ÉTUDE SUR LA SANTÉ DANS LA RÉGION DE

Belledune

AREA HEALTH STUDY

Belledune • Petit-Rocher • Pointe-Verte

Summary Report

Prepared for: Department of Health and Wellness, Government of New Brunswick

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Environmental & Occupational Health+Plus

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Summary

Purpose of report

The purpose of this report is to present and provide interpretations for the findings obtained from the Belledune Area Health Study. This document is the final report for the study and is accompanied by three detailed technical appendices. This report is general to the extent that it provides an overview of the findings, conclusions and recommendations rather than reporting the detailed methodology and findings which are contained in the significantly longer technical appendices.

Background

The area included in the study has been home and/or neighbor to various industrial activities over the past four decades. The lead smelter, initially owned by Brunswick Mining and Smelting and now owned by Noranda Ltd., began operations in the mid-1960s. In addition to the lead smelter, there have been other industrial activities including a fertilizer plant, a battery recycling plant, a coal-fired electricity generating facility, a gypsum plant, and a sawmill. These industries have had various types and quantities of emissions over the past four decades.

In the fall of 2003, the Minister of Health and Wellness (DHW) announced a health study for the residents of the Greater Belledune Area. Concerns had been raised with respect to the current health status of residents and the potential health impacts of local industry in general on the residents of the area. In early 2004, the Minister formed a Steering Committee for the study. This included the six mayors from the local areas (Belledune, Pointe-Verte, Petit-Rocher, Nigadoo, Beresford and Bathurst), a representative from Department of Environment and Local Government (DELG), the local Medical Officer of Health, and three representatives from the DHW. The study team and the review team were chosen via open competitions for which firms were invited to submit their qualifications to conduct or review the study.

Study objectives and research questions

The study objectives are necessarily broad in nature, and are further refined by developing explicit research questions and hypotheses, clarifying study scope, and defining specific terms. With this context in mind, the study objectives are:

- To ensure that residents' identified concerns are, where possible, addressed in this study and/or in the recommendations for future research.
- To describe and quantify the historical and current human health risks associated with past and current industrial activities in the Belledune Area.
- To describe the current health status of residents in the Belledune Area and any potential relation to environmental exposures.
- To produce recommendations for future studies and research based on the results of this study.

Based on the study objectives, the study team consulted with various stakeholder groups including community residents to determine what would be appropriate research questions for the study. This process resulted in four main research questions that built upon the study objectives:

1. *What are the potential types and sources of environmental contamination?*
2. *How are residents exposed to the environmental contamination?*
3. *What are the potential health risks for residents as a result of the exposure to the environmental contamination?*
4. *How does the health status of residents compare with other regions? New Brunswick?*

Study scope

There are two main components to the current study:

- *Human Health Risk Assessment (HHRA)* - The purpose of the HHRA is to provide estimates of the potential for risks of adverse health effect in Belledune Area residents that may result from exposure to the chemicals released from industrial activities in the area. It was designed to answer the first three research questions.

- *Community Health Status Assessment (CHSA)* - The purpose of the CHSA is to provide an assessment of the current health status of the residents of the Greater Belledune Area (GBA) compared to other people in New Brunswick. It was designed to answer the fourth research question.

Within and across these two components there were various scoping issues in defining the methodology for the study. The main issues included:

- *Periods covered in the study* - To a large extent, the historical periods considered relevant for the study components were determined by the quality and quantity of data available for each period as well as community concern with historical exposures. For the HHRA there were three historical periods analysed ranging from 1967 to 1999, as well as the current period (2000-2004). For the CHSA component, the time period chosen was 1989-2001.

- *Data sources* - The Terms of Reference (TORs) for the study indicated that the study team was to use pre-existing data to address the questions posed. The study team gathered existing data from a number of sources including the Noranda Enivronmental Monitoring Program (EMP), NB Government Departments, municipal governments, Conservation Council of New Brunswick, Department of Fisheries and Oceans, Environment Canada, Canadian Institute of Health Information, and from various published reports.

- *Populations and geographic areas* - The choice of populations and geographic areas for the study was based on consideration of the lead smelter and electricity generation facility in Belledune as a central point of important environmental emissions, and then encompassing a sufficiently wide area from this central point to capture potential health risks or differences in health status. The largest area considered in the study was that which encompasses the villages of Belledune, Pointe-Verte and Petit-Rocher. This was given the term the Greater Belledune Area (GBA) and was used for the CHSA and one level of analysis for the HHRA. Given the nature of the analysis and availability of data, the HHRA was also able to characterize human health risk on five other more detailed levels.

- *Chemicals and emissions* - The selection of chemicals of potential concern (COPC) is one of the important initial steps in the HHRA process. Various considerations include community concerns, toxicity of chemicals, levels measured and availability of data. The selection of COPC is carried out through a pre-determined step-wise process that ensures that those selected are relevant for the site or area and pose potential risk to human health. The COPC that were selected using this process were arsenic, cadmium, chromium, lead, mercury, thallium, zinc, and dioxins and furans.

Study findings

The study findings were summarized according to the four original research questions.

What are the potential types and sources of contamination?

While the study considered eight different COPC as well as combustion products (sulphur dioxide and nitrogen oxide), the findings indicated that the key potential issues in the community were related to concentrations of *lead, cadmium* and *arsenic* in the environment. The assessment determined that lead and cadmium exposures were as a result of the industrial activity in the area. The industrial activities contributed only a small portion to arsenic exposures, with the majority of the exposure due to baseline concentrations.

How are residents exposed to the contamination?

Historical exposures

The assessment considered both historical and current exposures to arsenic, cadmium and lead. In terms of historical exposure, lead exposure via the inhalation pathway (breathing) was significant in the 1967 to 1974 time period and has reduced significantly since that time. Another important pathway during that time period was the consumption of local seafood. It must be pointed out that the assessment considered that residents in the GBA obtained all the seafood that they consumed from local sources. These included the wild mussels along the shoreline, local lobster along the shoreline and fish in the local area in the Baie des Chaleurs. Wild mussels were used as a surrogate for other local shellfish. It is unlikely that the entire seafood diet of residents would be from the local area but this was done to ensure that exposures in the community were not underestimated.

Current exposures

Current exposures are also mainly associated with the consumption of local seafood. The main exposure pathways for cadmium and lead are associated with the consumption of wild mussels along the shoreline. Another important pathway is the consumption of local fish caught in the Baie des Chaleurs in close proximity to the GBA. The exposures due to the consumption of local fish should be viewed with caution, as the fish concentrations used in the assessment were twenty-five years old. Sampling of fish in the Baie des Chaleurs is necessary in order to reduce the uncertainty associated with exposures via consuming local fish.

Another potentially important pathway of exposure for cadmium in Townsite #2 was consuming root vegetables from backyard gardens. The data available for backyard vegetables in Townsite #2 and other areas of the GBA are sparse and efforts need to be made to collect more data to reduce the uncertainty in this pathway of exposure.

One interesting finding from this study was that soil was not a major pathway of exposure at the best estimate (average) concentration for most groups of residents. However, at the upper bound estimate (rather than the average), infants and toddlers exposed to lead in Townsite #2 had exposures that were above the chosen "toxicity reference value" (a level which corresponds to a blood lead level of medical concern for children). For the Townsite #2 toddlers and infants, consuming backyard vegetables was the major pathway of exposure followed by the ingestion of soil. In Lower Belledune, the soil was the dominant pathway for lead exposure for toddlers if upper bound estimates were used.

Environmental concentrations in Lower Belledune are higher than other areas in the GBA. Therefore, residents in Lower Belledune are the highest exposed individuals followed by Townsite #2. Children and toddlers are at potentially higher risks. Residents who consume local mussels from along the shoreline also experience higher risks and it may be prudent to reduce consumption of local mussels to reduce exposures.

Maximum local seafood eaters, such as maximum wild mussel eaters (approximately five ½-pound meals per week all year); maximum local lobster eaters who consume approximately two to three ½-pound meals per week all year, and maximum local fish eaters who consume approximately six to seven ½-pound meals per week all year of local fish from the local shoreline and area are at the highest risk. These individuals would most likely be a small proportion of the population. It is likely that exposures have been overestimated due to the assumptions in the analyses.

What are the potential health risks for residents as a result of the exposure to the contamination?

The potential health risks associated with exposure to lead, cadmium and the other COPC are outlined below. Both lead and cadmium are considered to be non-cancer causing chemicals via the oral (mouth) route of exposure. The health effects associated with lead exposure are most severe in children and involve neurocognitive and behavioural developmental effects with exposure *in utero* (in mother's womb) and in early childhood. The health effect associated with oral ingestion of cadmium is significant proteinurea, a reflection of abnormal kidney function.

Lower Belledune and Townsite #2

For the population in the highest exposed area, *Lower Belledune and Townsite #2*, the assessment showed that, based on the *best estimate* (average), the intakes are below toxicity reference values with the exception of *cadmium* and *lead* exposure for a *child in Lower Belledune*. The intake for these groups is influenced by the assumed consumption of local wild mussels and fish. Thallium and zinc exposures for infants, toddlers and children are predicted to be above the toxicity reference values; however, supermarket food is the dominant pathway. Local exposures to zinc and thallium are well below the toxicity reference value. It should be noted that the supermarket food intakes are obtained for the Canadian population and may not be appropriate for Northern New Brunswick.

At the *upper bound estimate* for this population, *Lower Belledune and Townsite #2,* exposures to *cadmium, lead* and *mercury* for *infants, toddlers and children* may exceed the toxicity reference value. These exposures are mainly due to the consumption of local mussels, fish and backyard vegetables. In Lower Belledune, the toddler exposure is due to soil ingestion. Again, thallium and zinc exposure are above the toxicity reference value due to supermarket food consumption.

Belledune, Pointe-Verte and Petit-Rocher

The *best estimate calculations* for residents in the core communities of *Belledune, Pointe-Verte and Petit-Rocher* show that exposures to cadmium, lead and mercury are predicted to be *below* toxicity reference values.

At the *upper bound estimate calculations*, *children* exposed to *cadmium, lead* and *mercury* in *Pointe-Verte* are predicted to be above the toxicity reference value. In *Petit-Rocher*, *child* exposures to *mercury* are above the toxicity reference value. In *Belledune, child* exposures to *cadmium* and *mercury* are above the toxicity reference value. This is primarily due to the consumption of local wild mussels and fish. Thallium and zinc exposures are also predicted to be above the toxicity reference values due to the dominance of the supermarket food pathway.

A sensitivity analysis was conducted for individuals who may consume a significant quantity of seafood (fish, wild mussels or lobster) from the local area on a continuous basis. The results show that the intakes for these individuals may be above toxicity reference values for cadmium, lead, mercury and thallium. It should be emphasized that this is an extreme estimate and would apply to only a very small portion of the population.

In summary, the HHRA described above is only a tool for determining the *risk of health effects*, it is important to note that it does not provide an absolute statement on the *experienced health effects* measurable in a population. Therefore, the findings from this HHRA need to be considered with the results of the CHSA to determine, where possible, whether adverse health impacts are actually occurring in the community.

How does the health status of residents compare with other regions?

Cancer and mortality

The ***health status pattern*** for the study area is ***different*** from that found in the surrounding health regions (HR 5&6 – North Central and North Eastern), and for NB overall for the time period of 1989-2001. There is a ***statistically significantly elevated*** incidence of ***oral***, ***respiratory*** and ***prostate cancer*** (stomach cancer was found to be statistically significantly elevated in both study area and HR 5&6); and ***elevated*** (albeit not statistically significant) incidence of ***kidney and colorectal cancer*** above expected. There is a ***higher mortality rate than expected***, and there are more deaths than expected due to ***circulatory disease***, ***cancer*** and to "***other causes***" such as accidents and suicide. Hospital separations were higher than expected for all disease groups; however, this was found to be the case for the HR 5&6 as well, so is not unique to the GBA.

As discussed in the full report, ecologic studies may be used to generate hypotheses of an association between exposure and disease, but these studies cannot by themselves establish causation. Further investigation will be required to assist in explaining what factors or characteristics of the residents of study area are related to their current pattern of health status.

