ARSENIC LEVELS IN BERRIES AND SOILS FROM THE WELEDEH YELLOWKNIVES DENE FIRST NATION TRADITIONAL TERRITORY

1.0 INTRODUCTION

The Yellowknives Dene have been occupying the land around the Yellowknife River, or *Weledeh*, for over 10,000 years. During this time, they have lived in complete harmony with the land; having very little impact on the environment. They relied almost completely on the plants (berries, lichens, roots, etc.) and animals (caribou, fish, birds, etc.) they found locally (the only exception was trade with other tribes) as they travelled with the seasons to places they would be closest to their food supply, shelter and water. Parts of their traditional territory include what is now the Ingraham Trail, the Yellowknife River, Wool Bay, parts of the East Arm of Great Slave Lake, Gordon Lake, the barrens and MacKay Lake. Throughout the generations, they passed down essential knowledge of the land and resources necessary for nutrition, survival, medicine, travel, religion and culture.

In the 1920's the traditional lifestyle of the Yellowknives Dene began to change. Prospectors from the south came into the area. Since the local people had never seen white man before, they feared them. These newcomers caused many changes, including introducing the fur trade, diseases which reduced the numbers of the Yellowknives Dene, a different religion and mission school. One of the largest impacts on these people was from the discovery of gold and the release of arsenic which resulted from the gold mining.

Gold was discovered in the 1930's and the gold rush started soon after. Yellowknives Dene had seen changes which had taken them from a semi-nomadic people living totally off the land to living in settlements, sending their children to mission schools, to learning foreign ways and a foreign religion.

The Yellowknives Dene, who did not understand English, knew very little about the changes that were taking place in their traditional territory. Without understanding the full reason why, they saw populations of moose and caribou becoming reduced and fish species becoming very sparse or extinct in the Yellowknife River. They named the river *Weledeh,* which means Coney River in their language

(Coney is also known as *inconnu)*, because they used to be so plentiful there. This fish species is no longer present in the river due to contamination and overfishing (Weledeh Yellowknives Dene, 1997a).

The traditional lifestyle of the Weledeh People (they named themselves after the river that sustained them) made them healthy, active and strong. People rarely got sick. However, when they were introduced to the new culture, they were also introduced to chemicals and poisons they knew nothing about. One of the main poisons inflicted on the Weledeh people and their lands was arsenic.

1.1 Arsenic

Arsenic (*As*) is an element occurring naturally in the environment, most often as a compound with sulfur and other metals. *As* is a natural constituent of approximately 245 other mineral species (NRC, 1976). Common *As* compounds include *As* with copper cobalt, silver, lead and zinc. Some natural sources of arsenic include shales, clays, phosphate rocks, and sedimentary iron and manganese oxides (NRC, 1976).

Trace levels of *As* are naturally present in water. Natural variability exists between different bodies of water. Hot springs, areas with rocks high in *As* content and ground waters from areas of thermal activity are reported to have a naturally high *As* content (NRC, 1976).

At low levels, arsenic is present in all living things and occurs everywhere in the environment. There has been suggestion that *As* may be a micro nutrient, although this has not been documented (Phillips, 1989). However, at higher than trace levels, environmental and health problems can occur.

As is a natural element; it is released into the environment by being transferred from one form to another. In some forms, such as those found in rocks, *As* is relatively dormant; it is tied up by other minerals and released, usually slowly, into the air, water and soil by weathering, volcanoes and soil and sediment volatiles. Worldwide, the combined *As* release from these sources is 69 x 10^6 Kg/yr (Cullen, 1997). Natural processes rarely release *As* at toxic levels. The reverse of weathering - fixing

- back into the rock and mineral compounds, takes place at the approximately the same rate as weathering, creating a constant level of available *As* in the environment. However, when rocks are treated with acids and other chemicals and high heat, the *As* is released, mainly as arsenic trioxide, many times faster then by nature, creating unnatural conditions toxic to nearly all organisms. Human activity releases about 160 x 10^6 Kg/yr (Cullen, 1997). The *As* by-products released after treatment of *As*-containing rocks are manufactured into other forms. The most common form, white arsenic (As_2O_3), also known as arsenic trioxide, has a variety of uses.

Pesticides, made from *As* compounds since the late 19th century, make up the greatest consumption of arsenic worldwide. The toxicity of arsenic trioxide make it useful in killing unwanted pests including insects, weeds, fungi, algae, and parasites ((NRC, 1976). Arsenic compounds were widely used in agriculture prior to 1975 (Government of Canada *et al.*, 1993).

Arsenic compounds are also used as desiccants, feed additives, drugs and war gases and riot control agents (NRC, 1976). Today, the most common use for arsenic is in wood preservatives (Dillon Consulting Limited, 1997). Arsenic compounds stay in the environment and may become an environmental hazard if they are over-used or if runoff occurs. One example of an environmental hazard is high *As* levels found in macadam products in Sweden, which are used for construction materials for roads, railways and filling material for house building. These products are by-products of an iron mine. The levels of *As* found in these products were found to be higher than the proposed levels of the Department of Environment (Qvarfort, 1992).

The annual additions of arsenic to land is an average of about 98 x 10^6 Kg worldwide (Government of Canada *et al.*, 1993), mainly from commercial products such as those listed above, coal fly ash and bottom ash, atmospheric fallout, mine tailings and smelter slag wastes.

1.2 Gold Mining in Yellowknife

In Canada, arsenic is released into the environment primarily from base-metal and gold production. Mining is one of the main employers of, and the largest single tax base in, the NWT (Scott, 1984) with 1500 people employed directly and 3000 indirectly, and another 500 in exploration (NWT Chamber of Mines, 1999). Mining has caused a dramatic change in the Northwest Territories from the time prior to the 1930's. The mining industry has made Yellowknife, the capital of the NWT, one of the fastest-growing regions in Canada and has had a profound influence on the *Yellowknives Dene First Nation*, the indigenous people who live there.

Gold mining is prominent throughout the Yellowknives Dene traditional territory. At gold mines with ore roasters, such as the *Giant Yellowknife Mines*, (see Figure #1) *As* can escape into the air and go through the environment under certain conditions (Government of Canada *et al.*, 1993). Early mines had little or no environmental control on disposal of wastes and mine wastes were deliberately expelled into waterways (Bernard, 1983; Cornett *et al.*, 1992; Marron, 1989; Mudroch and Clair, 1986, Mok and Wai, 1989). *Giant Yellowknife Mines* and *Miramar Con Mines*, both in the Yellowknife area, were no exception to this.

YELLOWKNIFER, Wednesday, September 1, 1999 A3

NNSL file photo

Figure #1
***Giant Mine** is still believed to be the most significant source of As in the Yellowknife area (Environmental Protection Services, 1996). This is one of only two gold mines in Canada with ore roasters. Ore roasting releases toxic arsenic trioxide into the air.*

When gold is mined, the ores are treated with cyanide, bringing *As* into solution. This solution is

Your report (forwarded to me via Carla Barry) did not contain any indication of the arsenic levels found in the samples. In this case, where there is no pre-existing tolerances or Maximum Residue Limit, it is important to know the situation prior to doing the health hazard evaluation (HHE). That includes knowledge about the consumption of the product, ie is it a significant portion of the diet, are children consuming them, etc?., as well as the levels of contaminant in the samples.

The short answer to your question is that there is no legal guideline or limit in the FD Act and regulations that apply to this situation and a HHE is required.

In order to get an HHE I suggest that you contact

Mr. John Salminen of Health Canada. He can be reached at (613) 957-1700.

regards

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Subject: Re: arsenic in berries
Content-Disposition: inline

As you have mentioned in your E-mail, there currently exists no guideline for arsenic in berries, and, therefore, I cannot provide advise to the use of a suitable guideline. Health hazard assessments for levels of arsenic in berries are conducted on a case by case basis.

If you wish, you could request this office to undertake a health hazard assessment of the levels of arsenic found in these berries. In this regard, information on the types of berries, speciation of the arsenic (inorganic or organic, if this has been determined), and the detection levels for the methodology used would be of assistance. It would be preferable to achieve the lowest levels of detection available using the methodology currently available.

Dear Tim

I have examined the paper Arsenic levels in berries and soils from the Weledeh Yellowknives Dene first nation traditional territory

The methods used in the study appear appropriate re collection of samples, analysis of arsenic and statistical analysis of results. A criticism that might arise is what precautions were taken to avoid cross contmination between samples. This is explained in appendix C but should be stressed in the methods in the paper. Rather than using tables in Apendix F it would be better to use bar graphs of the means with lettering above the bars indicating statistical significance at p = .01 ie the 99% confidence level. It is stated in the conclusions that there was no correlation between As in the berries and As in the soil. This statement weakens the argument put forth in the paper it should be further anaysed by using a regression analysis eith Arsenic levels in the berries as the y axis and As levels in the soil as the X axis. A line could be plotted and above the line show the r squared value. The conclusion section could be expanded and strengthened but there may be political reasons for not stating strong conclusions. The recommendations are appropriate and stress that more information on the species of Arsenic in the berry samples needs to be determined. Is this a proposed new project or is it possible to analyse existing samples? The study appears to be carried out accurately and utilized appropriate scientific methodology and analysis. The results could be presented in a more dramatic fashion by means of colour coded graphs. It cannot be conclude that the arsenic levels pose a definite health risk as the species of arsenic found in the berries is not known. However one of the recommendations from the study may be the posting of signs in Inuit and english that berries should not be consumed from the sites showing the highest Arsenic levels or berries should be washed. The study has outlined the problem and presents preliminary results but without further research the main recommendations about the danger to human health of consuming berries with high Arsenic levels cannot be made. I hope the comments I have made about the paper will not be taken as a criticism of the paper but as suggestions on how to improve the presentation of results and the strengthening of conclusions.

(TJB) Gary's mistake, He meant to say "Dene languages".

Yours truly

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Summer 1998

COMMUNITY REPORT

ARSENIC LEVELS IN BERRIES AND SOILS FROM THE WELEDEH YELLOWKNIVES DENE FIRST NATION TRADITIONAL TERRITORY

Summer 1998

Prepared for

Yellowknives Dene First Nation

Northern Contaminants Program
Department of Indian Affairs and Northern Development

By

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Contaminants Division

March 31, 1999

Yellowknives Dene First Nation
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ABSTRACT

Yellowknives Dene First Nation members have been concerned with possible arsenic (*As*) contamination of their traditional foods. This study was done to determine *As* levels in six traditionally important berry species in the *Yellowknives Dene First Nation* traditional territory. Throughout the summer of 1998, samples of highbush blueberry (*Vaccinium ovalifolium*), lowbush cranberry (*Vaccinium vitis-idaea*), rose hip (*Rosa acicularus*), gooseberry (*Ribes lacustre*), raspberry (*Rubus idaeus*) and cloudberry (*Rubus chamaemorus*) were collected from various locations along with a soil sample from each site. Frozen samples were sent to *Centre for Indigenous Peoples' Nutrition and Environment* (CINE) to be analysed for total arsenic. The Kolmogorov-Smirnov and Kruskal-Wallis tests revealed a statistically significant difference between *As* in berries from both the control and Dettah sites compared with all other locations. The berry and soil samples from the mine sites and within the city of Yellowknife had statistically higher levels of *As* than those from the control sites.

Acknowledgements

We would like to first thank all the Yellowknives Dene First Nation (YDFN) members who took part in the study. Thanks especially to elders Joe Martin, Michel Paper, Helen MacKenzie and Alexie MacKenzie who helped us to locate, identify and harvest traditionally important berry species. Thanks also to elders Judy Charlo, Helen Tobie and Therese Sangris who gave us valuable information concerning berries, traditional foods and traditional practices as well as environmental and historical information. Boat travel, necessary and definitely appreciated, was made possible by Paul MacKenzie and Louis Martin. Translators Lena Drygeese and Mary-Jane Betsina helped us overcome the language barrier between the elders and the project team; Margaret MacKenzie, of *Yati Translations Ltd.* translated the abstract into the Weledeh dialect. Thanks also to Chief Fred Sangris and YDFN Land & Environment coordinator, Rachel Crapeau, for their input throughout the study. The Dene Nation would also like to thank the project team: Denise Maxwell and Eric Davey, Dene Nation Lands and Environment Department; and Glen Stephens, Contaminants Division, DIAND, for their research and drafting of this report.

We would also like to thank the many people from outside the community who helped make this study possible. Dr. Laurie Chan and the laboratory technicians at *Centre for Indigenous Peoples' Nutrition and Environment* (CINE) analysed our samples and provided us with information on arsenic. Thanks to samplers Bill Shopa, of *Bathurst Arctic Expediting*; Amanda Peterson, of *Peterson's Point Lake Lodge* and Ragnar Wesstrom, of *Enodah Wilderness Travel,* who obtained samples from remote areas we could not travel to. Thanks to Clarissa Richardson for providing us with maps generated by GIS. The environmental representatives from both *Miramar Con Mine* and *Giant Mine,* Mike Borden and Stephen Schultz, respectively, were very co-operative and helpful in escorting us to locations around the mine sites in our search for berries.

Funding for this study was provided by Northern Contaminants Program, DIAND.

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treated with ferric sulfate or ferric chloride, resulting in most of the *As* being trapped in tailings ponds. Before the 1970's, gold roasting contributed to nearly one half of the 3700 tonnes of *As* being released into the air. By 1982, the change from roaster to hydro metallurgical methods reduced the *As* release in Canada to 19 tonnes (Government of Canada *et al.*, 1993).

