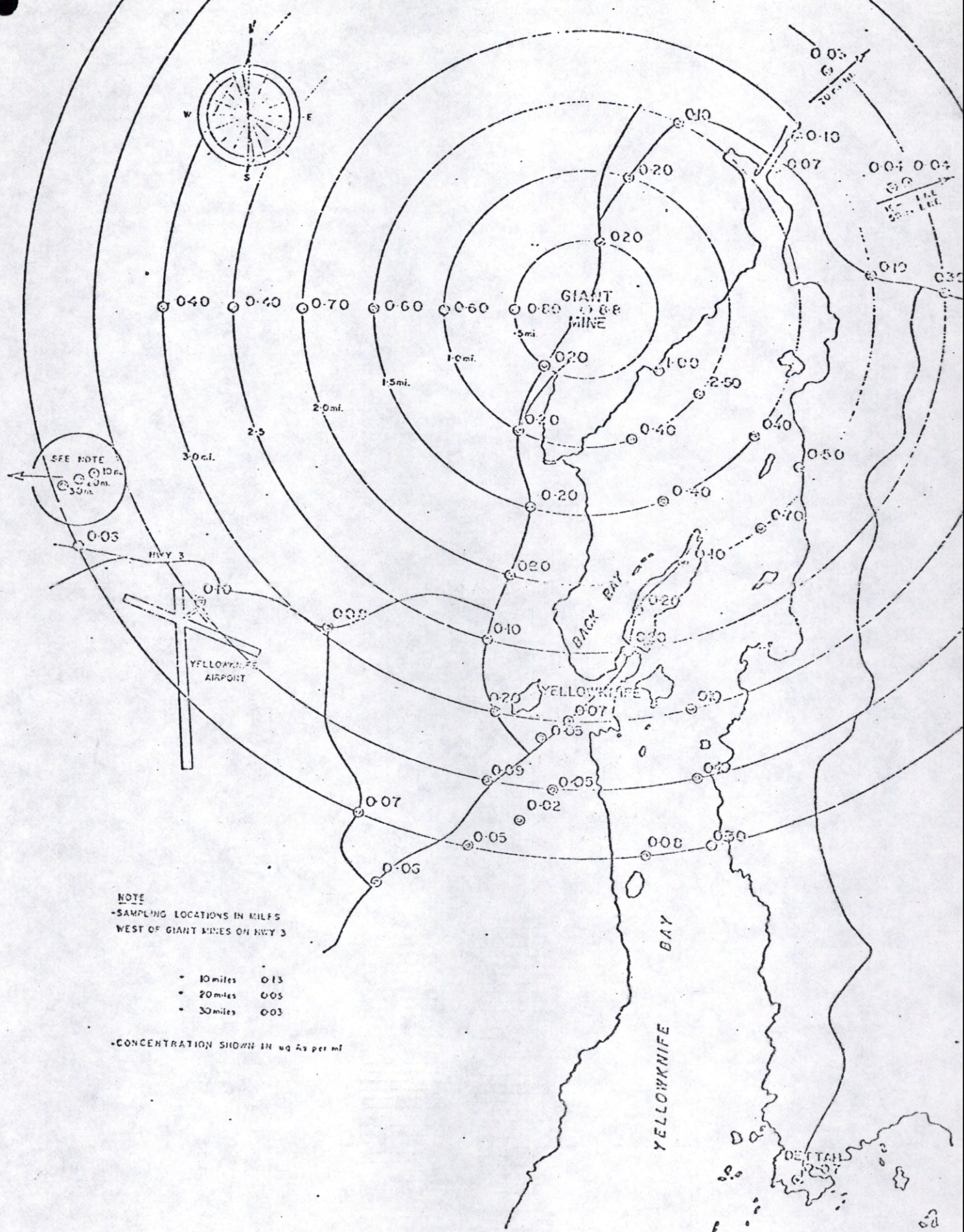
Garden A (Con Mine)	82 ppm
Garden B (Yellowknife town)	52 ppm
Garden C (Yellowknife town)	36 ppm
Garden D (Giant Mine)	287 ppm



ISOCONS OF ARSENIC CONCENTRATION IN SOIL LICHEN AND AO HORIZON SOIL

YELLOWKNIFE, N.W.T.

FIGURE 4 ARSENIC LEVEL MAP CORRELATION, 1975



2) Disturbed Soils

The disturbed soil and road dust study determined arsenic concentrations in area commonly utilized (disturbed) by the local people. Samples were taken in the town and at the Con and Giant mine sites. Analyses were carried out for total and insoluble arsenic. There was no differentiation between the forms of arsenic compounds present.

The study was conducted during the summer of 1975 (May to September) by Mr. R. Martin, EPS, Yellowknife. The procedure, analysis technique, and results are included in his report (16). Figures 6 to 10 inclusive illustrate the soil and road dust sample locations at Con and Giant mine sites and in Yellowknife. Tables 13 and 14 provide a summary of the arsenic concentrations in soil and road dust samples. A description of each site is provided in the report (16).