Pilot blood-lead survey for children in Townsite #2 and Lower Belledune

From the DHW pilot survey, ***children's average blood lead levels*** in the potentially most impacted communities indicate that, even though they are ***well below the the community or individual intervention level*** of 0.48 µmol/L (geometric mean was 0.14 µmol/L), they are ***higher than what have been recently measured in other communities***. In addition, there were two children (or 9% of participants) above the intervention level in this small community. This indicates that there is likely exposure occurring at such a level that it ***warrants additional investigation*** on a community level given the concerns expressed by the community and the pervasive toxicity of lead to young children.

These results in light of the findings from the HHRA component are discussed in depth in both this report and the various associated appendices.

Recommendations

The study team has a number of recommendations emerging from the results of this study. As requested in the TORs for the study, these focus on directions for future research. To assist stakeholders in decision-making, the study team indicates from their perspective whether the specific recommendation is of higher or lower priority.

Biological monitoring recommendations

Of high priority would be to conduct an expanded survey of blood lead among child residents and pregnant women for the GBA. Given the results from the pilot survey combined with the HHRA findings and concerns of the community, an expanded blood lead survey of a representative sample from the other communities within the GBA is warranted. *(Higher Priority)*

Environmental monitoring recommendations

Based on the above discussion, uncertainties surrounding the concentrations of COPC in fish from the Baie des Chaleurs and in backyard garden vegetables are large enough to influence the outcome of this assessment. Therefore, it is recommended that:

- programs be implemented in the GBA to collect data (metal concentrations) on fish from the Baie des Chaleurs (*Higher priority*); and,
- to obtain additional data (metal concentrations) on garden vegetable produce across the GBA (*Higher priority*).

Local wild mussel consumption was a significant pathway of exposure for a number of the COPC and there are enough data collected on local mussels to be confident in the results of this analysis. Local wild mussels were used as a surrogate for other local shellfish in the study area. Limited data are available on clams and the concentrations of COPC were lower in clams than in the wild mussels. There were no data available on oysters. It is recommended to collect data on other shellfish such as clams and oysters to confirm that the local wild mussels contained the highest concentrations of COPC. It may also be prudent for individuals who consume local wild mussels to limit their intakes.

The side bar analysis on specific sites in the GBA, for example, the Soil 9 location from the Noranda EMP and the school indicate that further studies should be conducted on both of these sites. It is understood that the DELG is currently investigating the property identified with Soil 9 location, and remedial action for soil has occurred at the school site.

Research on health determinants

In order to further understand the findings from the CHSA, it will be necessary to conduct research on some of the factors associated with the disease patterns characteristic of the GBA. This is of *higher priority* because it will help to better explain the findings for a community with elevated disease patterns. This research should focus on:

a. What are the current (and if possible) past smoking rates?
b. What is the prevalence of diabetes? Hypertension? Obesity?
c. What is the family history of cases of cancer?
d. What foodstuffs are/were eaten regularly such as pickled meats, fish and vegetables?
e. What are/were the rates of fresh vegetable consumption?

Of *lower priority* would be a study addressing *H. pylori* infection in stomach cancer cases and in the population in the larger region (HR 5&6).

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Acronyms

BAHS – Belledune Area Health Study

CCME – Canadian Council of Ministers of the Environment

CCNB – Conservation Council of New Brunswick

CHSA – Community Health Status Assessment

CIHI – Canadian Institute for Health Information

CNSC – Canadian Nuclear Safety Commission

COPC – Chemical of Potential Concern

DELG – New Brunswick Department of Environment and Local Government

DHW – New Brunswick Department of Health and Wellness

GBA – Greater Belledune Area

HC – Health Canada

HHRA – Human Health Risk Assessment

HR 5&6 – Health Regions 5 and 6

ICD – International Classification of Diseases

LOAEL – Lowest Observed Adverse Effects Level

NB – New Brunswick

RFQ – Request for Qualifications

SIR – Standardized Incidence Ratio

SMR – Standardized Mortality Ratio

TORs – Terms of Reference

TRV – Toxicity Reference Value

US EPA – United States Environmental Protection Agency

Acknowledgements

Many individuals and organizations contributed to the Belledune Area Health Study in various ways. The Steering Committee, chaired by Dr. Christofer Balram, Provincial Epidemiologist, provided guidance and support throughout the study process. Numerous community organizations, committees, businesses and groups provided input to the study design and assisted by providing the study team with data and information necessary for a quality study to be conducted. The Review Team (Dillon Consulting) provided advice and feedback on the proposed methods, findings and interpretations that have contributed to a solid study for the community.

Finally, we would like to express our gratitude to the many residents of the Greater Belledune Area who participated in the community consultation process either by dropping in to an open-house, completing a questionnaire, writing us e-mails, or phoning the study office. We appreciate the time and attention that you have given us as a study team. We hope that the findings from this study have answered some of the important questions that you have posed.

1.0 Introduction

The purpose of this report is to present and provide interpretations for the findings obtained from the Belledune Area Health Study. This document is the final report for the study and is accompanied by three detailed technical appendices. This report is general to the extent that it provides an overview of the findings, conclusions and recommendations rather than reporting the detailed methodology and findings which are contained in the significantly longer technical appendices. All main findings are contained in this report, however, readers with a background in science, risk assessment or health status measures may want also to consult the technical appendices. A glossary is provided at the end of this report to assist readers with definitions of specific terms.

This report is structured with seven main sections:

- Section 1.0 – This introductory section contains the study objectives, questions and scope, a brief description of the study background, an overview of the community consultations that took place in 2004, and an outline of data sources used for the study.

- Section 2.0 – The second section provides an overview of findings from the Human Health Risk Assessment (HHRA) component of the study.

- Section 3.0 – This section contains an overview of the findings from the Community Health Status Assessment (CHSA) component of the study.

- Section 4.0 – This section contains a description of the findings from a recent pilot survey of blood lead levels in children who live in closest proximity to the Belledune industrial settings.

- Section 5.0 – In this section, the challenges and limitations of the study findings are reviewed and discussed.

- Section 6.0 – The overall study conclusions according to research questions are presented in this section.

- Section 7.0 – The final section contains the recommendations arising out of the study findings.

1.1 Study objectives, questions and scope

Studies are conducted for various reasons including the desire to add to knowledge about a specific subject, replication of previous studies' findings, or need to gather information in a systematic manner to address specific issues or concerns. The primary reason for conducting the current study was to address issues and concerns with respect to community health and health risks, and, more specifically, with respect to their potential association with local industrial activity.

The Belledune region has been home to several industries for the past 40 years. These have contributed significant historical emissions and continue to emit a number of chemicals, though at lower levels than earlier. The Greater Belledune Area community has expressed concerns with respect to the burden of its exposure to these chemicals, both past and present.

Despite copious amounts and types of data collected over the three to four decades prior to the current study, these data had not been compiled or analysed in a manner that could address the community's issues and concerns about potential health risks associated with industrial activities. In order to inform future decision-making with respect to issues of potential remediation, human health, future industrial development or future research and monitoring, the current study focused on compiling and analyzing data made available by various governmental departments, community groups, and industry.

No single study can address all issues and concerns or answer all questions. The study team, under the guidance of the Steering Committee and the Review Team, conducted the current study with the understanding that it will provide a good foundation upon which more detailed questions can then be addressed in a systematic fashion at a later date, as required.

1.1.1 Study objectives

In developing the study objectives, the study team considered the primary issues and concerns raised by the various stakeholder groups within the context of the Terms of Reference (TORs) for the study. The study objectives are necessarily broad in nature, and are further refined by developing explicit research questions and hypotheses, clarifying study scope, and defining specific terms. With this context in mind, the study objectives were:

STUDY OBJECTIVES

1. To ensure that residents' identified concerns are, where possible, addressed in this study and/or in the recommendations for future research.
2. To describe and quantify the historical and current human health risks associated with past and current industrial activities in the Belledune Area.
3. To describe the current health status of residents in the Belledune Area and any potential relation to environmental exposures.
4. To produce recommendations for future studies and research based on the results of this study.

1.1.2 Study research questions

Based on the study objectives, the study team consulted with various stakeholder groups including community residents to determine what would be appropriate research questions for the study. This process resulted in four main research questions that built upon the study objectives:

STUDY RESEARCH QUESTIONS

1. What are the potential types and sources of environmental contamination?
2. How are residents exposed to the environmental contamination?
3. What are the potential health risks for residents as a result of the exposure to the environmental contamination?
4. How does the health status of residents compare with other regions? New Brunswick?

1.1.3 Study scope[1]

There are two main components to the current study: the HHRA and the CHSA. The purpose of the HHRA is to provide estimates of the potential for risks of adverse health effect in Belledune Area residents that may result from exposure to the chemicals released from industrial activities in the area. The purpose of the CHSA is to provide an assessment of the current health status of the residents of the Greater Belledune Area (GBA) compared to other people in New Brunswick. Within and across these two components there were various scoping issues in defining the methodology for the study. The main issues included:

- Periods covered in the study;
- Data sources;
- Populations and geographic areas included; and,
- Chemicals and emissions considered within the study areas and periods of study.

1.1.3.1 Time frames for study

To a large extent, the historical periods considered relevant for the study components were determined by the quality and quantity of data available for each period as well as community concern with historical exposures.

[1] Additional details on scoping issues are contained in Sections 2.0 and 3.0 and within the technical appendices.

HHRA Component
For the HHRA component, the time periods chosen were:

- Historical (three time periods)
  - Time period one: 1967-1974
  - Time period two: 1975-1984
  - Time period three: 1985-1999
- Current (2000-2004)

The rationale for choosing these time periods for the HHRA component was that the study team determined that there was an interest among residents to estimate past exposures as well as current exposures. The historical time period was divided into three periods according to when major changes to emissions and emission patterns occurred from Belledune industrial activities.

CHSA Component
For the CHSA component, the time period chosen was 1989-2001. The rationale for this time period was that it was the only period for which all data sources were able to provide accurate health status data for the geographic area in question. Because the latency (or delay) between when people are exposed to carcinogens and when they are actually diagnosed with cancer can be many years, the cancers identified during this recent period would be most reflective of historical exposures, when emissions were much higher.

1.1.3.2 Data sources

The Terms of Reference (TORs) for the study indicated that the study team was to use pre-existing data to address the questions posed. The study team gathered existing data from a number of sources including the Noranda Enivronmental Monitoring Program (EMP), NB Government Departments, municipal governments, Conservation Council of New Brunswick, Department of Fisheries and Oceans, Environment Canada, Canadian Institute of Health Information, and from various published reports. These sources have been referenced throughout this report and throughout the various technical reports that make up the appendices.

1.1.3.3 Population and geographic coverage

The choice of populations and geographic areas for the study was based on consideration of the lead smelter and electricity generation facility in Belledune as a central point of important environmental emissions, and then encompassing a sufficiently wide area from this central point to capture potential health risks or differences in health status. The largest area considered in the study was that which encompasses the villages of Belledune, Pointe-Verte and Petit-Rocher (please refer to Figure 1.1). This was given the term the Greater Belledune Area (GBA) and was used for the CHSA and one level of analysis for the HHRA. Given the nature of the analysis and availability of data, the HHRA was also able to characterize human health risk on five other more detailed levels as seen in Table 1.1 below.

