Characterization of the Potentia Human Health Risk From Consumption of Garden Produce in Yellowknife, NWT

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Executive Summary

An investigation by the Environmental Sciences Group has revealed that Yellowknife garden produce is safe to eat, despite containing levels of arsenic that are higher than national averages.

The presence of elevated soil arsenic concentrations in the Yellowknife area prompted some concern from local residents that arsenic levels in their vegetables might be above a level safe for consumption. Nine families voluntarily donated produce from their gardens, allowing us to determine levels of total arsenic in their vegetables and fruits. This data was then used to estimate the risk posed by the levels of arsenic in these samples.

Following washing procedures similar to those used in typical food preparation, vegetables and fruits were dried, ground, and acid digested. Total arsenic concentrations were determined in the acid digests by hydride generation-atomic absorption spectrometry (HG-AAS). A total of 61 garden vegetables were analyzed, with 30 different species being examined. Arsenic levels in dried and ground soils from each garden were determined by neutron activation analysis (NAA).

The concentration of arsenic in soils from the vegetable gardens was 31±13 ppm. This is within the range that is suggestive of the natural or background concentration in the soil of the Yellowknife area[1]. The garden soils collected on the Giant Mine Townsite property, which is a property no longer used residentially, contained a higher average arsenic concentration of 202±137ppm (median 174 ppm, range 81 – 351 ppm). This average is also consistent with a recently released study by the authors on the soil characteristics of the Giant Mine Townsite[2].

A significant finding is that arsenic concentrations in produce from Yellowknife gardens are almost always an order of magnitude greater than those found in like foods in a diet survey conducted in 1993[3]. The highest concentrations of arsenic were found in leafy vegetables such as lettuce (e.g., maximum 0.27 ppm fresh weight) and berries (maximum 0.440 ppm fresh weight).

The next step was then to determine if this ten-fold increase of arsenic in Yellowknife produce increases the risk of adverse effects to arsenic residents consuming local

[1] ESG 2001. Arsenic levels in the Yellowknife area: Distinguishing between natural and anthropogenic inputs. Prepared for Yellowknife Arsenic Soil Remediation Committee (YASRC). RMC-CCE-ES-01-01, pp. 1-62.

[2] ESG, Queen's University, 2001. Characterization of arsenic in solid phase samples collected on the Giant Mine Townsite, Yellowknife, NWT. Prepared for Royal Oak Project Team, Indian and Northern Affairs Canada (INAC), pp. 1-65.

[3] Dabeka, R. W., McKenzie, A. D., Lacroix, G. M. A., Cleroux, C., Bowe, S., Graham, R. A., Conacher, H. B.S., Verdier, P. 1993. Survey of arsenic in total diet food composites and estimation of the dietary intake of arsenic by Canadian adults and children. Journal of AOAC International, 76, 14-25.

produce. This was done by using a step-wise approach to risk assessment, recommended by Health Canada[4], to determine if the estimated daily intake of arsenic is over that of the provisional maximum daily intake (PMDI) of 2.1µg/kg/day, recommended by the Food and Agriculture Organization/World Health Organization (FAO/WHO).

The estimated daily intakes of arsenic from garden vegetables grown in Yellowknife were determined for two situations. The first situation involved the examination of *individual gardens* and the second situation involved an examination of a *generic garden.* The *generic garden* was created by using a range of arsenic concentrations (minimum, maximum, mean and median values) for each of 18 vegetables used in the risk assessments for *individual gardens.*

It was seen that for the *individual gardens* the estimated daily intake of arsenic from garden produce does not significantly increase the EDI above that reported by Dabeka *et al.*, when the produce consumption is limited to the growing season, and is supplemented by produce consumption from the supermarket. These levels are well below that recommended as the safe limit by the FAO/WHO. The worst case scenario, where garden produce is not supplemented by supermarket produce, resulted in EDIs that were slightly above the FAO/WHO safe level for children only. However, the unlikelihood of this scenario minimizes any increased risk.

The highest EDI calculated for the *generic garden* was a result of assuming, again, that only garden produce is consumed (scenario 3, 2.11 µg/kg/day, c.f. the tolerable daily intake of 2.1 µg/kg/day), for children between the ages of 1 to 4 years of age. All other EDIs were well below the safe level.

Thus, following the step-wise approach recommended by Health Canada, and using worst case, as well as realistic scenario calculations, we believe there is little, if any, risk posed to the residents consuming garden vegetables in the City of Yellowknife.

The statement above assumes that the gardens sampled in the Yellowknife area reflect the conditions in all other gardens in Yellowknife at the time of the study.

[4] Health Canada. 1995. Investigating Human Exposure to Contaminants in the Environment: A Handbook for Exposure Calculations. H49-96/1-1995E. pp. 1-66.

Acknowledgments

The determination of the concentrations of arsenic in vegetables and soils from gardens in the Yellowknife area was initiated by the Environmental Sciences Group (ESG), Royal Military College (RMC) of Canada. The investigation was conducted under the direction of Dr. Kenneth Reimer. Dr. Iris Koch, Christopher Hough, and Christopher Ollson carried out the collection of samples in September of 2001. Deborah Reimer oversaw the financial administration.

Several families contributed vegetables from their gardens in order to make this work possible. To ensure their privacy we can not name them here, but the ESG is extremely grateful to them.

The analytical work was performed by Niki Sharma, Dr. Iris Koch, Christopher Ollson, and the Analytical Services Group (ASG) at the Royal Military College of Canada. The financial support of the following is gratefully acknowledged: Academic Research Program, Department of National Defence, and Health Canada and Environment Canada's Toxic Substances Research Initiative (Grant #295).

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Table of Contents

Executive Summary 1

Acknowledgments 3

Table of Contents 4

List of Tables 5

List of Figures 6

List of Maps 6

List of Photographs 6

1 Introduction 7

2 Background 8
2.1 Arsenic in Yellowknife 8
2.2 Arsenic in Food 8
2.3 Arsenic in Canadian Food 9
2.4 Arsenic in Yellowknife Vegetables and Berries 10
2.5 Risk Assessment 11

3 Methods 13
3.1 Locations of Gardens in the Yellowknife Area 13
3.2 Analysis of Soil Samples 19
3.3 Analysis of Plant Samples 20

4 Results and Discussion 21
4.1 Arsenic Concentrations in Soils 21
4.2 Arsenic Concentrations in Vegetables 22
4.3 Risk Posed by the Consumption of Yellowknife Garden Vegetables 24
4.3.1 Assumptions and Calculations used in the Risk Assessment 25
4.4 Estimated Daily Intakes of Arsenic 28
4.4.1 Estimated Daily Intakes for Scenario 1 28
4.4.2 Estimated Daily Intakes for Scenario 2 29
4.4.3 Estimated Daily Intakes for Scenario 3 29
4.4.4 Estimated Daily Intakes for Scenario 4 29
4.5 Assessment of Risk Posed by the Consumption of Yellowknife Garden Vegetables 34

5 Conclusions 35

6 Future Work 36

7 References **38**

8 Appendices **40**

9 Appendix A: Data Tables for Individual Gardens **41**

10 Appendix B: Estimated Daily Intakes of Arsenic from Vegetable Gardens **44**

11 Appendix C: Quality Assurance/Quality Control **62**
11.1 Garden Soils 62
11.1.1 Detection Limit for Arsenic by Neutron Activation Analysis (NAA) 62
11.1.2 Accuracy for Arsenic by NAA 62
11.1.3 Precision/Reproducibility 62
11.1.4 Blanks 63
11.2 Vegetables and Plants 64
11.2.1 Detection Limit 64
11.2.2 Accuracy 64
11.2.3 Precision/Reproducibility 65
11.2.4 Blanks 68

List of Tables

Table 1. Summary of Daily Dietary Intakes of Arsenic Estimated in Dabeka *et al.*[18] 10

Table 2. Soil sample descriptions for all garden samples. 13

Table 3. Arsenic concentrations in soil samples from the garden locations in Yellowknife. 21

Table 4. Summary of Arsenic Concentrations in Yellowknife Vegetables (raw). The concentrations of arsenic found in vegetables in Canada (from Dabeka *et al.*, 1993) are included for comparison. 23

Table 5. Composition of the Yellowknife generic garden. 26

Table 6. Results for Scenario 1: Worst Case for Individual Gardens. The maximum potential increase in daily arsenic intakes (ug/kg/day) from individual gardens in Yellowknife (a) is added to the total daily arsenic intakes reported by Dabeka, 1993 (b), to obtain the total daily intake of arsenic (c). 30

Table 7. Results for Scenario 2: Most Realistic Case for Individual Gardens. The maximum potential increase in daily arsenic intakes (ug/kg/day) from individual gardens in Yellowknife (a) is added to the total daily arsenic intakes reported by Dabeka, 1993 (b), to obtain the total daily intake of arsenic (c). 31

Table 8. Results for Scenario 3: Worst Case for Generic Yellowknife Garden. The maximum, minimum, mean and median potential increase in daily arsenic intakes

(ug/kg/day) from a generic garden in Yellowknife (a) are added to the total daily arsenic intakes reported by Dabeka, 1993 (b), to obtain the total daily intake of arsenic (c). 32

Table 9. Results for Scenario 4. Most Realistic Case for Generic Yellowknife Garden. The maximum, minimum, mean and median potential increase in daily arsenic intakes (ug/kg/day) from a generic garden in Yellowknife (a) are added to the total daily arsenic intakes reported by Dabeka, 1993 (b), to obtain the total daily intake of arsenic (c). 33

List of Figures

Figure 1. The six step approach for estimating exposure to environmental contaminants (Health Canada, 1995) 24

List of Maps

Map 1. Location of gardens in the Yellowknife Area 14

List of Photographs

Photo 1. Garden 5, Latham Island 15
Photo 2. Garden 10, Latham Island 15
Photo 3. Garden 9, Old Town Yellowknife. 16
Photo 4. Garden 3, north end, Rat Lake area. 16
Photo 5. Garden 3, south end, Rat Lake area. 17
Photo 6. Garden 6, carrot patch, downtown area. 17
Photo 7. Garden 6, potato patch, downtown area 18
Photo 8. Garden 4, mine town site. 18

1 Introduction

For over ten years, the Environmental Sciences Group (ESG) at RMC has been studying arsenic in the terrestrial and freshwater environment in Yellowknife, NWT. Several studies describing the levels of arsenic surrounding the Giant Mine[1,2,3], the Con Mine[4], and the City of Yellowknife[5] have been published by ESG in the last few years. All of these publications reported elevated levels in most soil, sediment, water, and plant samples collected[6].

In the course of releasing these documents to the Yellowknife public and government regulators, concerns were raised about the levels of arsenic in produce grown in residential Yellowknife gardens. In response to these concerns, ESG undertook to study arsenic in garden vegetables from Yellowknife, and was successful in securing funding from Health Canada and Environment Canada's Toxic Substances Research Initiative to do so. Additionally, ESG is carrying out a detailed risk assessment for the Yellowknife area, for which this study provides crucial data.

In September 2001, ESG visited Yellowknife and conducted a sampling program of residential gardens in Yellowknife. Residents of Yellowknife generously donated samples for this study on a voluntary basis. An attempt was made to sample gardens from around the City of Yellowknife to ensure a representative collection of vegetables.

The objectives of this report are:

- To quantify and discuss levels of (total arsenic) in soil and produce from residential Yellowknife gardens; and
- To predict the potential risk to Yellowknife residents who consume garden produce.

This report is primarily intended to be a source of information for residents in the Yellowknife area. It should also be useful to the Yellowknife Arsenic Soil Remediation Committee (YASRC) in planning area-specific remediation guidelines.

2 Background

2.1 Arsenic in Yellowknife

Arsenic is a ubiquitous, naturally occurring element in the environment, ranking, in abundance, twentieth in the earth's crust, fourteenth in seawater, and twelfth in the human body. In spite of its ubiquity, arsenic is still nearly synonymous with poison, as some arsenic compounds were used for that purpose for centuries. While arsenic is often associated with adverse effects, its toxicity is actually dependent on its chemical form, or species (i.e., the specific combination of arsenic with other elements). For example, arsenobetaine, an organoarsenic compound, is found in marine animals and mushrooms, and is much less toxic than arsenic trioxide, an inorganic form of arsenic (and the main historical poison).

Arsenic can be introduced to the environment naturally as a result of the weathering of rocks that contain arsenic-rich minerals, and geothermal activities. It can also enter the environment anthropogenically as a consequence of its industrial use, through the application of arsenic-containing pesticides, and through mining and smelting activities. A very important example of the latter is gold mining.

Yellowknife has been an active gold mining community since 1938. The gold in Yellowknife ore is found with arsenopyrite (FeAsS), an arsenic containing iron sulphide. Consequently, the milling of the arsenic-rich ore generates a considerable amount of arsenic waste. This waste can enter the environment in the form of solid waste (waste rock and tailings), liquid effluent, and aerial emissions from the roaster stack.

As a result of both the anthropogenic inputs of arsenic from gold mining, as well as the natural inputs from the weathering of arsenic-containing minerals, the arsenic levels in the Yellowknife area are elevated compared to the typical Canadian background concentration range of 5 to 14 ppm in soils. In previous studies, the background levels have been estimated to range from 3 to 150 ppm in Yellowknife[7].

2.2 Arsenic in Food

In most regions of Canada, the concentration of arsenic in drinking water (usually of the order of 1 ppb) is much lower than the provisional maximum allowable concentration of 25 ppb. In spite of the elevated levels of arsenic in lakes in and surrounding the city of Yellowknife, the arsenic concentration in the municipal supply of drinking water is less than 1 ppb and is therefore safe to drink. Under these circumstances, the main contribution of arsenic to the human diet comes from food.

The U.S. Food and Drug Administration (FDA) has conducted a number of total diet studies that provide a thorough estimation of total arsenic in the U.S. diet. It was determined that food contributes 93% of total intake of arsenic in the human diet, and that seafood contributes 90% of that 93%[8,9].

A comprehensive summary of the levels and species of arsenic found in food is found in *Arsenic in Drinking Water*, a document prepared during the recent scientific review of the U.S. EPA's interim maximum contaminant level (MCL) for arsenic in drinking water of 50 ug/L (ppb)[9]. In general, the foods that contribute the majority of arsenic to the human diet (fish, shellfish and algae) contain non-toxic organoarsenic compounds (i.e., arsenobetaine and arsenosugars). Other foods, such as vegetables, rice, poultry, mushrooms, etc., contain much lower levels of arsenic. As a result of limitations in analysis methods arising from these low levels, the arsenic in these foods has been very difficult to characterize.

Studies using the most reliable methods have determined that most or a large proportion of extractable arsenic is inorganic in carrots[10], vegetables[11] and berries[12]. Some mushrooms have been reliably characterized with respect to their arsenic content[13,14,15,16,17], revealing that some choice edible mushrooms contain predominantly arsenobetaine, a non-toxic form of arsenic. However, no generalization can be made about the character of arsenic in mushrooms; the arsenic forms present vary depending on the mushroom species[13,17]. It is important to note that all of the studies cited here characterized arsenic in foods that contained elevated levels of arsenic. These foods are therefore not necessarily representative of foods that humans ingest on a daily basis.

2.3 Arsenic in Canadian Food

A comprehensive survey of total arsenic in Canadian foods was published in 1993 and is used throughout this report for comparison to our findings[18]. This survey found that the arsenic content ranged from low ug/kg (ppb) levels in milk and dairy products, soups, vegetables, fruit and fruit juices and beverages; to double digit ug/kg (ppb) levels in meat and poultry, bakery goods and cereals, fats and oils, sugar and candy and miscellaneous foods; to low mg/kg (ppm) levels in fish and shellfish. In other words, all foods other than fish and shellfish contained arsenic levels of less than 50 ppb.

From these numbers, daily dietary intakes of arsenic were estimated. The lowest values were calculated for children 1-4 years of age, and the highest values were calculated for men in the 20 to 39 year age group, as summarized in Table 1. For the average ingestion of arsenic by a Canadian adult, the daily intake is 40% of the provisional maximum daily

intake (PMDI) recommended by the Food and Agriculture Organization/World Health Organization (FAO/WHO), of 2.1 ug of arsenic/kg of body weight/day, or 15/ug/kg/week[19,20]. → inorganic As for HC.

Table 1. Summary of Daily Dietary Intakes of Arsenic Estimated in Dabeka *et al.*[18]

	Age/Group	Body Weight (kg)	Daily Intake per kg Body Weight (ug/kg/day)	Daily Intake (ug/day)
Lowest	1-4 years	13	1.15	14.9
Highest	20-39 years, males	70	0.85	59.2
Average	Canadian adult	60	0.8	48
PMDI	–	60	2.1	126

2.4 Arsenic in Yellowknife Vegetables and Berries

In 1979 a survey of arsenic in Yellowknife vegetables was published, summarizing total arsenic levels in a variety of vegetables and fruits sampled from five general areas in Yellowknife[21]. Arsenic levels ranged from a low of 0.05 mg/kg (ppm) fresh weight in pea pods to a high of 2.05 mg/kg (ppm) fresh weight in green onions, with an average overall concentration of 0.32 mg/kg (ppm) fresh weight (n=42). No attempt was made to predict human health risk from the consumption of the produce in this report, although it was noted that the levels of the arsenic were similar to those found in previous years.

Check CINE Study *

In the summer of 1998 an assessment of arsenic in berries in and around Yellowknife was initiated by the Dene Nation. This study was carried out in two parts: the first part examined total arsenic in samples[22], and the second part examined potential risk associated with the consumption of the berries, and included an attempt to characterize the arsenic in them[12]. Statistical analysis revealed that there were significantly higher levels of arsenic in berries from mine sites and within the city of Yellowknife compared with those from control and Dettah sites. A guideline of 0.1 ppm fresh weight for arsenic in fruit juices and beverages was used as a upper safety limit in this study, and 21 samples were found to contain arsenic levels above this limit. They were berry samples collected from Fred Henne Park, Joliffe Island, Taylor Road, Giant Mine, Con Mine, Yellowknife River, Baker Creek, Salmita (an abandoned gold mine), and Yellowknife Bay across from Giant Mine.

These 21 samples were subsequently characterized using an indirect arsenic speciation analysis method, better known as fractionation[12,23]. The proportion of inorganic arsenic found in the berry samples ranged from 10 to over 100%, with a qualifier that some analytical error may have been present. Nevertheless, based on these results, the authors assumed that berries contain 33% inorganic arsenic. Using this assumption, and a comprehensive estimate of berry intake, the risk from the intake of arsenic from the berries was predicted to be minimal, both with respect to daily intake guidelines, and calculated cancer risk.

2.5 Risk Assessment

As a result of the reporting of elevated levels of arsenic in soils in the Yellowknife area, concerns have arisen as to whether or not garden produce grown in the Yellowknife area poses a risk to residents consuming them.

Health Canada reports that if a contaminant level exceeds that of the Interim Assessment Criteria for Soil and Water[24], then further investigation of the contamination is recommended, including sampling of garden vegetables. In the case of Yellowknife the majority of soil samples collected in the City of Yellowknife exceed the recommended criteria of 12 ppm[7].

There are several ways by which one can conduct an assessment of risk to human health posed by a route of exposure. The Environmental Sciences Group has opted to follow the guidelines set out by Health Canada[25], for determining the exposure of humans to contaminants, in order to estimate the daily exposure to arsenic of Yellowknife residents consuming vegetables. The approach of this method is to determine the Estimated Daily Intake (EDI) by all possible pathways, and then to compare this EDI with a Tolerable Daily Intake (TDI) for non-carcinogenic substances, or with a Risk-specific Dose (RsD) for carcinogenic substances.

Currently there is limited knowledge as to how, or if, intake of arsenic from food ingestion can cause adverse health effects. Nevertheless, in their last toxicological evaluation of food contaminants in 1988, the Joint FAO/WHO Expert committee on Food Additives (JECFA) recommended a provisional tolerable weekly intake (PTWI) of 15 ug/kg/week (corresponding to a provisional maximum daily intake, PMDI, of 2.1 ug/kg/day) of inorganic arsenic. This PTWI was specifically recommended for the intake of arsenic from food. The specificity of this guideline allows us to conduct a comparison of daily intakes of arsenic from vegetables in Yellowknife with the PMDI recommended by FAO/WHO. This approach provides an initial basis for risk characterization

Although arsenic is a carcinogen, we will not consider the cancer risks associated with the consumption of vegetables grown in Yellowknife gardens at this preliminary stage of analysis. Such an evaluation should include estimated doses (ED) of arsenic from air, drinking water, soil ingestion, food, and skin absorption (water and soil)[25]. The measurement of arsenic intakes through these different pathways is beyond the scope of the present study.