TABLE 12 - ARSENIC CONCENTRATIONS IN YELLOWKNIFE AREA

O'Toole, Clark, Malaby and Trange

1970

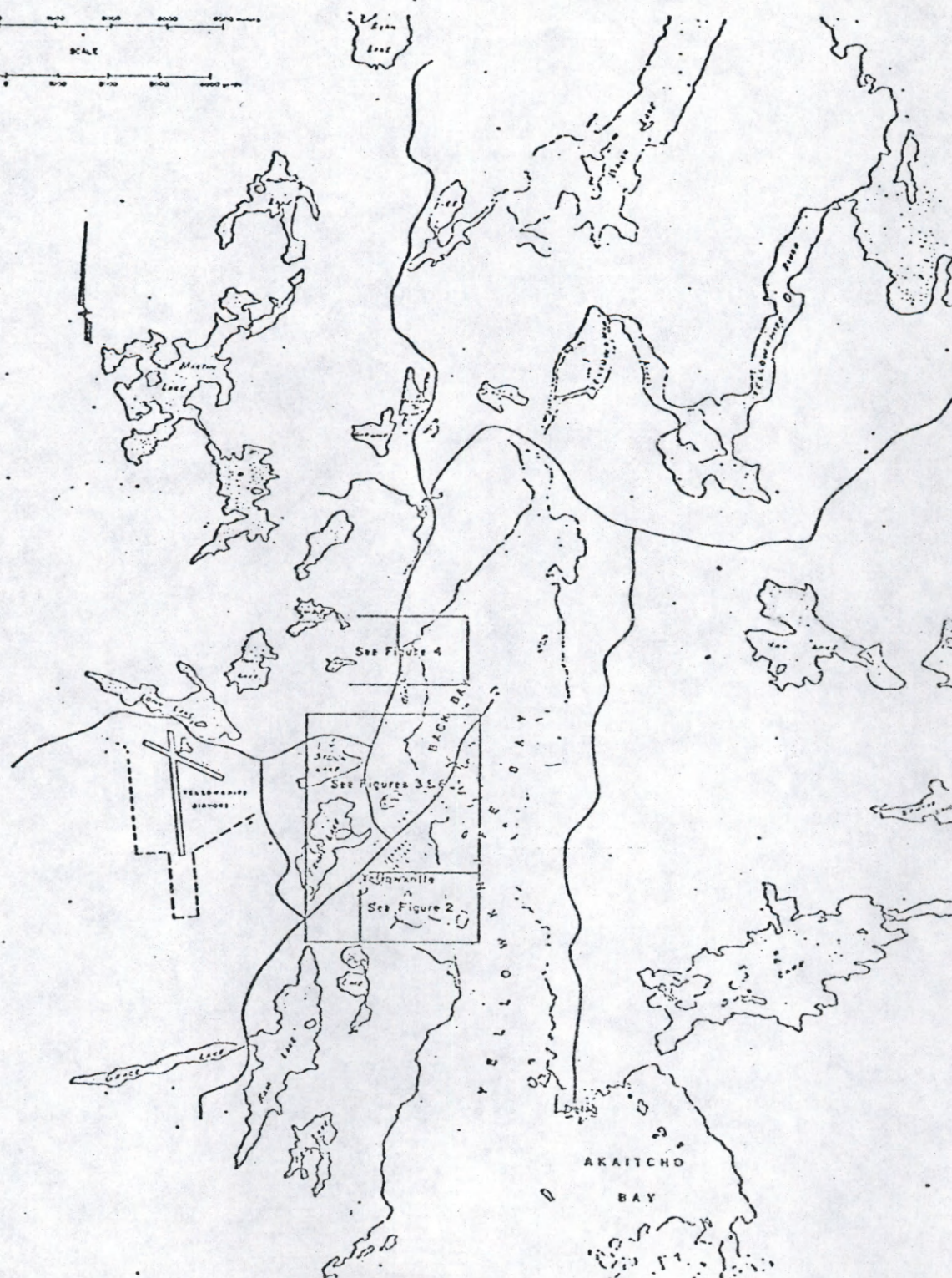
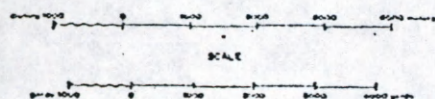
Sample	Distance from smelter (miles)	As (ppm)	Remarks
1	2.7 S.W.	219	Samples 1, 2, 4, 5, 6 and 7 are of mineralized type soils
1A		199	
2	1.9 S. W.	115	
2A		164	Samples 1A, 2A, 4A, 5A, 6A, 7B are of high organic mossy type soils
4	1.2 S. E.	601	
4A		8.4	
5	0.4 N.E.	602	
5A		852	
6	0.3 N.E.	3108	
6A		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	
		172	

A tabulated summary of some various soil studies and available arsenic data is included as a comparison to the results determined by the University of Alberta study.

TABLE 11 - VARIOUS SOIL STUDIES & AVAILABLE ARSENIC DATA

Study	Date	Location	Arsenic (ppm)	Remarks
O'Toole et al (2)	Summer, 1970	Yellowknife area	low of 34	Concentrations for the various samples are presented in the table following.
Temple et al	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 (20)	July, 1975	Yellowknife area	low of 12 to high of 4280	Nine sample locations and 4 soil depths outlined in the Cominco report.
(7)		Agricultural soils	0.1 to 40 range	Health Protection Branch report
(7)		Orchard soils	100	Health Protection Branch report