Figure 1.1: Map of study area

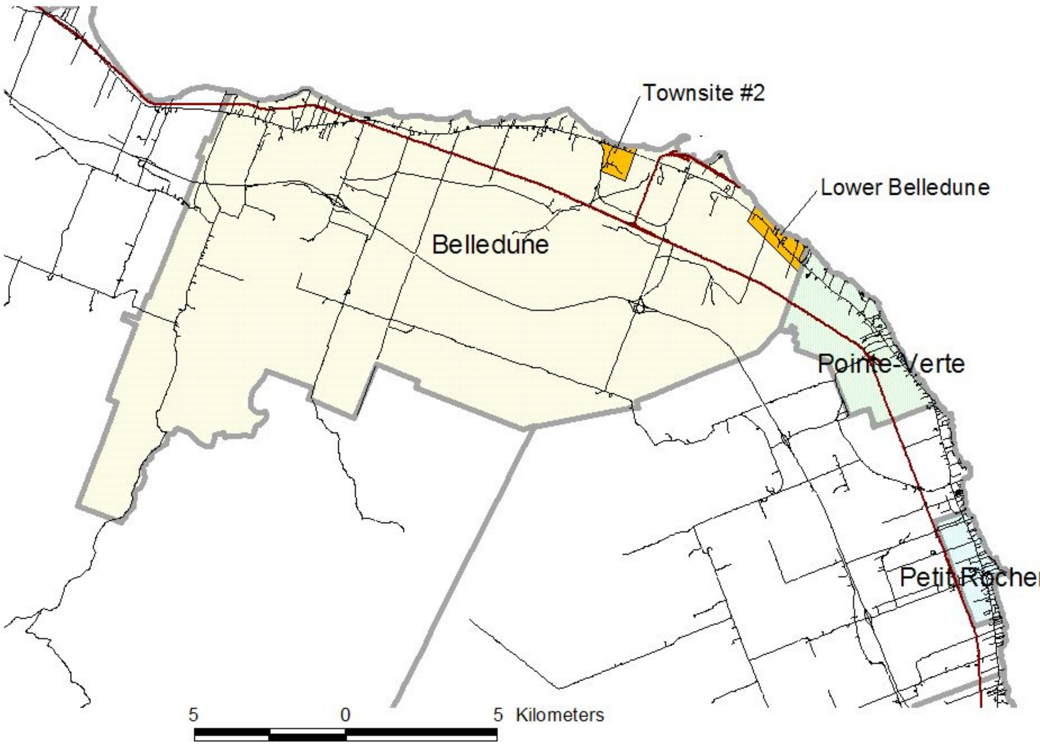


Table 1.1: Population and geographic coverage

Area	HHRA	CHSA
Townsite #2	✓	
Lower Belledune	✓	
Belledune	✓	
Pointe-Verte	✓	
Petit-Rocher	✓	
Greater Belledune Area	✓	✓

There is a necessary trade-off within the CHSA component in choosing the geographic areas for comparison. On one hand, it is necessary to be able to measure a reasonable magnitude of impact with a sufficiently large population as compared to another area. On the other hand, the population considered should not be too spread out and include potentially less exposed residents, a situation that can eclipse or underestimate the impacts on the potentially most exposed residents within the larger group. This must be balanced with the desire to ensure that there is sufficient population to be able to make statistical comparisons between groups.

1.1.3.4 Chemicals and emissions considered

The selection of chemicals of potential concern (COPC) is one of the important initial steps in the HHRA process. Various considerations include community concerns, toxicity of chemicals, levels measured and availability of data. The selection of COPC is carried out through a pre-determined step-wise process that ensures that those selected are relevant for the site or area and pose potential risk to human health.

For the three historical periods of the HHRA component, the COPC that were selected through this step-wise process were:

- Arsenic;
- Cadmium; and,
- Lead.

For the current period, the COPC that were selected were:

- Arsenic;
- Cadmium;
- Chromium;
- Lead;
- Mercury;
- Thallium;
- Zinc; and,
- Dioxins and Furans.

The detailed process for selection of COPC is described in Section 2.0 (and in Appendix A).

1.2 Background

The area included in the study has been home and/or neighbor to various industrial activities over the past four decades. The lead smelter, initially owned by Brunswick Mining and Smelting and now owned by Noranda Ltd., began operations in the mid-1960s. In addition to the lead smelter, there have been other industrial activities including a fertilizer plant, a battery recycling plant, a coal-fired electricity generating facility, a gypsum plant, and a sawmill. These industries have had various types and quantities of emissions over the past four decades.

In the fall of 2003, the Minister of Health and Wellness announced a health study for the residents of the Greater Belledune Area. Concerns had been raised with respect to the current health status of residents and the potential health impacts of local industry in general on the residents of the area. In late November 2003, the Department of

Health and Wellness (DHW) issued a Request for Qualifications (RFQ). The submissions were evaluated, and a study team was chosen. The TORs developed for the study team are presented in Appendix B.

In early 2004, the Minister formed a Steering Committee for the study. This included the six mayors from the local areas (Belledune, Pointe-Verte, Petit-Rocher, Nigadoo, Beresford and Bathurst), a representative from Department of Environment and Local Government (DELG), the local Medical Officer of Health, and three representatives from the DHW. The Provincial Epidemiologist (DHW) chaired the Steering Committee (see Appendix B for the Terms of Reference (TORs) for the Steering Committee).

In addition to the study team chosen through the RFQ process in late 2003, the DHW also conducted an open competition in the spring of 2004 to select a review team for the study. The review team reviews the scientific work of the study team (see Appendix B for the TORs for the Peer Review Team).

1.3 Community profile

This section provides a brief profile of the Greater Belledune Area with respect to socio-demographic characteristics such as population, age, education, employment and language. The profiles of Health Regions 5 & 6 and NB overall are provided as well for comparative purposes. It should be noted that the Health Regions 5 & 6 encompass Northern NB (Central and Eastern), and are the two Health Regions in which the GBA resides.

1.3.1 Population

The Greater Belledune Area (GBA) and Health Regions 5&6 (HR 5&6) have demonstrated a decline in total population over the Census years 1991, 1996, and 2001 (Table 1.2). The province of NB showed an increase in total population between Census years 1991 and 1996, followed by a decline between 1996 and 2001. Overall the population of NB declined from 1991 to 2001.

Table 1.2: Population by census years by geographical regions

Census Years	Greater Belledune Area N (% of NB)	Health Regions 5&6 N (% of NB)	New Brunswick N
1991	5,400 (0.72)	124,062 (16.64)	745,546
1996	5,338 (0.71)	122,218 (16.23)	752,995
2001	4,935 (0.68)	112,530 (15.47)	727,635

Source: Statistics Canada

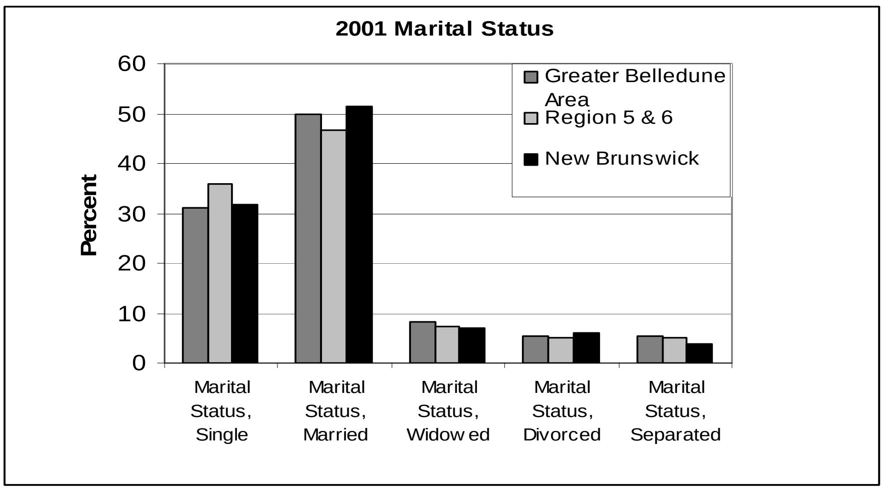
1.3.2 Age distribution

The population distribution of the GBA by age category is similar to that of HR 5&6 and the province of NB; however, some disparities exist. The most notable disparities exist in the age groups 20-29 and 50-59. The GBA has a lower proportion of people aged 20-29 when compared to Health Regions 5&6, and even lower when compared to NB overall. The GBA has a greater population of people aged 50-59 when compared to HR 5&6, and greater still when compared to NB.

1.3.3 Marital status

Recent census data demonstrates that the GBA has a similar composition of married couples when compared to HR 5&6 and the province of NB (Figure 1.2).

Figure 1.2: Marital Status of Residents

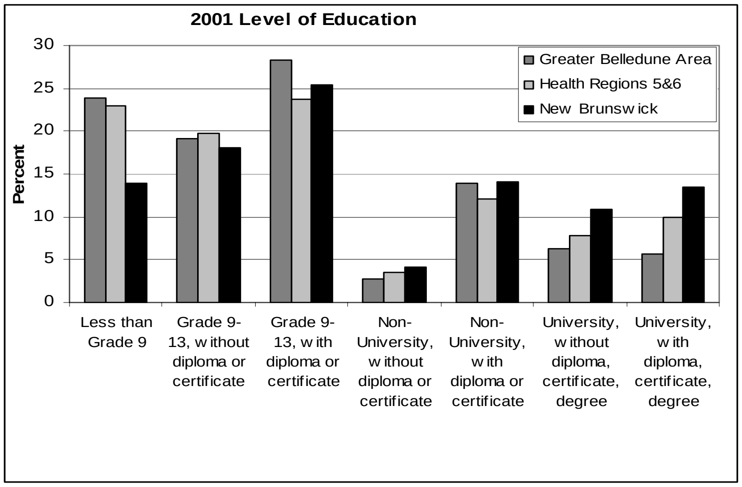


Source: Census 2001, Statistics Canada

1.3.4 Education

As illustrated in Figure 1.3, census data for people 20 years of age and older indicate that both the GBA and HR 5&6 have a higher proportion of people who have less than a high school diploma or certificate compared to NB figures. The GBA has a similar proportion of trade certificates and college diplomas (non-university, with diploma or certificate) when compared to Regions 5 & 6 and NB as a whole. With respect to university education, the GBA has the lowest percentage (5.6%) when compared to Regions 5 & 6 (10.0%) and NB (13.5%).

Figure 1.3: Highest level of education



Source: Census 2001, Statistics Canada

NOTE: It is noted that NB does not have Grade 13, however, the categories used in this graph are standard categories used by Statistics Canada. This ensures that NB residents who may have been educated elsewhere are included, and it allows for comparisons with Canada overall.

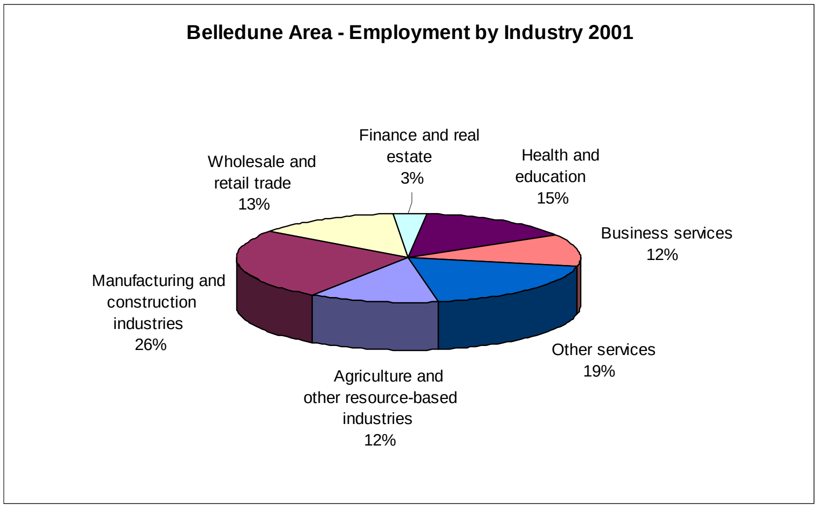
1.3.5 Employment and income

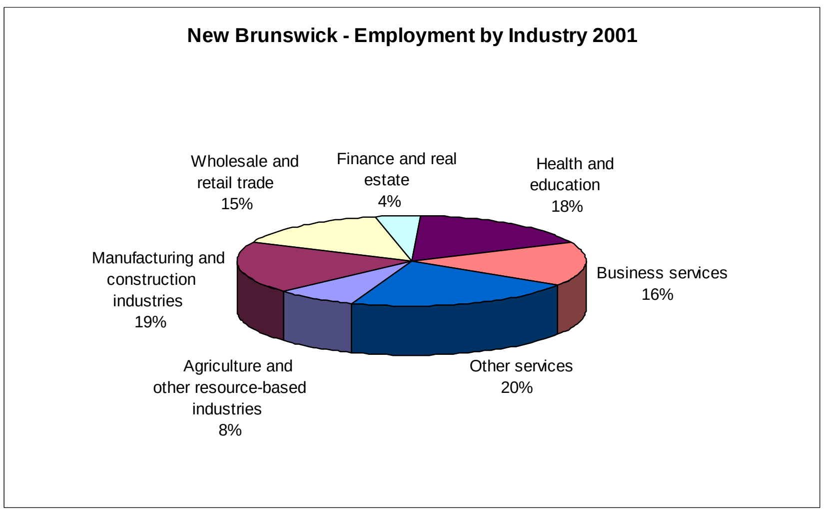
Data from the 2001 Census demonstrates that the Belledune Area offers a different composition of major types of employment from the NB provincial distribution (Figure 1.4). The greatest differences are seen in the Manufacturing and Construction industries and Agriculture and Other Resource-based industries. The Belledune Area is 7% above the NB average for Manufacturing and Construction and 4% above the provincial average for Agriculture and Other Resource-based industries. The Belledune Area is 4% below the provincial average for activity in the Business Services sector and 3% below average for activity in the Health and Education sector.