There are two gold roasters in Canada - *Giant Yellowknife Mines* in Yellowknife, NWT and *Golden Bear Mine* in northwestern British Columbia. Gold roasters are known for their emission of toxic arsenic trioxide released into the air. *Giant Mine* installed an electrostatic precipitator/bag house emission control system on the roaster stack in the 1970's. This reduced the *As* released into the air to 8.8 tonnes annually by *Giant Mines*.

Giant Yellowknife Mines began production in 1948 and had nearly continuous production since then. Located just north of the city of Yellowknife on the Ingraham Trail, it is surrounded by many bodies of water. This mine was in production a few decades before environmental regulations on tailings disposal and mine discharge were in place and arsenic controlling equipment was not available. In 1949, eight tons of *As* was released by Giant mine per day, causing serious problems (Heeler, 1995). Technology was not available to adequately deal with spills. This caused a buildup of toxic wastes in the surrounding waterways and sediments.

The January 11, 1975 issue of the *Yellowknifer* reports of an interview with former mayor Fred Henne. Henne tells *Yellowknifer* of a newspaper article warning Yellowknife citizens not to eat vegetables harvested in the Yellowknife area without washing them and a medical health officer advising people not to drink water from Yellowknife Bay in spring due to high *As* levels in the snow melt.

The *Yellowknifer* interviewed two Yellowknives Dene members in the same issue. They were told that the people in the community must not drink the water from the Great Slave Lake, where they had always gotten their drinking water, because of *As* pollution. At that time they did not have running water so they had to buy water from town. They told *Yellowknifer* that he still got water from the lake because he could not afford to buy water. He also said that he only recently found out about the warnings and that not even the chief did not know what the sign, written in English, had said. These elders expressed concern and anxiety about human health and the health of their dogs. They remembered Elizabeth Drygeese, an elder who had reportedly died of cancer. The autopsy revealed that she had an abnormally high level of *As* in her body. Elders today, along with long-term residents outside the Weledeh community, also remember Elizabeth Drygeese. Weledeh Elders say sled dogs taken through the mine area lost fur from their paws and eventually died (T. Sangris, pers. comm., 1999).

Today, in the 1990's, elders do not like to drink the water from the Great Slave Lake from the Yellowknife area or Dettah. They believe that there is still too much pollution. The residents of both N'Dilo and Dettah depend on truck water delivery (H. Tobie; J. Charlo, pers. comm, 1999).

There was a report of four children who died from eating snow in the Giant Mine area (Weledeh Yellowknives Dene, 1997a) The elders today recall that the children were taken to the hospital with an illness. The doctors told the parents that the children had arsenic poisoning and there was nothing the doctors could do, because their stomachs were already destroyed. The children lived for only one week after (J. Martin, pers. comm., 1998)

Dr. Tom Hutchison, a professor in the Environmental Studies program, who has conducted some environmental research around the Yellowknife area, told *Yellowknifer* for the January 11, 1975 issue that Environment Canada began legal proceedings against Giant Yellowknife Mines for affecting the fish, but since this was on behalf of people which is under another jurisdiction, Environment Canada could not take action. He stated that he believed the water and, through the food chain, the aquatic ecosystem and terrestrial plants were contaminated with *As* and other trace metals.

Arsenic trioxide dust, a by-product of ore processing has been stored underground at *Giant Mine* since the mid 1950's. Presently, it reaches underground chambers at a rate of 10-15 tons/day (Donison and Willacy, 1997). The dust now stored at *Giant Mine* could fulfill the worldwide demand for four years (Ledrum, 1997). On-going work involves trying to find ways to adequately treat or dispose of or sell the waste. This is very important because arsenic trioxide dust may be fatal. It can enter the body through ingestion, inhalation or absorption through the skin (Dillon Consulting Limited, 1997). See Appendix M for a newspaper article updating the current underground arsenic concern at Giant Mine).

To control the *As* in effluent, *Giant Mines* installed a waste water treatment plant at their site, reducing *As* concentrations in the effluent from 20,000 - 30,000 ug/L to an average of 300 ug/L (Government of Canada *et al.*, 1993).Although improvements to the *Giant Mine* arsenic control systems have been significant, there is still considerable emissions to the air and in solution at the tailings ponds. Since 1985, the total of *As* in the air in Yellowknife has risen above the standard used in Ontario twice (Ontario standard was used because NWT has no standard for air *As* levels). Equipment malfunction was believed to be the cause of the rise (Environmental Protection Services, 1996).

As can take a long time to be fixed into the biological form or in rocks. Most gold milling operations did not treat their effluent prior to 1975 (Government of Canada *et al.*, 1993). Therefore, there can still be large amounts of *As* in the soil around *Giant Mine*. Soil samples collected near Giant Mine contained up to 9300 ppm *As* in 1972 and 1974 (Government of Canada *et al.*, 1993). From Baker Creek, near *Giant Mine*, dead or dying shrubs and trees can be seen. The elders say it was not that way before mining came to Yellowknife. A study of the *As* levels in Baker Creek (Jackson *et al.*, 1996) showed concentrations greater than the 25 ppb Drinking Water Supply guideline.

Consolidated Mining and Smelting Company of Canada (now *Miramar Con Mine*) began operating in 1937. This mine is situated just south of the city of Yellowknife and is surrounded by a series of lakes. The lakes around the mines are believed to be contaminated with high levels of *As*. Dr. Hutchison told the *Yellowknifer* that the water and sediment pollution around the Yellowknife area was higher than he had personally seen, comparable to only the Bay in Tasmania in Australia. Kam Lake was reported to have a history of high *As* levels, possibly from contamination of the surrounding lakes by Con Mine.

The arsenic trioxide by-product can be made into marketable products. This helps to eliminate some of the environmental impact that the compound has on the mine site and helps to cover costs of production. Starting in 1981, *Con Mine* treated 70,000 tons of its accumulated arsenic trioxide. The supply was used up 1990 (Dillon Consulting Limited, 1997).

1.3 Arsenic and Human Health

There are two broad categories of *As* in the environment. The *As* contained in most foods is organic and gets excreted soon after ingestion. Food is the greatest source of *As* uptake in humans (NRC, 1976). Although there is little data to determine how much organic *As* is safe for consumption, it is believed to leave the body quickly with very low toxicity (World Health Organization, 1989). Therefore, *As* in foods such as caribou and fish can be at a fairly high level without being toxic to the consumer, although the tolerable level has not been agreed upon.

As is also present in the inorganic form. This is the most toxic form and is the form that is usually found in water. *Arsenic*, in the inorganic form, is on the *Priority Substances List*, established by the Ministers of Environment Canada and Health and Welfare Canada. This list identifies all substances which can be harmful to the environment or cause human danger (Government of Canada *et al.*, 1993). Since *As* is assessed to be toxic, regulations have been developed to control all aspects of the life cycle (from research to disposal).

Inorganic *As* is very toxic to humans; lethal at high levels. It is known to damage nerve, stomach, intestines and skin (http://www.healthfuture.com/arsenicals.htm). Acute toxicity can cause severe haemorrhagic gastritis and gastroenteritis, shock and collapse (NRC, 1976). High levels of inorganic *As* exposure over a long period of time can produce skin abnormalities such as darkening and the appearance of corns or warts on the hands, feet and torso. Exposure at lower levels can cause nausea, vomiting, diarrhea and abnormal heart rhythm (http://www.healthfuture.com/arsenicals.htm). Short-term exposure normally affects the liver and kidneys but can also affect the spleen, body weight, blood and biochemical balance (NRC, 1976). Arsenic, in the form of arsenic trioxide dust, is a known carcinogen (Donison, 1997) and can increase the risk of skin cancer and bladder, kidney, liver and lung tumours (http://www.healthfuture.com/arsenicals.htm). The EPA and IARC also classify *As* as a human carcinogen. *As* exposure can also cause muscular cramps, facial edema, anaemia and nerve damage, irritation of the respiratory tract can occur from inhaling *As* compounds and skin contact can cause stinging, inflammation and itching (NRC, 1976).

1.4 Arsenic and the Weledeh People

Arsenic became a problem for the *Yellowknives Dene First Nation* in the 1950's and '60's, a short time after gold production began in two locations close to the city (Weledeh Yellowknives Dene, 1997a). The Weledeh people have lost valuable land, dogs and even human lives to this pollution they have come to know as arsenic. This is why they have become so frightened. These people, once healthy, were getting strange illnesses. They were also told that they could not drink water from the Great Slave Lake. They had to buy water from town and they had to wash all plants and berries before eating them.

Since then, the Yellowknives Dene, or *Weledeh* people, as they call themselves, have been very uneasy about their traditional foods (Weledeh Yellowknives Dene, 1997a). Today, they will not drink water or harvest traditional foods (either land or aquatic) from areas around Giant or Con Mines, which used to be preferred berry-picking sites. They, along with many other people in Yellowknife, fear that plants near these mines are unfit to eat. Many Weledeh people, young and old alike, do not pick berries around the city of Yellowknife. They are more comfortable harvesting from areas away from Yellowknife, such as Wool Bay and towards Edzo, where they feel that contamination is significantly less.

Weledeh people see the land as poisoned and dangerous, although the elders still believe, and are advised by their doctors, that wild meat and the other traditional foods they were raised on are better for them than commercial foods (T. Sangris, pers. comm, 1999).These foods, along with the hunting, gathering and travelling activities, have, and still do, play a very important role in their lives. But since they have not been properly informed during critical times and have watched helplessly as people and animals have become sick and have seen nothing being done to stop it, they are sceptical when they are told something is safe. This wariness about the plants and animals around the places they now live year-round has not only caused a drastic change in diet, but a change in culture. An interference in culture can contribute to social problems within a community; this is seen within the *Yellowknives Dene* communities today (T. Sangris, pers. comm., 1999). Elders today fear this land now - the land they used to see as their provider and protector and the reason for celebrations. Therefore, it is difficult if not nearly impossible to pass on the rich culture that used to be and still is the ***Weledeh Yellowknives Dene***.

According to the *Yellowknifer* (January 11, 1975) some Yellowknife residents experienced symptoms which could have been mild to severe arsenic poisoning, possibly from drinking the water from Great Slave Lake. Dr. Bertram Carno, chairman of the University of Illinois and School of Public Health commented to the *Yellowknifer* on the findings of a 1969 study done by the *Canadian Department of National Health and Welfare*. He stated that the signs and symptoms of excessive arsenic exposure comply with the findings of the study. The study showed that skin lesions, lymphomas and leukaemia and heart disease was higher in the Yellowknife region than one would expect to find. These findings were, however, hidden from the public for several years. Figure #2 illustrates the present lack of concern about *As* levels in water in the Yellowknife Bay.

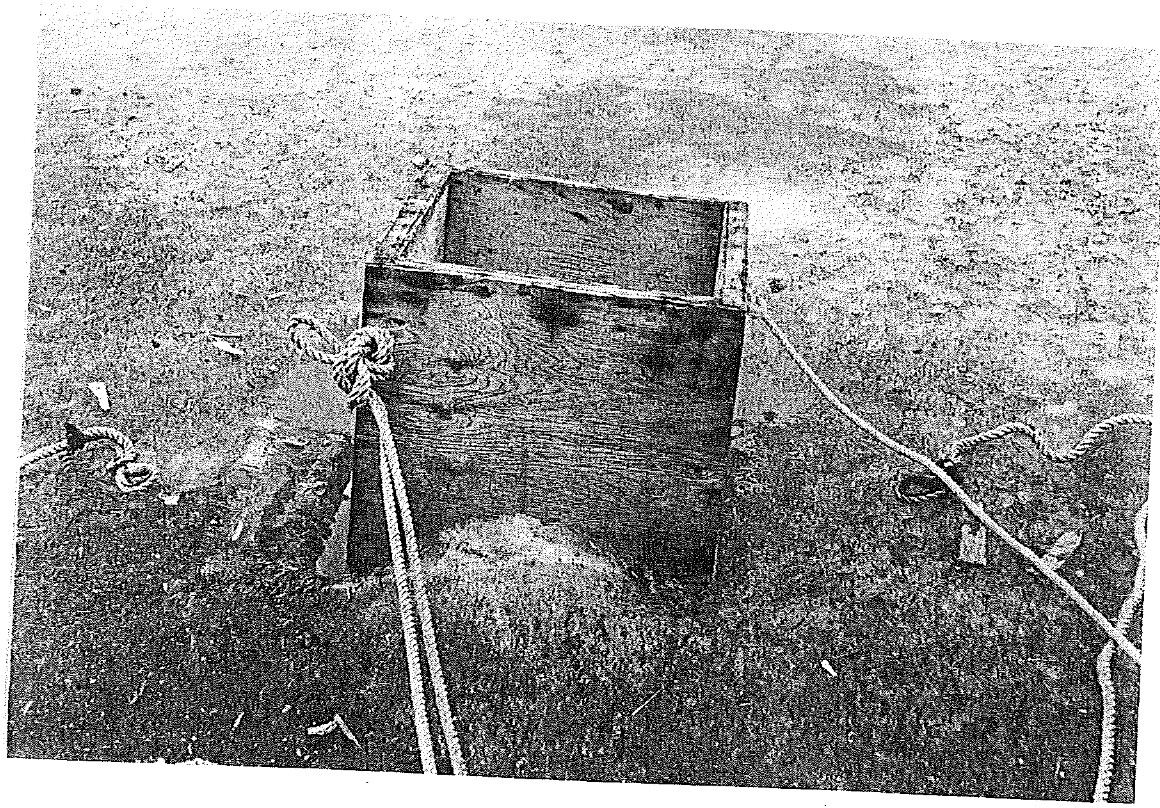

Figure #2
Despite the history of high arsenic levels, some people still drink the water from Yellowknife Bay. Pictured here is a typical insulated box used mostly by houseboaters in winter. This box helps prevent freezing, so that drinking water can easily be obtained

As is known to accumulate in the hair and hair *As* level is sometimes used to determine *As* levels in the body (Canadian Public Health Association, 1978). An article in the *News of the North* (June 4, 1975) reports of an independent study done by the *National Indian Brotherhood.* From this study, it was found that six of the eighteen people surveyed were found to have more than the acceptable 10 ppm of *As* in their hair. In a study done by the *Canadian Public Health Association* (1978), hair and urine samples were taken from residents of Yellowknife and Hay River from November 1977 to February 1978. The findings of this study showed that Yellowknife residents did have slightly higher levels of *As* in their bodies, but only people who lived close to the source (gold mines) and people who worked there. Higher levels of *As* in the hair of Yellowknife residents was thought to have been deposited onto the hair through the air, rather than by ingesting it directly, because of the lack of correlation with nerve damage, which is prominent in individuals with raised levels of *As* in their bodies.