Yellowknife Bay Area



6
FIGURE 1 GENERAL SAMPLING AREAS

Con Mine Yellowknife

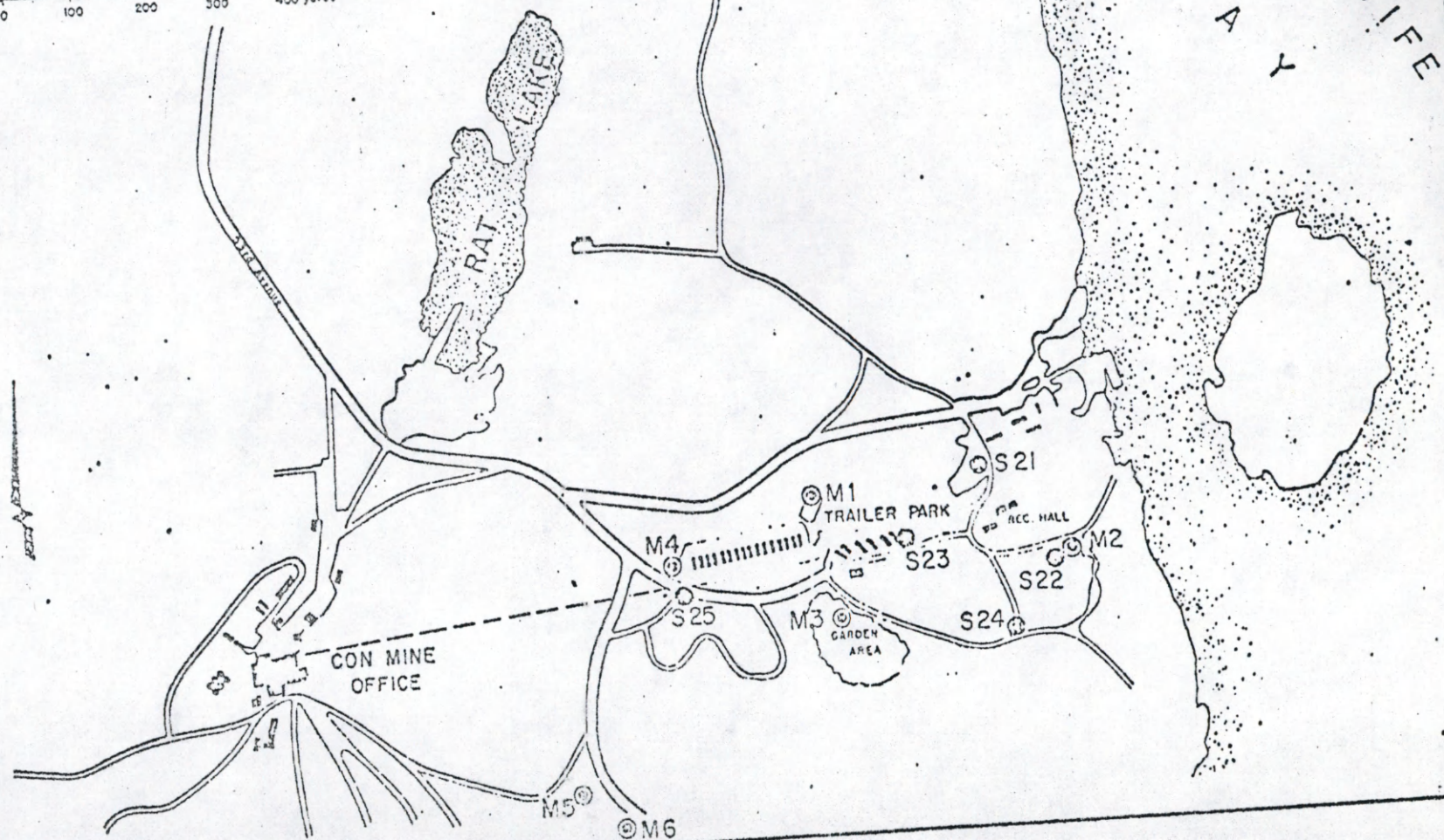
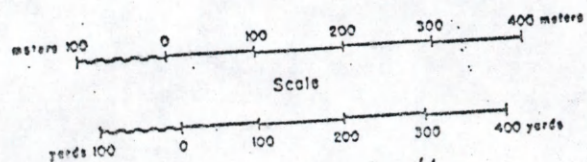


FIGURE 2 LOCATION OF SOIL SAMPLE SITES-1975

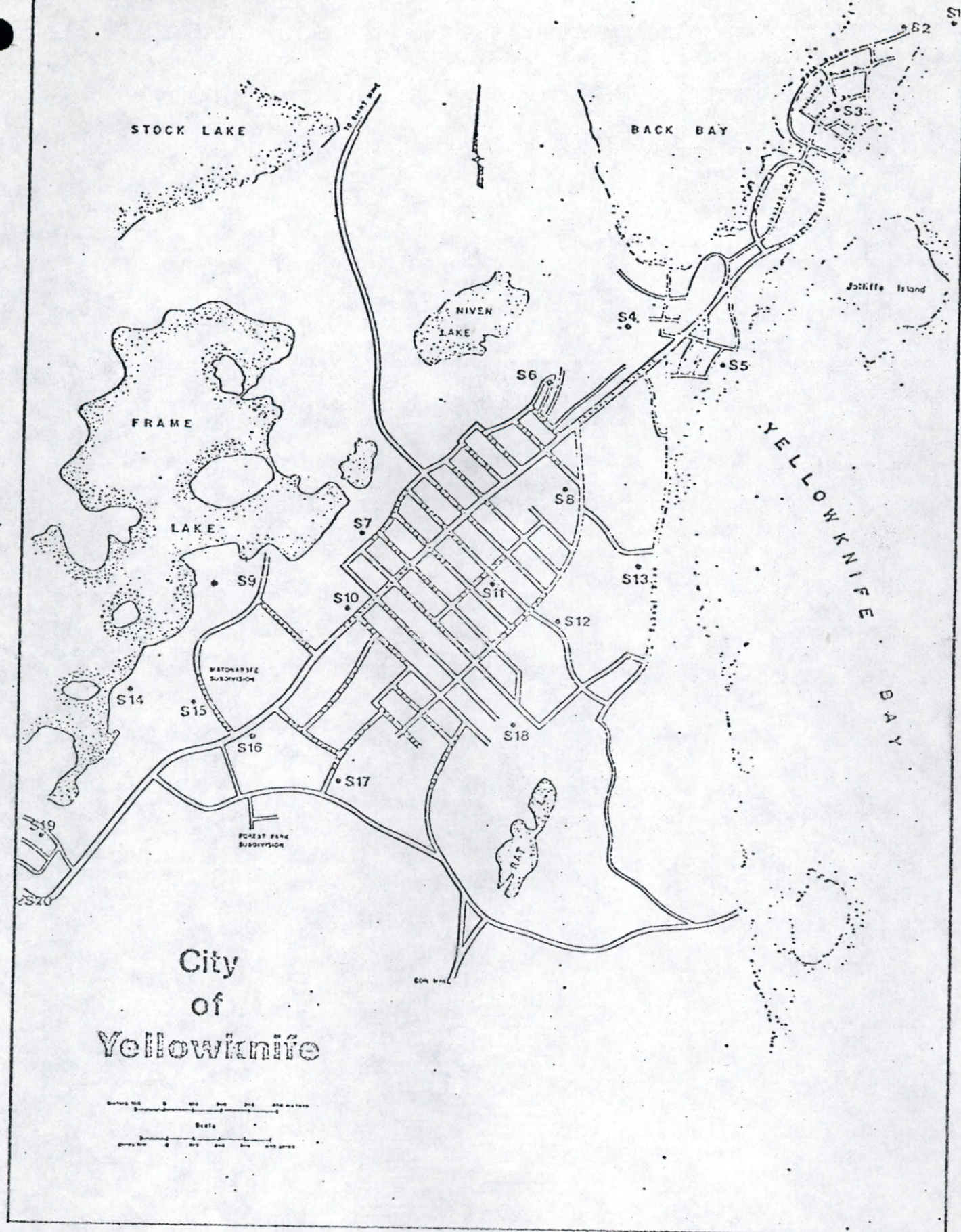
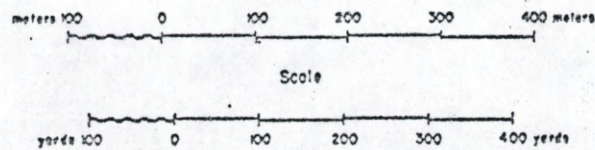