Details of the specific steps taken, assumptions and calculations used to determine the risk of arsenic intake posed by consumption of Yellowknife vegetables are found in the results section (4.3).

3 Methods

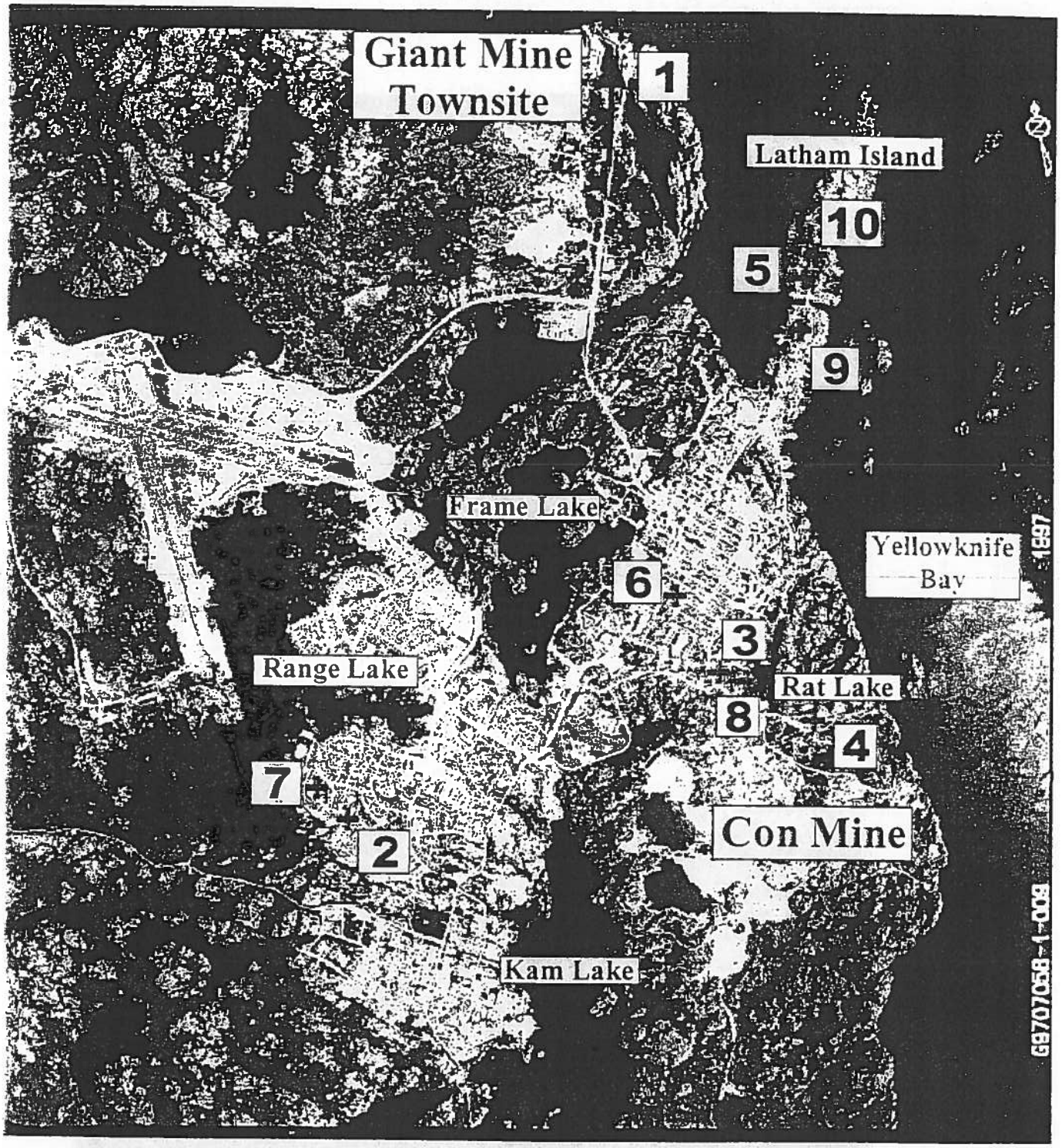
3.1 Locations of Gardens in the Yellowknife Area

Vegetables and soil samples were collected from 10 gardens in the Yellowknife area. In order to protect the privacy of the garden owners who donated their vegetables, each location has been assigned a number from between 1 and 10 (Map 1, Photos 1-8). Locations 2 through 10 were taken from residential gardens. Location 1 is a group of samples taken from two locations from residences not in use on the Giant Mine Townsite.

The soil composition of the gardens was noted at each location and is summarized in Table 2. All of the residential garden soils were black organic soils that had been amended with mulching agents.

Table 2. Soil sample descriptions for all garden samples.

Garden Location	Sample Number	Area	Depth (cm)	Soil Description
S end Garden 1	29137	Giant Mine town site	0-7	Black organic garden soil
Next to house Garden 1	29143	Giant Mine town site	0-5	Brown organic soil
Across from house Garden 1	29144	Giant Mine town site	0-5	Organic, dead wood and roots
E end Garden 2	29128	Range Lake	0-20	Black organic garden soil
Centre Garden 2	29129	Range Lake	0-20	Black organic garden soil
Centre Garden 2	29130	Range Lake	0-20	Black organic garden soil
W end Garden 2	29131	Range Lake	0-20	Black organic garden soil
Garden 3	29232	Rat Lake	0-10	Composite 6.7 g/each, black organic, clay at >10cm
Garden 4	29231	Con Mine town site	0-20	Composite 5 g/each, black organic garden soil
Garden 5	29234	Latham Island	0-10	Composite 6.7 g/each, black organic garden soil
Garden 6	29127	Downtown	0-10	Black organic
Garden 7	29236	Range Lake	0-10	Composite 4g/ea, black organic garden soil
Garden 8	29237	Rat Lake	0-20	Composite 4g/ea, black organic typical garden
Garden 9	29233	Old Town	0-15	Composite 4g/each, duplicate: 2 g/each, black organic garden soil
Garden 10	29235	Latham Island	0-15	Composite 4g/ea, duplicate: 2 g/each, black organic garden soil



Map 1. Location of gardens in the Yellowknife Area.

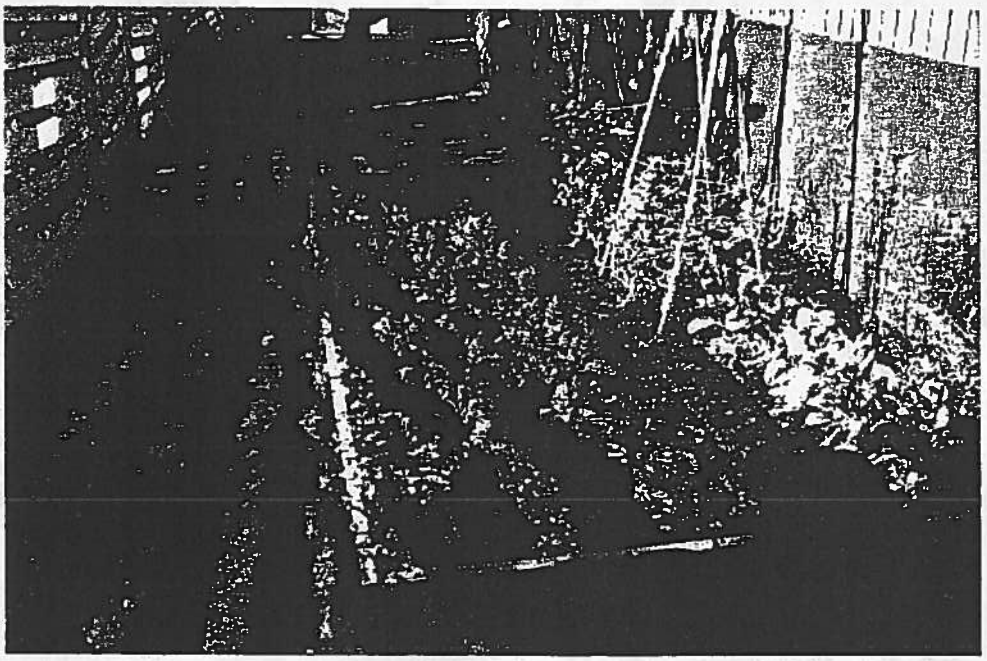


Photo 1. Garden 5, Latham Island.

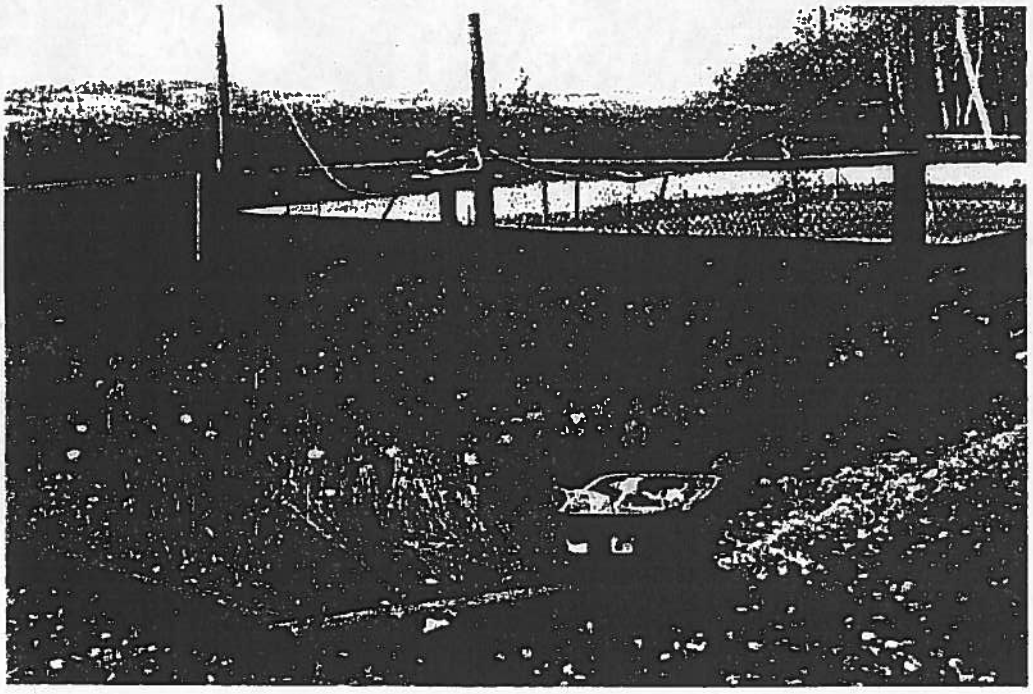


Photo 2. Garden 10, Latham Island.

Photo 3. Garden 9, Old Town Yellowknife.

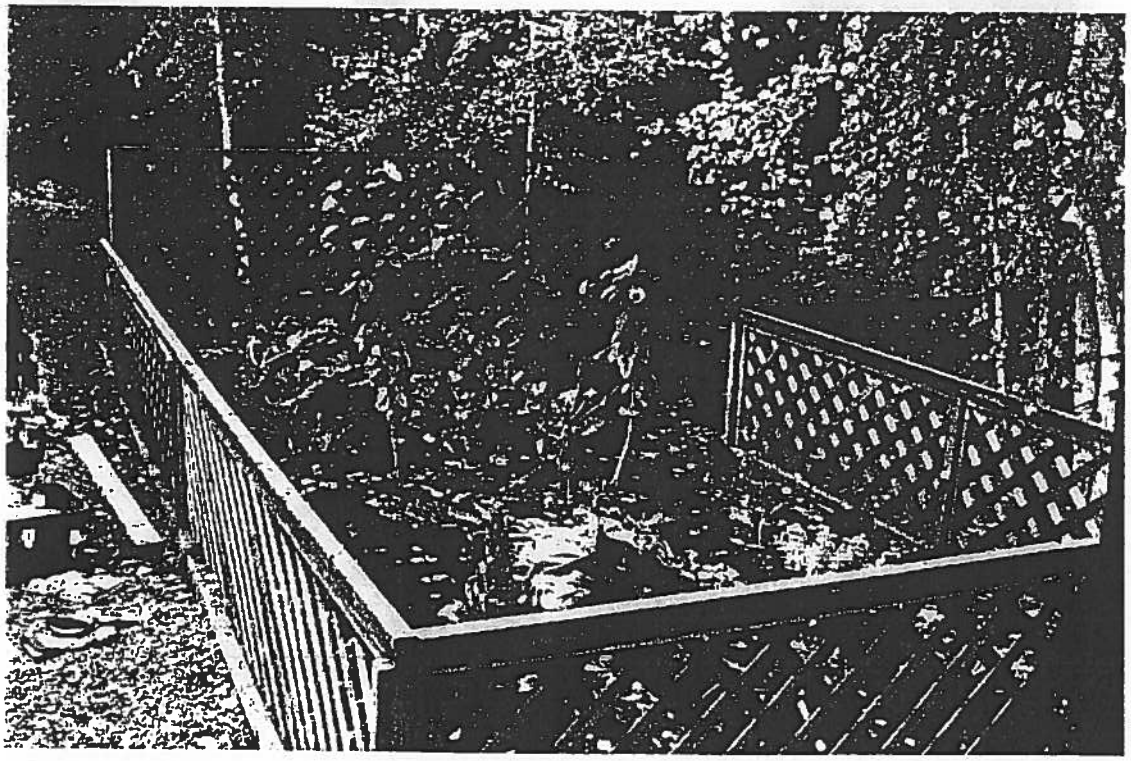


Photo 4. Garden 3, north end, Rat Lake area.

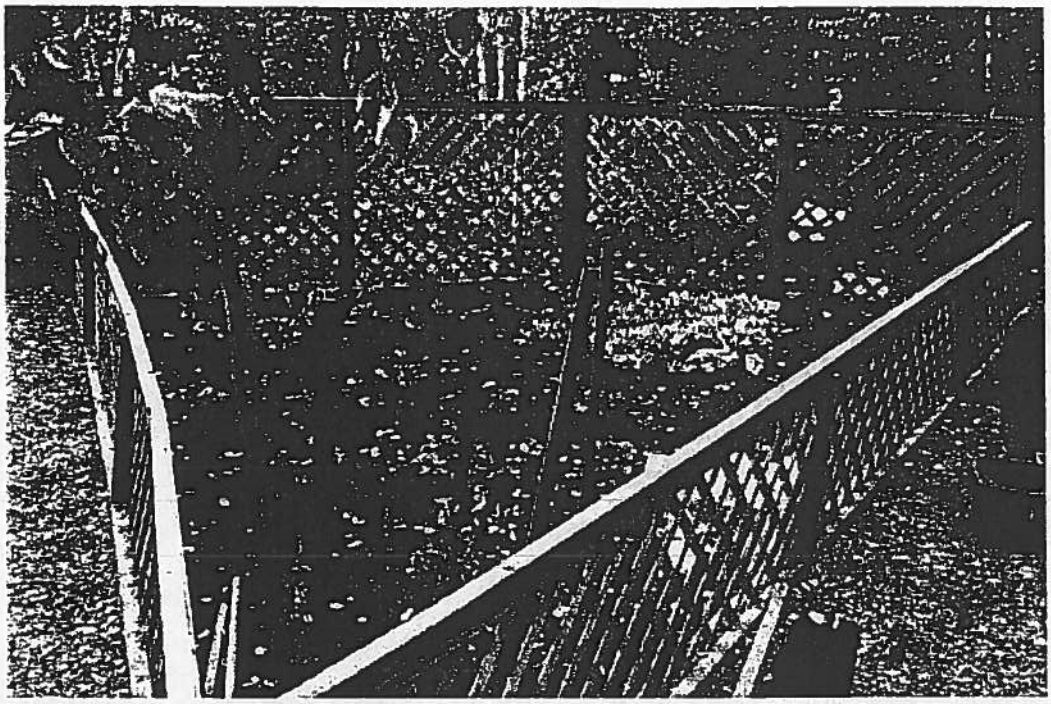


Photo 5. Garden 3, south end, Rat Lake area.

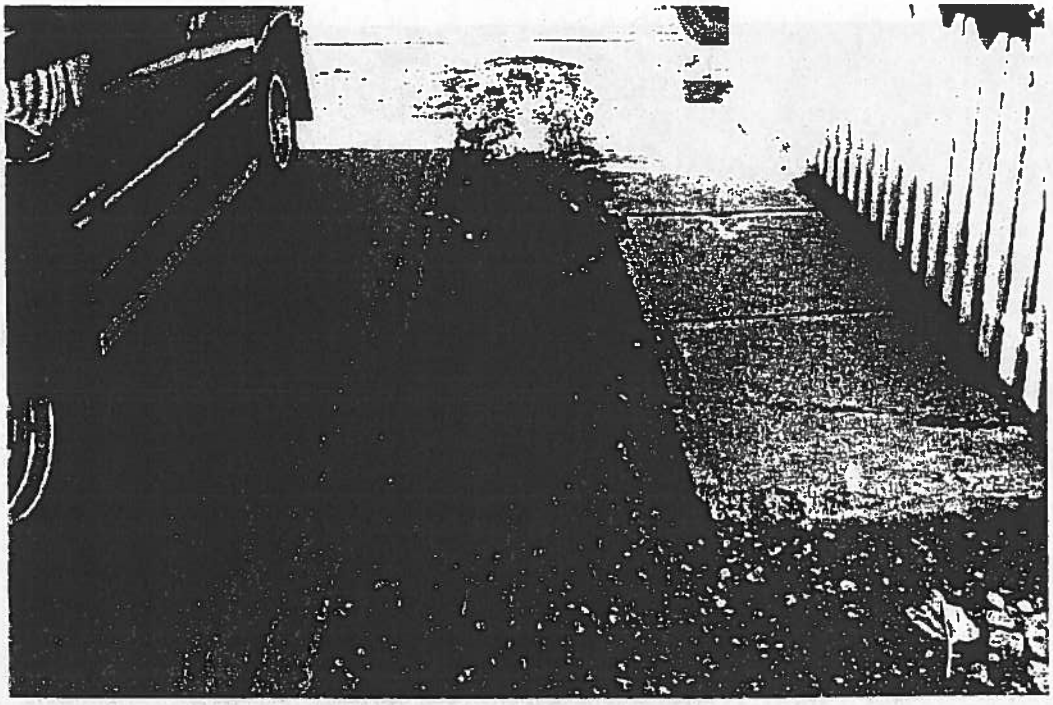


Photo 6. Garden 6, carrot patch, downtown area.

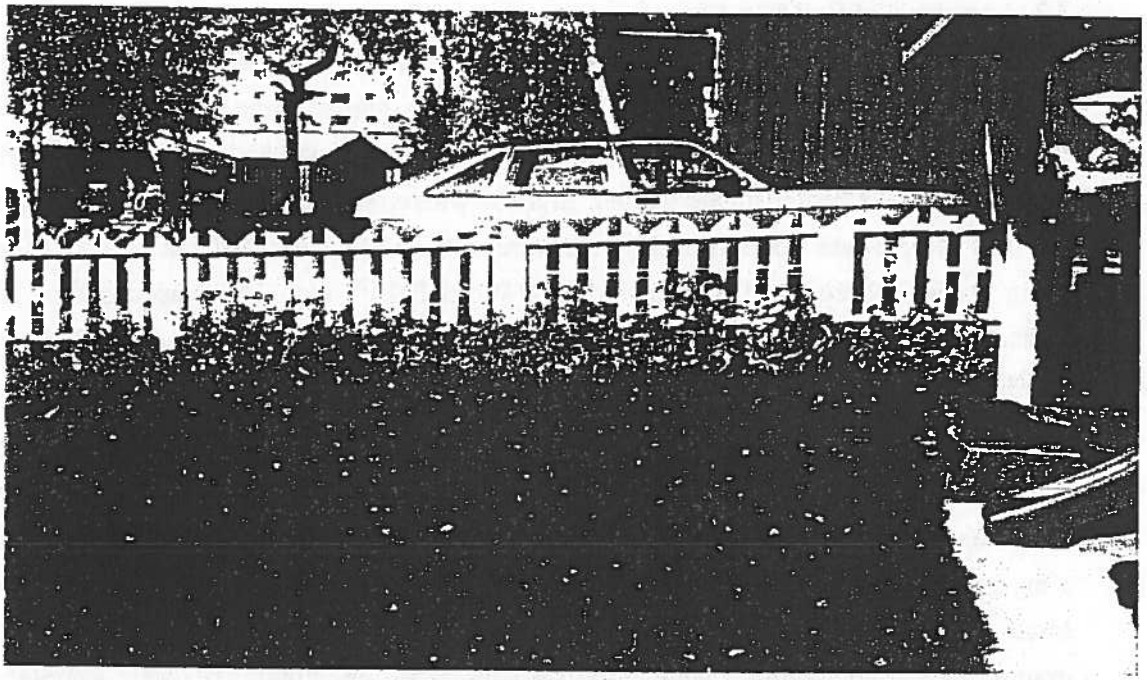


Photo 7. Garden 6, potato patch, downtown area.