It is important to note that the two studies were conducted differently. The study done by the *Indian Brotherhood* categorized eighteen children by residence - seven from the town of Dettah and eleven from Latham Island. Only one child had levels low enough to be called 'non-elevated'.

There are complicating factors in detecting *As* levels in animals (including humans) (Brockbank *et al.*, 1989). Arsenic may be present but can be in a form not detectible in blood and urine using conventional methods. This may have had some effect on the findings of the two studies.

1.5 Traditional Foods of the Weledeh people

Yellowknives Dene, along with indigenous groups throughout the world, relied, until recently, mostly on the local environment for food, as well as clothing, shelter, tools, games and toys. Their foods, called indigenous foods, come from the natural environment and are included in the cultural food use pattern of their particular group (Kuhnlein and Turner, 1991). Indigenous foods are therefore more than a way of getting adequate nutrition but also a way of maintaining culture. Other benefits the traditional food system are physical fitness and environmental awareness, through the process of hunting and gathering (Kuhnlein, 1994).

Indigenous foods (also called country foods), are healthier and less expensive than foods purchased in the store. An American dentist, Dr. Weston Price, did a worldwide study on the relationship between nutrition and disease. The findings of this study pointed out that traditional foods are nutritionally superior to commercial foods. Dr. Price observed almost perfect teeth and social health in peoples living in relative isolation (Coombs, 1981). Usher (1976) points out the importance of maintaining the productivity of the natural world. In the north, where there is much wilderness, it is possible to get adequate nutrition off the land with very little cost. In the wilderness, meat is naturally plentiful and there is an adequate supply of plant material to get a balanced diet. Traditional Dene foods are generally lower in fats than commercial foods (Appavoo *et al.*, 1991). These foods are still consumed in the north but are widely replaced with commercial foods.

Years ago, Yellowknives Dene, like all northern native peoples, lived on a diet mainly of meat and fish. Caribou, beaver, muskrat, moose, ptarmigan, duck, goose, whitefish, inconnu and jackfish are only a few of the traditional foods of the Weledeh people. Meat and fish contained the main supply of protein, zinc and iron (Receveur *et al.*, 1996). Many species were found in abundance in the Yellowknives Dene traditional territory and harvested at appropriate times of the year. Every generation would be taught by their elders the importance of conservation and proper storage, leaving the habitat undisturbed and using all parts of the animal.

The meat of the animals used by the Weledeh people were cooked and eaten, or dried to preserve it to make it easier for packing and travelling with. All the meat was used, either by the people or by their dogs. Hides were made into clothing and bones were used as tools.

To get a balanced diet, an adequate amount of plant material must be consumed. The Yellowknives Dene collected, cooked and stored, or consumed fresh, a variety a plant species. Lichens, flowers, weeds, berries and parts of different tree species were cooked in soups, eaten fresh, dried or ground into powders, or used as medicines.

Some of the berries used by these people were blueberries, cranberries, gooseberries, crowberries, saskatoons, raspberries, rose hips, cloudberries and timberberries. These berries provided essential nutrients such as vitamin C, fibre and carbohydrates and were harvested and stored in great quantities that they could be enjoyed all year by all ages, even babies were fed boiled berries (J. Charlo, pers. comm., 1999). Some berry species, such as rose hips, are very high in vitamin C at far north latitudes. (Alaska Magazine editors, 1982).

Different species of berries in the Yellowknife region become ripe throughout the summer, from June or July to September. The species mentioned were traditionally harvested all summer, mainly by women and children. One of the most bountiful areas was the Ingraham Trail. Where *Giant Mine* sits now and the town site of Yellowknife used to be two of the best berry-picking places in the Weledeh territory. The *Con Mine* area was also a good berry picking spot. The berries were collected in birchbark baskets and brought back to the camp site. They were then placed into another basket full of boiling water which was heated by placing rocks, heated in a fire, over and over until the water boiled. Then the cooked berries would be covered with grease to be stored for later use.

Food had to be stored carefully to prevent spoilage and to keep animals out. In the summer, meat and fish were dried or eaten fresh and plants were eaten fresh. In winter dried meat and preserved plants were stored in caches. For example, in Fort Smith, a cache used by the people was made by placing logs upright in the ground. Logs were placed down for a platform on top of the upright logs. Food was placed on this platform in a particular order, covered by hides and water (which quickly froze), to prevent avian species from eating it (Laraque, 1985). The Weledeh people would store berries in the ground within the permafrost in different places throughout their traditional territory. This way, they always had a supply in every season and location. Dried berries were also packed and brought on the long trips to the barrens (Weledeh Yellowknives Dene, 1997b).

There was a variety of ways berries were stored and prepared. They were harvested all throughout the Yellowknives' territory, even in the barrens, where blueberries, cranberries and cloudberries were plentiful. Some Elders would help women and children harvest berries, along with medicine plants, seeds, fish and bird eggs, moss and lichen (Weledeh Yellowknives Dene, 1997b). Berries played a vital role in survival in the winter months. While travelling in the barrens, Weledeh people would bring dried berries rolled in caribou fat for a high energy food (Weledeh Yellowknives Dene, 1997b).Some berries, such as cranberries, were collected to be eaten fresh, or to be boiled and stored in a cache to be later used as jam. Crowberry (*Empetrum nigrum*) was squeezed for juice (Weledeh Yellowknives Dene, 1997b) and cloudberry was said to relieve diarrhea (T. Sangris, pers. comm., 1999) or stomachache (Weledeh Yellowknives Dene, 1997b).

1.6 The Discovery of Gold

Prior to the discovery of gold in Yellowknife in 1933 (Aasen, 1994), Yellowknives Dene women would spend much of their time along the present-day Ingraham Trail, picking berries. They sometimes would find rocks that would have a special feature and take them home (See Figure #3). A visiting prospector noticed a gold nugget at the home of one of the women. Without telling her the true value of the nugget, he traded the nugget for two stove pipes (Weledeh Yellowknives Dene, 1997a). The nugget was found close to where the *Giant Mine* is now. After the prospector left with the nugget, the news soon spread that gold was discovered and the gold rush began.

Figure #3
***LIZA CROOKEDHAND (far left)** found a gold nugget while picking berries near the present Giant Mine site. It was common, before the gold rush, for women to find unusual rocks and take them home for display. They did not know the monetary value of a gold nugget.*

Since the gold discovery, Yellowknife has become known as a city built on gold mines. Mining in Yellowknife grew quickly. Yellowknife's first large producing gold mine was *Consolidated Mining and Smelting Company of Canada* (now *Miramar Con Mine*), which began in 1938 and the second; Giant Yellowknife Mines (now *Royal Oak*), in 1948 (Soniassy and Brown, 1980). A small gold mine operated in 1935 on the east side of Yellowknife Bay (Le Bourdais, 1957).

Despite the fact that mining and prospecting was growing rapidly in the Northwest Territories since the early 1930's, by 1939, there were still no native people employed in this industry and they were generally not welcome in the mining camps (Aasen, 1994). At this time, 95% of native people's income came from trapping; and hunting and fishing were their means of getting food (Fumoleau, 1973). A sudden change in the environment would be difficult to cope with, But change happened quickly. In 1939, the value of mineral production was more than the value of the fur catch (Fumoleau, 1973), even though the native people did not give consent to large-scale development on their traditional territory (Aasen, 1994). Also at this time, WWII began. This caused people to move north and widen the gap between whites and natives (Fumoleau, 1973).

Since then, Dene people have learned the language of the newcomers, have moved into settlements and began to move from hunting and trapping (development caused many animals to leave) to working in the cities. The lifestyle, in one generation, changed almost completely. Foreign ways and foreign foods had to be adjusted to. They used to eat what was available, and what was available was always good for them. Now there are many food choices, which are not always good food choices. For Dene people, it has become necessary to learn about new foods and a different diet. To rely on traditional foods is more difficult now, because they are scarcer and more difficult to obtain. Many Weledeh people feel they must travel far to get unpolluted traditional foods.

Yellowknives Dene, living at the heart of the development, were forced to adjust to changes which have and are still taking place. Today, in the 1990's, Yellowknives Dene number nearly one thousand and generally live in T'enehda (Dettah),N'Dilo, Yellowknife and in nearby settlements (Yellowknives Dene Band, 1993). Most of the full-time workers work in the city of Yellowknife in non-traditional occupations. The young people attend modern schools where English is the working language. Store-bought food, normally high in saturated fats and refined carbohydrates, comprise a large part of the diet.

Although the Dene of the Weledeh have nearly become urbanized , there have been considerable effort to retain the culture, language and heritage. Culture camps, community hunts, language courses and trips to various places within their traditional territory; by canoe, power boat, plane, car or by foot, are part of saving their cultural heritage. Many Weledeh land users continue to hunt, fish and harvest traditional wild plants for their families.

Elders in the community have seen the transition from the semi-nomadic lifestyle to modern day living in the cities. Many of these people are passing on information, skills and knowledge they have acquired in their youth. Young people can, and do, learn from their elders the skills and knowledge which was essential for survival in the north less than one hundred years ago. Elders are consulted for advise and recommendations when their traditional land is to be exploited, so that important and sacred places remain undisturbed for future generations. They pass on information on places, food and cultural practices to be documented for the benefit of the community.

2.0. OBJECTIVES

This study is being done to help determine if the traditional foods of the Weledeh Yellowknives Dene are safe to eat. Over two decades have passed since people in Yellowknife became aware of the problem with arsenic and vast improvements have been made in the gold mining industry. There have been many studies conducted on arsenic levels in the environment around the Northwest Territories. Some studies have dealt with traditional foods. Research results have been documented for *As* levels in soils (Government of Canada *et al.*, 1993), air (Environmental Protection Services, 1996), fish (Jackson *et al.*, 1996; Wagemann *et al.*,1978), sediments (Jackson *et al.*, 1996; Wagemann *et al.*,1978) and water (Wagemann *et al.*, 1978) around the Yellowknife area. There have also been tests for human health concerns associated with *As* poisoning (Canadian Public Health Program, 1978). There is, however, little literature available on *As* levels in berries from Yellowknife, although berries were traditionally important to the Dene. Berries provide a rich supply of vitamin C, fibre and carbohydrates (Alaska Magazine editors, 1982) and were traditionally eaten as 'sweets' (J. Charlo; H. Tobie; pers. Comm., 1999). This study, ***'Arsenic Levels in Berries and Soils From the Weledeh Yellowknives Dene Traditional Territory'***, will be part of the full picture of what the situation is like for indigenous foods in the Weledeh Yellowknives Dene traditional area.