The largest single source of employment in the Belledune Area is the Noranda Smelter, employing over 650 individuals.[2] Other major employers in the area include the Port of Belledune, NB Power, Chaleur Sawmills and Canadian Gypsum.

[2] Source: MITAC Member Site, 2003. http://www.mitac.ca/WebForms/about_mitac/membership_e.aspx.

Figure 1.4: Distribution of employment – GBA & NB





Source: 2001 Census, Statistics Canada

2001 Census data show that the employment rate in the GBA (83.4%) is similar to that of Regions 5 & 6 (82.9%), and slightly lower than NB overall (87.5%). Census data from 2001 also demonstrated that average household income for GBA ($42,821) was very similar to that of HR 5&6 ($42,378). Average household income was approximately $5,000 lower than that for NB overall ($47,587)

1.3.6 Language

According to the 2001 Census, the GBA varies from the NB linguistic distribution with 60% of the area's population reporting that their first language is French, and 39%, English. This compares with the distribution of 33% French and 65% English for NB overall. Within the GBA there are variations, with many in the Belledune community with English as a first language, while many residents in Pointe-Verte and Petit-Rocher have French as their first language.

1.4 Community consultations

One key aspect of the study was the effective communication and meaningful participation of the study communities and key stakeholder groups. To effectively engage communities and stakeholders in the study process, the study team undertook a series of consultation activities during the initial phase of the study (February 2004 – June 2004).

The objectives of this consultation process were:

- To collect input from individuals and groups with respect to the study; and,
- To provide an opportunity for the study team to explain study objectives and proposed approach.

The areas of input sought from the consultations included:

- The expectations of the study by groups and individuals;
- Particular issues they would like the study to address;
- How they would like to be kept informed of study progress; and,
- Any additional information they believe might assist the team in meeting the study objectives.

The majority of consultations occurred during the February to May time period in 2004, as the research team was working on the study design. Consultations took one of three forms:

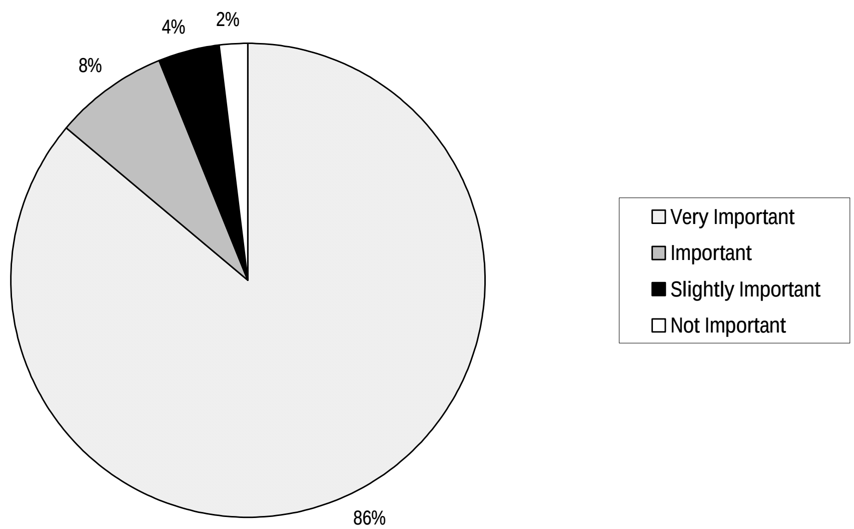
- participation in *open houses* held at community centres in Belledune, Pointe-Verte, and Petit-Rocher;
- *questionnaires* mailed out to approximately 4,300 households in the general study region; and,
- *interviews/meetings* with individuals or small groups who had been identified by the Steering Committee and/or other stakeholders as likely having an interest and/or information that would be useful for the study.

Please refer to Appendix C for additional details on consultation approach and participants.

1.4.1 How important is it to conduct a health study?

Across the different consultation approaches, there was a strong indication that a health study is important for the area. While there were often differences or variations among respondents with respect to the focus of the health study, the vast majority of those who participated in the consultations indicated that a health study is important. As illustrated in Figure 1.5, approximately 94% of respondents to the questionnaire reported that a health study was "very important" (86%) or "important" (8%) to them.

Figure 1.5: How important is it to conduct a health study?

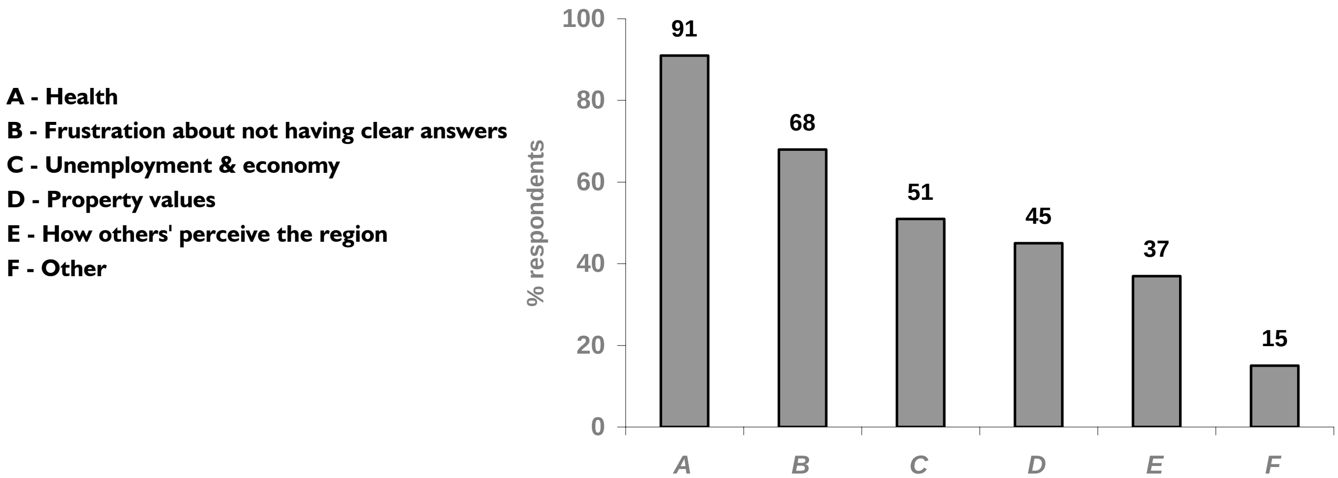


Source: Questionnaire on Residents' Issues and Concerns (n=1,003)

1.4.2 What are the main issues and concerns of the community?

One main objective of the consultations was to determine what were the main concerns and issues of residents. During the open houses, there were many visitors who indicated that health was a top priority with respect to the concerns they had for the region and industrial activity. The top concerns coming out of the first round of open houses were posed on the questionnaire for respondents. As illustrated in Figure 1.6, the two concerns most frequently identified were health (91%), and the lack of having clear answers to their questions (68%). For this question, respondents had the option of multiple responses (e.g., could identify both health and the lack of answers).

Figure 1.6: Main areas of concern for residents
Source: Questionnaire on Residents' Issues and Concerns (n=1,013)



When respondents were asked to indicate their "top concern" with respect to the concern areas, the area of highest concern among residents remained health (84%). In the open comments on the questionnaires, and among many of the visitors to the open houses, concerns were also expressed with respect to:

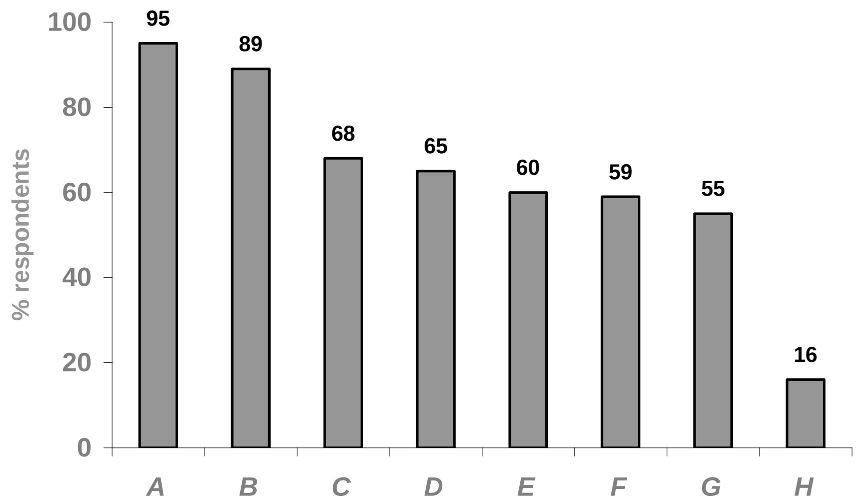
- The decision-making process with respect to local industrial development for the area; and,
- The perceived quality of previous studies with respect to assessing health risks.

1.4.3 What are specific health concerns?

Many of the participants in the various consultations identified specific health concerns that they would like to see addressed in the study. The top two health concerns were cancer and respiratory conditions (see Figure 1.7). Many visitors to the open houses indicated that child development issues were of particular concern due to the presence of lead. A number of other health conditions were identified by respondents on the questionnaires and through the open houses as areas to consider in the study including thyroid problems, specific cancers, and specific respiratory illnesses.

Figure 1.7: Specific areas of health concerns

A - Cancer
B – Respiratory
C –Circulatory-heart
D - Child development
E – Stomach - digestion
F - Depression and anxiety
G – Reproduction
H – Other



Source: Questionnaire on Residents' Issues and Concerns (n=922)

2.0 Summary of findings from HHRA

The human health risk assessment (HHRA) was designed to address three of the four study research questions:

HHRA RESEARCH QUESTIONS

1. What are the potential types and sources of environmental contamination?
2. How are residents exposed to the environmental contamination?
3. What are the potential health risks for residents as a result of the exposure to the environmental contamination?

This section contains the summary of findings for the HHRA component of the study. Details on methods and findings are presented in the technical Appendix A.

2.1 Overall approach

While the HHRA is a tool for determining the risk of health effects, it is important to note that it does not provide an absolute statement on the experienced health effects measurable in a population. Therefore, the findings from HHRA are considered with the results of the CHSA to determine, where possible, whether adverse health impacts are actually occurring in the community.

To characterize different ranges of potential exposure at various sites within the Greater Belledune Area (GBA), the HHRA produced two levels of risk estimates for individuals:

- *Upper bound exposure conditions* – risk estimates based on the highest measured concentrations of chemicals in the surrounding environments; and,
- *Best estimate exposure conditions* – risk estimates based on the best estimate or average concentrations of chemicals in the surrounding environments.