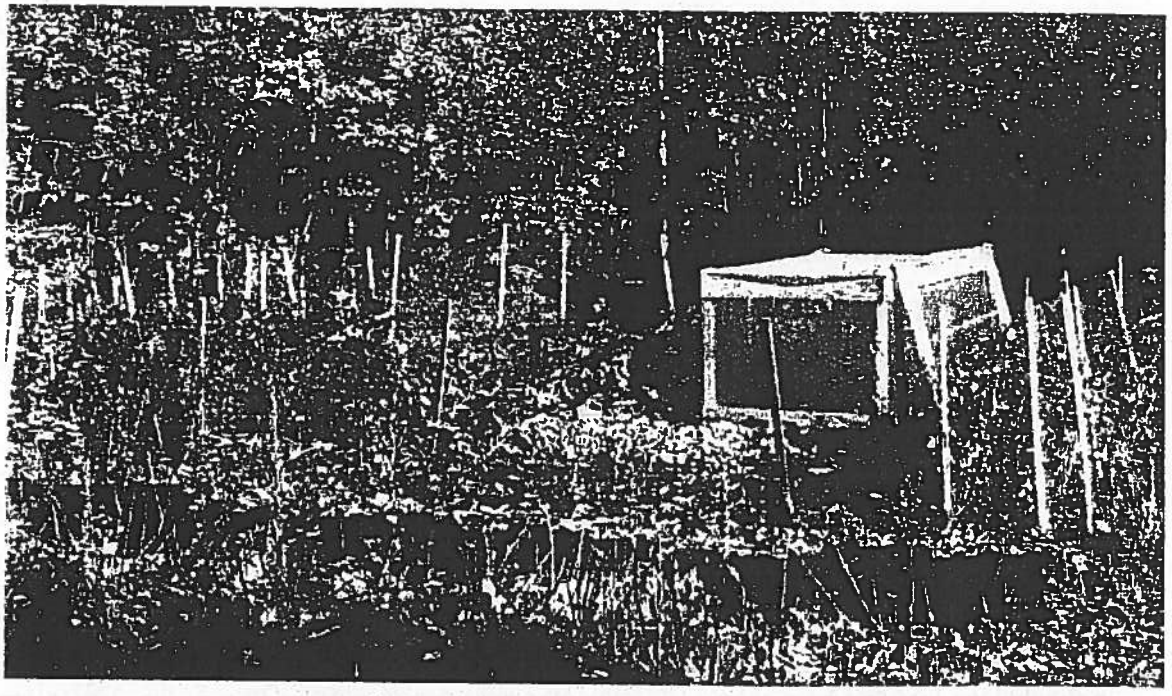


Photo 8. Garden 4, mine town site.

3.2 Analysis of Soil Samples

The soil sampling program was designed to obtain samples that, when composited, would be representative of the garden as a whole. For each garden three to five samples were collected, one from each corner (or end, depending on the size and shape of the garden) and one from the center of the garden. In areas where only one plant was collected, only one soil sample was collected. Samples were obtained between a depth of 0 to 20 cm, using a plastic scoop and then stored in a Whirl Pak^{TM} bag. The plastic scoops were discarded after each sample was obtained. Each sample was given a blind number, which was the only number provided on the label when the sample was submitted for analysis.

Soils were air-dried at room temperature for two to three days and then ground into a homogenous powder using a coffee grinder. In between samples care was taken to avoid cross contamination. After each sample, the coffee grinder was cleaned thoroughly using a dry brush and Kim-wipes, then rinsed with approximately two to three grams of Ottawa sand. At the beginning of each new sample the grinder was rinsed three times with 2-3 grams of each new sample which was then discarded and finally the new sample was homogenized.

Composite samples of approximately 20 g were made from soil samples that were collected from the same garden. The composites were made by adding an equal portion of each soil sample (prepared as above) to total 20 g (e.g., 4 g soil x 5 samples = 20 g). When field duplicates were taken from a garden location, they were included by using half the normal amount for each duplicate (e.g., as for the example above, for 4 g soil samples, 2 g of each duplicate). The composite sample was then homogenized in a coffee grinder following the same procedure as described above.

Analyses were conducted by a Canadian Association of Environmental Analytical Laboratories (CAEAL) accredited laboratory: the Analytical Services Group, Royal Military College of Canada (RMC), in Kingston, Ontario.

Neutron activation analysis (NAA) was used to determine the concentration for arsenic (As), using the SLOWPOKE-2 reactor located at RMC. This is a nondestructive method of analysis in which the sample preparation consists only of drying and grinding. The method allows for the determination of a true total concentration of the above-mentioned elements. Each sample was dried and ground, then weighed (1-2 g) into a 1.5-mL polyethylene vial and heat-sealed. The samples were irradiated at a flux of 5×10^{11} n.cm^{-2}.s^{-1} for 2 hours, cooled for 80-120 hours, and then counted for 2 hours using a GMC HpGe detector coupled with a Nuclear Data μ-multichannel analyzer (MCA).

3.3 Analysis of Plant Samples

After they were collected, samples were washed with tap water in a manner similar to that which would be used if they were being prepared for consumption. Root vegetables were gently scrubbed with a brush to remove all dirt and each sample was carefully inspected visually to ensure that cleaning was thorough. Samples were then dried with Kim towels and stored frozen in Ziplok^{TM} bags until further processing.

Samples were processed by chopping while frozen. They were then frozen completely with liquid nitrogen, and then pulverized and homogenized in a blender. A portion of the frozen ground sample was then weighed and dried in a 70°C oven overnight. The dry weight was then measured, and the dried sample was homogenized briefly in the blender or by using a mortar and pestle.

A quantity of 0.5 g of each dried sample was accurately measured (± 0.0001g) into a glass 50 ml test tube. A teflon boiling stone and 10ml of ultrapure nitric acid (Seastar Baseline grade) were added, and the samples were heated in a heating block from room temperature to 100°C for one hour and then heated and kept at 140 °C for 6 hours. The samples were then cooled, and 2 ml of hydrogen peroxide were added. The samples were heated at 140 °C for another 1.5 hours, then cooled and diluted to approximately 25 ml. The final diluted sample (approximately 25 ml) was measured by mass (± 0.01g).

Analysis was carried out by diluting the samples 10-fold with 1M HCl and introducing them to an AAS via a hydride generation system, using a reducing solution of 1% w/v $NaBH_4$ and 0.1% NaOH. The arsenic in the samples was quantified using calibration curves constructed from standards that were made up in matrices that matched the samples. An ICP standard was used to make up standards; this standard contains arsenic as As(V) which is the same form in which the arsenic is assumed to be, following concentrated nitric acid digestion. Some samples were reanalyzed to fit within the calibration curve, and required more or less dilution.

Quality assurance/quality control (QA/QC) measures were undertaken to ensure that the data was of high quality. Results are shown in the QA/QC section. Every batch of samples (18-19 in a batch) included 2 duplicates, 1-2 standard reference materials (Pine Needles NIST 1575 and Bush Branches GBW07603), and 1 blank. The blank consisted of 10ml of nitric acid/2 ml of H_2O_2 and was treated in the same manner as the rest of the samples. During HG-AAS analysis, calibration was conducted after every 10th sample, and an external QC check was included after every 5th sample. The external QC checks were within ±10% of the correct value.

4 Results and Discussion

4.1 Arsenic Concentrations in Soils

Arsenic concentrations found in garden soil samples from the City of Yellowknife were consistent with previously reported background concentrations (3 to 150 ppm) in the Yellowknife area[7] (Table 3). The average arsenic concentration in the gardens was 31±13 ppm (median 28 ppm, range 11 – 56 ppm).

Samples that were not included in the above average were collected from garden location 1, which was an abandoned garden on the Giant Mine Townsite. The average arsenic concentrations were much higher in this area with an average of 202±137ppm (median 174 ppm, range 81 – 351 ppm). These samples are considered separately because they are from a non-residential area.

Four soil samples (including one field duplicate) were individually analyzed from Garden Location 2 to ascertain the degree of variability that might be expected in a garden as a result of the sampling method used. The average concentration of the four soil samples was 26±12 ppm with a range of 17 to 44 ppm (median 22 ppm). This indicates that the sampling method was spatially representative, and that the composite analyses of the soils collected from the remaining gardens adequately reflect the arsenic concentrations in each garden.

Table 3. Arsenic concentrations in soil samples from the garden locations in Yellowknife.

Garden Location	As [ppm]
1	81
	351
	174
2	17
	22
	44
3	24
4	55
5	30
6	35
7	29
8	27
9	12
10	56

* G.M. Townsite

4.2 Arsenic Concentrations in Vegetables

Concentrations of total arsenic were determined in 30 different vegetable and fruit types with a total number of 61 samples analyzed, and the results are summarized in Table 4. The results for produce from individual gardens can be found in Appendix A. All arsenic concentrations in vegetables in this study are reported as fresh weight, since produce is most commonly consumed in the fresh (not dried) form.

The arsenic concentrations in Yellowknife garden vegetables found were almost always an order of magnitude greater than those found in the Dabeka survey of foods from supermarkets across Canada[18]. Leafy vegetables and greens contained the highest concentrations of arsenic in produce. The highest arsenic concentration in all produce was found in a sample of beet greens, as well as in celery leaves (0.29 ppm fresh weight), while the lowest concentrations of arsenic were below the analytical limit of detection in several samples, including potatoes, cabbage, peas, rhubarb, garlic, broccoli and zucchini.

Arsenic levels in vegetables collected for this study were substantially lower than those determined previously in Yellowknife by Soniassy in 1979[21]. This may possibly be a result of the cessation of arsenic from roaster stack emissions from the Giant Mine. While Soniassy was able to detect arsenic in all samples, we were not able to detect arsenic in many samples, as mentioned above. The arsenic levels in produce grown in Yellowknife appear to have dropped four to five-fold since 1979 for most vegetables. Lettuce and berries are the exceptions, as they appear to contain comparable concentrations of arsenic in both studies.

The limited number of berries (2 samples of Saskatoon berries and 1 sample of pin cherries) collected in this study had an average arsenic concentration of 0.227 ppm. These concentrations are consistent with those found by the Dene Nation in 1998[22] in berries sampled from areas near mine sites or impacted by the mines.

Although the forms of arsenic were not determined in the vegetables, ESG is assuming that 100% of the arsenic is found in its inorganic forms. This is a conservative assumption, since inorganic arsenic is considered to be more toxic than arsenic in its organic forms. The resulting human health risk assessment therefore represents a worst case senario. It should be noted, however, that previous studies have shown that inorganic arsenic forms are predominant in terrestrial plants [6]; this inorganic arsenic is likely to be the predominant form in these food samples, as they are of plant origin.

Table 4. Summary of Arsenic Concentrations in Yellowknife Vegetables (raw). The concentrations of arsenic found in vegetables in Canada (from Dabeka *et al.*, 1993) are included for comparison.

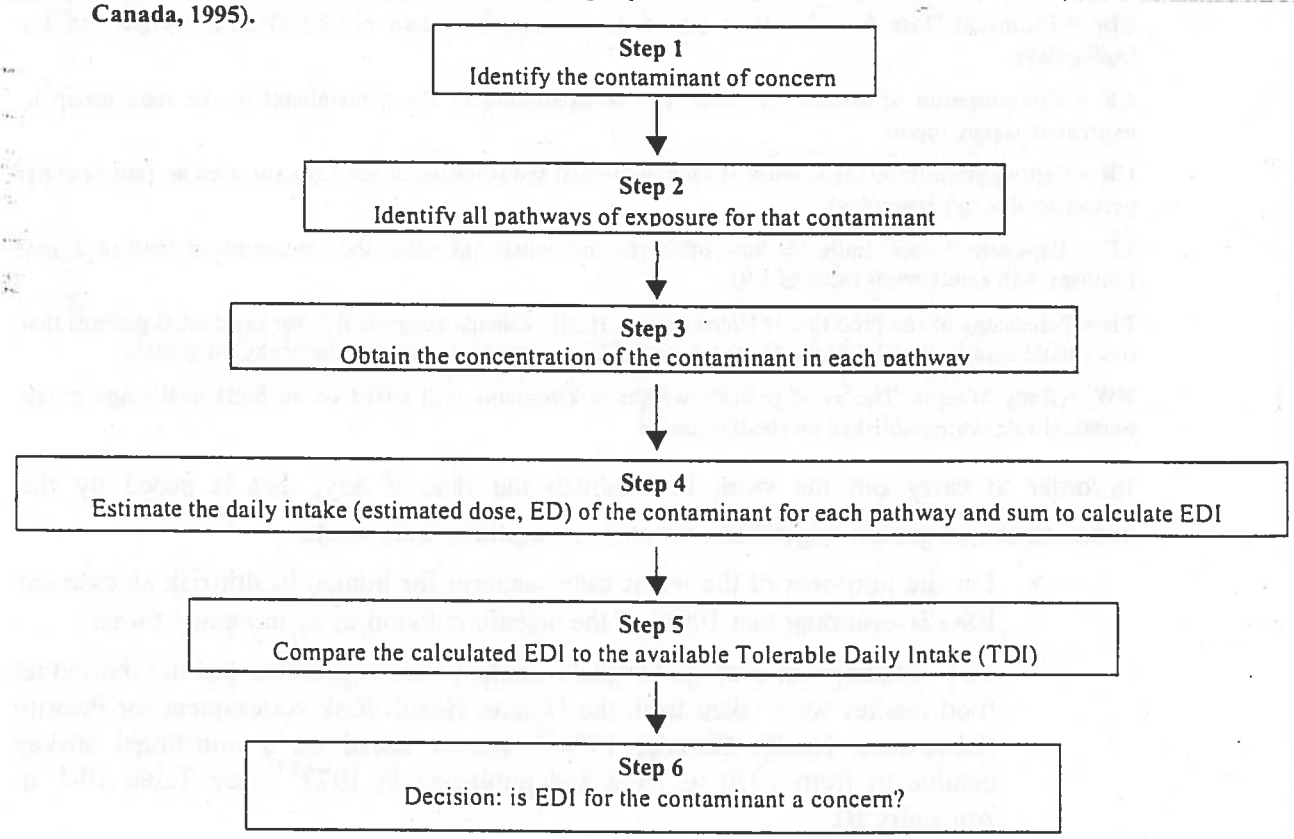
	Yellowknife					Canada					
Plant	**n**	**Minimum (ppm) fresh weight**	**Maximum (ppm) fresh weight**	**Mean (ppm) fresh weight**	**Median (ppm) fresh weight**	**n**	**Minimum (ppm) fresh weight**	**Maximum (ppm) fresh weight**	**Mean (ppm) fresh weight**	**Median (ppm) fresh weight**	**Comparison comments**
carrot	6	0.020	0.070	0.045	0.044	7	nd	0.0095	0.0045	0.0042	raw
white and red potatoes	8	nd	0.070	0.031	0.023	7	nd	0.011	0.0055	0.0042	raw
radish	1			0.170		6	nd	0.0079	0.0024	0.0013	canadian numbers based on turnips
peeled onion	2	0.017	0.041	0.029	0.029	7	nd	0.0200	0.0056	0.0034	
beets	3	0.02	0.19	0.081	0.034	5	0.0043	0.0049	0.0045	0.0045	raw and canned
leaf and romaine lettuce	5	0.06	0.27	0.132	0.12	7	nd	0.0054	0.0024	0.0016	not specified
celery	1			0.050		7	0.0032	0.0100	0.0064	0.0059	
swiss chard	2	0.060	0.090	0.075	0.075		na	Na	na	na	
white and red cabbage	3	nd	0.090	0.043	0.033	7	nd	0.012	0.0046	0.0027	
broccoli and kohlrabi	2	nd	0.044	0.027	0.027	7	nd	0.0096	0.0035	0.0027	
zucchini	1			0.003		0					not analyzed
tomatoes	1			0.009		16	nd	0.011	0.003	0.002	raw and cooked tomatoes
beans and broad beans	3	0.016	0.026	0.020	0.0181	7	nd	0.0120	0.0031	nd	
peas	3	nd	0.036	0.019	0.010	7	nd	0.0039	0.0014	nd	
rhubarb	5	nd	0.05	0.020	0.014		na	na	na	na	not analyzed
all root vegetables	21	nd	0.190	0.048	0.034	26	nd	0.02	0.005	0.00425	
herbs	3	0.07	0.23	0.133	0.1		na	na	na	na	not analyzed
garlic and onion greens	3	0.11	0.18	0.147	0.15		na	na	na	na	not analyzed
all greens	12	0.1	0.3	0.139	0.1						see lettuce
all fruit produce	11	nd	0.440	0.073	0.018						not comparable
berries	3	0.09	0.44	0.227	0.15	11	nd	0.011	0.0064	0.0074	cherries and blueberries

4.3 Risk Posed by the Consumption of Yellowknife Garden Vegetables

Given that the levels of arsenic in Yellowknife vegetables from gardens are typically 10 times higher than the national average, the question is: are they safe for human consumption? There are several risk assessment approaches that can be employed to answer this question. The method selected by ESG is to determine whether the increase in the estimated daily intake (EDI), through the consumption of arsenic-containing vegetables grown in Yellowknife, causes the PMDI recommended by FAO/WHO (2.1 µg/kg/day) to be exceeded.

The approach used to ascertain the estimated daily intake (EDI) of arsenic in the Yellowknife vegetables is outlined by Health Canada in their 1995 document *Investigating Human Exposure to Contaminants in the Environment: A Handbook for Exposure Calculations*[25]. Health Canada recommends a six-step approach for estimating exposure to environmental contaminants (Figure 1).

Figure 1. The six step approach for estimating exposure to environmental contaminants (Health Canada, 1995).



Arsenic has long been considered the contaminant of concern in Yellowknife (Step 1). As stated earlier, the only pathway of exposure for arsenic being considered here is the ingestion of Yellowknife garden produce (Step 2). Step 3 was carried out by determining the concentrations of arsenic in a large selection of produce, and these are summarized in Section 4.2 and Appendix A. The calculation of the EDIs (Step 4) for ingestion of arsenic in garden produce will be detailed in the following section. The resulting EDIs are compared with the aforementioned PMDI (i.e. Tolerable Daily Intake, or TDI) in Step 5. This comparison allows us to make comments on the decision making process in Step 6.

4.3.1 Assumptions and Calculations used in the Risk Assessment

The calculations for EDI of arsenic from vegetables were as follows:

$$EDI = ED_f = \frac{CF \times CR \times EF \times PH}{BW}$$

where:

EDI = Estimated Daily Intake

ED_f = Estimated Dose from Food: as µg of the contaminant eaten per kg of body weight per day (µg/kg/day).

CF = Concentration of arsenic in Food: The concentration of the contaminant in the food group is expressed as µg/g (ppm).

CR = Consumption Rate: the amount of each individual food consumed per day expressed as grams per per person per day (g/person/day).

EF = Exposure Factor: Indicates how often the individual has eaten the contaminated food in a year (unitless with a maximum value of 1.0).

PH = Percentage of the food that is Home grown. Health Canada suggests that for residential gardens that one should assume that 7% of the fruit and vegetables ingested are grown in the backyard garden.

BW = Body Weight: The average body weight in kilograms (kg) based on an individual's age group. Standard values are published by Health Canada.

In order to carry out the work to establish the risk, if any, that is posed by the consumption of garden vegetables, several assumptions were made:

- For the purposes of the worst case scenario for human health risk assessment ESG is assuming that 100% of the arsenic is found in its inorganic forms.
- The consumption average for daily intake of all vegetables and the individual food intakes were taken from the Human Health Risk Assessment for Priority Substances, Health Canada, 1994[26] and is based on a nutritional survey conducted from 1970 to 1972 and published in 1977[27] (see Table 10-1 in Appendix B).
- Eleven categories based on age, sex, weight and differing daily consumption rates were used[25]. These categories are meant as generalizations; there is an

obvious range of weights and daily consumption rates over each of these categories that are not taken into consideration in this model.

- All concentrations of arsenic in vegetables are reported as fresh (wet) weight. As mentioned earlier, this is the value that is most representative when modeling the ingestion of these foods.
- Although concentrations in herbs from a few gardens were determined, no consumption rates could be found in the literature and therefore they were not included in the calculations.