3.0. THE STUDY AREA

Taken from. Weledeh Yellowknives Dene (1997)

Map 3 - Weledeh Yellowknives canoe and portage routes between summer camps and the barrens

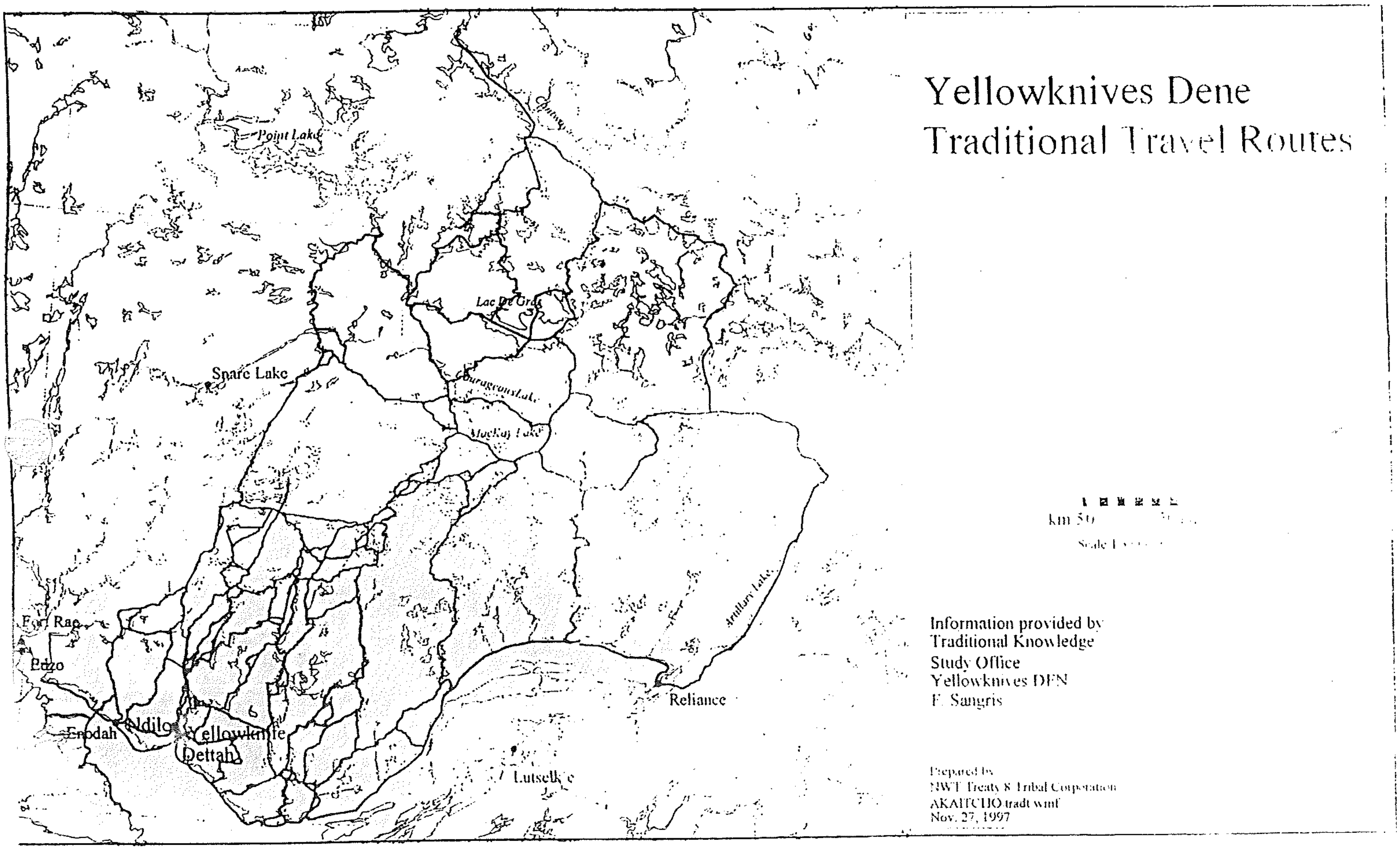

Figure #4

The traditional trails of the Weledeh people extended from Gros Cap to Contwyoto Lake; the East Arm to Enodah.

All soils have a natural arsenic content of between 0.1 and 40 ppm, with the average being 5-6 ppm (NRC 1976; Government of Canada *et al.*, 1993). The Yellowknives Dene traditional territory consists of rocks having a naturally high arsenic content. With the principle carrier of arsenic in rocks being pyrite (FeS_2) (Government of Canada *et al.*, 1993) and Yellowknife having sulfur containing volcanic rocks such as pyrite, the natural arsenic in the rocks and sediment around the Yellowknife area is very high.

The study area covers several hundred kilometres of land (see map Appendix A and Fig. #4) and includes the places the Weledeh people would travel through or camp. Throughout the study area, there are sections of permafrost, particularly in the peat bogs, where many layers of organic material insulate the frozen ground underneath. The sphagnum moss, which is the main component of peat, provides nutrients for the plants and can act as a buffer to absorb contaminants such as *arsenic*.

The northern limit of the Yellowknives Dene territory extends to the barrens (Weledeh Yellowknives Dene, 1997b). In the past, Weledeh men spent much of the winter around MacKay Lake, in the transitional forest area, where tree line meets tundra. Boreal species, such as jack pine and black and white spruce, are present but very sparse, with a prominence of dwarf birch and dwarf willow, characteristic of the tundra. Abundant berry species here are blueberry, cloudberry and cranberry. The *Salmita* mine site is in this area.

The Weledeh people travelled as far south as Wool Bay and the islands in the Yellowknife Bay. This area is covered by rocks of volcanic origin, as are the rocks in Yellowknife. This is one of the few areas the Weledeh people feel confident the water and food is not contaminated. There has been little development, except a couple of fishing camps and cabins. There was some deforestation done earlier this century for the mining companies. The land around Wool Bay has some historical significance. For example, Ruth Island used to be called ***Akaitcho Dee*** (Island) by the Weledeh people.

Akaitcho Island was named after one of the great leaders of the Weledeh people (along with other tribes who collectively call themselves the T'satsaot'ine). Akaitcho was at the East arm of Great Slave Lake when he realized he was dying. He asked two of his wives to take him to the mouth of the Weledeh, where he wanted to be buried. When he got to Wool Bay, the ice broke and they had to bury him on the island which bears his name (Weledeh Yellowknives Dene, 1997a).

Not far from Wool Bay, there is a cabin standing which belonged to Peter Pond. Pond was an explorer and trader who arrived in the territory of the Weledeh people in the 1700's. He introduced the T'satsaot'ine leader to gunpowder, trading, log cabins and stone fireplaces (Weledeh Yellowknives Dene, 1997a)

The Great Slave Lake, with an estimated area of 28,438 square kilometres (Hay River Recreation Department, 1999), played an important part in the lives of the Weledeh people; for drinking water, travel and game hunting. The lake contains hundreds of islands; many of which were used by the Weledeh people as they travelled throughout their traditional territory.

The Yellowknife River, which drains into the Yellowknife Bay of the Great Slave Lake, has a basin of 17,000 Km^2 (Spence, 1999). The surrounding lakes, bays and the Yellowknife River provide moisture for the flora in this semi-arid region. In a climate that normally dips below the freezing point from October - May and has an annual precipitation of only 267.3 mm per year (Environment Canada,1990), plants can flourish because of the vast fresh water supply in this relatively cool subarctic Boreal forest region., although growth of many species in this region is slower than it is in the south. Many berry species, such as gooseberry, cranberry, blueberry, crowberry, raspberry and cloudberry, are bountiful in this area.

Yellowknives Dene fear that the west side of the Yellowknife Bay may be contaminated by mine runoff from *Miramar Con Mine.* They believe that Pud Lake near the mine absorbs much waste from Con, which drains into Kam Lake. The water eventually leads into the Yellowknife Bay. The points sampled are #44, #45 and #46 on map Appendix A. If the *As* levels are high here, it may be due to runoff from the mine. This is the area the Weledeh people would travel to while moose hunting in the fall. There are many cranberries and crowberries in this area.

The Weledeh elders say the *Con Mine* area is where they would harvest blueberries. The creek running from the mine site used to be good water for drinking. The creek is no longer safe to drink, the elders say (M. Paper; J. Martin, pers. comm, 1998).

North of the mouth of the Yellowknife River, there is another gold mine. *Giant Yellowknife Mines* is located in a traditional berry-harvesting area. Blueberries, raspberries, saskatoons, strawberries and cloudberries were plentiful here. The creek running along the Ingraham Trail would supply water to a lush green wilderness. There are some species of animals which leave an area is people are living there or occupying the area for too long. This is what likely happened in this area when the city of Yellowknife was built.

The Yellowknife River and Bay are still important to the Weledeh people. The mouth of the river has special historic significance as the main camping location in spring for all Weledeh families, as this is the first place for the ice to break, making it a preferred place for water foul to gather. **This is a very important traditional site**, as it defines the Weledeh people as a distinct group.(See Figure #5) A recommendation has been made for the preservation of a legendary landmark at the mouth of the Yellowknife River (Weledeh Yellowknives Dene, 1997). This large spruce tree landmark is part of a creation story told through generations of Weledeh people.

Figure #5
The 1998 Dene National assembly was held at the mouth of the Yellowknife River. This is a special place for the Weledeh people, historically used as a gathering place during the spring break-up in the Yellowknife Bay.

The city of Yellowknife has a human population of approximately 18, 000 and is only a few kilometres from north to south. Yellowknife sits on the north shore of the Great Slave Lake and is just south of the mouth of the Yellowknife River. There are two active gold mines in the area, located approximately at the north and south ends of the city. Two Yellowknives Dene communities, N'Dilo and Dettah, are located near the city.

Weledeh people were discouraged by their elders to live or camp where the city of Yellowknife is today, for this is where moose would travel. They were told if people stayed there, the moose would leave. People would generally camp near the Yellowknife River, N'Dilo, Dettah, on an island or around what is now Back Bay.

There were several species of berries throughout the traditional territory of the Weledeh people. Berries, along with other kinds of plants and animals, were stored in caches along traditional trails.

This made it possible to have an ample supply of these basic foods in winter.

4.0. MATERIALS & METHODS

Sampling sites were selected on the basis of their significance to the Yellowknives Dene, either in the past or in the present. Significant sites could be where berries were traditionally harvested, places believed to be contaminated by mine waste or places with historical significance. These areas include the Yellowknife River, Baker Creek, the Ingraham Trail, south of Yellowknife along the Yellowknife Bay to Wool Bay on the east and the mainland south of Mac Lake on the west, Enodah (Trout Rock) on the east arm, north to the MacKay Lake area and points around the city of Yellowknife (see map Appendix A for a detailed look at the sampling sites and Figure #4 for a map of traditional areas used by the Weledeh people).

The berry species collected for this study were traditionally important to the Yellowknives Dene and are still harvested by Elders and youths. These species include **raspberry** (*Rubus idaeus*), **cloudberry** (*Rubus chamaemorus*), **blueberry** (*Vaccinium ovalifolium*), **cranberry** (*Vaccinium vitis-idaea*), **rose hip** (*Rosa acicularus*) and **gooseberry** (*Ribes lacustre*).

The study required samples to be taken from sites around active gold mines (Giant and Con), abandoned gold mines (Salmita) and points around places where there has been no mining to be used as control. The control points were chosen because they, along with being traditionally significant to the Weledeh people, are several kilometres away from the mine sites. The Weledeh elders believe berries from these places are safe to eat. These points were the islands around Wool Bay, the east side of Yellowknife Bay, Enodah and Point Lake. NOTE: *Point Lake is not included on the Yellowknives Dene traditional map. This area has no traditional significance to the Weledeh people. Samples were taken from this area because it is far enough away from any active gold or base metal mine that it can be a very good control. The area is also in a greenstone belt like the Yellowknife and area samples.* Elders and other knowledgeable Dene were consulted as to where the most appropriate places were to take the samples, based on traditional use of the area and their knowledge as to where the most likely places were to find berries. This study was conducted following guidelines suggested by the Yellowknives Dene.

A visit early in the berry season was made to the Giant and Con mine sites to determine what species of berries were present. Flagging tape was used to mark the places where berries were found. There were also trips around town to determine the presence of berry species.

Sample collecting began on July 13th, 1998. Blueberries were harvested by the project coordinator from the Miramar Con Mine site. On July 17th, raspberries were collected near the day-use area at Fred Henne Park. Sampling continued until September 28th, when cranberries and rose hips were still in season. (Aerial photos of Giant, Con and town sites are pointed out in Appendix B, C and D). Throughout the study, berry samples were collected by Dene elders, the study coordinator, the Lands & Environment Manager and Assistant Manager. Arsenic is taken up by plants primarily from the soil (Government of Canada *et al.*, 1993) and variations in the soil can enhance or reduce arsenic uptake by plants (Xu *et al.*, 1991). Therefore, to find potential arsenic uptake by the berries, a representative sample of soil was collected at root level. Due to the travel cost of going to the MacKay Lake area to take samples, expediters from *Bathurst Arctic Expediting* volunteered to collect samples while at their camp at Salmita. Similarly, outfitters from *Enodah Wilderness Travel* and *Peterson's Point Lake Lodge* gathered samples from areas around their camps at Trout Rock and Point Lake, respectively. Samples were collected following the procedure set by the laboratory staff at *Centre for Indigenous People's Nutrition and Environment* (*CINE*) at McGill University in Montreal (see Appendix E). Sample bags were labelled numerically with each number having an (a) and (b) part, with (a) representing the berry and (b) for the corresponding soil sample. A sample sheet was filled out for each sample (see Appendix F). All samples were frozen and shipped to the *CINE* Research Lab to be analysed for total arsenic (the laboratory analysis procedure is included in Appendix G). Since the sampling was not yet completed by the third week of September, the samples were sent in two shipments - one on September 21st and the other on October 21st. The results were analysed statistically using the Kolmogorov - Smirnov and Kruskal - Wallis methods (see Appendix

H, I and J for details) by the project team and presented to the *Yellowknives Dene First Nation.*

At each sampling site, a general description of the area was recorded. This included neighbouring plant species, land topography, water availability and proximity to mine. Prevailing wind direction and general weather patterns during the berry season were also noted. These factors are important in studying arsenic because this element can travel long distances by wind, precipitation and dust, and uptake of *As* by biota is a complex interaction between these factors.

After the sampling was completed and samples sent to the lab for analysis, interviews were conducted by the coordinator. Elders were interviewed to acquire information about traditional uses of berries, other plants used by the Yellowknives Dene, other traditional foods, the effect of the mining industry on them and their families (many of them were children and young adults when the mining industry began in Yellowknife) and the effect of arsenic on the Yellowknives Dene (especially before pollution regulation and prior to the time when Dene people understood arsenic). A copy of the transcripts may be obtained with permission by contacting the *Yellowknives Dene First Nation.*

4.1 Statistical Analysis

To determine the significance of the results, we used the Kolomogorov-Smirnov and the Kruskal-Wallis tests. It was important to know the degree of variation in *As* levels (a) between the *As* in the berries and the *As* in the corresponding soil sample (b) between the different species of berries and (c) between *As* in the different berry species from each site.