FIGURE 8, SOIL SAMPLE SITES - YELLOWKNIFE PROPER

Giant Mine Area Yellowknife



NOTE.

FROM GIANT YELLOWKNIFE MINES MAP 1967

FIGURE 4 LOCATION OF SOIL SAMPLE
SITES - 1975

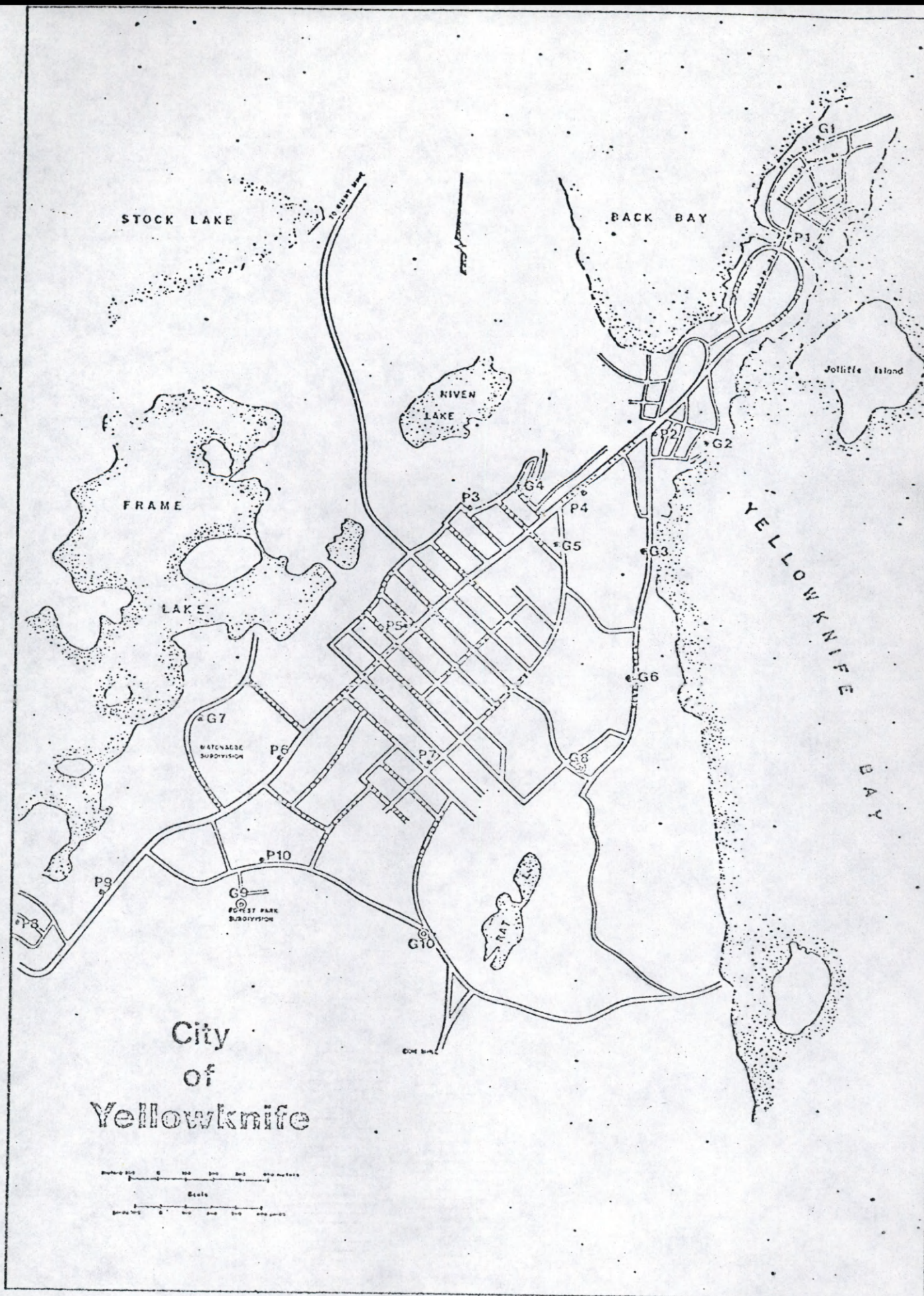


FIGURE 6, ROAD DUST SAMPLE SITES

TABLE 13. - ARSENIC CONTENT OF SOIL SAMPLES, DISTURBED SOILS STUDY
ARSENIC CONTENT OF SOIL SAMPLES

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

TABLE 13 - ARSENIC CONTENT OF SOIL SAMPLES, DISTURBED SOILS STUDY

ARSENIC CONTENT OF SOIL SAMPLES CONT'D

<u>Sample</u>	<u>Location</u>	<u>Total Arsenic (ppm)</u>	<u>Insoluble Arsenic (ppm)</u>
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

Vegetation

1) Soils Study

The soil and vegetation survey conducted by the University of Alberta (11) indicated high levels of arsenic in samples of fruit and vegetables in the Yellowknife area. Results are tabulated below with the garden soil arsenic analyses previously presented (section d.1.) included for comparison. It is evident that washing vegetables and fruit removes the bulk of the contamination. Ten (10) ppm arsenic was the detection limit for the apparatus and technique used for these analyses. More refined analysis is required to provide adequate information on arsenic levels.