Scenarios for two different situations were examined. EDIs were calculated for (1) each individual garden and (2) for a *generic garden* (Table 5). This *generic garden* was used to create a conservative estimated daily intake of arsenic for Yellowknife residents who would consume all of these vegetables. The *generic garden* is a more general situation that can be applied to Yellowknife residents whose gardens were not sampled. The generic garden was created by finding the minimum, maximum, mean and median values for the food types found in Table 4. To obtain numerical values, the minimum or maximum values that were below the detection limit were replaced with a value that was ½ the detection limit. Foods or food groups for which only one sample was collected were given ranges that consisted only of the one arsenic concentration (e.g., celery). Every attempt was made to collect as many vegetables and vegetable types grown by residents of the Yellowknife area so as to evaluate the risk as representatively as possible. However, it is possible that there are vegetables or other food products that are grown in backyard gardens that have not been analyzed in this report.

Table 5. Composition of the Yellowknife generic garden.

Produce	Minimum [As] ppm	Maximum [As] ppm	Mean [As] ppm	Median [As] ppm
Carrots	0.020	0.070	0.045	0.044
White and red potatoes	0.01	0.07	0.031	0.023
Radish	0.17	0.17	0.17	0.17
Peeled onion	0.017	0.041	0.029	0.029
Beets	0.02	0.19	0.081	0.034
Leaf and Romaine lettuce	0.06	0.27	0.132	0.12
Celery	0.05	0.05	0.05	0.05
Swiss chard	0.06	0.09	0.075	0.075
White and red cabbage	0.005	0.09	0.043	0.033
Broccoli and kohlrabi	0.01	0.044	0.027	0.027
Zucchini	0.003	0.003	0.003	0.003
Tomatoes	0.009	0.009	0.009	0.009
Beans and broad beans	0.016	0.026	0.02	0.018
Peas	0.01	0.036	0.019	0.01
Pin cherry fruit	0.09	0.09	0.09	0.09
Saskatoon berries	0.15	0.44	0.295	0.295
Rhubarb stalks	0.005	0.05	0.0196	0.014

There are a number of risk scenarios that can be tested, by using different values for the variables in the EDI calculation. We have done this for the following variables:

- **CF**. (1) For the individual gardens: (a) concentrations that were found in the individual foods were used, and (b) an average concentration for each garden was determined and used. (2) For the generic garden: (a) concentration ranges that were found in the individual food groups were used, and (b) concentration ranges for the average of arsenic in all food groups were used.
- **CR**. For both (1) the individual gardens and (2) the generic garden, (a) consumption rates for only the individual foods were used, and (b) a consumption rate for overall vegetable intake was used. Note that CF(a) corresponds with CR(a) and CF(b) corresponds with CR(b).
- **PH**. For both (1) the individual gardens and (2) the generic garden, (a) the worst case (PH = 1) was used and (b) the most realistic case (PH = 0.07, or 7%), for residential land use, was used. The PH was also varied for the generic garden as follows: (c) 25%, (d) 50%, (e) 75%.

Only four scenarios from all the possibilities described above will be summarized here:

Scenario 1. Worst case for individual gardens. CF (b) was used, that is, the average concentration of arsenic in all vegetables for each garden. This then corresponded to the use of CR (b), the overall vegetable consumption rate suggested by Health Canada. A PH of 1 was used, meaning that the calculations were made assuming consumption of vegetables only from residential gardens year-round.

Scenario 2 Most realistic case for individual gardens. CF (a) was used, that is, the concentrations found in the individual foods from each garden. The corresponding CR (a) was used, which takes into account the consumption rates only for the individual vegetables available from each garden. A PH of 0.07 (7%) was used, as recommended by Health Canada for residential gardens, indicating that only 7% of a person's intake of vegetables is from the garden, and the remainder is from other sources (e.g., grocery store).

Scenario 3. Worst case for the generic garden. CF (b) was used, that is, the average concentration of arsenic in all vegetables for the generic garden. This then corresponded to the use of CR (b), the overall vegetable consumption rate suggested by Health Canada.

A PH of 1 was used, meaning that the calculations were made assuming consumption of vegetables only from residential gardens year-round.

Scenario 4 Most realistic case for the generic garden. CF (a) was used, that is, the concentrations found in the individual foods from the generic garden. The corresponding CR (a) was used, which takes into account the consumption rates only for the individual vegetables available from the generic garden. A PH of 0.07 (7%) was used. This scenario represents the consumption of only the available vegetables from a residential garden for the typical garden owner in Yellowknife.

4.4 Estimated Daily Intakes of Arsenic

4.4.1 Estimated Daily Intakes for Scenario 1

The full details of the calculations for each individual garden can be found in Appendix B.

The estimated daily intakes of arsenic for the worst case scenario for each individual garden is summarized in Table 6. This scenario represents the consumption of garden produce as the only source of vegetables, at the relatively high consumption rate suggested by Health Canada. The total daily intake of arsenic was calculated by summing the amount estimated from vegetables alone and the amount reported by Dabeka *et al.*[18] (Table 1).

The general trends that emerge from these data are that in all cases the EDIs for children in the age groups 1-4 years and 5-11 years are higher than those of all the other age and gender groups. This is the result of a smaller body weight (1/4 to1/5 of other age groups) for these groups combined with a consumption rate that is not proportionally smaller (only 1/2 of other age groups). In addition, the EDI of arsenic tends to be slightly higher on average for males over females. This can be attributed to higher consumption rates of foods. These findings are not surprising, as these trends are also true for the Canadian averages determined by Dabeka *et al*[18].

Almost all of the EDIs calculated are below the TDI of 2.1 µg/kg/day, with only a few exceptions. EDIs were slightly above the TDI for children aged 1-11 for Garden 3, as well as for Garden 1. Garden 3 is a residential garden but Garden 1, on the Giant Mine Townsite, is abandoned and not likely to constitute a risk at the present time.

This worst case is extremely conservative, and it is unlikely that any resident of Yellowknife would be consuming vegetables strictly from their garden as the growing season is approximately 2 to 3 months long.

4.4.2 Estimated Daily Intakes for Scenario 2

Scenario 2 is a reasonable, yet still conservative, representation of how vegetables are likely to be consumed. Most people only consume the vegetables that grow in their garden, and they do this for the duration of the growing season. The results for this scenario are summarized in Table 7.

The same trends are observed for different age groups in these results as were observed in scenario 1; namely, that the EDIs are highest for the 1-11 year age group, and that they tend to be higher for males than for females. In all cases, the consumption of vegetables from residential gardens barely increases the amount of arsenic that is normally consumed in the Canadian diet. The gardens that resulted in the higher EDIs (garden produce only) were the ones that were more comprehensively sampled, and that contained a larger variety of produce.

4.4.3 Estimated Daily Intakes for Scenario 3

Again, the worst case is depicted in scenario 3, but this time for the generic garden. The average minimum, maximum, mean and median arsenic concentrations were determined for the entire garden. Only the EDI for the maximum concentrations, and for children 1-4 years of age is equal to the TDI (2.1 ug/kg/day) and the remaining EDIs are all less than the TDI. Again, the same trends with respect to age and gender are observed in this scenario, as those that were established for scenarios 1 and 2.

4.4.4 Estimated Daily Intakes for Scenario 4

The final scenario depicts the consumption of the available produce from the generic garden, realistically assuming that most of the produce that a Yellowknife resident eats is from sources other than a local garden. This scenario is the broadest for all Yellowknife residents who are likely to consume garden foods.

As was calculated for scenario 2 (individual gardens), no significant increase to the total daily intake of arsenic from the locally grown produce was seen for any age/gender groups. It is clearly important to take the percentage of homegrown produce actually consumed into account, when calculating EDIs, so as not to obtain an overly conservative estimate.

Table 6. Results for Scenario 1: Worst Case for Individual Gardens. The maximum potential increase in daily arsenic intakes (ug/kg/day) from individual gardens in Yellowknife (a) is added to the total daily arsenic intakes reported by Dabeka, 1993 (b), to obtain the total daily intake of arsenic (c).

Garden		Child M/F		Male				Female				M/F
	Age (years)	a1-4	a5-11	a12-19	20-39	40-64	65+	a12-19	20-39	40-64	65+	all ages
	Body Weight (kg)	13	27	57	70	70	70	57	70	70	70	70
	Canadian Daily Average Consumption Vegetables g/person/day	125	198	250	250	250	250	250	250	250	250	250
	Canadian Estimated Daily Intakes (ug/kg/day) (b)	1.15	1.11	0.72	0.83	0.61	0.51	0.56	0.49	0.75	0.37	0.54
Garden 2	Estimated Daily Arsenic Intake (ug/kg/day) (a)	0.40	0.31	0.18	0.15	0.15	0.15	0.18	0.15	0.15	0.15	0.15
	Total daily intake of arsenic (ug/kg/day) (c)	1.55	1.42	0.90	0.98	0.76	0.66	0.74	0.64	0.90	0.52	0.69
Garden 3	Estimated Daily Arsenic Intake (ug/kg/day)	1.44	1.10	0.66	0.54	0.54	0.54	0.66	0.54	0.54	0.54	0.54
	Total daily intake of arsenic (ug/kg/day)	2.59	2.21	1.38	1.37	1.15	1.05	1.21	1.02	1.29	0.90	1.08
Garden 4	Estimated Daily Arsenic Intake (ug/kg/day)	0.38	0.29	0.18	0.14	0.14	0.14	0.18	0.14	0.14	0.14	0.14
	Total daily intake of arsenic (ug/kg/day)	1.53	1.40	0.89	0.97	0.76	0.65	0.73	0.63	0.90	0.51	0.69
Garden 5	Estimated Daily Arsenic Intake (ug/kg/day)	0.48	0.37	0.22	0.18	0.18	0.18	0.22	0.18	0.18	0.18	0.18
	Total daily intake of arsenic (ug/kg/day)	1.63	1.47	0.94	1.01	0.79	0.69	0.78	0.67	0.93	0.55	0.72
Garden 6	Estimated Daily Arsenic Intake (ug/kg/day)	0.43	0.33	0.20	0.16	0.16	0.16	0.20	0.16	0.16	0.16	0.16
	Total daily intake of arsenic (ug/kg/day)	1.58	1.44	0.91	0.99	0.78	0.67	0.75	0.65	0.92	0.53	0.71
Garden 7	Estimated Daily Arsenic Intake (ug/kg/day)	0.28	0.21	0.13	0.10	0.10	0.10	0.13	0.10	0.10	0.10	0.10
	Total daily intake of arsenic (ug/kg/day)	1.43	1.32	0.84	0.94	0.72	0.61	0.68	0.59	0.86	0.47	0.65
Garden 8	Estimated Daily Arsenic Intake (ug/kg/day)	0.47	0.36	0.21	0.18	0.18	0.18	0.21	0.18	0.18	0.18	0.18
	Total daily intake of arsenic (ug/kg/day)	1.62	1.47	0.93	1.01	0.79	0.69	0.77	0.66	0.93	0.54	0.72
Garden 9	Estimated Daily Arsenic Intake (ug/kg/day)	0.17	0.13	0.08	0.06	0.06	0.06	0.08	0.06	0.06	0.06	0.06
	Total daily intake of arsenic (ug/kg/day)	1.32	1.24	0.80	0.90	0.68	0.57	0.64	0.55	0.82	0.43	0.61
Garden 10	Estimated Daily Arsenic Intake (ug/kg/day)	0.51	0.39	0.23	0.19	0.19	0.19	0.23	0.19	0.19	0.19	0.19
	Total daily intake of arsenic (ug/kg/day)	1.66	1.50	0.95	1.02	0.80	0.70	0.79	0.68	0.94	0.56	0.73
Garden 1	Estimated Daily Arsenic Intake (ug/kg/day)	2.1	1.6	1.0	0.8	0.8	0.8	1.0	0.8	0.8	0.8	0.8
	Total daily intake of arsenic (ug/kg/day)	3.26	2.72	1.68	1.62	1.40	1.30	1.52	1.27	1.54	1.15	1.33
Average Daily Arsenic Intake if no other Vegetables are consumed (ug/kg/day)		1.89	1.67	1.05	1.11	0.89	0.78	0.89	0.76	1.03	0.64	0.82

Table 7. Results for Scenario 2: Most Realistic Case for Individual Gardens. The maximum potential increase in daily arsenic intakes (ug/kg/day) from individual gardens in Yellowknife (a) is added to the total daily arsenic intakes reported by Dabeka, 1993 (b), to obtain the total daily intake of arsenic (c).

Garden		Child M/F		Male				Female				M/F
	Age (years)	a1-4	a5-11	a12-19	20-39	40-64	65+	a12-19	20-39	40-64	65+	all ages
	Body Weight (kg)	13	27	57	70	70	70	57	70	70	70	70
	Canadian Estimated Daily Intakes (ug/kg/day) (b)	1.15	1.11	0.72	0.83	0.61	0.51	0.56	0.49	0.75	0.37	0.54
Garden 2	Estimated Daily Arsenic Intake (ug/kg/day)	0.207	0.159	0.115	0.134	0.099	0.094	0.093	0.088	0.089	0.082	0.084
	7% of EDI (ug/kg/day) (a)	0.014	0.011	0.008	0.009	0.007	0.007	0.007	0.006	0.006	0.006	0.006
	Total daily intake of arsenic (ug/kg/day) (c)	1.16	1.12	0.73	0.84	0.62	0.52	0.56	0.49	0.76	0.37	0.55
Garden 3	Estimated Daily Arsenic Intake (ug/kg/day)	0.089	0.076	0.055	0.098	0.068	0.061	0.067	0.078	0.089	0.064	0.061
	7% of EDI (ug/kg/day)	0.006	0.005	0.004	0.007	0.005	0.004	0.005	0.005	0.006	0.004	0.004
	Total daily intake of arsenic (ug/kg/day)	1.15	1.11	0.72	0.84	0.62	0.51	0.56	0.49	0.76	0.37	0.55
Garden 4	Estimated Daily Arsenic Intake (ug/kg/day)	0.137	0.105	0.073	0.066	0.059	0.066	0.053	0.043	0.039	0.046	0.047
	7% of EDI (ug/kg/day)	0.010	0.007	0.005	0.005	0.004	0.005	0.004	0.003	0.003	0.003	0.003
	Total daily intake of arsenic (ug/kg/day)	1.16	1.11	0.72	0.84	0.62	0.51	0.56	0.49	0.76	0.37	0.55
Garden 5	Estimated Daily Arsenic Intake (ug/kg/day)	0.046	0.030	0.015	0.018	0.022	0.024	0.017	0.018	0.024	0.026	0.017
	7% of EDI (ug/kg/day)	0.003	0.002	0.001	0.001	0.002	0.002	0.001	0.001	0.002	0.002	0.001
	Total daily intake of arsenic (ug/kg/day)	1.15	1.11	0.72	0.83	0.62	0.51	0.56	0.49	0.76	0.37	0.55
Garden 6	Estimated Daily Arsenic Intake (ug/kg/day)	0.15	0.11	0.08	0.07	0.06	0.05	0.05	0.04	0.03	0.04	0.05
	7% of EDI (ug/kg/day)	0.010	0.008	0.005	0.005	0.004	0.004	0.004	0.003	0.002	0.003	0.003
	Total daily intake of arsenic (ug/kg/day)	1.16	1.12	0.72	0.84	0.62	0.51	0.56	0.49	0.76	0.37	0.55
Garden 7	Estimated Daily Arsenic Intake (ug/kg/day)	0.10	0.07	0.05	0.04	0.04	0.04	0.03	0.03	0.02	0.03	0.03
	7% of EDI (ug/kg/day)	0.007	0.005	0.004	0.003	0.003	0.002	0.002	0.002	0.002	0.002	0.002
	Total daily intake of arsenic (ug/kg/day)	1.15	1.11	0.72	0.83	0.62	0.51	0.56	0.49	0.76	0.37	0.55
Garden 8	Estimated Daily Arsenic Intake (ug/kg/day)	0.121	0.093	0.067	0.057	0.053	0.061	0.045	0.041	0.047	0.054	0.044
	7% of EDI (ug/kg/day)	0.009	0.007	0.005	0.001	0.004	0.004	0.003	0.003	0.003	0.004	0.003
	Total daily intake of arsenic (ug/kg/day)	1.15	1.11	0.72	0.84	0.62	0.51	0.56	0.49	0.76	0.37	0.55
Garden 9	Estimated Daily Arsenic Intake (ug/kg/day)	0.091	0.070	0.052	0.045	0.036	0.035	0.033	0.026	0.023	0.026	0.030
	7% of EDI (ug/kg/day)	0.006	0.005	0.004	0.003	0.003	0.002	0.002	0.002	0.002	0.002	0.002
	Total daily intake of arsenic (ug/kg/day)	1.15	1.11	0.72	0.83	0.62	0.51	0.56	0.49	0.76	0.37	0.55
Garden 10	Estimated Daily Arsenic Intake (ug/kg/day)	0.549	0.422	0.314	0.271	0.215	0.208	0.207	0.156	0.137	0.148	0.181
	7% of EDI (ug/kg/day)	0.038	0.030	0.022	0.019	0.015	0.015	0.014	0.011	0.010	0.010	0.013
	Total daily intake of arsenic (ug/kg/day)	1.18	1.14	0.74	0.85	0.63	0.52	0.57	0.50	0.76	0.38	0.56
Garden 1	Estimated Daily Arsenic Intake (ug/kg/day)	0.072	0.052	0.037	0.025	0.029	0.058	0.016	0.021	0.027	0.044	0.024
	7% of EDI (ug/kg/day)	0.005	0.004	0.003	0.002	0.002	0.004	0.001	0.001	0.002	0.003	0.002
	Total daily intake of arsenic (ug/kg/day)	1.15	1.11	0.72	0.83	0.62	0.51	0.56	0.49	0.76	0.37	0.55
Average Total Daily intake of arsenic (ug/kg/day)		1.16	1.12	0.72	0.84	0.62	0.51	0.56	0.49	0.76	0.37	0.55

Table 8. Results for Scenario 3: Worst Case for Generic Yellowknife Garden. The maximum, minimum, mean and median potential increase in daily arsenic intakes (ug/kg/day) from a generic garden in Yellowknife (a) are added to the total daily arsenic intakes reported by Dabeka, 1993 (b), to obtain the total daily intake of arsenic (c).

		Child M/F		Male				Female				M/F
	Age (years)	a1 -4	a5-11	a12-19	20-39	40-64	65+	a12-19	20-39	40-64	65+	all ages
	Body Weight (kg)	13	27	57	70	70	70	57	70	70	70	70
	Canadian Daily Average Consumption Vegetables (g/person/day)	125	198	250	250	250	250	250	250	250	250	250
	Canadian Estimated Daily Arsenic Intakes (ug/kg/day) (b)	1.15	1.11	0.72	0.83	0.61	0.51	0.56	0.49	0.75	0.37	0.54
Yellowknife Minimums	Estimated Daily Arsenic Intake (ug/kg/day) (a)	0.38	0.29	0.17	0.14	0.14	0.14	0.17	0.14	0.14	0.14	0.14
	Total daily intake of arsenic (ug/kg/day) (c)	1.53	1.40	0.89	0.97	0.76	0.65	0.73	0.63	0.90	0.51	0.69
Yellowknife Maximums	Estimated Daily Arsenic Intake (ug/kg/day)	0.96	0.73	0.44	0.36	0.36	0.36	0.44	0.36	0.36	0.36	0.36
	Total daily intake of arsenic (ug/kg/day)	2.11	1.84	1.16	1.19	0.97	0.87	0.99	0.84	1.11	0.73	0.90
Yellowknife Mean	Estimated Daily Arsenic Intake (ug/kg/day)	0.63	0.48	0.29	0.23	0.23	0.23	0.29	0.23	0.23	0.23	0.23
	Total daily intake of arsenic (ug/kg/day)	1.77	1.58	1.00	1.06	0.85	0.74	0.84	0.72	0.99	0.60	0.78
Yellowknife Median	Estimated Daily Arsenic Intake (ug/kg/day)	0.57	0.43	0.26	0.21	0.21	0.21	0.26	0.21	0.21	0.21	0.21
	Total daily intake of arsenic (ug/kg/day)	1.71	1.54	0.98	1.04	0.83	0.72	0.81	0.70	0.97	0.58	0.76

Table 9. Results for Scenario 4. Most Realistic Case for Generic Yellowknife Garden. The maximum, minimum, mean and median potential increase in daily arsenic intakes (ug/kg/day) from a generic garden in Yellowknife (a) are added to the total daily arsenic intakes reported by Dabeka, 1993 (b), to obtain the total daily intake of arsenic (c).