5.0. RESULTS AND DISCUSSION

A total of fifty-one berry and fifty-one soil samples were collected from the various locations throughout the Yellowknives Dene traditional territory. A complete list of the berry and soil data is provided in Appendix K. The table below summarizes the samples that we believe should be of **concern to the Yellowknives Dene, exceeding the 0.1 ppm guideline set for this study** (this guideline is discussed later in this report).

Table 1. Berry Samples from various locations throughout the study area found to exceed accepted guideline of 0.1 *ug*/g *As* wet wt

Location	*Berry*	*As level (ug/g wet wt)*
Fred Henne Park, Yellowknife	Raspberry	0.20
Joliffe Island, Yellowknife	Blueberry	0.16
Joliffe Island, Yellowknife	Raspberry	0.13
Taylor Road, Yellowknife	Cranberry	0.15
Giant Mine (active)	Gooseberry	0.20
Giant Mine (active)	Raspberry	1.91
Giant Mine (active)	2 Cranberry	0.30, 0.46
Giant Mine (active)	Rose Hip	0.20
Con Mine (active)	2 Cranberry	0.32, 0.64
Con Mine (active)	2 Rose Hip	0.86, 0.23
Con Mine (active)	Gooseberry	0.18
Yellowknife River	Cranberry	0.19
Yellowknife River	Rose Hip	0.11
Baker Creek	Rose Hip	0.15
Salmita (non active)	2 Cloudberry	0.16, 0.32
Salmita (non active)	Blueberry	0.16
Yellowknife Bay east side, across from Giant Mine	Cranberry	0.12

5.1 Berry Collection

Berry samples were collected from various sites around the Yellowknives Dene territory for this study throughout the summer of 1998. Although it would have been ideal to have samples from each species from every sampling site, it was impossible. Because of unusual weather conditions, berries were sparse during the summer of 1998. The summer was very mild and dry with temperatures reaching into the 30's (Celsius). Very little rain fell from June to August. With the dry weather, a forest fire swept through a large part of the Ingraham Trail in July. The smoke was so thick it obscured the sun for days and left a blanket of ash on the city and surrounding area. This was detrimental to the berry crop of 1998.

The species most affected by the unusual conditions seemed to be cloudberries. This species requires cool, moist peat to produce fruit. Many cloudberry plants were found in the region but not enough berries for a sample. However, this species was plentiful in the northern part of the *Yellowknives*' territory.

In the Yellowknife area, raspberries, rose hips and gooseberries were particularly plentiful. Cranberries were more plentiful in the Wool Bay area than in the city. Blueberries were sparse, except in the north.

Proximity to the mine sites did not seem to have an effect on the macroscopic appearance of the berry plants. Plants near and on the mine sites generally appeared no different in colour, size or quantity than those further away in the city. However, all berries in Yellowknife and surrounding area seemed to have some signs of drought stress - smaller, sparser fruit and discolouration of leaves was prominent (lack of drought resistance is a sign of *As* toxicity but the unusual weather probably had more influence on the berry plants in this case).

The elders say that berries are not as large or as plentiful as they were in the past. They blame pollution for the decrease (H. Tobie; M. Paper; J. Martin, pers. comm., 1999). They also have commented on the small size of the berries recently (J. Charlo, pers. comm., 1998).

5.2 Arsenic in the Yellowknives Dene Environment

The Canadian Public Health Program (1978) summarizes a study on *As* levels in snow samples that have been conducted in the Yellowknife area 1975. This study revealed that 96% of all scoop snow obtained in 1975 has a level of *As* higher than the recommended allowable limit of 0.05 ppm in drinking water. This may have relevance to the *As* levels in the soil samples, and possibly the berry samples, because the high *As* levels settle into the soils when the snow melts in April and May.

Although dangerously high levels of *As* have been reported in areas around the world, there is still very little known about this element in the environment, and what is known is vague and incomplete. Therefore, to determine acceptable levels of *As* in the berries gathered for this study, it was necessary to compile information on *As* in other foods from various sources.

The level of *As* allowable in foods is generally 2.0 ppm and 0.1 ppm for drinking water. The acceptable levels in foods is higher because foods usually contain the less toxic organic form. Inorganic *As*, found in water, is many times more toxic. It is unknown at this time if the *As* in berries is in the organic form (pulp) or in the inorganic form (juice). The *Department of National Health and Welfare's* standards for allowable *As* in foods is as follows:

Table #2 Allowable Arsenic Limits in Foods
Food and Drug Act Regulations
Health Protection Branch, Dept. of National Health and Welfare

Food	Arsenic ppm
Marine and Freshwater animal products	5.0
Liver	1.0
Fresh Fruits	2.0
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

(Ad Hoc Standing Committee on Arsenic, 1977)

Unfortunately, there is no guideline level for *As* in berries. For this study, acceptable levels were determined by using the guideline of 0.1 ppm (0.1 *u*g/g), used for fruit juices and beverage. Using this guideline, which was recommended by Dr. Laurie Chan of CINE at McGill University in Montreal, PQ, 21 of the 51 samples exceeded this guideline and were called unsuitable for human consumption. Refer to table #1.

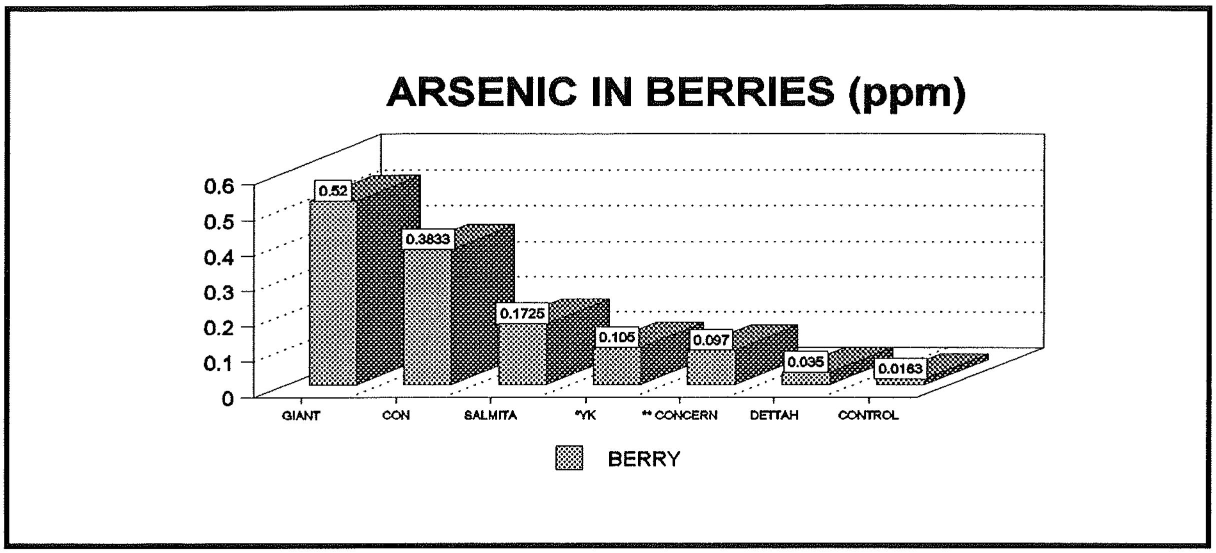

Figure #6:Mean Arsenic Levels (ppm) in All Species of Berries From Each Sampling Location

*YK represents samples taken from the city of Yellowknife
** CONCERN represents samples taken from areas the Weledeh elders believe to be contaminated

- ie. Yellowknife Bay west side, Yellowknife River, Yellowknife Bay east side across from Giant Mine, Kam Lake and Baker Creek

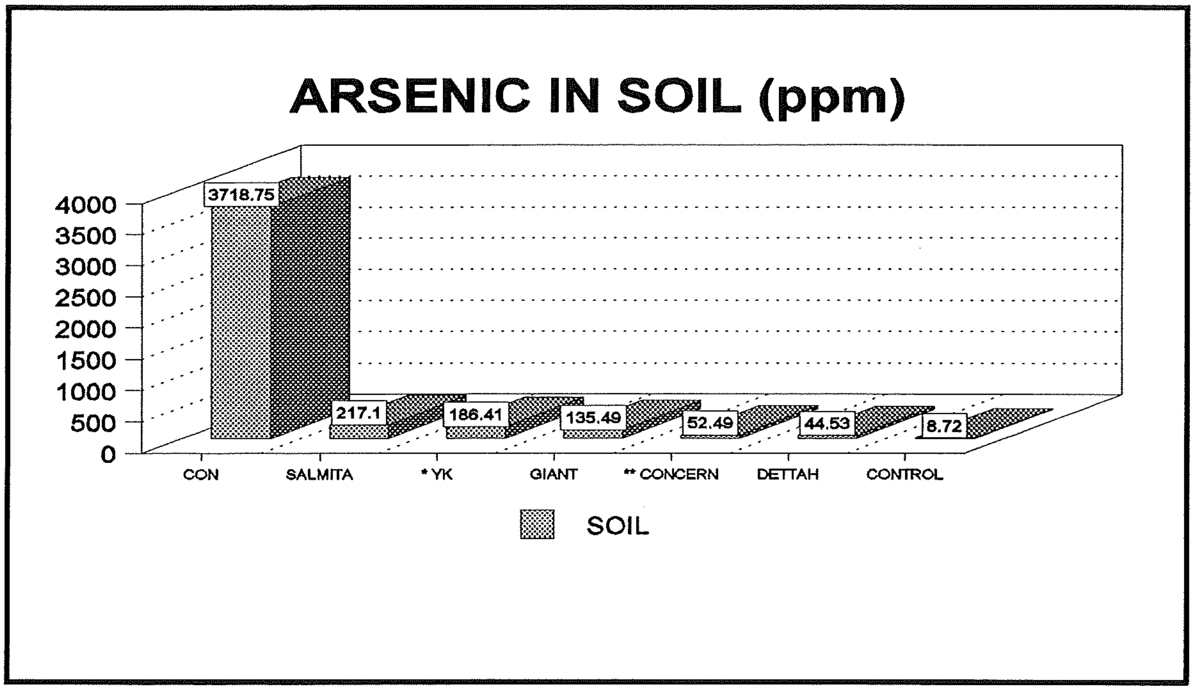

Figure #7: Mean Arsenic Levels (ppm) in Soils From Each Location

*YK represents samples taken from the city of Yellowknife
** CONCERN represents samples taken from areas the Weledeh elders believe to be contaminated

- ie. Yellowknife Bay west side, Yellowknife River, Yellowknife Bay east side across from Giant Mine, Kam Lake and Baker Creek

It is easy to determine, without statistical analysis, that the levels of *As* in berries from around the active mine sites is much higher than those from all the control areas - Wool Bay area, Point Lake and Trout Rock. The *As* in berries from Dettah is also slightly lower than in the Yellowknife area. This suggests that the mines do have an impact on *As* levels in berries in this region.(See Figures #6 and #7)

Since the different species collected for this study have different root systems and need different substrates to live, the soil samples varied greatly. Raspberries and gooseberries thrive in sandy, well drained soils, while cloudberries require moist, cool peat bogs. Cranberries and rose hips were generally found near the forested areas in soils rich in organic material. Blueberries were present in the sphagnum moss and in places near water.

5.3.0 Active Mine Sites

Burwash Mine was productive only for the year 1935. This was the first gold mine in the Yellowknife area. It had high quality gold that did not last long, but lead to the discovery of gold on the west side of Yellowknife Bay (Le Bourdais, 1957), eventually leading to ***Con*** and ***Giant.***

Twelve berry and soil samples were collected from the two active mine sites. Of the twelve berry samples, only two were within the recommended arsenic limit for consumption, while the control yielded all twelve berry samples in this group suitable for consumption. This is indicative (but not by any means conclusive) that the gold mines do play an important part in the level of *As* in the berries in the Yellowknives Dene traditional territory. See Appendix L for data details and Figures #6 and #7 for visual display of the data.

5.3.1 Giant Mine

With a mean arsenic level of 0.5200 ppm in berries, the berries from the Giant Mine site was the highest in arsenic of all the sampling locations. There was only one of the six berry samples obtained from this site that was suitable for consumption. The soil from Giant had a mean of 135.49 ppm arsenic. Berries in this area were sparse and small.

5.3.2 Miramar Con Mine

There were six berry samples collected from the Con Mine site. Since the *As* level in the berries does not correlate with the soil *As,* it is necessary to analyse the data further. Sample 1 was a blueberry sample from Miramar Con Mine site. The *As* level in this berry sample was an unexpectedly low 0.07 ppm (this was the only berry sample from the Con Mine site that was suitable for consumption using the guideline set for this study). The soil sample contained a high 260.14 ppm. It was noted when collecting the berries that the area was low topography and very close to the mine itself (< 1 Km). Also, there was an abundance of *Sphagnum* moss and Potentilla. Nearby, there were many spruce and jack pine trees, alder and willow. It is hypothesized that much of the *As* in the environment around the sample site was taken up by other species of biota (samples of other species would have to be obtained to conclude this hypothesis).

The other five samples from Miramar Con Mine site contained *As* levels above the recommended limit for consumption. The mean of the six samples from this location was the second highest, at 0.3833 ppm.

The soil from Con Mine had the highest mean value, 3718.75 ppm. Very high *As* levels have been reported near the gold mines in Yellowknife (Canadian Public Health Association, 1977; Ad Hoc Standing Committee on Arsenic, 1977).

5.4 The City of Yellowknife

Elders suggested berry samples be taken from the Yellowknife town area because of accessibility - if berries from Yellowknife were found to be uncontaminated, they will harvest from there.