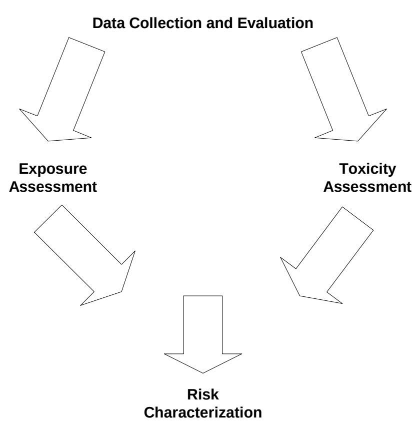
The use of these different ranges of exposure provides a means of characterizing the risks for health effects in the Belledune area under different sets of exposure assumptions.

2.1.1 HHRA Framework

The human health assessment was conducted using an approach that is acceptable to regulatory agencies such as Health Canada and the U.S.EPA. Such assessments follow a stepwise process as shown in Figure 2.1which involves:

- **Data collection and evaluation -** Involves summarizing the concentrations of chemicals in the soil, water, air, fish, garden vegetables and other environmental media.
- **Estimation of exposure** – Using the data collected in the first step to calculate how much exposure to each chemical people may experience. This depends on the concentration of the chemical, who is exposed and how they are exposed.
- **Determination of toxicity** – This involves enumeration of the diseases, conditions, or any health effects that can result from exposure to a given chemical. Toxicity reference values (TRV) determine at what level harmful effects are likely to occur. They are obtained from regulatory health agencies or from the scientific literature.
- **Characterization of the risk** – Involves the integration of the exposure and toxicity assessment to determine which chemicals are posing risks above a benchmark and what the risks are, at or above that benchmark. It also involves a discussion of the uncertainty in the risks.

Figure 2.1: Overall steps in the human health risk assessment process

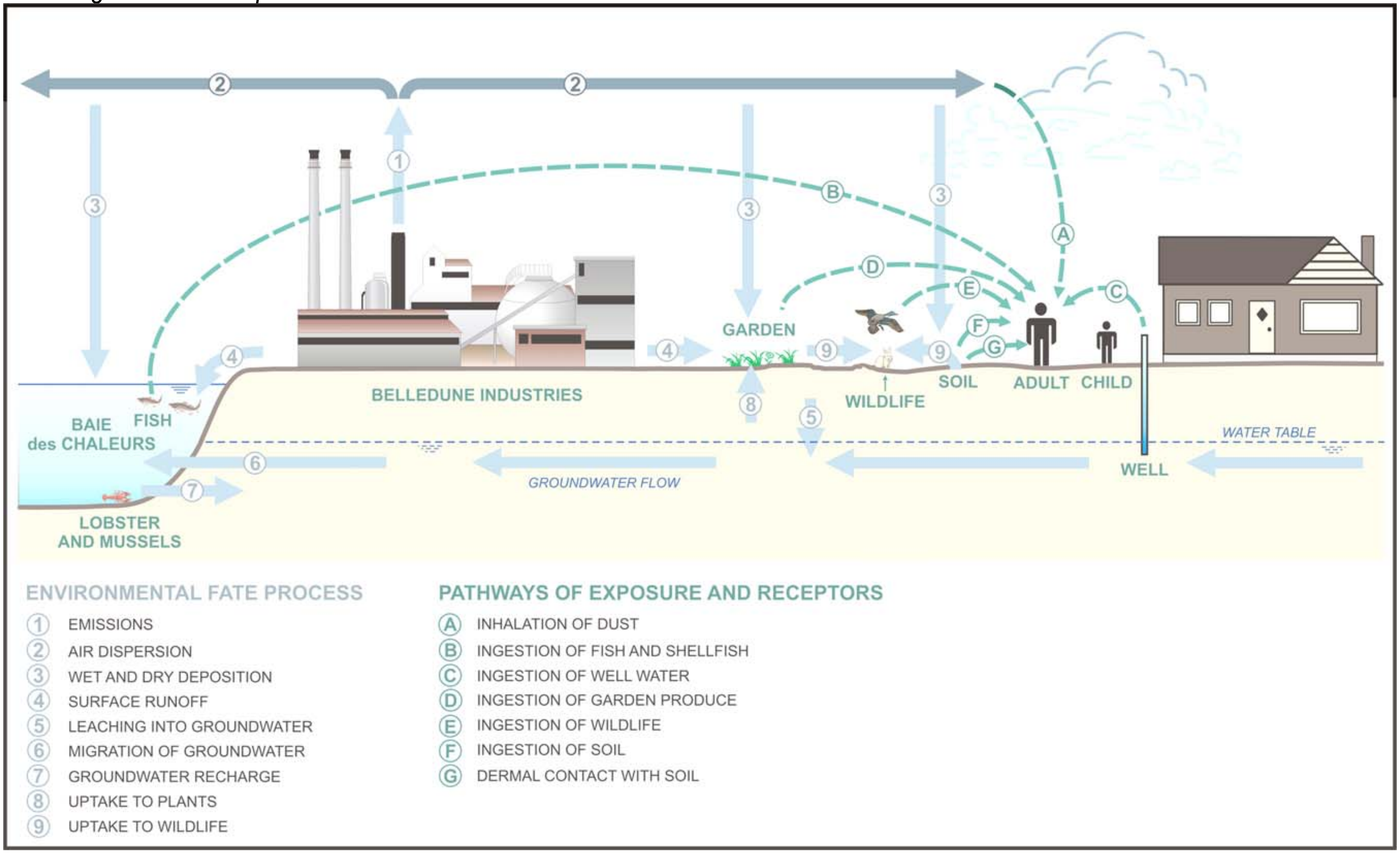


It should be noted that there are many ways to conduct a risk assessment. The framework outlined above provides an orderly approach for conducting a risk assessment that, in the end, is usually based on both scientific rigour and professional judgment. Thus, risk assessments generally rely on making inferences, assumptions and developing models that inherently lead to uncertainties in the estimates obtained. A goal of a risk assessment is to make assumptions about exposure that are more likely overestimations to ensure that the uncertainties do not underestimate potential risks. The uncertainties that have been identified for the current HHRA are discussed in more detail in Section 5.0 of this report and in the technical Appendix A.

Residents in Belledune and its vicinity can be exposed to chemicals of potential concern (COPC) through several routes such as inhalation, ingestion and dermal contact. Each route has various components. For example, the ingestion route includes ingestion of soil, consumption of backyard produce, wildlife, fish and water.

These components are known as pathways of exposure and contribute to total daily exposure to a particular COPC. Figure 2.2 provides a conceptual model of the area for the study and outlines many of the considerations taken in conducting the HHRA, further discussed in the sections below.

Figure 2.2: Conceptual model for HHRA for Belledune Area



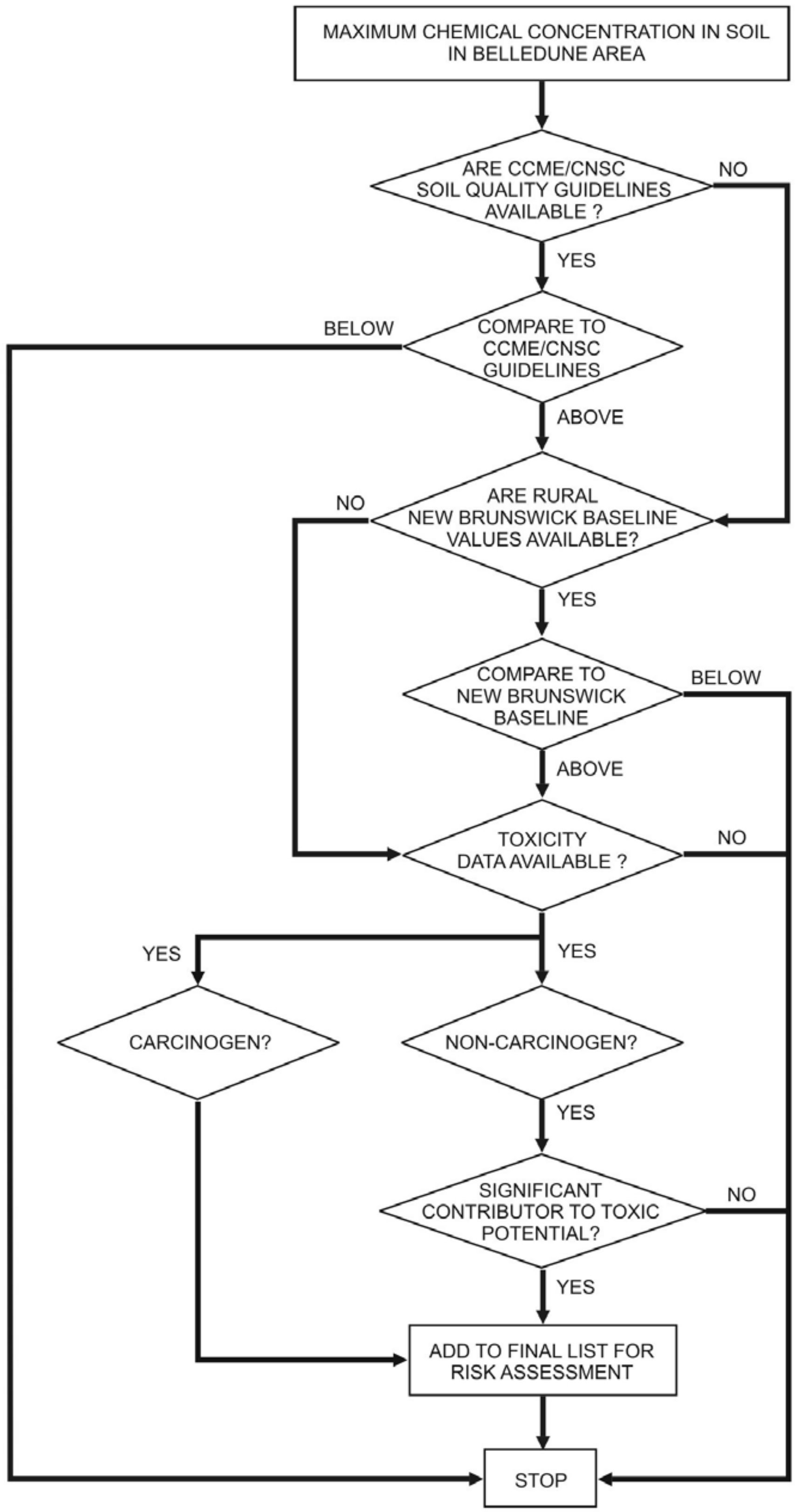
2.2 Selection of COPC

The selection of chemicals of potential concern (COPC) is one of the important initial steps in the HHRA process. The choice of COPC considers community concerns, toxicity of chemicals, levels measured and availability of data. These choices are made through a pre-determined, step-wise process to ensure that the COPC selected are relevant for the site or area and pose potential risk to human health. This step-wise approach for selection of COPC is depicted in Figure 2.3 below. More details on this process are presented in technical Appendix A.

In summary, the study team considered all chemicals for which there were measured soil concentrations. The data collected on soils are more extensive than other data and therefore, these data were used to select the chemicals to carry through the risk assessment evaluation. The selection of chemicals of potential concern (COPC) to be carried through to the more detailed assessment was based on a screening process called “Toxic Potential” that takes into account the toxicity of the chemical, its persistence in the environment, and/or its potential to bioaccumulate in various media. This screening process is generally acceptable to regulatory agencies such as Health Canada and the Ontario Ministry of the Environment and is described in Figure 2.3. This approach was deemed acceptable since the chemicals that were being considered were not volatile and thus exposure would occur mainly via the oral route. Therefore, the use of the oral toxicity values to assess toxicity of the chemicals was appropriate. This process ensures that chemicals that are most likely to cause the greatest risk are considered in the assessment.

Throughout this report, the term Toxicity Reference Value (TRV) is used to assess exposure to a chemical. A TRV is an estimate of a rate of exposure that is likely to be without appreciable risk of harmful effects. There are two types of TRVs. For non-carcinogenic chemicals the TRV is an estimate of a daily oral exposure that is likely to be without an appreciable risk of harmful effects during a lifetime. For carcinogens, the TRV is an upper bound, approximating a 95% confidence limit, on the increased cancer risk from a lifetime exposure to a chemical.