		Child M/F		Male				Female				M/F
	Age (years)	a1 -4	a5-11	a12-19	20-39	40-64	65+	a12-19	20-39	40-64	65+	all ages
	Body Weight (kg)	13	27	57	70	70	70	57	70	70	70	70
	Canadian Estimated Daily Arsenic Intakes (ug/kg/day) (b)	1.15	1.11	0.72	0.83	0.61	0.51	0.56	0.49	0.75	0.37	0.54
Yellowknife Minimums	Estimated Daily Arsenic Intake (ug/kg/day)	0.14	0.10	0.07	0.07	0.07	0.09	0.05	0.06	0.07	0.07	0.06
	7% of EDI (ug/kg/day) (a)	0.010	0.007	0.005	0.005	0.005	0.006	0.004	0.004	0.005	0.005	0.004
	Total daily intake of arsenic (ug/kg/day) (c)	1.16	1.11	0.72	0.84	0.62	0.52	0.56	0.49	0.76	0.37	0.55
Yellowknife Maximums	Estimated Daily Arsenic Intake (ug/kg/day)	0.51	0.39	0.27	0.28	0.24	0.27	0.21	0.20	0.21	0.22	0.20
	7% of EDI (ug/kg/day)	0.036	0.027	0.019	0.019	0.017	0.019	0.014	0.014	0.014	0.015	0.014
	Total daily intake of arsenic (ug/kg/day)	1.18	1.13	0.74	0.85	0.63	0.53	0.57	0.50	0.77	0.38	0.56
Yellowknife Mean	Estimated Daily Arsenic Intake (ug/kg/day)	0.28	0.21	0.14	0.15	0.13	0.16	0.11	0.11	0.12	0.13	0.11
	7% of EDI (ug/kg/day)	0.020	0.015	0.010	0.010	0.009	0.011	0.008	0.008	0.008	0.009	0.008
	Total daily intake of arsenic (ug/kg/day)	1.17	1.12	0.73	0.84	0.62	0.52	0.56	0.49	0.76	0.38	0.55
Yellowknife Median	Estimated Daily Arsenic Intake (ug/kg/day)	0.24	0.17	0.12	0.13	0.11	0.14	0.09	0.10	0.11	0.11	0.09
	7% of EDI (ug/kg/day)	0.017	0.012	0.008	0.009	0.008	0.010	0.006	0.007	0.007	0.008	0.007
	Total daily intake of arsenic (ug/kg/day)	1.16	1.12	0.73	0.84	0.62	0.52	0.56	0.49	0.76	0.38	0.55

4.5 Assessment of Risk Posed by the Consumption of Yellowknife Garden Vegetables

The EDIs calculated in the previous sections are all lower than the TDI being used in this study, with only a few exceptions. These exceptions are for the scenario of children ages 1-11 eating vegetables from Garden 3 and Garden 1, as their only source of vegetables year round. In general, when a TDI is exceeded, recommendations can be made to reduce the exposure to the contaminant[25]. For example, in this case, one might recommend reducing the consumption of the vegetables, or reducing the release of arsenic to the environment. However, given that it is highly unlikely that the only source of vegetables to children 1-11 years of age is from the two particular gardens studied, these steps are not considered to be necessary.

Since the EDIs for the realistic consumption scenarios are not significantly increased (over the normal intake of dietary arsenic) by the consumption of Yellowknife-grown produce, and since they are well below the TDI, the risk to people's health is likely to be small, as the potential exposure to arsenic is low[25].

Although residents of Yellowknife may be consuming vegetables that contain arsenic concentrations that are approximately 10 times greater than those found in vegetables from Canadian supermarkets, there is no indication that this consumption incurs an increased health risk.

5 Conclusions

Based on the results of the present investigations the following conclusions can be drawn.

- Arsenic concentrations in garden soils from the City of Yellowknife are within the previously reported background concentrations for the area.
- Arsenic concentrations in soils collected from the Giant Mine Townsite are six to seven times higher than those found in the City of Yellowknife, and typical of soils found on the Giant Mine Townsite.
- The concentrations of arsenic in produce from Yellowknife gardens are approximately ten times higher than those found in produce from supermarkets across Canada.
- The risk assessment, consisting of a comparison of estimated daily intakes (including intakes from sources other than local produce) to a safe level recommended by FAO/WHO, reveals that locally grown Yellowknife produce is safe to eat. This is the case for both the individual gardens and for a generic garden. The generic garden represents a garden that may be grown by Yellowknife residents who were not able to participate in this study. The only exceptions to the above statement are when young children eat produce from two individual gardens year round, with no other source of produce. This scenario not likely to happen and represents the worst case only.

6 Future Work

The Environmental Sciences Group remains committed to determining the risk, if any, that the elevated levels of arsenic in the Yellowknife area pose to human or ecological health.

To this end we are continuing to study the uptake of arsenic into produce in the Yellowknife area. As part of a Strategic Initiative funded by NSERC (Canada's basic research funding agency), ESG intends to grow a garden on mine property during the summer of 2001. One purpose of this project is to model the worst case scenario of later use of mine property; that is, residential use of mine soil that has not been remediated. By determining the arsenic uptake by plants growing on soils that contain elevated arsenic concentrations, we hope to study any biological responses to high soil arsenic concentrations (e.g., limitation of arsenic uptake). With these results, we intend to determine if consumption of vegetables grown on this soil, containing elevated levels of arsenic (i.e., not background), will increase the EDIs above acceptable levels.

Human health risk calculations (including the ones used in this study) conservatively assume that all arsenic in food is absorbed. However, it is likely that not all arsenic is bioavailable, i.e., subsequently absorbed by the human body. We are currently applying gastric fluid extraction (an assay that mimics the conditions of the human gastro-intestinal system) of the vegetables analyzed in the present study. The purpose of this is to determine the extent to which we can use this methodology to estimate an actual level of arsenic bioaccessibility to the human body. The results from this methodology (e.g., percent bioavailable/bioaccessible fractions) can then be applied to human health risk assessment to improve the accuracy of the calculations.

It is important to note that the levels from Dabeka *et al.* (1993) that were used (Table 1) to calculate EDIs in this study resulted from summing the arsenic intake from all food sources. These included fish and seafood, which contain higher levels of arsenic than all other food types. It is the fish/seafood arsenic concentrations that contribute the majority of the arsenic to the EDIs in both the Dabeka study and this one. However, as was also noted in the Dabeka study, fish and seafood contain predominantly organic arsenic (specifically, arsenobetaine), which is non-toxic. Additionally, the FAO/WHO TDI used, of 2.1 ug/kg/day, refers to inorganic arsenic only. Therefore, the inclusion of fish/seafood arsenic concentrations likely overestimates EDIs in both studies. These points underline the necessity of determining the chemical form of arsenic included in the exposure calculations. We are currently undertaking this analysis and expect that such data,

together with bioavailability data, will be used to more accurately predict risk from the consumption of arsenic-containing foods both in Yellowknife and elsewhere.

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8 Appendices

Appendix A: Data Tables for Individual Gardens

Appendix B: Estimated Daily Intakes of Arsenic from Vegetable Gardens

Appendix C: Quality Assurance/Quality Control

9 Appendix A: Data Tables for Individual Gardens

Garden 1

Sample	Plant Species	[As] ppm fresh weight
Radish	*Raphanus sativus*	0.17
Beet greens	*Beta vulgaris var. crassa*	0.29
Rhubarb stalks	*Rheum rhababarum*	0.05
Saskatoon berries	*Amelanchier alnifolia*	0.44

Garden 2

Sample	Plant Species	[As] ppm fresh weight
Carrots	*Daucus carota*	0.034
Red potatoes	*Solanum tuberosum*	0.034
Onion (peeled)	*Allium cepa*	0.041
Beets	*Beta vulgaris var. crassa*	0.020
Beet greens	*Beta vulgaris var. crassa*	0.18
Onion tops	*Allium cepa*	0.15
Leaf lettuce	*Lactuca sativa*	0.06
Romaine lettuce	*Lactuca sativa*	0.13
Celery leaves	*Apium graveolens var. dulce*	0.29
Celery	*Apium graveolens var. dulce*	0.05
Rhubarb stalks	*Rheum rhababarum*	0.014
Peas	*Pisum sativum*	<0.02
Beans	*Phaseolus vulgaris*	0.016

Garden 3

Sample	Plant Species	[As] ppm fresh weight
Beets	*Beta vulgaris var. crassa*	0.19
Beet greens	*Beta vulgaris var. crassa*	0.13
Leaf lettuce	*Lactuca sativa*	0.27
Romaine lettuce	*Lactuca sativa*	0.12
Tomatoes	*Lycopersicon esculentum*	0.009

Garden 4

Sample	Plant Species	[As] ppm fresh weight
Red potatoes	*Solanum tuberosum*	0.026
Kohlrabi	*Brassica oleracea var. gongylodes*	0.044
Red cabbage	*Brassica oleracea var. capitata*	0.09
Kale	*Brassica oleracea var. acephala*	0.16
Peas	*Pisum sativum*	<0.02
Broad beans	*Phaseolus vulgaris*	0.018

Garden 5

Sample	Plant Species	[As] ppm fresh weight
Carrots	*Daucus carota*	0.05
Swiss chard	*Beta vulgaris*	0.09
Italian parsley	*Petroselinum crispum var. neapolitanum*	0.10
Oregano	*Origanum sp.*	0.23
Rhubarb stalks	*Rheum rhababarum*	<0.01

Garden 6

Sample	Plant Species	[As] ppm fresh weight
Carrots	*Daucus carota*	0.06
White potatoes	*Solanum tuberosum*	<0.03

Garden 7

Sample	Plant Species	[As] ppm fresh weight
Carrots	*Daucus carota*	0.037
White potatoes	*Solanum tuberosum*	<0.02

Garden 8

Sample	Plant Species	[As] ppm fresh weight
Carrots	*Daucus carota*	0.020
Red potatoes	*Solanum tuberosum*	<0.02
Onion (peeled)	*Allium cepa*	0.017
Garlic bulb	*Allium sativum*	<0.03
Beets	*Beta vulgaris var. crassa*	0.034
Beet greens	*Beta vulgaris var. crassa*	0.1
Onion tops	*Allium cepa*	0.18
Garlic tops	*Allium sativum*	0.11
White cabbage	*Brassica oleracea var. capitata*	0.033
Dill	*Anethum graveolens*	0.07
Swiss chard	*Beta vulgaris*	0.06
Rhubarb stalks	*Rheum rhababarum*	0.015
Pin cherries	*Prunus pensylvanica*	0.09
Saskatoon berries	*Amelanchier alnifolia*	0.15

Garden 9

Sample	Plant Species	[As] ppm fresh weight
Red potatoes	*Solanum tuberosum*	0.020
White cabbage	*Brassica oleracea var. capitata*	<0.01
Broccoli	*Brassica oleracea cymosa*	<0.02
Peas	*Pisum sativum*	0.036
Zucchini	*Curcurbita pepo*	<0.005

Garden 10

Sample	Plant Species	[As] ppm fresh weight
Carrots	*Daucus carota*	0.07
White potatoes	*Solanum tuberosum*	0.07
Red potatoes	*Solanum tuberosum*	0.06
Leaf lettuce	*Lactuca sativa*	0.08
Rhubarb stalks	*Rheum rhababarum*	0.014
Beans	*Phaseolus vulgaris*	0.026

10 Appendix B: Estimated Daily Intakes of Arsenic from Vegetable Gardens

Table 10-1. Canadian Estimated Food Intakes (g/person/day) by age (years) and sex (adapted from Dabeka, 1993).

		Child M/F		Male				Female				M/F
	Age (years)	a1 -4	a5-11	a12-19	20-39	40-64	65+	a12-19	20-39	40-64	65+	all ages
	Body Weight (kg)	13	27	57	70	70	70	57	70	70	70	70
food intakes, g/person/day	Canadian Daily Average Consumption Vegetables g/person/day*	125	198	250	250	250	250	250	250	250	250	250
potatoes, raw	food intake (g/person/day)	0.28	0	0	0.12	0	0	0	0.05	0.05	0	0.05
potatoes, cooked	food intake (g/person/day)	47.48	77.66	125.92	126.42	98.29	96.05	77.76	66	55.59	63.45	82.84
Cabbage	food intake (g/person/day)	3.01	5.05	5.1	7.61	10.79	14.98	7.25	9.26	9.2	11.18	7.7
Celery	food intake (g/person/day)	1.61	2.43	2.9	5.79	7.29	9.06	3.96	5.65	11.2	11.41	5.65
peppers	food intake (g/person/day)	0.06	0.27	0.12	0.94	2.9	0.44	0.71	1.16	1.38	0.21	0.93
Lettuce	food intake (g/person/day)	2.64	4.49	7.5	15.77	10.71	9.47	8.87	13.26	14.96	10.39	9.86
Broccoli	food intake (g/person/day)	0.38	1.34	0.225	6	1.71	1.83	0.16	1.18	2.17	0.29	1.74
Beans	food intake (g/person/day)	2.9	4.27	3.84	9.97	6.86	4.27	5.09	8.29	5.96	4.87	5.94
Peas	food intake (g/person/day)	4.87	6.09	9.13	9.92	10.73	9.09	6.29	9.17	7.52	10.42	8.46
carrots	food intake (g/person/day)	8.49	10.34	10.9	13.44	16.23	15.29	11.25	14.8	12.42	13.13	12.44
Onions	food intake (g/person/day)	0.98	2.45	2.03	5.58	6.17	5.98	4	6.35	6.31	6.37	4.53
rutabagas or turnip	food intake (g/person/day)	2.59	3.51	4.28	5.36	6.35	10.97	2.37	2.75	5.08	5.3	4.36
tomatoes, raw	food intake (g/person/day)	3.56	7.47	11.14	25.65	15.54	13.91	11.17	19.26	19.83	10.56	14.41
cucumbers	food intake (g/person/day)		8.27	12.22	19.88	8.41	8.31	10.39	11.64	12.2	6.72	10.7
beets, raw	food intake (g/person/day)	0.48	1.26	0.67	2.59	2.51	2.48	1.3	0.71	1.28	1.75	1.44
strawberries	food intake (g/person/day)	3.35	7.56	6.51	6.26	6.23	11.19	4.34	2.94	8.54	14.48	1.33
Cherries	food intake (g/person/day)	1.01	1.15	1.1	1.82	1.54	1.88	0.62	1.71	0.93	2.46	6.34
blueberries	food intake (g/person/day)	0.74	1	2.45	1.22	1.39	3.67	0.64	1.94	1.29	3.35	1.49

*Average amount of vegetable food group consumed by Canadians daily (Health Canada, 1995)

Table 10-2. Estimated daily intake of arsenic was calculated by multiplying (a) individual ingestion rates by the (b) concentrations of arsenic in individual produce and dividing it by the (c) weight (kg) from Garden 2.

	Child M/F		Male				Female				M/F
Age (years)	a1-4	a5-11	a12-19	20-39	40-64	65+	a12-19	20-39	40-64	65+	all ages
Weight (kg) (c)	13	27	57	70	70	70	57	70	70	70	70
potatoes, raw (g/person/day) (a)	0.28	0	0	0.12	0	0	0	0.05	0.05	0	0.05
red potatoes (ug/g) (b)	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034
Daily intake of arsenic (ug/kg/day)	0.00073	0	0	5.829E-05	0	0	0	2.429E-05	2.429E-05	0	2.429E-05
potatoes, cooked (g/person/day)	47.48	77.66	125.92	126.42	98.29	96.05	77.76	66	55.59	63.45	82.84
red potatoes (ug/g)	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034
Daily intake of arsenic (ug/kg/day)	0.124	0.098	0.075	0.061	0.048	0.047	0.046	0.032	0.027	0.031	0.040
celery (g/person/day)	1.61	2.43	2.9	5.79	7.29	9.06	3.96	5.65	11.2	11.41	5.65
celery (ug/g)	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Daily intake of arsenic (ug/kg/day)	0.0062	0.0045	0.0025	0.0041	0.0052	0.0065	0.0035	0.0040	0.0080	0.0082	0.0040
Lettuce (g/person/day)	2.64	4.49	7.5	15.77	10.71	9.47	8.87	13.26	14.96	10.39	9.86
leaf lettuce (ug/g)	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Daily intake of arsenic (ug/kg/day)	0.012	0.010	0.008	0.014	0.009	0.008	0.009	0.011	0.013	0.009	0.008
Romaine lettuce (ug/g)	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
Daily intake of arsenic (ug/kg/day)	0.03	0.02	0.02	0.03	0.02	0.02	0.02	0.02	0.03	0.02	0.02
Beans (g/person/day)	2.9	4.27	3.84	9.97	6.86	4.27	5.09	8.29	5.96	4.87	5.94
beans (ug/g)	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Daily intake of arsenic (ug/kg/day)	0.0036	0.0025	0.0011	0.0023	0.0016	0.0010	0.0014	0.0019	0.0014	0.0011	0.0014
Peas (g/person/day)	4.87	6.09	9.13	9.92	10.73	9.09	6.29	9.17	7.52	10.42	8.46
peas (ug/g)	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020
Daily intake of arsenic (ug/kg/day)	0.0075	0.0045	0.0032	0.0028	0.0031	0.0700	0.0022	0.0026	0.0021	0.0030	0.0024
carrots (g/person/day)	8.49	10.34	10.9	13.44	16.23	15.29	11.25	14.8	12.42	13.13	12.44
carrot (ug/g)	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034
Daily intake of arsenic (ug/kg/day)	0.022	0.013	0.007	0.007	0.008	0.007	0.007	0.007	0.006	0.006	0.006
Onions (g/person/day)	0.98	2.45	2.03	5.58	6.17	5.98	.4	6.35	6.31	6.37	4.53
onion (peeled) (ug/g)	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041
Daily intake of arsenic (ug/kg/day)	0.0031	0.0037	0.0015	0.0033	0.0036	0.0035	0.0029	0.0037	0.0037	0.0037	0.0027
beets, raw (g/person/day)	0.48	1.26	0.67	2.59	2.51	2.48	1.3	0.71	1.28	1.75	1.44
beets (ug/g)	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020
Daily intake of arsenic (ug/kg/day)	0.0007	0.0009	0.0002	0.0007	0.0007	0.0007	0.0005	0.0002	0.0004	0.0005	0.0004
strawberries (g/person/day)	3.35	7.56	6.51	6.26	6.23	11.19	4.34	2.94	8.54	14.48	6.34
rhubarb stalks (ug/g)	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014
Daily intake of arsenic (ug/kg/day)	0.0036	0.0039	0.0016	0.0013	0.0012	0.0022	0.0011	0.0006	0.0017	0.0029	0.0013
Total Estimated Daily Intake of arsenic per age group (ug/kg/day)	**0.207**	**0.159**	**0.115**	**0.124**	**0.099**	**0.161**	**0.093**	**0.088**	**0.089**	**0.082**	**0.084**

Table 10-3. Estimated daily intake of arsenic was calculated by multiplying (a) individual ingestion rates by the (b) concentrations of arsenic in individual produce and dividing it by the (c) weight (kg) from Garden 3.

	Child M/F		Male				Female				M/F
Age (years)	**a1 -4**	**a5-11**	**a12-19**	**20-39**	**40-64**	**65+**	**a12-19**	**20-39**	**40-64**	**65+**	**all ages**
Weight (kg) (c)	**13**	**27**	**57**	**70**	**70**	**70**	**57**	**70**	**70**	**70**	**70**
Lettuce (g/person/day) (a)	2.64	4.49	7.5	15.77	10.71	9.47	8.87	13.26	14.96	10.39	9.86
leaf lettuce (ug/g) **(b)**	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27
Daily intake of arsenic (ug/kg/day)	0.055	0.045	0.036	0.061	0.041	0.037	0.042	0.051	0.058	0.040	0.038
Romaine lettuce (ug/g)	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
Daily intake of arsenic (ug/kg/day)	0.024	0.020	0.016	0.027	0.018	0.016	0.019	0.023	0.026	0.018	0.017
tomatoes, raw (g/person/day)											
tomatoes (ug/g)	3.56	7.47	11.14	25.65	15.54	13.91	11.17	19.26	19.83	10.56	14.41
Daily intake of arsenic (ug/kg/day)	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009
	0.0025	0.0025	0.0018	0.0033	0.0020	0.0018	0.0018	0.0025	0.0025	0.0014	0.0019
rutabagas or turnip (g/person/day)	0.48	1.26	0.67	2.59	2.51	2.48	1.3	0.71	1.28	1.75	1.44
beets (ug/g)	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
Daily intake of arsenic (ug/kg/day)	0.0070	0.0089	0.0022	0.0070	0.0068	0.0067	0.0043	0.0019	0.0035	0.0048	0.0039
Total Estimated Daily intake of arsenic per age group (ug/kg/day)	**0.089**	**0.076**	**0.055**	**0.098**	**0.068**	**0.061**	**0.067**	**0.078**	**0.089**	**0.064**	**0.061**

Table 10-4. Estimated daily intake of arsenic was calculated by multiplying (a) individual ingestion rates by the (b) concentrations of arsenic in individual produce and dividing it by the (c) weight (kg) from Garden 4.