TABLE 15 - ARSENIC CONTENT OF VEGETABLES AND FRUIT, U. OF A. STUDY
ARSENIC CONTENT OF VEGETABLES AND FRUITS (ppm)

Garden	Soil	Carrots	Potato			Chard	Lettuce	Rhubarb
			whole	peeled	tops			
A-Con Mine	82	10	10	10	24 (red) 19 (wht)	10	10	
B-Town	52	10	10	10				
C-Town	36	10	16	10			46	
D-Giant	287		10	10			59	16

Wild Fruits

Gooseberries (115⁰; 1.4 km from Con Mine) 21 ppm
Gooseberries (197⁰; 3.4 km from Giant Mine) 10 ppm
Black currants (343⁰; 1.04 km from Giant Mine) 10 ppm

The Health Protection Branch (7) states that "Terrestrial organisms, plants and animals do not accumulate arsenic; ... they discriminate against it and contain relatively low amounts of this element. Most plants contain around 0.1 - 0.2 (ppm) ..." Following is a tabulated summary of some available data on arsenic content of vegetation. It is worth noting that the Canadian Food and Drug Directorate permits 0.5 to 1.0 ppm of arsenic for major foods (e.g. potatoes) and 1.0 to 2.0 ppm for minor foods (carrots, beets, etc.). By comparison, the United States Food and Drug Administration has set a limit of 3.5 ppm for both major and minor foods.

TABLE 14 - ARSENIC CONTENT IN ROAD DUST SAMPLES

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

TABLE 16 - SUMMARY OF SOME AVAILABLE DATA ON ARSENIC CONTENT OF VEGETATION

• ARSENIC CONTENT OF VEGETATION - SUMMARY

(all arsenic values in ppm)

Vegetable	Fruit	Grass, Shrubs	Remarks
1.0 0.1	2.0		Federal maximum acceptable limits. Level for vegetables grown in uncontaminated area.
		12-138 range	O'Toole et al (2) 1970
0.02	0.02-0.10 0.0-5.0		NHW data (7) Canadian apples, 1962-1964; higher results possibly due to use of arsenic compounds as pesticides on fruit crops
0.03-1.28			Cominco survey, August, 1970 (Yellowknife) (20)
0.30-6.80			Leafy vegetables; August, 1971 survey; "as received" analysis; see following table
0.10-2.70			Leafy vegetables; above samples; washed and dried analysis
0.07-1.60			Vegetables; August, 1971 survey; "as required" analyses.
0.01-0.51			Vegetables; above samples; "kitchen cleaned" analysis
1.0	1.0	1.0-62	Temple et al (19). Near smelters (1974)
0.162-0.450	0.102-0.249		Cominco survey, August, 1975 (Yellowknife 20)
10.0	10.0		Detection limit as determined by University of Alberta study (11).

TABLE 17:

ARSENIC CONTENT IN YELLOWKNIFE FRUITS AND VEGETABLES COLLECTED AUGUST, 1971

		Location	As Rec'd	Arsenic ppm Washed & Dried	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 - 204 B. 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	0.61		0.39
	Beets	" "	1.60		0.51
	Rhubarb	" "	-		0.12
	Potatoes	" "	0.96		0.07
13.	Carrots	Mrs. Richardson	0.25		0.07
	Beets	" "	0.49		0.27
	Peas and Pods	" "	0.16		0.08
	Potatoes	" "	0.45		0.02
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

TABLE 17

ARSENIC CONTENT IN YELLOWKNIFE FRUITS AND VEGETABLES COLLECTED AUGUST, 1971 CONT'D

		Location	As Rec'd	Arsenic ppm Washed & Dried	Cleaned As In Kitchen
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	0.49		0.07
	Potatoes	" "	0.34		0.06
	Onions	" "	-		0.49
	Peas and Pods	" "	0.11		0.06
17.	Onions	5018 - 54 Street	0.73		0.77
	Beans, green	" "	0.07		0.25

Results indicate that vegetables and fruits grown in a contaminated area contain arsenic chiefly at the surface and that customary cleaning procedures reduce the arsenic content to what would be considered "normal" levels. Therefore, as long as vegetables and fruit are washed and cleaned prior to eating, there should be no major problem.

2) Plant Ecology Survey

According to Kuchar (17), pollution zones around smelters normally follow the prevailing wind pattern. In the Yellowknife area, he found that deterioration of vegetation was most severe west and northwest of the Giant stack; less severe to the south, and rapidly diminished to the east and northeast. Close to Giant's stack, the vegetation is greatly damaged, no doubt due to air pollution sources. More research would be required to determine if the cause of vegetation injury is due to sulfur dioxide (SO_2) or due to arsenic compounds.

f) Fish and Wildlife

Fish samples have been analyzed for arsenic concentration (21). Fish were taken from Baker Creek as well as from a control area (East Minage Island). In all samples, arsenic concentrations were 0.2 ppm. According to the Food and Drug Act, the maximum allowable arsenic concentration in marine and freshwater animal products is 5.0 ppm. Toft et al (7) presents a tabulation of arsenic concentrations in a variety of fresh and marine water fish samples.

The Wildlife Branch of the Government of the Northwest Territories conducted a brief survey during February, 1976 on small wildlife in the Yellowknife area (18). Results are briefly summarized below.