There was a wide variation in arsenic levels in berries from the different sampling locations throughout the city. There were ten samples taken from the city proper. Sites selected were Fred Henne Park, Taylor Road, Frame Lake, Joliffe Island and Tin Can Hill (see map Appendix A and air photo Appendix D).

Situated in the Yellowknife Bay approximately 3 Km SE of Giant Mine, Joliffe Island is a likely destination for *As* coming from Giant on a NW wind. Two of the three berry samples from Joliffe were above the 0.1 ppm guideline. In January, the most frequent wind direction is NW (Environment Canada, 1990). This could leave Joliffe Island a good target for snow containing *As*-laden dust coming from Giant.

The high *As* level in the raspberry sample from Fred Henne Park (0.2 ppm) may have been influenced by three factors. 1) The sample was taken from the day-use parking lot, which sits on a hill near Long Lake. This is a high point of land and there are few wind blocks. Wind-blown *As* from Giant in the north west could accumulate here. 2) The soil was very sandy, with very little/no organic material to absorb *As.* Any available *As* in this soil would have been taken up by the berry plants. 3) raspberries and cloudberries are cluster fruits; many single fruits within one berry. Because of this morphology, there are many crevasses for *As*-containing dust to accumulate. Although the berry samples for this study were washed thoroughly (see Appendix G), it may have been impossible to eliminate all the dust.

The soil and berries from the out-of-town sites were lower in *As* than those from the town sites. However, the town sites were generally not very high in *As*, with a mean of .105 ppm (only .05 ppm above the limit for consumption). It is not known at this time whether or not the *As* is in the toxic form or the less toxic form, but it is not likely that all the *As* is in the toxic inorganic form. Therefore, berries harvested from the city of Yellowknife are probably safe to eat. The species of *As* in all the samples will be known when the second part of the study, conducted by the staff at CINE, is completed, early in the new millennium.

5.5.0 Abandoned Mine Sites

Past-producing mines (or abandoned mines) can still have an environmental impact long after the mine closure. Insufficiently treated tailings contain high levels of *As*. There is still potential, in many cases, for acid mine drainage to occur, a condition causing leaching of metals into the waterways. The former owners of the abandoned mines still have responsibility for reclamation, even if the closure was before environmental regulations were thorough. If the owner is unknown, it is up to the federal and provincial/territorial governments to assume responsibility (Environment Canada, 1991).

5.5.1 Salmita Mine

Salmita Gold Mine is a past-producing mine located about 230Km northeast of Yellowknife, near MacKay Lake. This mine has been in operation from 1983-87, producing 5624Kg gold from 217,000 tonnes (Jones, 1997). Salmita is one of two past-producers and fourteen prospects in a thirty-five kilometre stretch.

Three of the five berry samples from Salmita were above the recommended 0.1 ppm *As* level, making these samples higher in *As* than those from the control areas, although the mine has not been in production in over ten years.

5.6 Control Areas and Dettah Sites

There were three control areas selected for this study. Two of these sites were selected by the Yellowknives Dene, who, through their knowledge of the land prior to, and during, development, recommended samples be taken from these sites because they believe them to be uncontaminated. The Wool Bay Area (located on map Appendix A) is south of Dettah on the Great Slave Lake. This area is more than 10 Km from the gold mines. Since the soil and rock structure is similar to that of the Yellowknife area, the *As* in the environment from natural sources in control, mine and town areas should be close to identical. However, there is a wide discrepancy in *As* levels in berries and soil from these areas.

The other control areas were Enodah (Trout Rock), on the north arm of the Great Slave Lake and Point Lake (both located on map Appendix A). Only blueberry samples from these areas were obtained. In both locations, berry and soil samples yielded lower *As* levels than the town and mine site locations.

The Dettah sites were included in this section because there was no significant difference between the Dettah sites and the control areas for *As* in berries. Both were significantly different than all the other locations. Dettah is approximately 5 Km south east of the city of Yellowknife. Although Dettah is only one or two kilometres from the old Burwash site, it appears to have been only minimally affected (if at all) by this one-year mine.

6.0 LABORATORY COMPARISON

Arsenic compounds have been used in herbicides in the past. In plants, artificial applications of *As* can lead to an uptake that would be considered higher than normal for that species. For example, lettuce grown on soil treated with 250 lb/ac lead arsenate was found to have 0.08 ppm arsenic; when grown on soil treated with 1,000 lb/ac the arsenic level was 0.12 ppm (NRC, 1976). Some species were found to follow the same pattern (radish, beet) while others appeared not to take up significant levels of *As* (eggplant, tomato, carrot). Arsenic toxicity in plants normally results in a decrease in water mobility, loss of turgor, root plasmolysis, discolouration and necrosis (Environment Canada, 1991). Soils treated with *As*-containing pesticides have been found to have high enough levels of *As* to be phytotoxic.

Some plants have been found to have reduced growth from soils with high levels of *As*. Growth in green beans (*Phaseolus vulgaris*) has been reduced by 40 - 60% in soils contaminated with 10 mg

As(v)/ Kg and 25 mg of *As*(III) /Kg (Jacobs *et al.*, 1970; Woolson, 1973). Spinach plants (*Sinacia oleracea)* have also been shown to have growth reductions of about 40% when exposed to 10 mg *As*(v)/Kg (Woolson, 1973). Not all *As* in the soil is available to plants. Some of the variables are soil organic matter content, type and amount of clay in the soil, pH, and other minerals present (Environment Canada, 1991).

Studies of *As* levels on berries and vegetables have been done in the past. A study be Soniassy (1979) showed *As* levels (ppm) in washed berries from the Con Mine area harvested during the summer of 1978. Many of the berry and vegetable samples indicated levels of *As* greater than the 0.1 ppm limit used in this study for berries. Samples from this 1979 study were taken from Con Mine, Giant Mine, Old Town, Downtown and Frame Lake.

Comparing these samples with our samples collected from Con Mine shows that *As* levels (ppm) in berries has generally increased since 1978. A comparison of *As* levels from Soniassy (1979) and our 1998 study is found in Table #3.

Table #3. Comparison of *As* Levels in Berries Harvested From Con Mine in 1978 and 1998

BERRY SPECIES	1978 STUDY	1998 STUDY
Gooseberry	0.07	0.18
Blueberry	0.14	0.07
Cranberry	0.15	0.32; 0.64
Rose Hip	0.06	0.86; 0.23

However, from this study, it is impossible to determine with certainty if the levels of *As* in the berries around Con Mine has increased, as no map was provided showing the exact sample locations around the mine site, soil type was not mentioned and the samples in the 1978 study were washed with water only. The sample size is also very small.

The Food and Agriculture/World Health Organization (FAO/WHO) Expert Committee established a value of 2 *ug*/ Kg body weight/day to be the maximum allowable limit of inorganic arsenic (World Health Organization, 1989). This is the value used by Health Canada.

For additional reading on past and recent newspaper articles regarding the arsenic problem in Yellowknife, refer to Appendix L.

7.0 CONCLUSION

As advised by L. Chan, three questions must be answered before we can draw conclusions. They are:

1) Is there a correlation between the *As* in the berries and the soil? No correlation was found

2) Is there a correlation between each individual species of berry and the site they were chosen from? No correlation was found.

3) Is there a correlation between berries from each site? If there is a significant difference, all berries from one site can be lumped into one data set with the assumption that the species is not a significant factor in *As* uptake. There was no significant difference, so all berries were lumped together from each location.

* For soil samples, grain size, organic matter content and other vegetation at the location must be taken into

consideration in a more thorough investigation of the *As* in the soil and berries.

Based on the difference between the arsenic level in berries and soils obtained at the mine sites (and around the mine sites) and the control areas, we have observed statistically higher levels of *As* in five species of berries from areas around gold mines(and close to these mines)- *blueberries, cranberries, raspberries, rose hips and gooseberries* than the control sites. The results suggest (but does not conclude) that gold mining does have an effect on the *As* levels in these species of berries in the Yellowknives Dene traditional territory. Most berries harvested at the mine sites and some harvested within the city of Yellowknife are above the recommended concentration of 0.1 ppm for consumption. Proximity to the active mine sites appears to be a significant factor determining the level of *As* in berries in this region, as berries from the Dettah sites, further away from the mine sites than the town sites, were statistically lower in *As* than those from the city of Yellowknife. Cloudberries were analysed in this study but there were insufficient samples to determine whether or not mining has an effect on this species.

8.0 RECOMMENDATIONS

1) Because there were many berry samples over the recommended 0.1 ppm *As* level, it is recommended by the project team that further study be conducted to determine the species of *As* which is in the berry species in the Yellowknives Dene First Nation traditional territory.

2) Until the species of *As* is determined, it is recommended that berries harvested on or near the mine sites (along with those from Baker Creek and Yellowknife River) not be consumed.

3) Berries from around the town site of Yellowknife had a mean *As* level of slightly above 0.1 ppm. However, they are not unnecessarily unfit for consumption, as the species of *As* is not known at this time. However, we recommend that berries from Yellowknife be washed before consumption. The same recommendation is given for berries harvested from the Yellowknife Bay east side across from Giant Mine.

4) Berries from all other locations may be harvested and consumed without discretion, as the *As* levels in the berries and soils are very low.

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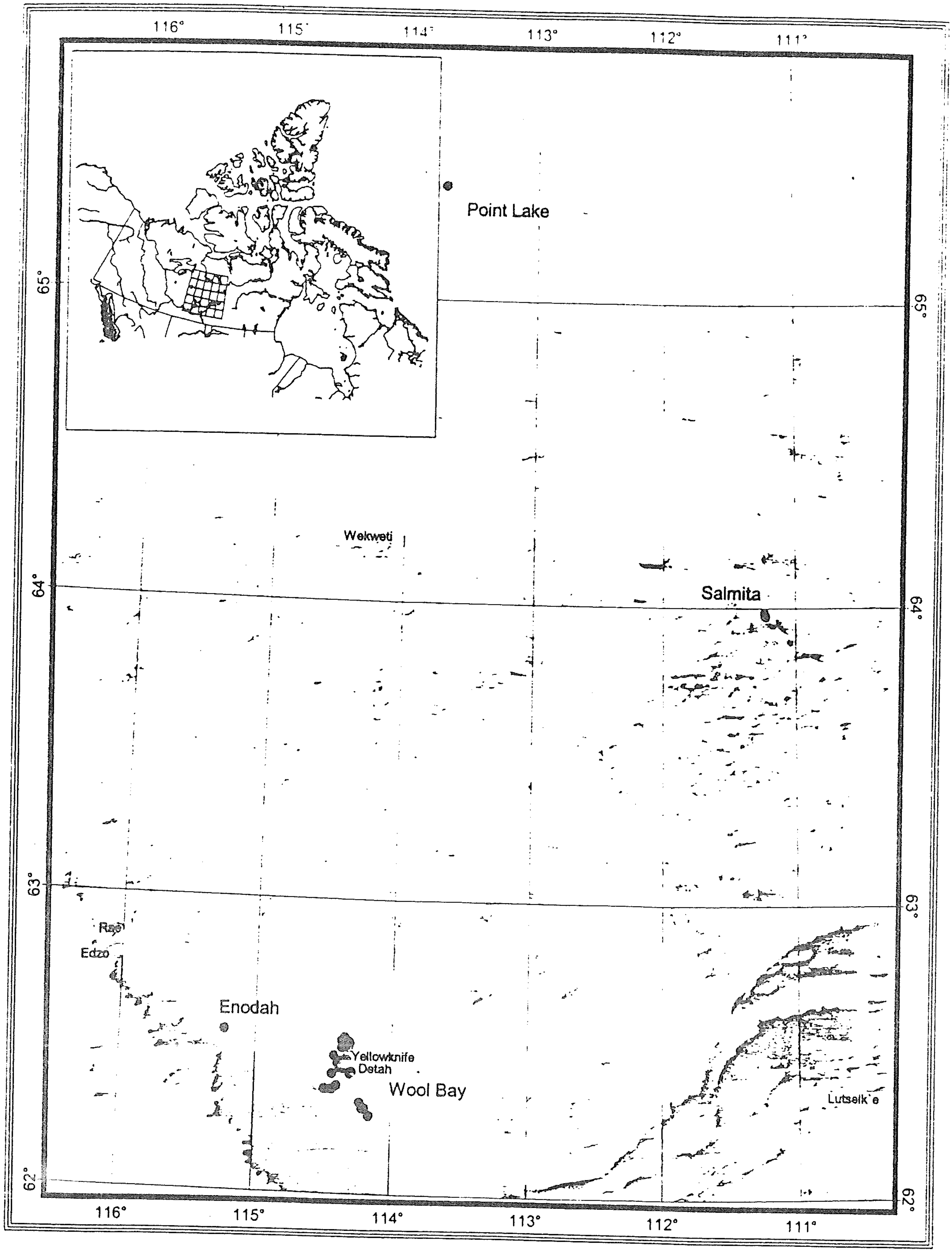
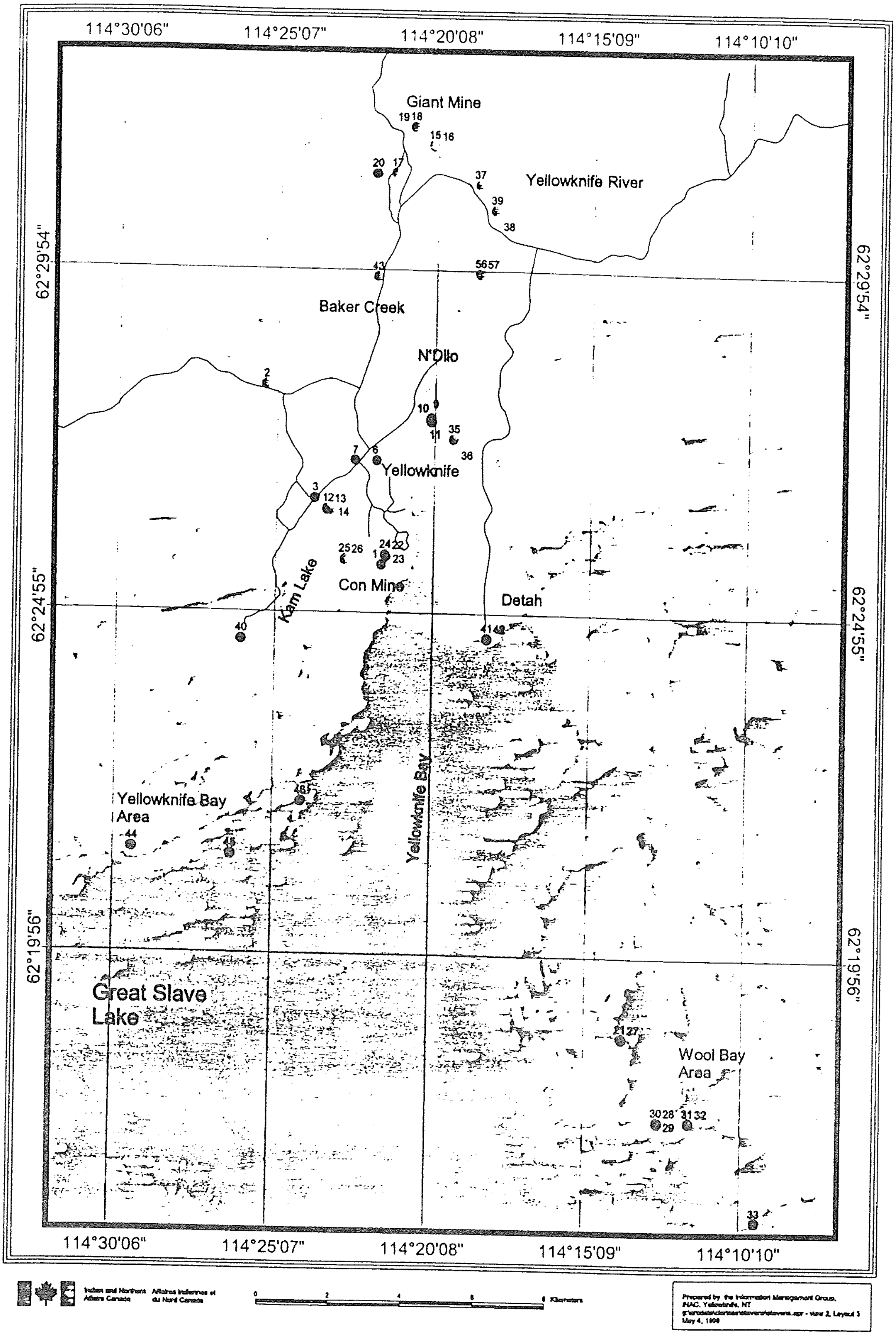
APPENDIX A