	Child M/F		Male				Female				M/F
Age (years)	a1 -4	a5-11	a12-19	20-39	40-64	65+	a12-19	20-39	40-64	65+	all ages
Weight (kg) (c)	13	27	57	70	70	70	57	70	70	70	70
potatoes, raw (g/person/day) (a)	0.28	0	0	0.12	0	0	0	0.05	0.05	0	0.05
red potatoes (ug/g) (b)	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026
Daily intake of arsenic (ug/kg/day)	0.00056	0	0	4.457E-05	0	0	0	1.857E-05	1.857E-05	0	1.857E-05
potatoes, cooked (g/person/day)	47.48	77.66	125.92	126.42	98.29	96.05	77.76	66	55.59	63.45	82.84
red potatoes (ug/g)	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026
Daily intake of arsenic (ug/kg/day)	0.095	0.075	0.057	0.047	0.037	0.036	0.035	0.025	0.021	0.024	0.031
Cabbage (g/person/day)	3.01	5.05	5.1	7.61	10.79	14.98	7.25	9.26	9.2	11.18	7.7
red cabbage (ug/g)	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
Daily intake of arsenic (ug/kg/day)	0.021	0.017	0.008	0.010	0.014	0.019	0.011	0.012	0.012	0.014	0.010
Beans (g/person/day)	2.9	4.27	3.84	9.97	6.86	4.27	5.09	8.29	5.96	4.87	5.94
broad beans (ug/g)	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018
Daily intake of arsenic (ug/kg/day)	0.0040	0.0028	0.0012	0.0026	0.0018	0.0011	0.0016	0.0021	0.0015	0.0013	0.0015
Peas (g/person/day)	4.87	6.09	9.13	9.92	10.73	9.09	6.29	9.17	7.52	10.42	8.46
peas (ug/g)	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020
Daily intake of arsenic (ug/kg/day)	0.0075	0.0045	0.0032	0.0028	0.0031	0.0026	0.0022	0.0026	0.0021	0.0030	0.0024
rutabagas or turnip (g/person/day)	2.59	3.51	4.28	5.36	6.35	10.97	2.37	2.75	5.08	5.3	4.36
kohlrabi (ug/g)	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044
Daily intake of arsenic (ug/kg/day)	0.0088	0.0057	0.0033	0.0034	0.0040	0.0069	0.0018	0.0017	0.0032	0.0033	0.0027
Total Estimated Daily intake of arsenic per age group (ug/kg/day)	**0.137**	**0.105**	**0.073**	**0.066**	**0.059**	**0.066**	**0.053**	**0.043**	**0.039**	**0.046**	**0.047**

Table 10-5. Estimated daily intake of arsenic was calculated by multiplying (a) individual ingestion rates by the (b) concentrations of arsenic in individual produce and dividing it by the (c) weight (kg) from Garden 5.

	Child M/F		Male				Female				M/F
Age (years)	a1 -4	a5-11	a12-19	20-39	40-64	65+	a12-19	20-39	40-64	65+	all ages
Weight (kg) (c)	13	27	57	70	70	70	57	70	70	70	70
Celery (g/person/day) (a)	1.61	2.43	2.9	5.79	7.29	9.06	3.96	5.65	11.2	11.41	5.65
swiss chard (ug/g) (b)	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
Daily intake of arsenic (ug/kg/day)	0.011	0.008	0.005	0.007	0.009	0.012	0.006	0.007	0.014	0.015	0.007
carrots (g/person/day)	8.49	10.34	10.9	13.44	16.23	15.29	11.25	14.8	12.42	13.13	12.44
carrots (ug/g)	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Daily intake of arsenic (ug/kg/day)	0.033	0.019	0.010	0.010	0.012	0.011	0.010	0.011	0.009	0.009	0.009
strawberries (g/person/day)	3.35	7.56	6.51	6.26	6.23	11.19	4.34	2.94	8.54	14.48	6.34
rhubarb stalks (ug/g)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Daily intake of arsenic (ug/kg/day)	0.0026	0.0028	0.0011	0.0009	0.0009	0.0016	0.0008	0.0004	0.0012	0.0021	0.0009
Total Estimated Daily intake of arsenic per age group (ug/kg/day)	0.046	0.030	0.015	0.018	0.022	0.024	0.017	0.018	0.024	0.026	0.017

Table 10-6. Estimated daily intake of arsenic was calculated by multiplying (a) individual ingestion rates by the (b) concentrations of arsenic in individual produce and dividing it by the (c) weight (kg) from Garden 6.

	Child M/F		Male				Female				M/F
Age (years)	a1 -4	a5-11	a12-19	20-39	40-64	65+	a12-19	20-39	40-64	65+	all ages
Weight (kg) (c)	13	27	57	70	70	70	57	70	70	70	70
potatoes, raw (g/person/day) (a)	0.28	0	0	0.12	0	0	0	0.05	0.05	0	0.05
red potatoes (ug/g) (b)	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030
Daily intake of arsenic (ug/kg/day)	0.00065	0.00000	0.00000	0.00005	0.00000	0.00000	0.00000	0.00002	0.00002	0.00000	0.00002
potatoes, cooked (g/person/day)	47.48	77.66	125.92	126.42	98.29	96.05	77.76	66	55.59	63.45	82.84
red potatoes (ug/g)	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030
Daily intake of arsenic (ug/kg/day)	0.110	0.086	0.066	0.054	0.042	0.041	0.041	0.028	0.024	0.027	0.036
carrots (g/person/day)	8.49	10.34	10.9	13.44	16.23	15.29	11.25	14.8	12.42	13.13	12.44
carrots (ug/g)	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Daily intake of arsenic (ug/kg/day)	0.039	0.023	0.011	0.012	0.014	0.013	0.012	0.013	0.011	0.011	0.011
Total Estimated Daily intake of arsenic per age group (ug/kg/day)	**0.15**	**0.11**	**0.08**	**0.07**	**0.06**	**0.05**	**0.05**	**0.04**	**0.03**	**0.04**	**0.05**

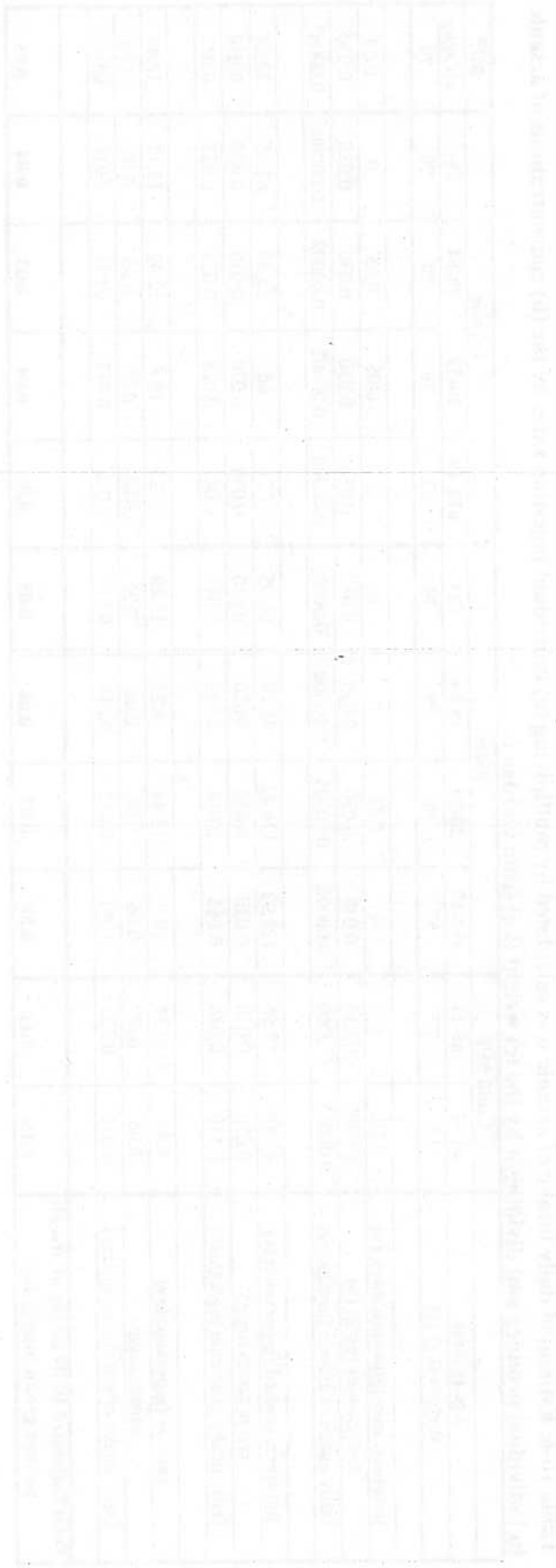

Table 10-8. Estimated daily intake of arsenic was calculated by multiplying (a) individual ingestion rates by the (b) concentrations of arsenic in individual produce and dividing it by the (c) weight (kg) from Garden 8.

	Child M/F		Male				Female				M/F
Age (years)	a1 -4	a5-11	a12-19	20-39	40-64	65+	a12-19	20-39	40-64	65+	all ages
Weight (kg) (c)	13	27	57	70	70	70	57	70	70	70	70
potatoes, raw (g/person/day) (a)	0.28	0	0	0.12	0	0	0	0.05	0.05	0	0.05
red potatoes (ug/g) (b)	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020
Daily intake of arsenic (ug/kg/day)	0.00043	0.00000	0.00000	0.00003	0.00000	0.00000	0.00000	0.00001	0.00001	0.00000	0.00001
potatoes, cooked (g/person/day)	47.48	77.66	125.92	126.42	98.29	96.05	77.76	66	55.59	63.45	82.84
red potatoes (ug/g)	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020
Daily intake of arsenic (ug/kg/day)	0.073	0.058	0.044	0.036	0.028	0.027	0.027	0.019	0.016	0.018	0.024
Cabbage (g/person/day)	3.01	5.05	5.1	7.61	10.79	14.98	7.25	9.26	9.2	11.18	7.7
white cabbage (ug/g)	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033
Daily intake of arsenic (ug/kg/day)	0.0076	0.0062	0.0030	0.0036	0.0051	0.0071	0.0042	0.0044	0.0043	0.0053	0.0036
Celery (g/person/day)	1.61	2.43	2.9	5.79	7.29	9.06	3.96	5.65	11.2	11.41	5.65
swiss chard (ug/g)	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Daily intake of arsenic (ug/kg/day)	0.0074	0.0054	0.0031	0.0050	0.0062	0.0078	0.0042	0.0048	0.0096	0.0098	0.0048
carrots (g/person/day)	8.49	10.34	10.9	13.44	16.23	15.29	11.25	14.8	12.42	13.13	12.44
carrots (ug/g)	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020
Daily intake of arsenic (ug/kg/day)	0.0129	0.0076	0.0038	0.0038	0.0046	0.0043	0.0039	0.0042	0.0035	0.0037	0.0035
Onions (g/person/day)	0.98	2.45	2.03	5.58	6.17	5.98	4	6.35	6.31	6.37	4.53
onion (peeled) (ug/g)	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017
Daily intake of arsenic (ug/kg/day)	0.0013	0.0015	0.0006	0.0014	0.0015	0.0015	0.0012	0.0015	0.0015	0.0015	0.0011
beets, raw (g/person/day)	0.48	1.26	0.67	2.59	2.51	0.07	1.3	0.71	1.28	1.75	1.44
beets (ug/g)	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034
Daily intake of arsenic (ug/kg/day)	0.0013	0.0016	0.0004	0.0013	0.0012	0.0000	0.0008	0.0003	0.0006	0.0009	0.0007
strawberries (g/person/day)	3.35	7.56	6.51	6.26	6.23	11.19	4.34	2.94	8.54	14.48	6.34
rhubarb stalks (ug/g)	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015
Daily intake of arsenic (ug/kg/day)	0.0039	0.0042	0.0017	0.0013	0.0013	0.0024	0.0011	0.0006	0.0018	0.0031	0.0014
blueberries (g/person/day)	0.74	1	2.45	1.22	1.39	3.67	0.64	1.94	1.29	3.35	1.49
pin cherries (ug/g)	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
Daily intake of arsenic (ug/kg/day)	0.0051	0.0033	0.0039	0.0016	0.0018	0.0047	0.0010	0.0025	0.0017	0.0043	0.0019
saskatoon berries (ug/g)	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Daily intake of arsenic (ug/kg/day)	0.0085	0.0056	0.0064	0.0026	0.0030	0.0079	0.0017	0.0042	0.0028	0.0072	0.0032
Total Estimated Daily intake of arsenic per age group (ug/kg/day)	0.121	0.093	0.067	0.057	0.053	0.063	0.045	0.041	0.042	0.054	0.044

Table 10-9. Estimated daily intake of arsenic was calculated by multiplying (a) individual ingestion rates by the (b) concentrations of arsenic in individual produce and dividing it by the (c) weight (kg) from Garden 9.

	Child M/F		Male				Female				M/F
Age (years)	**a1 -4**	**a5-11**	**a12-19**	**20-39**	**40-64**	**65+**	**a12-19**	**20-39**	**40-64**	**65+**	**all ages**
Weight (kg) (c)	**13**	**27**	**57**	**70**	**70**	**70**	**57**	**70**	**70**	**70**	**70**
potatoes, raw (g/person/day) (a)	0.28	0	0	0.12	0	0	0	0.05	0.05	0	0.05
red potatoes (ug/g) (b)	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020
Daily intake of arsenic (ug/kg/day)	0.00043	0.00000	0.00000	0.00003	0.00000	0.00000	0.00000	0.00001	0.00001	0.00000	0.00001
potatoes, cooked (g/person/day)	47.48	77.66	125.92	126.42	98.29	96.05	77.76	66	55.59	63.45	82.84
red polatoes (ug/g)	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020
Daily intake of arsenic (ug/kg/day)	0.073	0.058	0.044	0.036	0.028	0.027	0.027	0.019	0.016	0.018	0.024
Cabbage (g/person/day)	3.01	5.05	5.1	7.61	10.79	14.98	7.25	9.26	9.2	11.18	7.7
white cabbage (ug/g)	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
Daily intake of arsenic (ug/kg/day)	0.0023	0.0019	0.0009	0.0011	0.0015	0.0021	0.0013	0.0013	0.0013	0.0016	0.0011
Broccoli (g/person/day)	0.38	1.34	0.225	6	1.71	1.83	0.16	1.18	2.17	0.29	1.74
broccoli (ug/g)	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Daily intake of arsenic (ug/kg/day)	0.00058	0.00099	0.00008	0.00171	0.00049	0.00052	0.00006	0.00034	0.00062	0.00008	0.00050
Peas (g/person/day)	4.87	6.09	9.13	9.92	10.73	9.09	6.29	9.17	7.52	10.42	8.46
peas (ug/g)	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036
Daily intake of arsenic (ug/kg/day)	0.013	0.008	0.006	0.005	0.006	0.005	0.004	0.005	0.004	0.005	0.004
cucumbers (g/person/day)	3.09	8.27	12.22	19.88	8.41	8.31	10.39	11.64	12.2	6.72	10.7
zucchini (ug/g)	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Daily intake of arsenic (ug/kg/day)	0.0012	0.0015	0.0011	0.0014	0.0006	0.0006	0.0009	0.0008	0.0009	0.0005	0.0008
Total Estimated Daily intake of arsenic per age group (ug/kg/day)	**0.091**	**0.070**	**0.052**	**0.045**	**0.036**	**0.035**	**0.033**	**0.026**	**0.023**	**0.026**	**0.030**

Table 10-10. Estimated daily intake of arsenic was calculated by multiplying (a) individual ingestion rates by the (b) concentrations of arsenic in individual produce and dividing it by the (c) weight (kg) from Garden 10.

	Child M/F		Male				Female				M/F
Age (years)	a1 -4	a5-11	a12-19	20-39	40-64	65+	a12-19	20-39	40-64	65+	all ages
Weight (kg) (c)	13	27	57	70	70	70	57	70	70	70	70
potatoes, raw (g/person/day) (a)	0.28	0	0	0.12	0	0	0	0.05	0.05	0	0.05
white potatoes (ug/g) (b)	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
Daily intake of arsenic (ug/kg/day)	0.0015	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0001	0.0001	0.0000	0.0001
potatoes, cooked (g/person/day)	47.48	77.66	125.92	126.42	98.29	96.05	77.76	66	55.59	63.45	82.84
white potatoes (ug/g)	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
Daily intake of arsenic (ug/kg/day)	0.26	0.20	0.15	0.13	0.10	0.10	0.10	0.07	0.06	0.06	0.08
potatoes, raw (g/person/day) (a)	0.28	0	0	0.12	0	0	0	0.05	0.05	0	0.05
red potatoes (ug/g) (b)	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Daily intake of arsenic (ug/kg/day)	0.00129	0.00000	0.00000	0.00010	0.00000	0.00000	0.00000	0.00004	0.00004	0.00000	0.00004
potatoes, cooked (g/person/day)	47.48	77.66	125.92	126.42	98.29	96.05	77.76	66	55.59	63.45	82.84
red potatoes (ug/g)	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Daily intake of arsenic (ug/kg/day)	0.22	0.17	0.13	0.11	0.08	0.08	0.08	0.06	0.05	0.05	0.07
Lettuce (g/person/day) (a)	2.64	4.49	7.5	15.77	10.71	9.47	8.87	13.26	14.96	10.39	9.86
leaf lettuce (ug/g) (b)	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
Daily intake of arsenic (ug/kg/day)	0.016	0.013	0.011	0.018	0.012	0.011	0.012	0.015	0.017	0.012	0.011
Beans (g/person/day)	2.9	4.27	3.84	9.97	6.86	4.27	5.09	8.29	5.96	4.87	5.94
broad beans (ug/g)	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026
Daily intake of arsenic (ug/kg/day)	0.0058	0.0041	0.0018	0.0037	0.0025	0.0016	0.0023	0.0031	0.0022	0.0018	0.0022
carrots (g/person/day)	8.49	10.34	10.9	13.44	16.23	15.29	11.25	14.8	12.42	13.13	12.44
carrots (ug/g)	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
Daily intake of arsenic (ug/kg/day)	0.046	0.027	0.013	0.013	0.016	0.015	0.014	0.015	0.012	0.013	0.012
strawberries (g/person/day)	3.35	7.56	6.51	6.26	6.23	11.19	4.34	2.94	8.54	14.48	6.34
rhubarb stalks (ug/g)	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014
Daily intake of arsenic (ug/kg/day)	0.0036	0.0039	0.0016	0.0013	0.0012	0.0022	0.0011	0.0006	0.0017	0.0029	0.0013
Total Estimated Daily intake of arsenic per age group (ug/kg/day)	0.55	0.42	0.31	0.27	0.21	0.21	0.21	0.16	0.14	0.15	0.18

Table 10-11. Estimated daily intake of arsenic was calculated by multiplying (a) individual ingestion rates by the (b) concentrations of arsenic in individual produce and dividing it by the (c) weight (kg) from Garden 1.