Figure 2.3: Process for selection of COPC



As previously mentioned, the chemicals that were selected for COPC for the HHRA that focused on current exposures were:

- Arsenic;
- Cadmium;
- Chromium;
- Lead;
- Mercury;
- Thallium;
- Zinc; and,
- Dioxins and Furans.

Three of these COPC (arsenic, cadmium, and lead) were also examined from a historical perspective to determine potential past exposures experienced in three different time periods.

2.3 Selection of receptors

"Receptors" are individuals who are potentially exposed to the COPC in the study area. For the HHRA, receptors were selected according to different geographical areas (e.g., Townsite #2, Pointe-Verte) and age groups that generally refer to life stages. The HHRA considered different age groups of residents (receptors) because exposure pathways differ in importance in different age groups. For example, soil ingestion among toddlers would normally be significantly higher than among teens or adults. Another consideration, given the importance of the exposure pathway, was whether or not the residents (receptors) ate local seafood (wild mussels, fish, lobster). Three different types of seafood consumers were considered: no seafood, an average amount of seafood, and maximum seafood consumers. As examples, receptors were considered as "maximum local seafood eaters" (5-7 large meals per week or either local lobster, wild mussels or fish) or "average local seafood eaters" (1-2 medium meals per week). Figure 2.4 below outlines the different receptor groups selected for the HHRA.

The assumptions included in defining the different receptors are intended to ensure that maximum residential exposures are considered in the HHRA. In most cases, these assumptions are conservative (i.e. overestimates of reality) but will serve to ensure that potential risks are not overlooked. Making assumptions such as these is part of common practice in conducting HHRAs.

The assumptions with respect to receptors used for this assessment are:

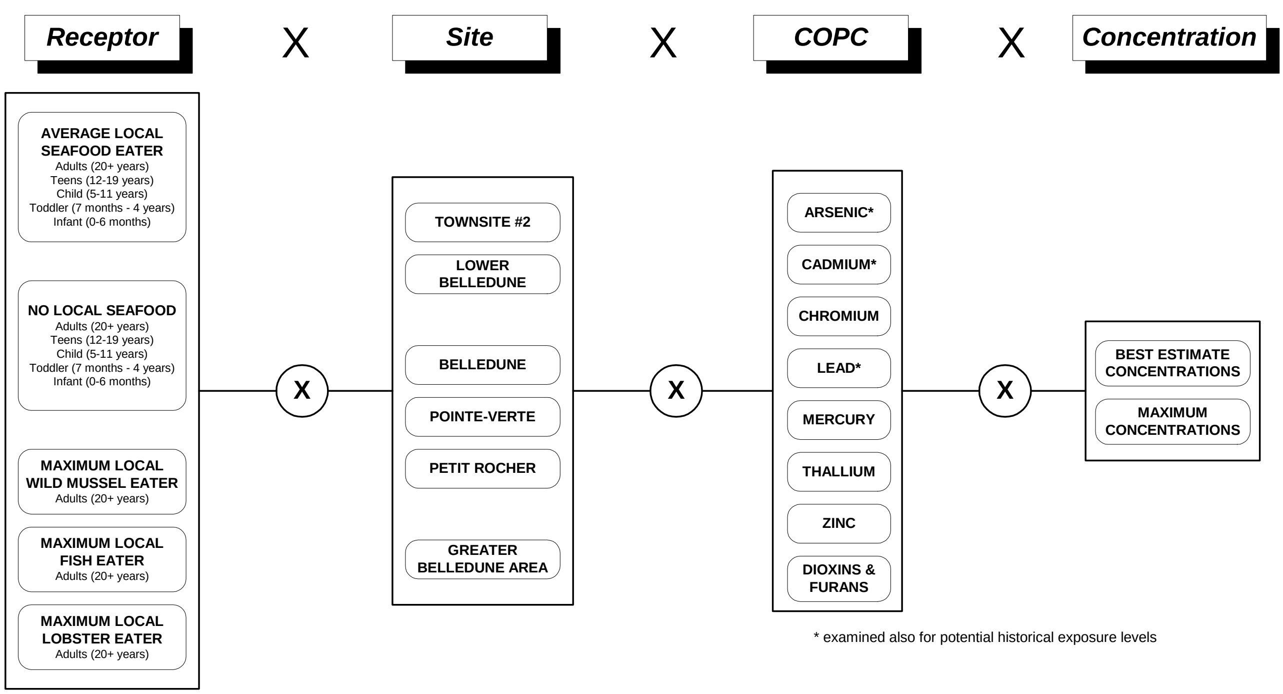
- Residential exposure occurs for 100% of the time. Since residential exposures are generally longer in duration than for work or school hours, this will capture the most exposed scenario.
- Adults and children are present at home 24 hours a day 365 days a year for a 70-year lifetime. This will likely overestimate exposures and potential health risks for

those persons living close to the industrial area, and potentially underestimate the exposures and potential health risk for those persons whose residences are farther away but travel closer to the Belledune industrial area for work or school.

- Residents ingest soil while outdoors.
- Soil adheres to skin every day of the year.
- Best estimates (average) and maximum soil levels (95th percentile or maximum measurement) are both used for each site.
- All drinking water is from wells at the various receptor locations.
- All inhaled air is derived from modeled concentrations at the receptor locations.
- Best estimates (average) and maximum levels of COPC (95th percentile or maximum measurement) are both assumed to be in backyard produce are consumed according to site.
- Best estimates (average) and maximum levels of COPC (95^{th} percentile or maximum measurement) are both present in additional dietary components (e.g., fish, lobster, rabbit, partridge) consumed according to site.

Risk estimates were calculated for each of these receptor groups for each of the eight COPC (e.g., arsenic, cadmium). As well, risk estimates were calculated for each of these groups for both *upper bound estimates* (i.e., maximum or upper bound concentrations of COPC) and *best estimates* (i.e., average concentrations of COPC). In addition, risk estimates for historical exposure to arsenic, cadmium and lead were calculated for three time periods: 1967-1974; 1975-1984; 1985-1999.

Figure 2.4: HHRA receptors, sites, COPC and concentrations



2.4 Selection of pathways

People come into contact with COPC in a variety of ways: breathing contaminated air, touching contaminated soil, consuming contaminated water, soil or food. For all routes and pathways of exposure, the exposure assessment estimates the amount that can reach the person's lungs, digestive system or skin and the amount that is absorbed into the body by each pathway from each route of exposure. Thus, the exposure assessment comprises three elements:

- determination of potential routes and pathways of exposure;
- frequency and duration of actual and/or potential exposure; and,
- magnitude of exposure.

Using the model presented previously (Figure 2.2 above), the study team determined that the essential routes and pathways to be considered for the GBA residents in this assessment were:

- Inhalation – respiratory tract
- Contact – skin
- Ingestion – gastrointestinal tract
    - Soil
    - Well Water
    - Root Vegetables
    - Other Vegetables
    - Wild Game
    - Fish caught in Baie des Chaleurs
    - Lobster caught along the shore line
    - Wild Mussels collected along the shore line
    - Supermarket Foods

2.5 Estimates of environmental concentrations

Risk assessment predicts the risks to human health arising from the intake of chemicals into the body. The intake depends not only on the intake or consumption rate but also on the concentration and bioavailability of chemicals in the food, water and soil ingested and in the air that is inhaled. For chemicals related to air releases, the concentrations in the environment will vary with distance from the facility, and will vary over time depending on the rate of emissions from the facility. It should be noted that the bioavailability of chemicals was not considered in this assessment. This results in overestimates of exposure.

For the HHRA, the study team developed estimates of environmental concentrations of COPC for the various sites (e.g., Townsite #2, Pointe-Verte) by combining historic and ongoing environmental monitoring data, air dispersion model predictions and environmental fate models. These estimates included “best estimates” which correspond to average concentrations for a site, and “upper bound estimates” which correspond to either the 95th percentile upper confidence level of the mean, or the maximum measured concentration for a specific site. Best estimate and upper bound estimate of concentrations of COPC were developed for the following media for all sites: air, soil, well water, root vegetables, other vegetables, wild game, fish, lobster, and wild mussels.

The main objective to be addressed by this component of the study was:

- *To describe and quantify the historical and current human health risks associated with past and current industrial activities in the Belledune Area*.

Working towards this objective, the focus was placed on community residents and environmental measurements found within the community. As a result, environmental measurements found directly in the Belledune industrial area were not included in the assessment. As well, given that the focus was on health risks associated with industrial activities, the overall assessment did not take into account environmental measurements that were unlikely related directly to Belledune industrial activity emissions (e.g., road-side measures, soil placement). In order to consider these and address some identified concerns with respect to these types of locations, the study team conducted a separate set of analyses using these types of exposures (see Appendix A for more details and results of these analyses).

In developing the estimates of environmental concentrations, numerous sources of data and information were used by the study team. The study team was required to use a combination of approaches in estimating concentrations. For some media, the best estimates and upper bound are based on direct measurements only. To fill geographical and temporal data gaps, the study team used site-specific empirical relationships. In other cases, the study team used concentrations measured in earlier or later time periods if there was a lack of data for the period under consideration, if it made sense to use these data. A summary of the types and sources of data used to develop estimates is presented in Table 2.1 below[3].

[3] For details on steps, models, empirical relationships and actual concentrations, please refer to the technical appendix for the HHRA (Appendix A)

Table 2.1: Summary of data used in HHRA

Media	Historical Time Periods	Current Time Period
Air	**Modeled**	**Modeled**
Soil	**Empirical relationship** with air (*soil data from Noranda EMP*)	**Empirical relationship** with air (*soil data from Noranda EMP & CCNB*)
Well Water	**Measured** (*data from NB Gov't and Belledune Village*)	**Measured** (*data from NB Gov't and Belledune Village*)
Vegetables	**Measured** and **empirical relationship** with soil (*data from Noranda EMP*)	**Measured** and **empirical relationship** with soil (*data from Noranda EMP*)
Fish	**Measured** (*data from published studies*)	**Application** of historical data set
Lobster	**Measured** (*data from Noranda EMP and published studies*)	**Measured** (*data from Noranda EMP and published studies*)
Wild Mussels	**Measured (***data from Noranda EMP and published studies*)	**Measured** and **empirical relationship** with distance (*data from Noranda EMP and published studies*)
Wild Game	**Not considered**	**Measured** (*data from Noranda EMP*)

2.6 Summary of historical exposure findings

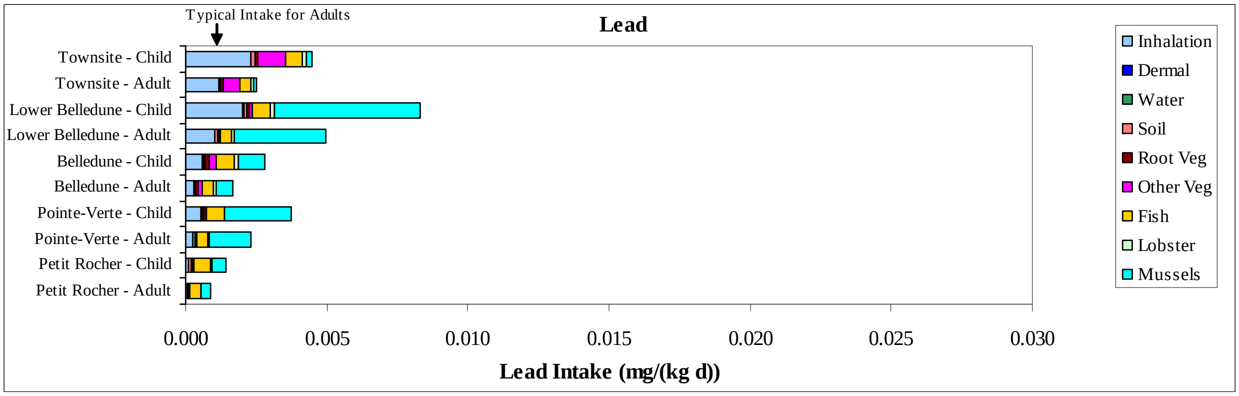
The main finding with respect to historical exposure and associated potential health risk relates to lead and cadmium. As discussed previously, the historical analysis focused on exposure to arsenic, cadmium and lead. In general, the best estimate results are discussed in this section. The results relating to the upper bound estimates are provided in Appendix A. The results for all life stages are discussed to illustrate the range of exposure experienced for different life stages. Figures are presented for the adult and child. In the historic time period, the exposures for a child were higher than for an infant or toddler.