Sampling Locations

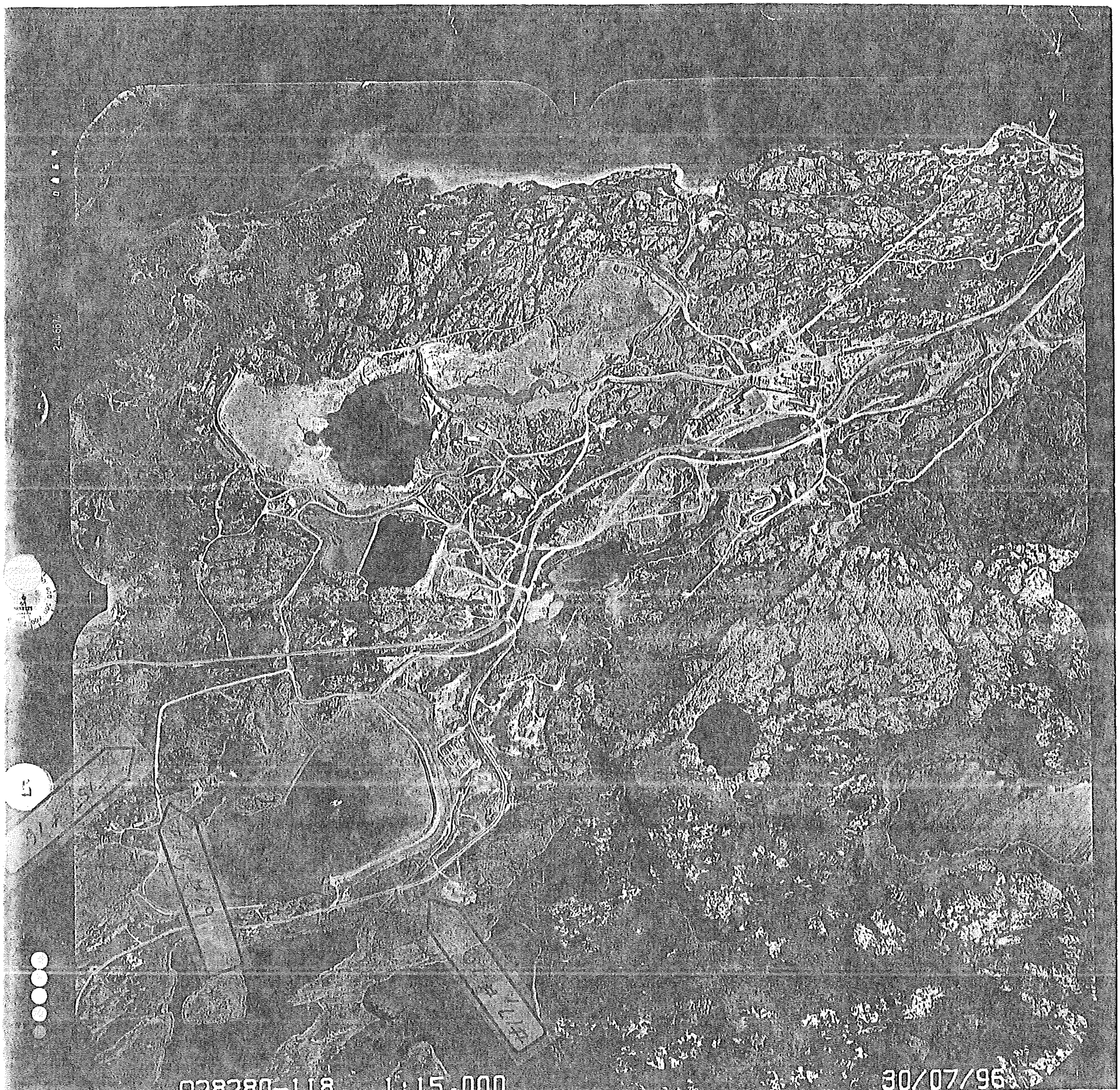


. Sampling Locations
Yellowknife and Area



APPENDIX B

Giant mine Sampling Sites



GEODESY
REMOTE SENSING INC.

FOTO FLIGHT SURVEYS LTD.

APPENDIX C

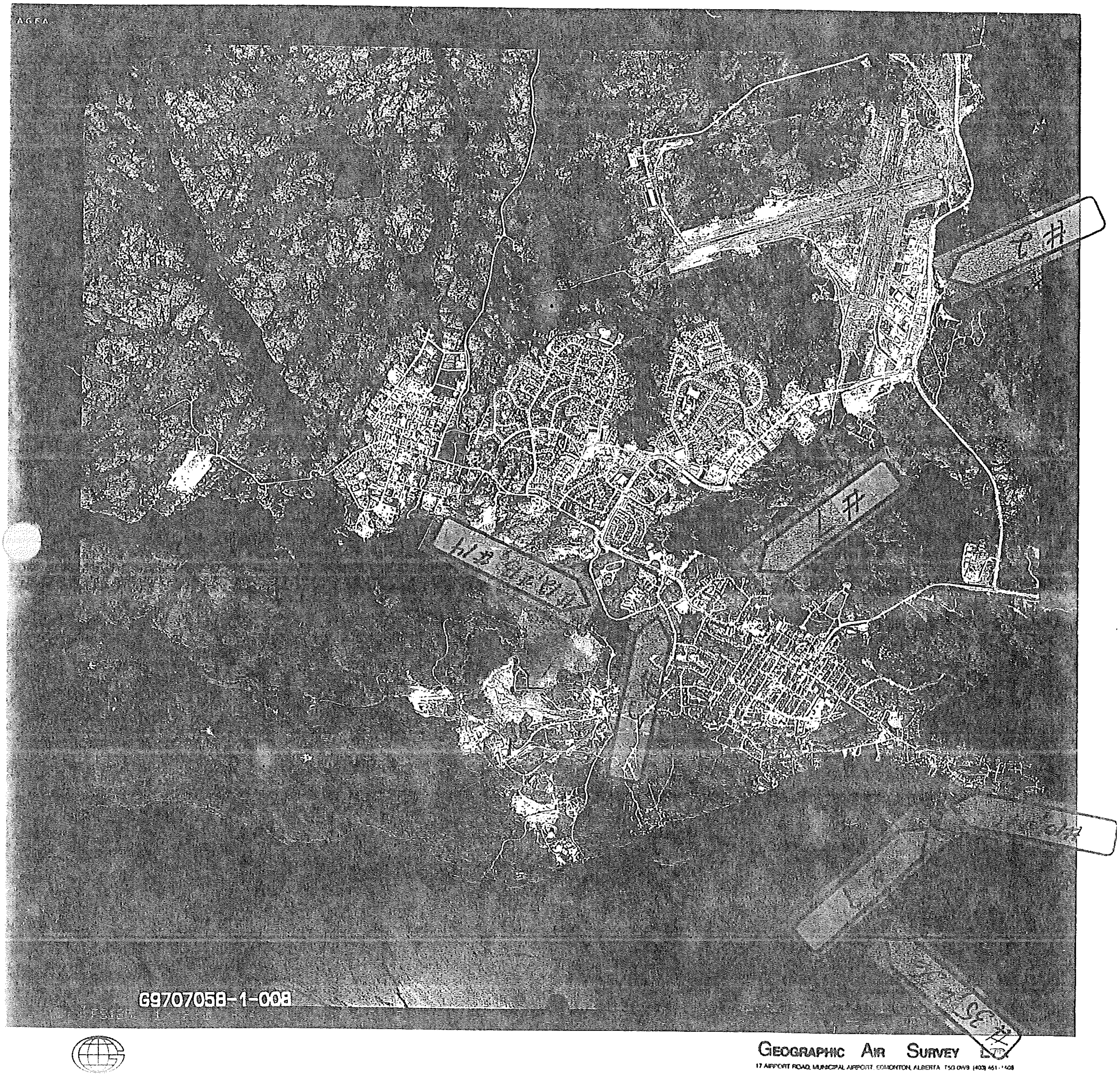
Con Mine Sampling Sites

GEODESY
REMOTE SENSING INC.

FOTO FLIGHT SURVEYS LTD.

APPENDIX D

Yellowknife Sampling Sites



APPENDIX E

Field Sampling Procedures for CINE Lab

Standard procedures are required for sample harvesting, packaging and shipping, to prevent or minimize contamination, spoilage or loss of volatile metals or organic compounds.

REFERENCE: MANUAL OF METHODS IN AQUATIC ENVIRONMENT RESEARCH: PART 3 SAMPLING AND ANALYSES OF BIOLOGICAL MATERIAL. FAO FISHERIES TECHNICAL PAPER NO.158. 1976.

Two main field sampling procedures will be used to collect samples for the CINE Labs:

1 - Sampling for food and metal analysis.
2 - Sampling for organic contaminant analysis.

1. Metal Analysis

Berries should be collected from different positions of the bush and placed in labelled sampling bags (high density Polyethylene bags)

Glass, plastic or stainless steel utensils should be used for food preparation.

Label should include

- i) date and location of
- ii) name of sample collector
- iii) name of species supplied
- iv) coded name or number of sample

- Each samples should be accompanied with a data sheet filled as completely as possible at the time of harvest.
- As much air as possible should be excluded from sample bags before sealing
- Labelled samples should then be placed in thermo-insulated cooler with ice, and frozen as quickly as possible (ie: within 5 to 10 hrs).
- Frozen samples should be transported to the CINE Lab at the earliest possible time.

2. Organic contaminant analysis

Sampling for organic contaminant analysis should be the same as described for food analysis, however, to prevent exogenous contamination from packaging material, samples must first be wrapped in pre-cleaned aluminum foil before placing them in high density polyethylerc bags.

Pre-cleaned aluminum foils will be provided by the CINE Labs. Al sheets are cut to the desirable dimension (45 cm x 25 cm) and rinsed with 1) Acetone and 2) 1:1 methylene chloride and hexane.

Samples must be clearly labelled for organic contaminant analysis.

Materials required for supplying; thermoisolated coolers, measuring devices, stainless steel knifes

Glass or metal utensils should be used for food preparation.

Freezer storage space must be made available nearby from the sampling site so that samples can be kept frozen at all times before transporting to the CINE Labs.