TABLE 18: ARSENIC CONTENT OF SMALL WILDLIFE

(value are in ppm)

Wildlife Sample	<u>Arsenic Content</u>		
	Low	High	Average
Willow ptarmigan (9 Samples)	0.10	0.75	0.45
Snowshoe Hare (1 Sample)			1.44
Raven (5 Samples)	0.10	0.10	0.10

According to Toft et al (7), most animals contain less than 0.10 to 0.20 ppm arsenic.

g) • Human Health

Schafer (4) investigated arsenic exposure in workplace areas at the two gold mine milling operations in Yellowknife during 1975. On the basis of observations and air sampling measurements made, it is considered that workers in the Yellowknife gold mills are not unduly exposed to harmful arsenic-in-air concentrations (4). Air sample values were compared with a value of 0.05 mg As/m^3 of air. This is a value under which it is believed that nearly all workers may be repeatedly exposed day after day without adverse effect. This comparison was made to assist in assessing the degree of health hazard. All concentrations determined in this study were below the limit of 0.05.

Schaefer recommended the annual monitoring of arsenic exposures be continued, especially for those who worked in roasting and gas treatment processes. He also recommended preventative measures be implemented at the work site. These included:

- 1) Posting of workplace safety instructions with the intent of minimizing exposure to arsenic oxide dust;
- 2) Provision of safety equipment and facilities (respirator and shower baths) for employees who regularly work in the cottrell and baghouse areas.

Schafer also investigated arsenic levels in human hair samples during the summer of 1975 (22). Arsenic levels in hair are not a measure of a degree of health hazard as can be seen from the following summary of average arsenic levels in healthy humans (7):

Bone 0.057 ppm	Nails 0.3-0
Hair 0.510	Skin 0.090
Kidney 0.033	Stomach 0.037
Liver 0.028	Blood 0.380

Levels up to 10 ppm arsenic in hair have been found in populations with no known exposure to arsenic (22). Hair samples may contain 15 to 15 ppm arsenic (7). O'Toole obtained a mean value of 13.5 ppm, based upon 12 hair samples in his 1970 study (2).

However, arsenic levels in hair do indicate degree of exposure to arsenic and are of value in determining whether individuals should be further examined for body levels.

During the summer of 1975, 700 persons were tested in Yellowknife:

	<u>under 5ppm</u>	<u>5-10 ppm</u>	<u>over 10 ppm</u>	<u>total</u>
Mine and Mill Workers	61	30	44	135
Other residents	<u>516</u>	<u>30</u>	<u>19</u>	<u>565</u>
All person tested	577	60	63	700

The information indicates that there is no evidence that the general public of Yellowknife is exposed to excessive or dangerously high levels of arsenic.

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ARSENIC SAMPLING IN THE YELLOWKNIFE VICINITY

During the 1976 Spring melt and runoff period water samples were collected from a variety of sources around the city of Yellowknife and analysed for arsenic content at the Yellowknife Water Laboratory. This sampling program was initiated and carried out during the Spring melt and runoff season for the purpose of measuring arsenic levels in the Yellowknife area when they are at their highest. The entire winter accumulation is suddenly released to the aquatic environment during this short period. Canada Drinking Water Standards (1969) set an acceptable limit for arsenic at 0.01 ppm and a maximum limit at 0.05 ppm.

On April 13, 1976 the first date of sampling, the spring melt was in the early stage; flows were minimal and ice cover remained on all lakes and rivers. On April 27 the melting rate was near its maximum; the Yellowknife River was flowing, surface runoff flows were peaking and most lakes were melting around the edges. On May 11 the melt was nearing completion; surface runoff was beginning to decrease and most lakes had only ice patches remaining. On June 11 several of the drainage ditches and surface meltwater pools were dry.

SAMPLE DESCRIPTIONS (SEE ATTACHED MAP)

- 1) Yellowknife River - at the bridge on the Ingraham Trail. On April 13, 1976 the river was ice covered and a sample of meltwater was collected from a small pool on the surface of the ice. The arsenic content at that time was 0.09 ppm; however on April 27 and May 11 the river ice was gone and samples were collected from the river water, arsenic contents on those dates were 0.001 ppm and 0.0009 ppm respectively. Arsenic content of the river water on June 11 was 0.0008 ppm.
- 2) Giant Mine Tailings Pond - On April 13, 1976 a sample was collected from the meltwater at the edge of the tailings area and the arsenic level was measured as 13.9 ppm. On April 27 and May 11 samples were collected from a seepage pond just outside the tailings area dyke. Arsenic levels on those dates were 2.8 ppm and 5.7 ppm respectively. This seepage is pumped back

into the tailings area. The arsenic level of the water in the seepage pond on June 11 was 6.0 ppm.

- 3) Surface Meltwater on Giant Mine Property - On April 13, 27 and May 11, 1976 samples of surface meltwater were collected from a shallow pool beside the road around the Giant Mine Tailings Area. Arsenic levels on those dates were measured at 0.023 ppm, 0.23 ppm and 0.30 ppm respectively. On June 11 this area was dry.
- 4) Giant Mine Tailings Area Effluent - Samples were collected of the discharge from the Giant Mine Tailings Area as it passes under the Ingraham Trail and enters Baker Creek. On April 13, 1976 a flow had just begun and the arsenic level was measured as 31.0 ppm. On April 27, 1976 the flow was peaking near maximum and the arsenic level was 4.20 ppm. On May 11, 1976 the flow had dropped substantially and the arsenic level was 14.4 ppm. On June 11 the flow was approximately the same as during May and the arsenic level was 9.5 ppm.
- 5) Baker Creek - On April 13, 27 and May 11, 1976 samples were collected from the upstream side of the culvert under the road the Giant Mine Open Pit area. These samples represent arsenic levels after the tailings area effluent has been diluted with the fresh water in Baker Creek. Measured levels of arsenic on the dates specified were 1.20 ppm, 1.20 ppm and 0.70 ppm respectively. On June 11 the arsenic level was 0.80 ppm.
- 6) Mouth of Baker Creek - On the same dates samples were collected from the mouth of Baker Creek as it discharges into Yellowknife Bay. Arsenic levels on April 13, 27 and May 11, 1976 were measured as 1.50 ppm, 1.00 ppm and 0.73 ppm respectively. On June 11 the arsenic level was 1.32 ppm.
- 7) Near Junction of Giant Road and Airport Road - On the northeast side of this junction there is a slough. On April 13 this slough was covered with ice and snow so a sample of runoff water was collected from the ditch beside the road and the arsenic level was 0.036 ppm. On April 27, 1976 the slough

was open and melting near the edge; arsenic in the meltwater was 0.28 ppm. On May 11 the slough surface was completely ice free and the arsenic level was 0.068 ppm. On June 11 the arsenic level was 0.17 ppm.