	Child M/F		Male				Female				M/F
Age (years)	a1 -4	a5-11	a12-19	20-39	40-64	65+	a12-19	20-39	40-64	65+	all ages
Weight (kg) (c)	13	27	57	70	70	70	57	70	70	70	70
rutabagas or turnip (g/person/day) (a)	2.59	3.51	4.28	5.36	6.35	10.97	2.37	2.75	5.08	5.3	4.36
radish (ug/g) (b)	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17
Daily intake of arsenic (ug/kg/day)	0.034	0.022	0.013	0.013	0.015	0.027	0.007	0.007	0.012	0.013	0.011
strawberries (g/person/day)	3.35	7.56	6.51	6.26	6.23	11.19	4.34	2.94	8.54	14.48	6.34
rhubarb stalks (ug/g)	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Daily intake of arsenic (ug/kg/day)	0.013	0.014	0.006	0.004	0.004	0.008	0.004	0.002	0.006	0.010	0.005
blueberries (g/person/day)	0.74	1	2.45	1.22	1.39	3.67	0.64	1.94	1.29	3.35	1.49
saskatoon berries (ug/g)	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44
Daily intake of arsenic (ug/kg/day)	0.025	0.016	0.019	0.008	0.009	0.023	0.005	0.012	0.008	0.021	0.009
Total Estimated Daily intake of arsenic per age group (ug/kg/day)	**0.072**	**0.052**	**0.037**	**0.025**	**0.029**	**0.058**	**0.016**	**0.021**	**0.027**	**0.044**	**0.024**

Table 10-12. Calculation of the estimated daily arsenic intake from each garden if the only produce eaten is that from the garden at a rate of ingestion of produce as published by Health Canada. The calculation is made by multiplying (a) the canadian dail

		Child M/F		Male				Female				M/F
	Age (years)	a1 -4	a5-11	a12-19	20-39	40-64	65+	a12-19	20-39	40-64	65+	all ages
	Weight (kg) (c)	13	27	57	70	70	70	57	70	70	70	70
	Canadian Daily Average Consumption Vegetable (g/person/day) (a)	125	198	250	250	250	250	250	250	250	250	250
Garden 2	Average concentration in garden vegetables (ug/g) (b)	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
	Daily intake of arsenic (ug/kg/day)	0.40	0.30	0.18	0.15	0.15	0.15	0.18	0.15	0.15	0.15	0.15
Garden 3	Average concentration in garden vegetables (ug/g)	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
	Daily intake of arsenic (ug/kg/day)	1.44	1.10	0.66	0.54	0.54	0.54	0.66	0.54	0.54	0.54	0.54
Garden 4	Average concentration in garden vegetables (ug/g)	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
	Daily intake of arsenic (ug/kg/day)	0.38	0.29	0.18	0.14	0.14	0.14	0.18	0.14	0.14	0.14	0.14
Garden 5	Average concentration in garden vegetables (ug/g)	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
	Daily intake of arsenic (ug/kg/day)	0.48	0.37	0.22	0.18	0.18	0.18	0.22	0.18	0.18	0.18	0.18
Garden 6	Average concentration in garden vegetables (ug/g)	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045
	Daily intake of arsenic (ug/kg/day)	0.43	0.33	0.20	0.16	0.16	0.16	0.20	0.16	0.16	0.16	0.16
Garden 7	Average concentration in garden vegetables (ug/g)	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029
	Daily intake of arsenic (ug/kg/day)	0.28	0.21	0.13	0.10	0.10	0.10	0.13	0.10	0.10	0.10	0.10
Garden 8	Average concentration in garden vegetables (ug/g)	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049
	Daily intake of arsenic (ug/kg/day)	0.47	0.36	0.21	0.18	0.18	0.18	0.21	0.18	0.18	0.18	0.18
Garden 9	Average concentration in garden vegetables (ug/g)	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018
	Daily intake of arsenic (ug/kg/day)	0.17	0.13	0.08	0.06	0.06	0.06	0.08	0.06	0.06	0.06	0.06
Garden 10	Average concentration in garden vegetables (ug/g)	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053
	Daily intake of arsenic (ug/kg/day)	0.51	0.39	0.23	0.19	0.19	0.19	0.23	0.19	0.19	0.19	0.19
Garden 1	Average concentration in garden vegetables (ug/g)	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22
	Daily intake of arsenic (ug/kg/day)	2.12	1.61	0.96	0.79	0.79	0.79	0.96	0.79	0.79	0.79	0.79

Table 10-13. Total estimated daily intake of arsenic per age group (ug/kg/day) based on the minimum concentration of arsenic in the generic garden vegetables. Individual daily intakes were calculated by multiplying (a) ingestion rate of produce by (b) the concentration of arsenic in the produce (if less than detection limit, 1/2 of the detection limit was used) and dividing it by (c) the weight for each age and sex category.

	Child M/F		Male				Female				M/F
Age (years)	a1 -4	a5-11	a12-19	20-39	40-64	65+	a12-19	20-39	40-64	65+	all ages
Weight (kg) (c)	13	27	57	70	70	70	57	70	70	70	70
carrots (g/person/day) (a)	8.49	10.34	10.9	13.44	16.23	15.29	11.25	14.8	12.42	13.13	12.44
carrots (ug/g) (b)	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020
Daily intake of arsenic (ug/kg/day)	0.013	0.008	0.004	0.004	0.005	0.004	0.004	0.004	0.004	0.004	0.004
potatoes, raw (g/person/day) (a)	0.28	0	0	0.12	0	0	0	0.05	0.05	0	0.05
white and red potatoes (ug/g) (b)	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
Daily intake of arsenic (ug/kg/day)	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
potatoes, cooked (g/person/day)	47.48	77.66	125.92	126.42	98.29	96.05	77.76	66	55.59	63.45	82.84
white and red potatoes (ug/g)	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
Daily intake of arsenic (ug/kg/day)	0.04	0.03	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01
rutabagas or turnip (g/person/day)	2.59	3.51	4.28	5.36	6.35	10.97	2.37	2.75	5.08	5.3	4.36
radish (ug/g)	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17
Daily intake of arsenic (ug/kg/day)	0.034	0.022	0.013	0.013	0.015	0.027	0.007	0.007	0.012	0.013	0.011
Onions (g/person/day)	0.98	2.45	2.03	5.58	6.17	5.98	4	6.35	6.31	6.37	4.53
onion (peeled) (ug/g)	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017
Daily intake of arsenic (ug/kg/day)	0.0013	0.0015	0.0006	0.0014	0.0015	0.0015	0.0012	0.0015	0.0015	0.0015	0.0011
beets, raw (g/person/day)	0.48	1.26	0.67	2.59	2.51	2.48	1.3	0.71	1.28	1.75	1.44
beets (ug/g)	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020
Daily intake of arsenic (ug/kg/day)	0.00074	0.00093	0.00024	0.00074	0.00072	0.00071	0.00046	0.00020	0.00037	0.00050	0.00041
Lettuce (g/person/day)	2.64	4.49	7.5	15.77	10.71	9.47	8.87	13.26	14.96	10.39	9.86
Romaine and leaf lettuce (ug/g)	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060
Daily intake of arsenic (ug/kg/day)	0.012	0.010	0.008	0.014	0.009	0.008	0.009	0.011	0.013	0.009	0.008
celery (g/person/day)	1.61	2.43	2.9	5.79	7.29	9.06	3.96	5.65	11.2	11.41	5.65
celery (ug/g)	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Daily intake of arsenic (ug/kg/day)	0.0062	0.0045	0.0025	0.0041	0.0052	0.0065	0.0035	0.0040	0 0080	0.0082	0 0040
Celery (g/person/day)	1.61	2.43	2.9	5.79	7.29	9.06	3.96	5.65	11.2	11.41	5.65
swiss chard (ug/g)	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060
Daily intake of arsenic (ug/kg/day)	0.0074	0.0054	0.0031	0.0050	0.0062	0.0078	0.0042	0.0048	0.0096	0.0098	0.0048
Cabbage (g/person/day)	3.01	5.05	5.1	7.61	10.79	14 98	7.25	9.26	9.2	11.18	7.7
white and red cabbage (ug/g)	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Daily intake of arsenic (ug/kg/day)	0.001	0.001	0.000	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Broccoli (g/person/day)	0.38	1.34	0.225	6	1.71	1.83	0.16	1.18	2.17	0.29	1.74
Broccoli and kohlrabi (ug/g)	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
Daily intake of arsenic (ug/kg/day)	0.0003	0.0005	0.0000	0.0009	0.0002	0.0003	0.0000	0.0002	0.0003	0.0000	0.0002
cucumbers (g/person/day)	3.09	8.27	12.22	19.88	8.41	8.31	10.39	11.64	12.2	6.72	10.7
zucchini (ug/g)	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
Daily intake of arsenic (ug/kg/day)	0.00059	0.00077	0.00054	0.00071	0.00030	0.00030	0.00046	0.00042	0.00044	0.00024	0.00038
tomatoes, raw (g/person/day)	3.56	7.47	11.14	25.65	15.54	13.91	11.17	19.26	19.83	10.56	14 41
tomatoes (ug/g)	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009
Daily intake of arsenic (ug/kg/day)	0.0025	0.0025	0.0018	0.0033	0.0020	0.0018	0.0018	0.0025	0.0025	0.0014	0.0019
Beans (g/person/day)	2.9	4.27	3.84	9.97	6.86	4.27	5.09	8.29	5.96	4.87	5 94
beans broad beans (ug/g)	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Daily intake of arsenic (ug/kg/day)	0.0036	0.0025	0.0011	0.0023	0 0016	0.0010	0.0014	0.0019	0.0014	0.0011	0.0014
Peas (g/person/day)	4.87	6.09	9.13	9.92	10.73	9.09	6.29	9.17	7.52	10.42	8.46
peas (ug/g)	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
Daily intake of arsenic (ug/kg/day)	0.004	0.002	0.002	0.001	0.002	0.001	0.001	0.001	0.001	0.001	0 001
Cherries (g/person/day)	1.01	1.15	1.1	1.82	1.54	1.88	0.62	1.71	0.93	2.46	1 33
pin cherry fruit (ug/g)	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0 09
Daily intake of arsenic (ug/kg/day)	0.0070	0.0038	0.0017	0.0023	0.0020	0.0024	0.0010	0.0022	0.0012	0.0032	0 0017
blueberries (g/person/day)	0.74	1	2.45	1.22	1.39	3.67	0.64	1.94	1.29	3.35	1 49
saskatoon berries (ug/g)	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0 15
Daily intake of arsenic (ug/kg/day)	0.0085	0.0056	0.0064	0.0026	0.0030	0.0079	0.0017	0.0042	0.0028	0.0072	0 0032
strawberries (g/person/day)	3.35	7 56	6 51	6 26	6 23	11 19	4 34	2.94	8 54	14 48	6 34
rhubarb stalks (ug/g)	0.005	0 005	0 005	0 005	0 005	0 005	0.005	0.005	0 005	0 005	0 005
Daily intake of arsenic (ug/kg/day)	0.0013	0 0014	0 0006	0 0004	0 0004	0 0008	0.0004	0.0002	0 0006	0 0010	0 0005
Total Estimated Daily intake of arsenic per age group (ug/kg/day)	0.14	0.10	0.07	0.07	0.07	0.09	0.05	0.06	0.07	0.07	0.06

Table 10-14. Total estimated daily intake of arsenic per age group (ug/kg/day) based on the maximum concentration of arsenic in the generic garden vegetables. Individual daily intakes were calculated by multiplying (a) ingestion rate of produce by (b) the concentration of arsenic in the produce (if less than detection limit, 1/2 of the detection limit was used) and dividing it by (c) the weight for each age and sex catagory.

	Child M/F		Male				Female				M/F
Age (years)	a1 -4	a5-11	a12-19	20-39	40-64	65+	a12-19	20-39	40-64	65+	all ages
Weight (kg) (c)	13	27	57	70	70	70	57	70	70	70	70
carrots (g/person/day) (a)	8.49	10.34	10.9	13.44	16.23	15.29	11.25	14.8	12.42	13.13	12.44
carrots (ug/g) (b)	0.070	0.070	0.070	0.070	0.070	0.070	0.070	0.070	0.070	0.070	0.070
Daily intake of arsenic (ug/kg/day)	0.046	0.027	0.013	0.013	0.016	0.015	0.014	0.015	0.012	0.013	0.012
potatoes, raw (g/person/day) (a)	0.28	0	0	0.12	0	0	0	0.05	0.05	0	0.05
white and red potatoes (ug/g) (b)	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
Daily intake of arsenic (ug/kg/day)	0.0015	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0001	0.0001	0.0000	0.0001
potatoes, cooked (g/person/day)	47.48	77.66	125.92	126.42	98.29	96.05	77.76	66	55.59	63.45	82.84
white and red potatoes (ug/g)	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
Daily intake of arsenic (ug/kg/day)	0.26	0.20	0.15	0.13	0.10	0.10	0.10	0.07	0.06	0.06	0.08
rutabagas or turnip (g/person/day)	2.59	3.51	4.28	5.36	6.35	10.97	2.37	2.75	5.08	5.3	4.36
radish (ug/g)	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17
Daily intake of arsenic (ug/kg/day)	0.034	0.022	0.013	0.013	0.015	0.027	0.007	0.007	0.012	0.013	0.011
Onions (g/person/day)	0.98	2.45	2.03	5.58	6.17	5.98	4	6.35	6.31	6.37	4.53
onion (peeled) (ug/g)	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041
Daily intake of arsenic (ug/kg/day)	0.0031	0.0037	0.0015	0.0033	0.0036	0.0035	0.0029	0.0037	0.0037	0.0037	0.0027
beets, raw (g/person/day)	0.48	1.26	0.67	2.59	2.51	2.48	1.3	0.71	1.28	1.75	1.44
beets (ug/g)	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
Daily intake of arsenic (ug/kg/day)	0.00702	0.00887	0.00223	0.00703	0.00681	0.00673	0.00433	0.00193	0.00347	0.00475	0.00391
Lettuce (g/person/day)	2.64	4.49	7.5	15.77	10.71	9.47	8.87	13.26	14.96	10.39	9.86
Romaine and leaf lettuce (ug/g)	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27
Daily intake of arsenic (ug/kg/day)	0.055	0.045	0.036	0.061	0.041	0.037	0.042	0.051	0.058	0.040	0.038
celery (g/person/day)	1.61	2.43	2.9	5.79	7.29	9.06	3.96	5.65	11.2	11.41	5.65
--- celery (ug/g)	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Daily intake of arsenic (ug/kg/day)	0.0062	0.0045	0.0025	0.0041	0.0052	0.0065	0.0035	0.0040	0.0080	0.0082	0.0040
Celery (g/person/day)	1.61	2.43	2.9	5.79	7.29	9.06	3.96	5.65	11.2	11.41	5.65
swiss chard (ug/g)	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
Daily intake of arsenic (ug/kg/day)	0.0111	0.0081	0.0046	0.0074	0.0094	0.0116	0.0063	0.0073	0.0144	0.0147	0.0073
Cabbage (g/person/day)	3.01	5.05	5.1	7.61	10.79	14.98	7.25	9.26	9.2	11.18	7.7
white and red cabbage (ug/g)	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
Daily intake of arsenic (ug/kg/day)	0.021	0.017	0.008	0.010	0.014	0.019	0.011	0.012	0.012	0.014	0.010
Broccoli (g/person/day)	0.38	1.34	0.225	6	1.71	1.83	0.16	1.18	2.17	0.29	1.74
Broccoli and kohlrabi (ug/g)	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044
Daily intake of arsenic (ug/kg/day)	0.0013	0.0022	0.0002	0.0038	0.0011	0.0012	0.0001	0.0007	0.0014	0.0002	0.0011
cucumbers (g/person/day)	3.09	8.27	12.22	19.88	8.41	8.31	10.39	11.64	12.2	6.72	10.7
zucchini (ug/g)	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
Daily intake of arsenic (ug/kg/day)	0.00059	0.00077	0.00054	0.00071	0.00030	0.00030	0.00046	0.00042	0.00044	0.00024	0.00038
tomatoes, raw (g/person/day)	3.56	7.47	11.14	25.65	15.54	13.91	11.17	19.26	19.83	10.56	14.41
tomatoes (ug/g)	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009
Daily intake of arsenic (ug/kg/day)	0.0025	0.0025	0.0018	0.0033	0.0020	0.0018	0.0018	0.0025	0.0025	0.0014	0.0019
Beans (g/person/day)	2.9	4.27	3.84	9.97	6.86	4.27	5.09	8.29	5.96	4.87	5.94
beans broad beans (ug/g)	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026
Daily intake of arsenic (ug/kg/day)	0.0058	0.0041	0.0018	0.0037	0.0025	0.0016	0.0023	0.0031	0.0022	0.0018	0.0022
Peas (g/person/day)	4.87	6.09	9.13	9.92	10.73	9.09	6.29	9.17	7.52	10.42	8.46
peas (ug/g)	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036
Daily intake of arsenic (ug/kg/day)	0.013	0.008	0.006	0.005	0.006	0.005	0.004	0.005	0.004	0.005	0.004
Cherries (g/person/day)	1.01	1.15	1.1	1.82	1.54	1.88	0.62	1.71	0.93	2.46	1.33
pin cherry fruit (ug/g)	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
Daily intake of arsenic (ug/kg/day)	0.0070	0.0038	0.0017	0.0023	0.0020	0.0024	0.0010	0.0022	0.0012	0.0032	0.0017
blueberries (g/person/day)	0.74	1	2.45	1.22	1.39	3.67	0.64	1.94	1.29	3.35	1.49
saskatoon berries (ug/g)	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44
Daily intake of arsenic (ug/kg/day)	0.0250	0.0163	0.0189	0.0077	0.0087	0.0231	0.0049	0.0122	0.0081	0.0211	0.0094
strawberries (g/person/day)	3.35	7.56	6.51	6.26	6.23	11.19	4.34	2.94	8.54	14.48	6.34
rhubarb stalks (ug/g)	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Daily intake of arsenic (ug/kg/day)	0.0129	0.0140	0.0057	0.0045	0.0045	0.0080	0.0038	0.0021	0.0061	0.0103	0.0045
Total Estimated Daily intake of arsenic per age group (ug/kg/day)	0.508	0.389	0.272	0.277	0.237	0.265	0.205	0.195	0.205	0.219	0.197

Table 10-15. Total estimated daily intake of arsenic per age group (ug/kg/day) based on the mean concentration of arsenic in the generic garden vegetables. Individual daily intakes were calculated by multiplying (a) ingestion rate of produce by (b) the concentration of arsenic in the produce (if less than detection limit, 1/2 of the detection limit was used) and dividing it by (c) the weight for each age and sex category.

	Child M/F		Male				Female				M/F
Age (years)	a1 –4	a5-11	a12-19	20-39	40-64	65+	a12-19	20-39	40-64	65+	all ages
Weight (kg) (c)	13	27	57	70	70	70	57	70	70	70	70
carrots (g/person/day)	8.49	10.34	10.9	13.44	16.23	15.29	11.25	14.8	12.42	13.13	12.44
carrots (ug/g)	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045
Daily intake of arsenic (ug/kg/day)	0.029	0.017	0.009	0.009	0.010	0.010	0.009	0.010	0.008	0.008	0.008
potatoes, raw (g/person/day) (a)	0.28	0	0	0.12	0	0	0	0.05	0.05	0	0.05
white and red potatoes (ug/g) (b)	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031
Daily intake of arsenic (ug/kg/day)	0.0007	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
potatoes, cooked (g/person/day)	47.48	77.66	125.92	126.42	98.29	96.05	77.76	66	55.59	63.45	82.84
white and red potatoes (ug/g)	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031
Daily intake of arsenic (ug/kg/day)	0.11	0.09	0.07	0.06	0.04	0.04	0.04	0.03	0.02	0.03	0.04
rutabagas or turnip (g/person/day)	2.59	3.51	4.28	5.36	6.35	10.97	2.37	2.75	5.08	5.3	4.36
radish (ug/g)	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17
Daily intake of arsenic (ug/kg/day)	0.034	0.022	0.013	0.013	0.015	0.027	0.007	0.007	0.012	0.013	0.011
Onions (g/person/day)	0.98	2.45	2.03	5.58	6.17	5.98	4	6.35	6.31	6.37	4.53
onion (peeled) (ug/g)	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029
Daily intake of arsenic (ug/kg/day)	0.0022	0.0026	0.0010	0.0023	0.0026	0.0025	0.0020	0.0026	0.0026	0.0026	0.0019
beets, raw (g/person/day)	0.48	1.26	0.67	2.59	2.51	2.48	1.3	0.71	1.28	1.75	1.44
beets (ug/g)	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081
Daily intake of arsenic (ug/kg/day)	0.00300	0.00380	0.00096	0.00301	0.00292	0.00288	0.00185	0.00082	0.00149	0.00203	0.00167
Lettuce (g/person/day)	2.64	4.49	7.5	15.77	10.71	9.47	8.87	13.26	14.96	10.39	9.86
Romaine and leaf lettuce (ug/g)	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
Daily intake of arsenic (ug/kg/day)	0.027	0.022	0.017	0.030	0.020	0.018	0.021	0.025	0.028	0.020	0.019
celery (g/person/day)	1.61	2.43	2.9	5.79	7.29	9.06	3.96	5.65	11.2	11.41	5.65
celery (ug/g)	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Daily intake of arsenic (ug/kg/day)	0.0062	0.0045	0.0025	0.0041	0.0052	0.0065	0.0035	0.0040	0.0080	0.0082	0.0040
Celery (g/person/day)	1.61	2.43	2.9	5.79	7.29	9.06	3.96	5.65	11.2	11.41	5.65
swiss chard (ug/g)	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075
Daily intake of arsenic (ug/kg/day)	0.0093	0.0068	0.0038	0.0062	0.0078	0.0097	0.0052	0.0061	0.0120	0.0122	0.0061
Cabbage (g/person/day)	3.01	5.05	5.1	7.61	10.79	14.98	7.25	9.26	9.2	11.18	7.7
white and red cabbage (ug/g)	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043
Daily intake of arsenic (ug/kg/day)	0.010	0.008	0.004	0.005	0.007	0.009	0.005	0.006	0.006	0.007	0.005
Broccoli (g/person/day)	0.38	1.34	0.225	6	1.71	1.83	0.16	1.18	2.17	0.29	1.74
Broccoli and kohlrabi (ug/g)	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027
Daily intake of arsenic (ug/kg/day)	0.0008	0.0013	0.0001	0.0023	0.0007	0.0007	0.0001	0.0005	0.0008	0.0001	0.0007
cucumbers (g/person/day)	3.09	8.27	12.22	19.88	8.41	8.31	10.39	11.64	12.2	6.72	10.7
zucchini (ug/g)	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
Daily intake of arsenic (ug/kg/day)	0.00059	0.00077	0.00054	0.00071	0.00030	0.00030	0.00046	0.00042	0.00044	0.00024	0.00038
tomatoes, raw (g/person/day)	3.56	7.47	11.14	25.65	15.54	13.91	11.17	19.26	19.83	10.56	14.41
tomatoes (ug/g)	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009
Daily intake of arsenic (ug/kg/day)	0.0025	0.0025	0.0018	0.0033	0.0020	0.0018	0.0018	0.0025	0.0025	0.0014	0.0019
Beans (g/person/day)	2.9	4.27	3.84	9.97	6.86	4.27	5.09	8.29	5.96	4.87	5.94
beans broad beans (ug/g)	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Daily intake of arsenic (ug/kg/day)	0.0045	0.0032	0.0013	0.0028	0.0020	0.0012	0.0018	0.0024	0.0017	0.0014	0.0017
Peas (g/person/day)	4.87	6.09	9.13	9.92	10.73	9.09	6.29	9.17	7.52	10.42	8.46
peas (ug/g)	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019
Daily intake of arsenic (ug/kg/day)	0.007	0.004	0.003	0.003	0.003	0.002	0.002	0.002	0.002	0.003	0.002
Cherries (g/person/day)	1.01	1.15	1.1	1.82	1.54	1.88	0.62	1.71	0.93	2.46	1.33
pin cherry fruit (ug/g)	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
Daily intake of arsenic (ug/kg/day)	0.0070	0.0038	0.0017	0.0023	0.0020	0.0024	0.0010	0.0022	0.0012	0.0032	0.0017
blueberries (g/person/day)	0.74	1	2.45	1.22	1.39	3.67	0.64	1.94	1.29	3.35	1.49
saskatoon berries (ug/g)	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Daily intake of arsenic (ug/kg/day)	0.0168	0.0109	0.0127	0.0051	0.0059	0.0155	0.0033	0.0082	0.0054	0.0141	0.0063
strawberries (g/person/day)	3.35	7.56	6.51	6.26	6.23	11.19	4.34	2.94	8.54	14.48	6.34
rhubarb stalks (ug/g)	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020
Daily intake of arsenic (ug/kg/day)	0.0051	0.0055	0.0022	0.0018	0.0017	0.0031	0.0015	0.0008	0.0024	0.0041	0.0018
Total Estimated Daily intake of arsenic per age group (ug/kg/day)	0.279	0.208	0.143	0.149	0.132	0.155	0.109	0.109	0.119	0.128	0.109