APPENDIX F

Sampling Data Sheet **Specimen #**__________

Date: __________
day-month-year

Harvest Location: __________ Harvest Date: __________
Month/Year

Person Harvesting: __________

Food Name : __________

Food Part: __________

Weight: __________

Time Placed in Freezer: __________
Date

Time from killing/collection to freezing of sample: __________

~~If animals : Age:~~ __________ ~~Sex:~~ __________

Comments:

Label on packaged frozen sample should include:
Specimen #
Food Name and Parts
Raw/Cooked

Frozen samples should be shipped:
Laurie Chan
Centre for Nutrition and the Environment of Indigenous Peoples
Macdonald Campus of McGill University
21,111 Lakeshore, Ste-Anne-de-Bellevue
Quebec, Canada, H9X 3V9
Telephone:(514)398-7754 Fax:(514)398-1020

APPENDIX G

Procedure for digestion of Akaitcho Soil Samples

1a) 2 g of all the samples excluding samples seen in 1b) were weighed and placed in a 100-ml digestion tube. Two replicates were done per sample

1b) 1g of samples 39, 45, 23, 33, 54, 44, 50, 55, 9, 46, 19. 21, 31, 52, 38, 37. These samples were done last. Because the samples were so organic it was difficult to work with 2 g because the samples were more likely to overflow when digested.

2) 15 ml of HNO3 were added to the tubes

3) The tubes sat overnight in the fume hood (minimum 16 hours)
NOTE: Steps 1-3 completed at CINE –McGill University Macdonald Campus

4) The tubes were placed in a digestion block in HCL04 fume hood

5) The digestion block was turned on and started at a setting of 120C. The temperature was increased until a final temperature of 150C was reached.

6) While waiting, the tubes were swirled around until the reaction was finished (no brown smoke)

7) The samples were cooled for at least 15 minutes.

8) 5 ml of concentrated HCL04 were added to each tube

9) The tubes were placed on the heating block and the temperature was raised gradually to 150C. The temperature has to be monitored carefully because the samples may spray or overflow because the reaction is too strong. (170C)

10) The tubes were monitored often-when the smoke died down and the soil looked white with black specs-the digestion was complete

11) The tubes were cooled

NOTE: Steps 4 – 11 completed at McGill University Macdonald Campus Soil Lab

12) The samples were vortexed after adding 40 ml of Nanopure water

13) The samples were brought up to volume (100-ml line) with Nanopure water

14) The samples were covered with parafilm and inverted 13X.

15) The samples sat over night (18 h)

16) 70-80 ml of solution were decanted in 30-ml polypropylene vials.

NOTE: Steps 12 – 13 were completed at CINE McGill University Macdonald Campus

Reference:
1st Draft of: Procedure for digesting soil samples with hot HNO3 and HCL04, Nicole Cook, November 1996

Comment: Most soil was very organic and because it wasn't uniform in material matter (i.e. dead leafs, decaying sticks etc.) therefore values may vary for a given sample. Sample 24 appeared to have some kind of carbonate (probably calcium carbonate) because the soil was a fine powder gray (limestone?). When acid was added it reacted very quickly. The same kind of reaction seen with sodium bicarbonate (baking soda) and acetic acid (vinegar).

Digestion for Akaitcho Berries

1) 2.2 grams of fresh, berries were weighed in a 20cm boiling tube. 2 replicates were done per sample

2) 8 ml of concentrated nitric acid was added to each tube. The tubes were covered with glass reflux bulbs and allowed to soak thoroughly in the acid overnight at room temperature

3) The tubes in the morning were then placed on theThermolyn Dri-Bath and raise the temperature from ambient to 120C over a period of 2-3 hours. The temperature was held at 120 for 5 hours. After the tubes were allowed to cool.

4) The tube contents were transferred into a 25ml volumetric flask with a Pasteur pipette. The tubes were rinsed with Nanopure twice, each time transferring a small amount to the volumetric flask until at least ¾ were full. The flask was placed in cool water to cool down the reaction. The remainder of the flask was filled to the 25-ml line using a Pasteur Pipette. The contents were transferred into a 25-ml snap cap polypropylene vial for storage.

Completed at CINE McGill University Macdonald Campus

Reference:

Comment: The seeds in the berries did not digest completely. So there may be some variation between the two replicates of a sample. However, if there was a lot a seed residue the samples were filtered.

AAS –Hitachi Polarized Zeeman Atomic Absorption Spectrometer

A) Warming up machine
-The EDL lamp was installed in position #1
-The AAS was turned on
-For As the Lamp current was set at 8.0 on parameter screen on computer
-The Output for the EDL was turned on at the lowest setting
-After 15 minutes, the output was increased to 6.0
-After 15 more minutes the output was increased to 8.0
-The machine was left on overnight to warm up before use.
-The lamp was conditioned to 0.8

B) Calibration of Standard Curve Plot

Standards 0,5,10,20,50 were used (with 24% HNO3 for berries and 20% for HNO3 for soil. 20% HNO3 was used for the soil because more acid was used for digestions. If samples did not fall with in this curve, a dilution would have to be completed

C) Preparation of Samples

Modifier 2 ml of 5% ascorbic acid
8 ml of 1000 ppm palladium

DORM 2 –Dogfish muscle (NRC Certified Reference Material) 1/50->. 1 ml Dorm-2 +4.9 ml HNO3 24%(always used at this concentration)

Samples – Place about 0.5 ml of sample into a AAS polystyrene sample cup.
If samples had to be diluted: 24% HNO3 was used for berries and 20% for soil samples

Completed at CINE McGill University Macdonald Campus

Comment:

Reference:

APPENDIX H

ARSENIC IN BERRIES (GROUPED) BY LOCATION

LOCATION	Giant	Con	YK	Abandoned	Dettah sites	Out of Town sites	Control
Giant							
Con	NSSD						
YK	SSD	SSD					
Abandoned	NSSD	NSSD	NSSD				
Dettah sites	SSD	SSD	SSD	SSD			
Out of Town sites	SSD	NSSD	NSSD	NSSD	SSD		
Control	SSD	SSD	SSD	SSD	NSSD	SSD	

Notes:

The test used was the Kolmogorov-Smirnov Test.

NSSD - indicates that there is not a statistically significant difference between the distributions.

SSD - indicates that there is a statistically significant difference between the distributions.

Test results generated by ***STATGRAPHICS PLUS*** statistical software

APPENDIX I

ARSENIC IN BERRIES COMPARED TO ARSENIC IN THE SOIL

TEST	P-VALUE	MEANING	R-SQUARED (%)	CORRELATION
All	0.3449	NSSD	1.86	-0.2326
Blueberries	0.0642	SSD	61.66	-0.6187
Raspberries	0.9109	NSSD	0.2760	-0.6565
Cranberries	0.3170	NSSD	7.691	-0.3042
Rosehip	0.0	SSD	96.33	-0.4795
Gooseberries	0.1134	NSSD	42.36	-0.5528
Cloudberries	-	-	100.0	-
Abandoned	0.5439	NSSD	9.885	-0.6081
Con	0.9863	NSSD	0.008	-0.5141
Control	0.0269	SSD	43.64	-0.6054
Giant	0.9562	NSSD	0.0853	-0.8595
Dettah sites	0.3514	NSSD	42.07	-0.8524
Out of Town sites	0.5215	NSSD	8.669	-0.6477
Yellowknife	0.4173	NSSD	8.377	-0.6823

KW = Kruskal-Wallis test

KS = Kolmogorov-Smirnov test

SSD = statistically significant difference

NSSD = no statistically significant difference

Test results generated by ***STATGRAPHICS PLUS*** statistical software

APPENDIX J

ARSENIC IN BERRIES BY LOCATION/ LOCATION BY BERRY

TEST	P-VALUE	MEANING	TEST
All	0.3871	NSSD	KW
Cranberries	0.0160	SSD	KW
Rosehip	0.0638	NSSD	KW
Gooseberries	1.0	NSSD	KW
All Locations	0.000002	SSD	KW
Abandoned (Cran \ Cloud)	0.2710	NSSD	KS
Con (Cran \ Rose)	0.9639	NSSD	KS
Control (Blue \ Cran)	0.2912	NSSD	KS
Control (Blue \ Rose)	0.5320	NSSD	KS
Control (Rose \ Cran)	0.2912	NSSD	KS
Control (All three)	0.0949	NSSD	KW
Giant (Cran \ Rose)	0.2710	NSSD	KS
Dettah sites (Goose \ Rose)	0.9639	NSSD	KS
Out of Town sites (Cran \ Rose)	0.3220	NSSD	KS
Yellowknife (Goose \ Rasp)	0.6826	NSSD	KS

KW = Kruskal-Wallis test

KS = Kolmogorov-Smirnov test

SSD = statistically significant difference

NSSD = no statistically significant difference

Test results generated by ***STATGRAPHICS PLUS*** statistical software

APPENDIX K

As Levels in Berries and Soils

Sample Code	Location	Lat./Long.	Berry	As (ug/g wet wt)	As (soil) ug/g wet wt
3	Taylor Rd.	62.4435, -114.3983	Raspberry	0.09	41.73
6	Tin Can Hill	62.4449, -114.4417	Raspberry	0.06	39.14
7	Frame Lake	62.4527, -114.3775	Raspberry	0.08	329.73
2	Fred Henne Park	62.4708, -114.4250	Raspberry	0.2	6.3
9	Joliffe Island	62.4658, -114.3367	Blueberry	0.16	162.98
10	Joliffe Island	62.4658, -114.3383	Gooseberry	0.08	10.35
11	Joliffe Island	62.4657, -114.3382	Raspberry	0.13	422.31
12	Taylor Rd.	62.4410, -114.3917	Gooseberry	0.02	32.49
13	Taylor Rd.	62.4407, -114.3917	Cranberry	0.15	625.11
14	Taylor Rd.	62.4407, -114.3900	Rose hip	0.08	193.98
15	Giant Mine	62.5293, -114.3382	Gooseberry	0.2	71.07
16	Giant Mine	62.5290, -114.3380	Raspberry	1.91	112.21
17	Giant Mine	62.5225, -114.3576	Cranberry	0.3	305.62
19	Giant Mine	62.5338, -114.3480	Cranberry	0.46	149.9
20	Giant Mine	62.5336, -114.3482	Rose hip	0.05	72.86
18	Giant Mine	62.5223, -114.3678	Rose hip	0.2	101.25
21	Akaitcho Island *	62.3131, -114.2333	Cranberry	0.04	81.64
1	Con Mine	62.4275, -114.3627	Blueberry	0.07	260.14
22	Con Mine	62.4297, -114.3608	Cranberry	0.32	10985.91
23	Con Mine	62.4295, -114.3606	Cranberry	0.64	595.5
24	Con Mine	62.4299, -114.3610	Rose hip	0.86	1393.55
25	Con Mine	62.4288, -114.3823	Gooseberry	0.18	392.56
26	Con Mine	62.4286, -114.3821	Rose hip	0.23	356.71
27	Akaitcho Island *	62.3129, -114.2330	Rose hip	0	23.65
28	Wool Bay Island	62.2928, -114.2137	Cranberry	0.02	NA
29	Wool Bay Island	62.2926, -114.2136	Gooseberry	0.03	6.25
30	Wool Bay Island	62.2929, -114.2138	Raspberry	0.02	4.7
31	Mainland near Wool Bay	62.2928, -114.1971	Rose hip	0	0.9
32	Mainland near Wool Bay	62.2927, -114.1970	Cranberry	0.01	15.8
33	Unnamed I. near Wool Bay	62.2685, -114.1618	Cranberry	0.04	36.49
34	Unnamed I. near Wool Bay	62.2684, -114.1617	Rose hip	0.02	14.14
35	Dettah Road	62.4581, -114.3255	Gooseberry	0.04	26.01
36	Dettah Road	62.4579, -114.3256	Rose hip	0.04	84.84
37	Yellowknife River		Cranberry	**	12.93
38	Yellowknife River	62.5135, -114.3050	Cranberry	0.19	4.13
39	Yellowknife River	62.5137, -114.3048	Rose hip	0.11	64.16
40	Kam Lake	62.4092, -114.4363	Cranberry	0.07	36.35
41	Dettah	62.4099, -114.3069	Rose hip	0.01	13.88
42	Dettah	62.4098, -114.3068	Gooseberry	0.05	53.39
43	Baker Creek	62.4973, -114.3667	Rose hip	0.15	180.89
44	Yellowknife Bay	62.3582, -114.4917	Cranberry	0.06	1.96
46	Yellowknife Bay	62.3696, -114.3255	Cranberry	0.05	0.63
45	Yellowknife Bay	62.3568, -114.4402	Cranberry	0.05	64.48

49	Trout Rock	62.5473, -115.2333	Blueberry	0.02	6.99
50	Salmita	63.9740, -111.2283	Blueberry	0.15	627.77
51	Salmita	63.9833, -111.2333	Cranberry	0.05	14.2
52	Salmita	63.9750, -111.2283	Cloudberry	0.16	34.8
53	Salmita	63.9750, -111.2267	Cloudberry	0.32	191.64
54	Point Lake	65.3725, -113.7333	Blueberry	0.01	0.59
55	Point Lake	65.3722, -113.7333	Blueberry	0.01	0.57
56	Burwash	62.4982, -114.3128	Cranberry	0.12	73.8
57	Burwash	62.4980, -114.3126	Rose hip	0.07	45.63

Note: Highlighted areas for berries indicate samples that are above the recommended *As* limit of 0.1 ug/g wet wt.

Highlighted areas for soil indicate samples which are above the natural soil *As* limit of 40 ppm