- 8) Surface Runoff to Stock Lake - On April 13, 1976 surface meltwater was collecting in pools and was sampled from one such pool near the Bristol Monument; arsenic level was 0.075 ppm. On April 27 the surface runoff was flowing rapidly beside the airport road down toward Stock Lake. A sample was collected as the meltwater passed through the culvert under the road and into Stock Lake; the arsenic level was 0.184 ppm. On May 11 the flow in the ditch beside the road was slightly reduced and the arsenic level was 0.160 ppm. On June 11 a sample was collected from Stock Lake itself beside the new Airport Road and the arsenic level was 0.096 ppm.
- 9) Long Lake - On April 13, 1976 the lake was completely ice covered so a sample of meltwater flowing into the lake was collected near the boat ramp at the picnic area beside the beach; the arsenic level was 0.030 ppm. On April 27 and May 11 the lake was ice free near the edge and arsenic levels in the lake itself were measured at 0.048 ppm and 0.074 ppm. Arsenic level in Long Lake on June 11 was 0.122 ppm.
- 10) Surface Meltwater near Northland Trailer Court - On April 13, 27 and May 11, 1976 samples were collected from a pool of meltwater on the south-east side of the junction of Franklin Avenue and the road to the Correctional Institute. Arsenic levels on those dates were 0.014 ppm, 0.056 ppm and 0.035 ppm respectively. This meltwater appeared to be seeping slowly in the direction of Kam Lake. On June 11 the area of sampling was dry so a sample was collected from Kam Lake itself at the north end. Arsenic level was measured at 1.45 ppm.
- 11) Yellowknife Bay at Con Mine Pumphouse - On April 13, 1976 a sample was collected from inside the pumphouse; arsenic level was 0.032 ppm. On April 27 and May 11 the ice was melting back from the shore and samples

were collected from the bay just outside of the pumphouse; arsenic levels were 0.015 ppm and 0.016 ppm. This water is used only for industrial purposes in the mill. On June 11 a sample was collected from the pipeline within the pumphouse and arsenic level was 0.22 ppm.

- 12) Back Bay at Rainbow Valley - On April 13, 1976 ice cover was solid and a sample of meltwater was collected from a small pool on the surface; the arsenic level was measured as 0.177 ppm. On April 27 and May 11 the ice was melting around the shoreline and samples were collected near the edge; arsenic levels were 0.08 ppm and 0.016 ppm. On June 11 the arsenic level was 0.36 ppm.
- 13) Rat Lake - On April 13, 27 and May 11, 1976 samples of surface runoff water were collected from a small stream running beside the ore stock pile at the end of Con Mine Road as the stream entered Rat Lake. Measured arsenic levels on those dates were 0.16 ppm, 0.45 ppm and 0.40 ppm respectively. On June 11 the runoff stream was dry so a sample was collected from Rat Lake itself at the south-east end and the arsenic level was measured at 0.56 ppm.
- ✓14) Con Mine Tailings Area - On April 13, 1976 the Con Mine Tailings Area was still frozen but a sample of surface metwater was collected near the control dam at the outlet in Pud Lake; arsenic level was 4.0 ppm. On April 27 and May 11 the tailings area was melting and an outflow was discharging at the control dam. Arsenic levels measured in samples of that outflow on those dates were 4.2 ppm and 7.4 ppm. This discharge flows to Meg Lake from which it seeps its way through a series of swamps and small lakes and eventually enters Great Slave Lake. On June 11 the control dam was blocked with stop logs and no water was being discharged. A sample of water was collected from within the tailings pond and arsenic level was 3.6 ppm.
- 15) Meltwater beside City Snowdump Area - On April 13, 27 and May 11, 1976 open water was sampled in a ditch beside the snow dump area located approximately one half mile north of Niven Lake on the east side of the highway. Arsenic

levels were measured at 0.044 ppm, 0.056 ppm and 0.035 ppm. On June 11 the arsenic level was 0.058 ppm.