The estimated health risks from historical lead and cadmium exposures are significantly higher in the earlier time periods when emissions from the lead smelter were highest. By contrast, the health risk estimates related to arsenic remain relatively constant across all time periods.

2.6.1 Historical exposure to lead

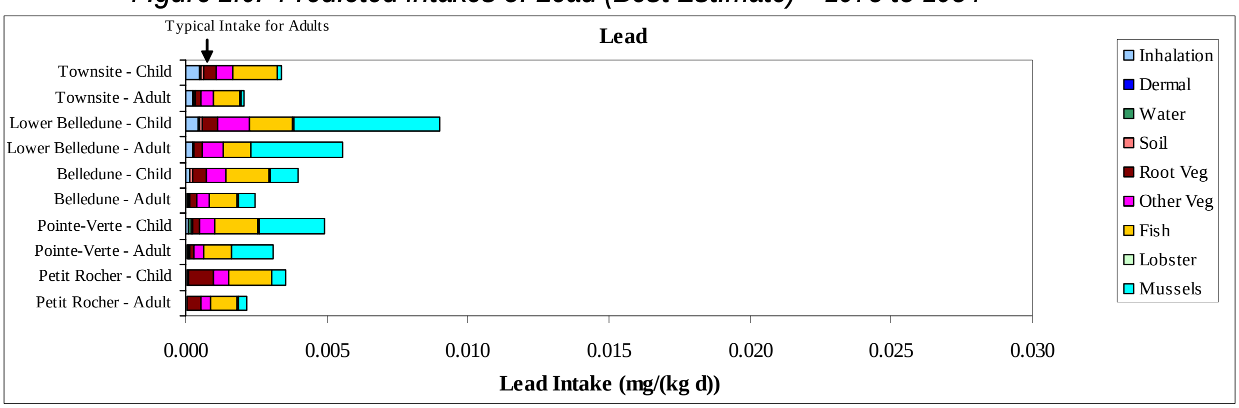
During the earliest time period studied (1967-1974), using best estimates or average concentrations in the environmental media, infants in Townsite #2 and children and adults in Lower Belledune would have had oral exposure levels at or beyond the current toxic reference value (TRV) associated with a blood lead level of 10µg/dL, which itself is associated with adverse neurocognitive developmental outcomes (see Section 2.2 for a brief discussion of TRVs). For children living just west of the smelter along the shoreline, and in Lower Belledune, inhalation was estimated to be the main exposure pathway for lead followed by ingestion of local wild mussels and fish. The soil pathway was relatively minor. For children living further west or east of the smelter (greater Belledune, Pointe-Verte, Petit-Rocher) during this period, inhalation was an important pathway, but their diet of local wild mussels and fish also contributed to their exposure in similar proportions (refer to Figure 2.5 below).

Figure 2.5: Predicted Intakes of Lead (Best Estimate) – 1967 to 1974



As illustrated in Figure 2.6, by the 1975-1984 period, again using best estimates or average concentrations, exposures in Townsite#2 have decreased. In Lower Belledune exposures have increased and all age groups were predicted to have had oral exposure to lead beyond the current oral toxic reference value (TRV). The interesting change in this period is that the inhalation pathway was estimated to be significantly lower than in the earlier time period. Most of the estimated exposure commitment to lead was predicted to occur from local wild mussels, fish and backyard garden vegetables. The intake of soil was still a relatively minor pathway. In greater Belledune, infants and children were predicted to have exposures above the oral TRV. Lead exposures in Pointe-Verte and Petit-Rocher also increased during this time period, mainly due to consumption of fish and backyard vegetables. In Pointe-Verte, children were predicted to have exposures above the oral TRV. In Petit-Rocher, the infant and child were predicted to have oral exposures above the TRV.

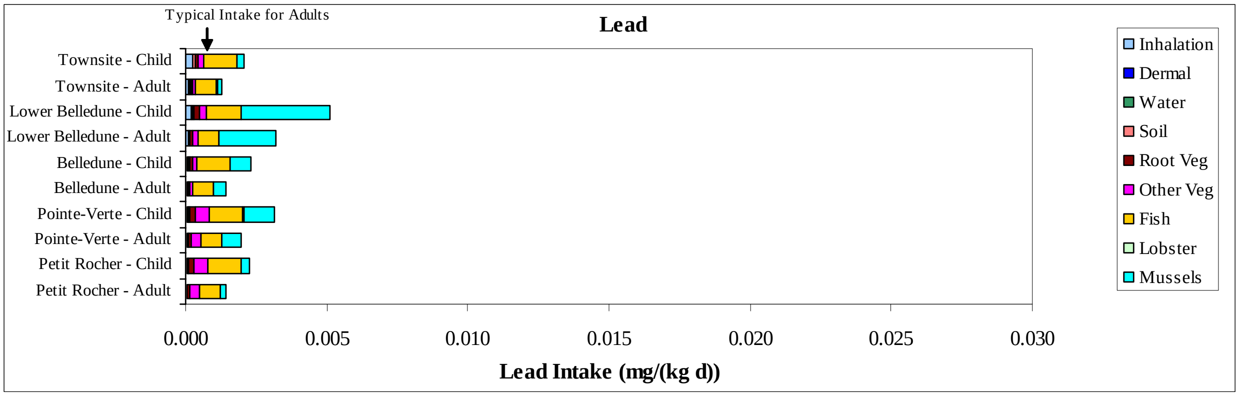
Figure 2.6: Predicted Intakes of Lead (Best Estimate) – 1975 to 1984



By the 1985-1999 period, the intakes predicted from the best estimates of environmental media indicate that the intakes had decreased substantially from the previous time period. During this period, the inhalation pathway is minimal, with the main pathways remaining ingestion of local wild mussels, and fish (refer to Figure 2.7 below). The backyard vegetable pathway has also decreased. In this time period, only children in Lower

Belledune were predicted to have oral exposures to lead above the TRV.

Figure 2.7: Predicted Intakes of Lead (Best Estimate) – 1985 to 1999



As will be discussed in the next section, current estimated exposure to lead are lower than the historical exposures. Most of the estimated exposure in the current time period relates to ingestion of local fish and wild mussels.

2.6.2 Historical exposure to cadmium

Unlike the historical pattern of lead where the study team saw a prominent pathway of inhalation in the earliest period, the historical pattern of cadmium exposure is estimated to be primarily due to ingestion rather than inhalation in all periods. Similar to the lead exposure pattern, the cadmium exposure pattern illustrates a decreasing estimated exposure over time periods examined with the highest exposure being experienced in 1975-1984.

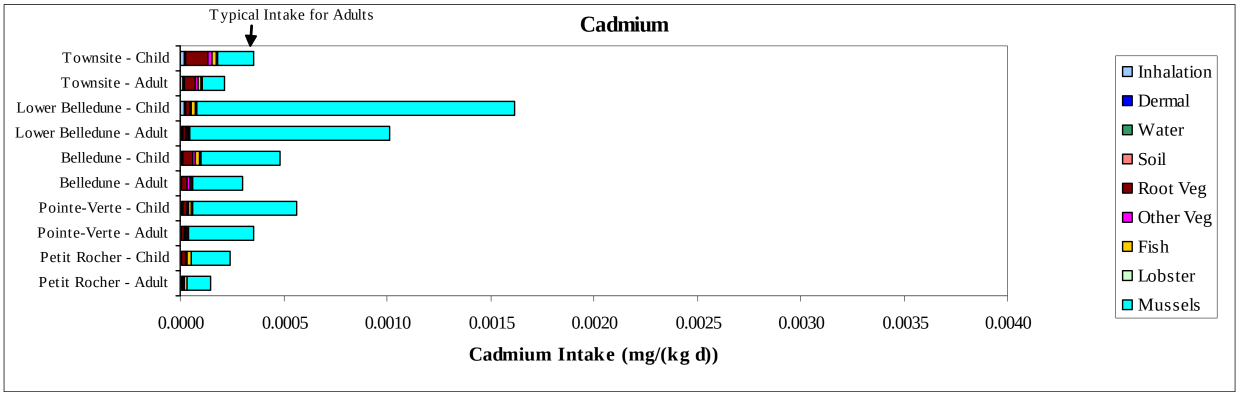
During the early period (1967-1974), no exposures above the oral TRV were predicted for infants and toddlers; however, exposure estimates indicate that children in Lower Belledune, Belledune, and Pointe-Verte exceeded the oral TRV. Similarly, adults in Lower Belledune exceeded the TRV. Cadmium is not considered to be carcinogenic through the oral pathway. The kidney is the target tissue of non-cancer cadmium toxicity. The health effects associated with oral ingestion are significant proteinurea, a reflection of abnormal kidney function.[6] The most significant pathway during this period for all receptors was the ingestion of local wild mussels, as illustrated in Figure 2.8 below.

Cadmium is also considered to be carcinogenic via the inhalation pathway. The incremental inhalation risks for an adult in the 1967-1974time period at the different receptor locations were above the currently acceptable limit of 1 x 10^{-5} in Townsite #2 and Lower Belledune. The risks decreased the farther away the study areas are from the

[6] US EPA (2004) – United States Environmental Protection Agency. *Integrated Risk Information System.* On-line database.

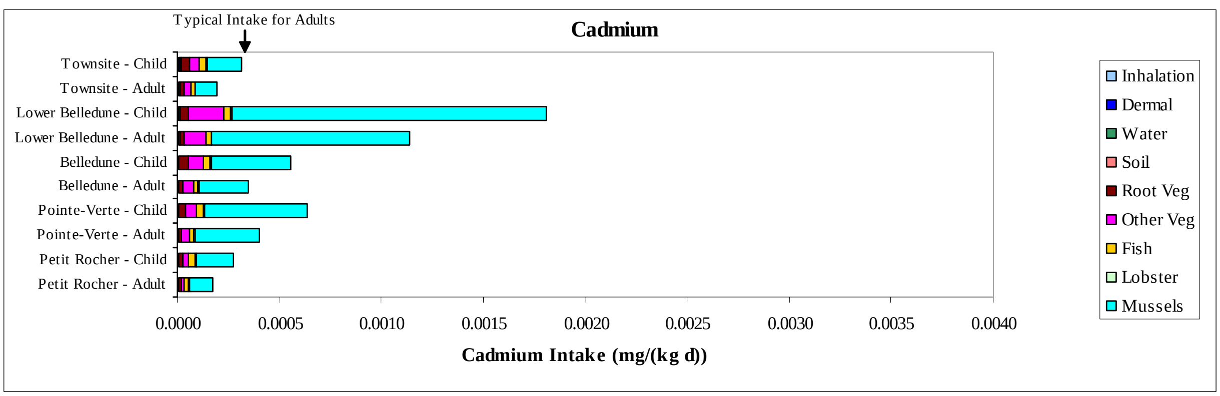
industrial activities.