Table 10-16. Total estimated daily intake of arsenic per age group (ug/kg/day) based on the median concentration of arsenic in the generic garden vegetables. Individual daily intakes were calculated by multiplying (a) ingestion rate of produce by (b) the concentration of arsenic in the produce (if less than detection limit, 1/2 of the detection limit was used) and dividing it by (c) the weight for each age and sex category.

	Child M/F		Male				Female				M/F
Age (years)	a1 -4	a5-11	a12-19	20-39	40-64	65+	a12-19	20-39	40-64	65+	all ages
Weight (kg) (c)	13	27	57	70	70	70	57	70	70	70	70
carrots (g/person/day)	8.49	10.34	10.9	13.44	16.23	15.29	11.25	14.8	12.42	13.13	12.44
carrots (ug/g)	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044
Daily intake of arsenic (ug/kg/day)	0.028	0.017	0.008	0.008	0.010	0.010	0.009	0.009	0.008	0.008	0.008
potatoes, raw (g/person/day) (a)	0.28	0	0	0.12	0	0	0	0.05	0.05	0	0.05
white and red potatoes (ug/g) (b)	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023
Daily intake of arsenic (ug/kg/day)	0.0005	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
potatoes, cooked (g/person/day)	47.48	77.66	125.92	126.42	98.29	96.05	77.76	66	55.59	63.45	82.84
white and red potatoes (ug/g)	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023
Daily intake of arsenic (ug/kg/day)	0.08	0.07	0.05	0.04	0.03	0.03	0.03	0.02	0.02	0.02	0.03
rutabagas or turnip (g/person/day)	2.59	3.51	4.28	5.36	6.35	10.97	2.37	2.75	5.08	5.3	4.36
radish (ug/g)	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17
Daily intake of arsenic (ug/kg/day)	0.034	0.022	0.013	0.013	0.015	0.027	0.007	0.007	0.012	0.013	0.011
Onions (g/person/day)	0.98	2.45	2.03	5.58	6.17	5.98	4	6.35	6.31	6.37	4.53
onion (peeled) (ug/g)	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029
Daily intake of arsenic (ug/kg/day)	0.0022	0.0026	0.0010	0.0023	0.0026	0.0025	0.0020	0.0026	0.0026	0.0026	0.0019
beets, raw (g/person/day)	0.48	1.26	0.67	2.59	2.51	2.48	1.3	0.71	1.28	1.75	1.44
beets (ug/g)	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034
Daily intake of arsenic (ug/kg/day)	0.00126	0.00159	0.00040	0.00126	0.00122	0.00120	0.00078	0.00034	0.00062	0.00085	0.00070
Lettuce (g/person/day)	2.64	4.49	7.5	15.77	10.71	9.47	8.87	13.26	14.96	10 39	9.86
Romaine and leaf lettuce (ug/g)	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
Daily intake of arsenic (ug/kg/day)	0.024	0.020	0.016	0.027	0.018	0.016	0.019	0.023	0.026	0.018	0.017
celery (g/person/day)	1.61	2.43	2.9	5.79	7.29	9.06	3.96	5.65	11.2	11.41	5.65
celery (ug/g)	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Daily intake of arsenic (ug/kg/day)	0.0062	0.0045	0.0025	0.0041	0.0052	0.0065	0.0035	0.0040	0.0080	0.0082	0.0040
Celery (g/person/day)	1.61	2.43	2.9	5.79	7.29	9.06	3.96	5.65	11.2	11.41	5.65
swiss chard (ug/g)	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075
Daily intake of arsenic (ug/kg/day)	0.0093	0.0068	0.0038	0.0062	0.0078	0.0097	0.0052	0.0061	0.0120	0.0122	0.0061
Cabbage (g/person/day)	3.01	5.05	5.1	7.61	10.79	14.98	7.25	9.26	9.2	11.18	7.7
white and red cabbage (ug/g)	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033
Daily intake of arsenic (ug/kg/day)	0.008	0.006	0.003	0.004	0.005	0.007	0.004	0.004	0.004	0.005	0.004
Broccoli (g/person/day)	0.38	1.34	0.225	6	1.71	1.83	0.16	1.18	2.17	0.29	1.74
Broccoli and kohlrabi (ug/g)	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027
Daily intake of arsenic (ug/kg/day)	0.0008	0.0013	0.0001	0.0023	0.0007	0.0007	0.0001	0.0005	0.0008	0.0001	0.0007
cucumbers (g/person/day)	3.09	8.27	12.22	19.88	8.41	8.31	10.39	11.64	12.2	6.72	10.7
zucchini (ug/g)	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
Daily intake of arsenic (ug/kg/day)	0.00059	0.00077	0.00054	0.00071	0.00030	0.00030	0.00046	0.00042	0.00044	0.00024	0.00038
tomatoes, raw (g/person/day)	3.56	7.47	11.14	25.65	15.54	13.91	11.17	19.26	19 83	10.56	14.41
tomatoes (ug/g)	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009
Daily intake of arsenic (ug/kg/day)	0.0025	0.0025	0.0018	0.0033	0.0020	0.0018	0.0018	0.0025	0.0025	0.0014	0.0019
Beans (g/person/day)	2.9	4.27	3.84	9.97	6.86	4 27	5.09	8.29	5.96	4.87	5.94
beans broad beans (ug/g)	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018
Daily intake of arsenic (ug/kg/day)	0.0040	0.0028	0.0012	0.0026	0.0018	0.0011	0.0016	0.0021	0.0015	0.0013	0.0015
Peas (g/person/day)	4.87	6.09	9.13	9.92	10.73	9 09	6.29	9.17	7.52	10.42	8.46
peas (ug/g)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Daily intake of arsenic (ug/kg/day)	0.004	0.002	0.002	0.001	0.002	0.001	0.001	0.001	0.001	0.001	0.001
Cherries (g/person/day)	1.01	1.15	1.1	1.82	1.54	1.88	0.62	1.71	0.93	2.46	1.33
pin cherry fruit (ug/g)	0.09	0.09	0 09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
Daily intake of arsenic (ug/kg/day)	0 0070	0.0038	0.0017	0.0023	0.0020	0.0024	0.0010	0.0022	0.0012	0.0032	0.0017
blueberries (g/person/day)	0.74	1	2.45	1.22	1.39	1.67	0.64	1.94	1.29	3.35	1.49
saskatoon berries (ug/g)	0.30	0.30	0 30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Daily intake of arsenic (ug/kg/day)	0 0168	0.0109	0 0127	0 0051	0 0059	0 0155	0.0033	0 0082	0.0054	0 0141	0.0063
strawberries (g/person/day)	3 35	7.56	6.51	6.26	6.23	11 19	4.34	2.94	8.54	14 48	6.34
rhubarb stalks (ug/g)	0 014	0 014	0 014	0 014	0 014	0 014	0.014	0 014	0.014	0.014	0.014
Daily intake of arsenic (ug/kg/day)	0 0036	0 0039	0 0016	0 0013	0 0012	0 0022	0 0011	0 0006	0.0017	0 0029	0.0013
Total Estimated Daily intake of arsenic per age group (ug/kg/day)	0.237	0.175	0.120	0.127	0.113	0.136	0.092	0.095	0.106	0.113	0.094

Table 10-17. Calculation fo the daily intake of arsenic for the generic garden if the consumption rate is based solely on the Canadian daily average consumption rate of vegetables. The calculation was made by multiplying (a) the average consumption rate of vegetables by (b) the average concentration of arsenic found in the produce and dividing it by (c) the weight for the individual age and sex catagories.

		Child M/F		Male				Female				M/F
	Age (years)	a1 -4	a5-11	a12-19	20-39	40-64	65+	a12-19	20-39	40-64	65+	all ages
	Weight (kg) (c)	13	27	57	70	70	70	57	70	70	70	70
	Canadian Daily Average Consumption Vegetable (g/person/day) (a)	125	198	250	250	250	250	250	250	250	250	250
Yellowknife Minimums	Average concentration of arsenic in produce (ug/g) (b)	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040
	Daily intake of arsenic (ug/kg/day)	0.38	0.29	0.17	0.14	0.14	0.14	0.17	0.14	0.14	0.14	0.14
Yellowknife Maximums	Average concentration of arsenic in produce (ug/g)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Daily intake of arsenic (ug/kg/day)	0.96	0.73	0.44	0.36	0.36	0.36	0.44	0.36	0.36	0.36	0.36
Yellowknife Mean	Average concentration of arsenic in produce (ug/g)	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065
	Daily intake of arsenic (ug/kg/day)	0.63	0.48	0.29	0.23	0.23	0.23	0.29	0.23	0.23	0.23	0.23
Yellowknife Median	Average concentration of arsenic in produce (ug/g)	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059
	Daily intake of arsenic (ug/kg/day)	0.57	0.43	0.26	0.21	0.21	0.21	0.26	0.21	0.21	0.21	0.21

11 Appendix C: Quality Assurance/Quality Control

11.1 Garden Soils

11.1.1 Detection Limit for Arsenic by Neutron Activation Analysis (NAA)

The detection limit was provided by the service laboratory, the Analytical Services Group (ASG) at the Royal Military College, carrying out the soil analyses by NAA.

Table 10. Limit of Detection for arsenic in soils.

Limit of Detection (LOD)	Dry Weight Concentration (ppm)
[As]	0.05

11.1.2 Accuracy for Arsenic by NAA

Accuracy of the NAA analysis was monitored by ASG using two standard reference materials from China, GSS5, a soil, and GSR6, a rock material. These standards (one of each) were analyzed concurrently with the sample batch throughout the analytical program. Good agreement with the certified value for arsenic was obtained; therefore the analysis is estimated to be accurate.

Table 11. Standard reference material results.

GSS5	[As] ppm	GSR6	[As] ppm
Control	5.3	Control	4.8
Control Target	4.4	Control Target	4.7
% Difference	20	% Difference	2.1

11.1.3 Precision/Reproducibility

Precision was monitored by ESG using field duplicate samples; these were homogenized in the field and submitted blind as separate samples to ASG for analysis. When the duplicates were included in a composite sample the reproducibility could not be monitored in this way. However, half the amount of the normal composite amount was included for each duplicate (see Table 1). Exceptional agreement was found for the field duplicate (1.9% relative standard deviation), although a greater spread was seen in a garden where samples were taken from different locations in the garden (17-44 ppm).

Precision was monitored throughout the NAA analysis by conducting duplicate analyses. The % relative standard deviation (%RSD) for laboratory duplicates was very good at 5-6%, indicated good reproducibility.

Table 12. Field duplicate results for soils.

Sample Number	[As] ppm
29129	22
29130	22.6

Average	22.3
Stdev	0.42
%RSD	1.9

Table 13. Garden replicate results for soils.

Sample Number	[As] ppm
29128	16.9
29129/30	22.3
29131	43.9
Average	33.1
Stdev	15
%RSD	46

Table 14. Laboratory duplicate results for soils

Sample Number	[As] ppm
29232	23.4
29232, Dup	25.4
Average	24.4
Stdev	1.4
%RSD	5.7
29131	42.2
29131, Dup	45.6
Average	43.9
Stdev	2.4
%RSD	5.5

11.1.4 Blanks

A blank consisting of Ottawa sand was subjected to the grinding and analysis process and contained 1.1 ppm arsenic. This is a negligible amount; however, a qualifier was provided with the analysis indicating that the decay time of 164 hours may have been too long and that the sample should be reanalyzed.

Table 15. Results for Ottawa Sand grinding blank.

Sample Number	[As] ppm dry weight
29229	1.1

11.2 Vegetables and Plants

11.2.1 Detection Limit

The detection limit was determined by the replicate digestion and analysis (8x) of Pine Needles NIST1575 Standard Reference Material. This sample was appropriate as it provided a low level of the analyte of interest, arsenic. The standard deviation (σ) was determined from the 8 analyses of NIST 1575, and this was used in the following equation (recommended by CAEAL) to give a limit of detection of 0.11 ppm As dry weight.

Degrees of freedom = n-1 = (8-1) = 7
t = one sided student's t at 95% confidence for 7 degrees of freedom = 1.9
LOD = 2 x t x σ = 3.8 x σ

Limit of Detection (LOD)	Dry weight Concentration (ppm)
[As]	0.11

11.2.2 Accuracy

Accuracy was monitored by using two standard reference materials, Bush Branches and Leaves, GBW07603, and Pine Needles, NIST 1575. Acceptability was based on lab standard concentrations determined by the digestion and analysis of 8 replicate samples of each SRM. An analysis is defined to be in control if it is within 2σ of the laboratory determined mean. If it is between 2 and 3σ, it is in the warning range, and if it is outside of 3σ, it is out of control.

All standard reference materials analyzed with the samples were found to be in control. Some replicates for NIST 1575 were found to be in the warning range (but not out of control). Since NIST 1575 is so close to the limit of detection this is not a surprising result.

The lab standard concentrations are within the error of the certified value for GBW07603, but only 76% of the certified value for NIST 1575. Therefore the digestion method used completely solubilizes the arsenic present in GBW07603, and incompletely solubilizes it in NIST 1575. Overall, the analysis is estimated to be accurate.

Table 16. Bush Branches and Leaves, GBW07603

Sample	[As] ppm dry weight	Acceptable low [As] Ppm dry weight	Acceptable high [As] ppm dry weight
Certified value	1.25	1.15	1.35
Lab control value	1.16	0.96	1.36

Lab warning value	1.16	0.87	1.45
GBW07603 replicate 1	1.17	In control	
GBW07603 replicate 2	1.09	In control	
GBW07603 replicate 3	1.29	In control	

Table 17. Pine Needles, NIST 1575

Sample	[As] ppm dry weight	Acceptable low [As] ppm dry weight	Acceptable high [As] ppm dry weight
Certified value	0.210	0.170	0.250
Lab control value	0.162	0.102	0.222
Lab warning value	0.162	0.072	0.252
NIST 1575 replicate 1	0.151	11.2.2.1.1 In control	
NIST 1575 replicate 2	0.175	In control	
NIST 1575 replicate 3	0.212	In control	
NIST 1575 replicate 4	0.243	Warning but ok	
NIST 1575 replicate 5	0.227	Warning but ok	
NIST 1575 Replicate 6	0.225	Warning but ok	

11.2.3 Precision/Reproducibility

Precision was monitored throughout the digestion and analysis processes by conducting replicate analyses; in most cases samples were analyzed in duplicate. In some cases, two batches contained the same samples and thus a few samples were analyzed in triplicate.

The % relative standard deviation (%RSD) was calculated for the values that were above the limit of detection. From these numbers, the %RSD ranged from 2% to 49%, with a mean %RSD for all replicates of 19%. This mean %RSD is under the maximum allowable limit for analytical precision (20%), indicating that the analysis was conducted with good precision. For samples containing arsenic levels greater than approximately 0.5 ppm, the %RSD ranged from 2%-22%, indicating that lower precision (i.e., higher %RSD) is exhibited only at lower arsenic concentrations.

Table 18. Summary of Precision/Reproducibility

Average %RSD	Range	
	Low %RSD	High %RSD
19	2	49

Table 19. Digestion Duplicates. Nd = not determined.

Sample ID	[As] ppm dry weight
29001.3S	0.338
29001.3S-dup	0.290
Average	0.314
Stdev	0.034
%RSD	11
29001.7B	<0.11
29001.7B-dup	0.337
Average	Nd
Stdev	Nd
%RSD	Nd
29001.7S	0.972
29001.7S	0.791
Average	0.882
Stdev	0.127
%RSD	14
29001.10F	0.163
29001.10F-dup	0.330
Average	0.247
Stdev	0.118
%RSD	48
29001.11	0.725
29001.11-dup	0.746
Average	0.736
Stdev	0.015
%RSD	2.0
29108.1R	0.493
29108.1R-dup	0.551
Average	0.522
Stdev	0.041
%RSD	7.8

29114.3	<0.11
29114.3-dup	0.127
Average	Nd
Stdev	Nd
%RSD	Nd
29117.1	0.309
29117.1-dup	0.149
Average	0.229
Stdev	0.113
%RSD	49
29123.1	1.595
29123.1-dup	1.948
Average	1.772
Stdev	0.249
%RSD	14
29127.2	<0.11
29127.2-dup	<0.11
Average	<0.11
Stdev	Nd
%RSD	Nd
29128.1R	1.185
29128.1R-dup	0.864
Average	1.024
Stdev	0.227
%RSD	22
29128.7	0.215
29128.7-dup	0.179
Average	0.197
Stdev	0.026
%RSD	13
29128.10	0.249
29128.10-dup	0.195
Average	0.222
Stdev	0.038
%RSD	17
29137.1	2.706

29137.1-dup	2.203
Average	2.455
Stdev	0.355
%RSD	14
29144.1	0.589
29144.1-dup	0.512
Average	0.551
Stdev	0.055
%RSD	10

Table 20. Digestion Triplicates. Nd = not determined.

Sample ID	[As] ppm dry weight
29117.5	<0.11
29117.5	<0.11
29117.5	<0.11
Average	<0.11
Stdev	Nd
%RSD	Nd
29128.8R	0.294
29128.8R	0.278
29128.8R	0.247
Average	0.273
Stdev	0.024
%RSD	8.7
29133.3	0.589
29133.3	0.536
29133.3	0.967
Average	0.697
Stdev	0.235
%RSD	34

11.2.4 Blanks

All blanks were found to contain arsenic levels that were below the limit of detection. Therefore no contamination was introduced during the digestion and analysis of the samples.

Table 21. Arsenic in Blanks

Blank #	[As] ppm dry weight
BL1	<0.11
BL2	<0.11
BL3	<0.11
BL4	<0.11
BL5	<0.11