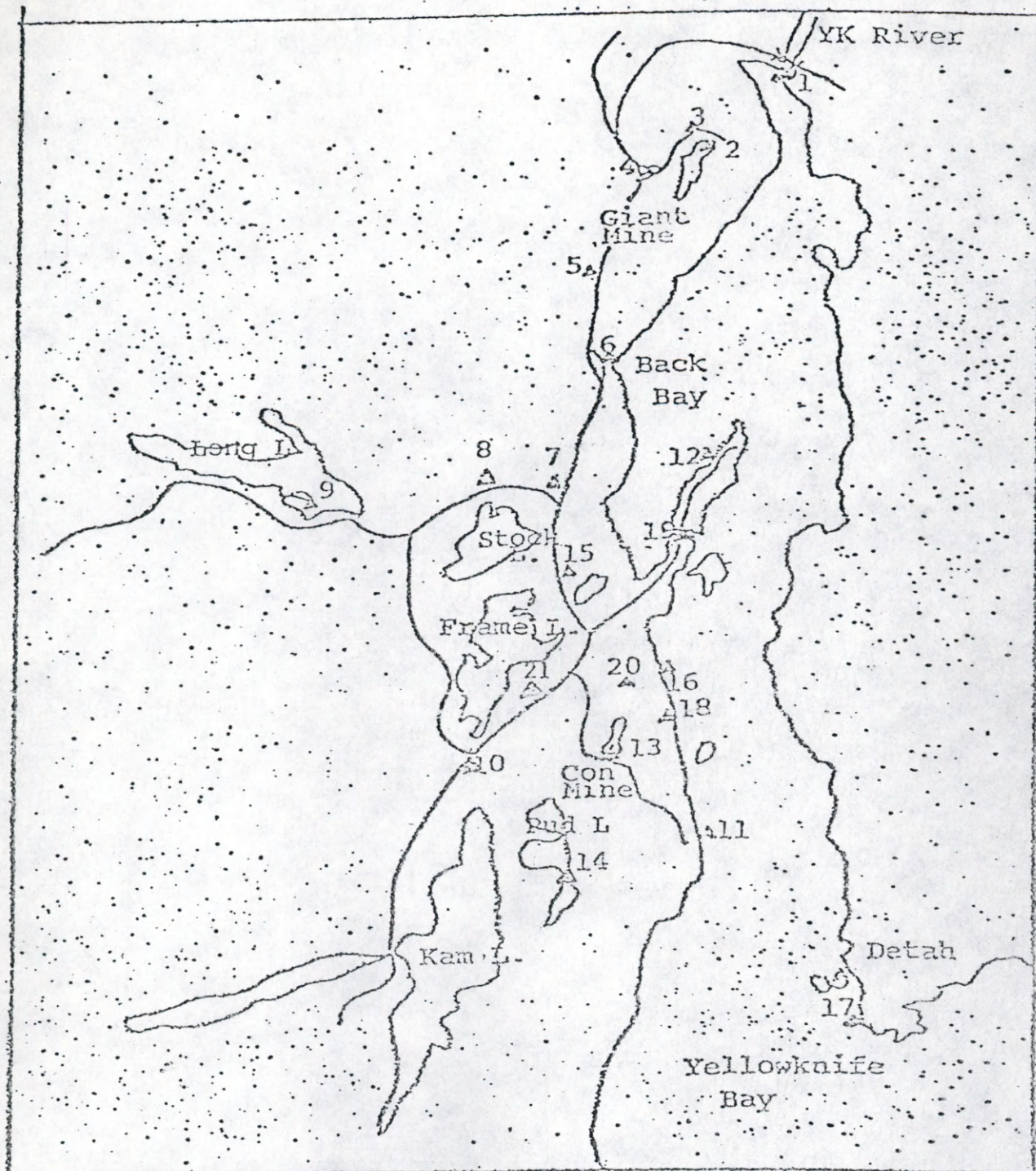
- 16) Yellowknife Bay at Schooldraw Road Culvert - On April 13, 27 and May 11, 1976 surface runoff water from the Schooldraw Road area was sampled as it passed under Schooldraw Road into Yellowknife Bay. Arsenic levels were measured as 0.012 ppm, 0.052 ppm and 0.024 ppm. On June 11 the arsenic level was 0.067 ppm.
- 17) Village of Detah Water Hole - On April 13, 27 and May 11, 1976 water samples were collected from a hole in the ice just offshore from the Village of Detah. The arsenic levels measured on those dates were 0.0043 ppm, 0.0070 ppm and 0.0050 ppm respectively. On June 11 a water sample was collected from a point of land at the edge of Detah. The arsenic level was 0.0034 ppm.
- 18) (a) City of Yellowknife Water Supply - On April 11, 27 and May 11, 1976 samples were collected at the Schooldraw Road pumphouse of water which is pumped from the Yellowknife River. Measured arsenic levels on those dates were 0.0007 ppm, 0.0001 ppm and 0.0005 ppm respectively. On June 11 the arsenic level was 0.0046 ppm.
- 18) (b) City of Yellowknife Emergency Water Supply - On April 13, 27 and May 11, 1976 water samples were collected of Yellowknife Bay from the wet well in the Schooldraw Road pumphouse. Measured arsenic levels on those dates were 0.0045 ppm, 0.0090 ppm and 0.020 ppm respectively. This water is used in emergency situations only when the water supply from the Yellowknife River is inadequate, such as during a fire when the demand for water is high. On June 11 the arsenic level was 0.014 ppm.
- 19) Causeway to Latham Island - On April 13, 1976 a water sample was collected from a hole drilled through the ice on the northside of the causeway to Latham Island. The arsenic level was measured as 0.0036 ppm. On April 27

and May 11, 1976 water samples were collected from the open water on the northside of the causeway; the arsenic levels were measured as 0.007 ppm and 0.017 ppm respectively. On June 11 the arsenic level was 0.036 ppm.

- 20) City of Yellowknife Tapwater - Tapwater is sampled every week on a routine basis at the Yellowknife Water Laboratory. Measured arsenic levels in the tapwater on dates closest to the sampling dates of April 13, 27 and May 11, 1976 were 0.0005 ppm, 0.0008 ppm and 0.0005 ppm respectively. This sampling program is carried out year round. Also the two samples from the Schooldraw Road Pumphouse (#18(a) and 18(b)) are collected once every month, year round, and checked for arsenic. So far no arsenic levels have been measured above the Canadian Drinking Water Standards acceptable level of 0.01 ppm. In fact most values are between 10 and 100 times lower. On June 11 the tap water arsenic level was 0.0005 ppm.
- 21) McNiven Beach Slough - On April 13, 1976 the slough on the northside of Franklin Avenue near the McNiven Beach entrance was frozen solid and no sample was collected. On April 27 and May 11, 1976 the slough was draining toward Frame Lake and water samples were collected at the discharge point in the slough. Measured arsenic levels were 0.012 ppm and 0.015 ppm on those dates respectively. Seepage water from a construction site on the south side of Franklin Avenue was being pumped into this slough as well. On June 11 the outflow from the slough was minimal so a sample was also collected from Frame Lake. Arsenic level in the slough was 0.011 ppm and in Frame Lake it was 0.27 ppm at McNiven Beach.

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Arsenic sampling sites in vicinity of Yellowknife. 1976