Figure 2.8: Predicted Intakes of Cadmium (Best Estimate) – 1967 to 1974



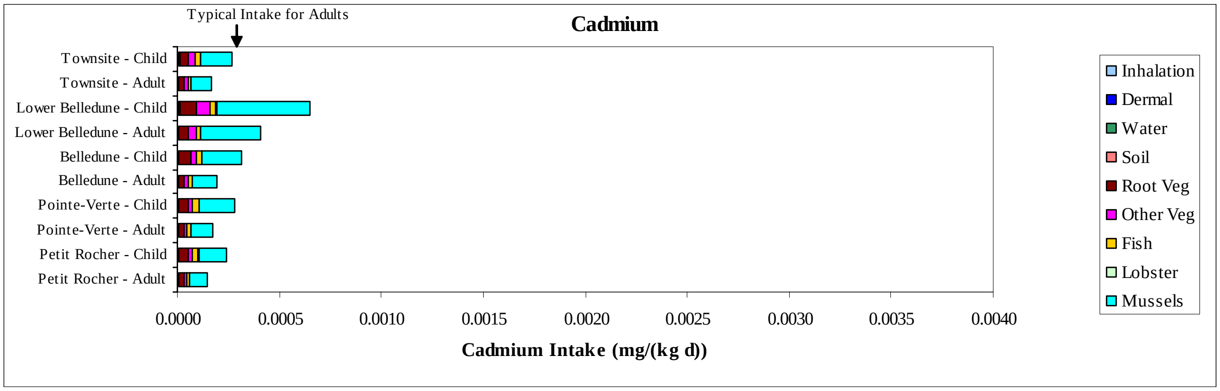
The second time period studied (1975-1984) showed an increase in exposure estimates for cadmium compared to the first period (see Figure 2.9). This is due to the fact that exposure to backyard vegetables had increased. In this time period, the oral TRV was predicted to be exceeded by children, teens and adults in Lower Belledune. The incremental risks due to cadmium inhalation exposure for the 1975-1984 time period are lower than the previous time period; however, the incremental risks predicted in Townsite #2 and Lower Belledune are still above the currently acceptable limit of 1 x 10^{-5}.

Figure 2.9: Predicted Intakes of Cadmium (Best Estimate) – 1975 to 1984



By the 1985-1999 time period, exposure levels to cadmium had decreased substantially. At the best estimate environmental concentrations, there are no exposures that were predicted to exceed the oral TRV. As illustrated in Figure 2.10 below, the predominant pathway remained ingestion of local wild mussels. While being an important pathway, ingestion of backyard vegetables is lower than in the previous time period. The incremental risks from the inhalation of cadmium are similar to the previous time period.

Figure 2.10: Predicted Intakes of Cadmium (Best Estimate) – 1985 to 1999



As will be discussed in the next section, the current estimated exposure to cadmium is lower than historical exposures

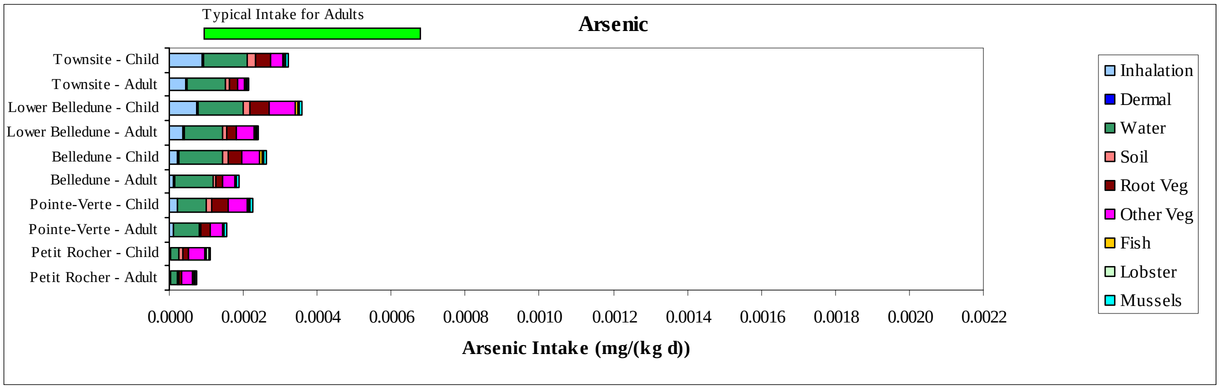
2.6.3 Historical exposure to arsenic

Arsenic is an unusual COPC in that it has TRV for both cancer causing and non-cancer causing properties. The cancer causing TRV is based on risk of internal cancers (liver, lung, bladder and kidney). Evidence from many studies shows that long-term intake of arsenic at sufficiently high doses results in a pattern of skin changes. The changes can include the appearance of small “corns” or “warts” on the torso and on the palms of hands and the soles of feet as well as darkening of the skin. A small proportion of corns may develop into skin cancer. The skin cancers generally develop after prolonged exposure, predominantly occur as squamous cell and basal cell carcinomas, and are highly treatable if detected early. However, the basis for the non-carcinogenic TRV that Health Canada uses in federal jurisdictions is not provided.

Figure 2.11 shows the predicted arsenic intakes in the early period (1967 – 1974). Oral exposures at the best estimate environmental concentrations were predicted to be below the non-carcinogenic arsenic oral TRV. Backyard vegetables and well water were the major contributors to exposure.

The figure (2.11) also shows the typical intake for adult Canadians. The predicted intakes for adults are below this range. The incremental risks due to inhalation and oral exposure to arsenic were also estimated for this time period. The incremental inhalation risks were all found to be above an acceptable risk of 1×10^{-5} except in Petit-Rocher. The incremental ingestion risk in Lower Belledune is marginally above the acceptable risk level (1.2×10^{-5}), while in the rest of the study area, the incremental ingestion risks are below the acceptable risk level. Since the endpoints of inhalation (lung cancer) and ingestion (lung cancer and internal cancers) are similar, the incremental risks can be added together. Thus, the total incremental risks due to arsenic exposure for an adult are all above an acceptable risk level of 1×10^{-5} with the exception of the Petit-Rocher location.

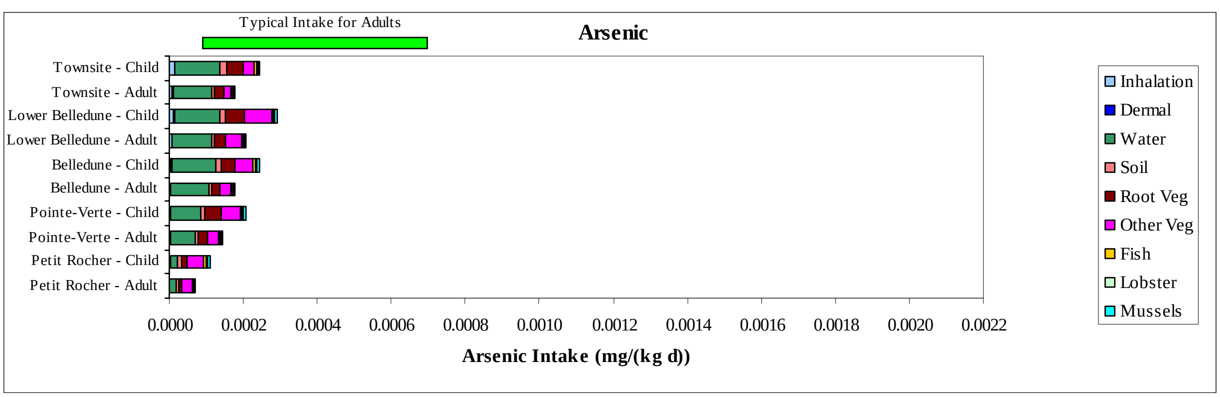
Figure 2.11: Predicted Intakes of Arsenic (Best Estimate) – 1967 to 1974



The second time period studied (1975-1984) showed very similar exposure estimates for arsenic compared to the first period. Similarly, the TRV was not predicted to be exceeded at any location as illustrated in Figure 2.12 below. Predicted risks for this time period were similar to the early time period and were within background arsenic risks.

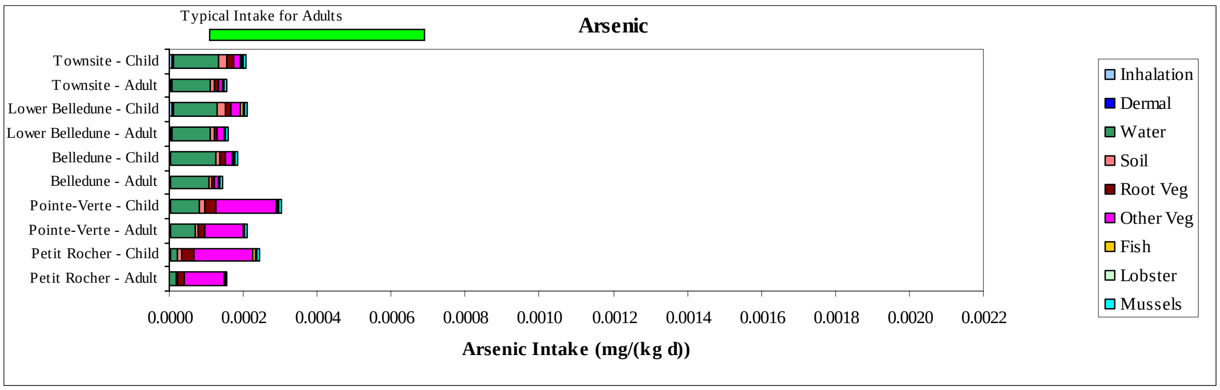
The second time period studied (1975-1984) showed very similar exposure estimates for arsenic compared to the first period. Similarly, the oral TRV was not predicted to be exceeded at any location as illustrated in Figure 2.12 below. Well water and backyard vegetables are the major pathways of exposure. Incremental risks for this time period were estimated to be above the acceptable risk level in Townsite #2 and Lower Belledune in this time period. Similarly, incremental ingestion risks are above the acceptable level in Lower Belledune and Pointe-Verte. This is mainly due to a lack of baseline data for backyard vegetables. As such, incremental ingestion risks are overestimated. Summing the incremental risks results in the acceptable risk level being exceeded at all study areas with the exception of Petit-Rocher.

Figure 2.12: Predicted Intakes of Arsenic (Best Estimate) – 1975 to 1984



By the 1985-1999 time period, exposure to arsenic had increased slightly, with the backyard vegetable pathway, (mainly aboveground vegetables) increasing above other time periods (see Figure 2.13). All best estimate exposures were not predicted to exceed the oral TRV for any location. The incremental inhalation risks were estimated to be slightly lower than the previous time period; however, the incremental ingestion risks have increased over the acceptable risk level of 1 x 10-5 in Pointe-Verte and Petit-Rocher. This is due to the lack of baseline data for backyard vegetables and thus the incremental risks have been over estimated.

Figure 2.13: Predicted Intakes of Arsenic (Best Estimate) – 1985 to 1999



As will be discussed in the next section, the current estimated exposure to arsenic decreases to below historical levels.

2.7 Summary of current exposure findings

This section contains the summary of findings for current exposure levels to each COPC. In order to describe the potential range of exposures and the associated potential health risks, the findings are presented according to COPC with a description of the both the “best estimate” and “upper-bound” exposures according to the various receptor age groups (.i.e., adult, teen, child, toddler, infant), local seafood consumption, and various sites (e.g., Townsite #2, Pointe-Verte). The adult and child exposures are provided in figures as an example, the other life stages are provided in a summary table at the end of this section.

2.7.1 Current exposure to arsenic

As illustrated in Figure 2.14, the predicted arsenic exposures for the best estimates for an average seafood eater (adult and child) are below the oral arsenic TRV. Intakes for infants, toddlers and teens are also below the oral TRV. As seen in Figure 2.14 and Figure 2.15, the inhalation pathway is insignificant and thus a comparison to the oral TRV is appropriate. The figures also show that supermarket food is the most significant pathway for arsenic exposure. The total intakes due to arsenic exposure for adults are within the typical intakes for the general Canadian population. The upper bound estimates for average seafood eating adults are slightly higher than typical background exposures but are still below the oral TRV. Exposures for other life stages are not predicted to exceed the oral TRV.

As well, these figures demonstrate that the primary pathway for exposure is consumption of well water. Soil ingestion and backyard vegetables are minor pathways and dermal contact is insignificant.

The incremental inhalation risks in Townsite #2 and Lower Belledune are above an acceptable risk of 1 x 10^{-5}; however, it should be pointed out that the predicted air concentrations are not different from those experienced in other areas in Canada. Incremental inhalation risks have not been calculated for Petit-Rocher since the arsenic air concentrations are within baseline levels. Incremental ingestion risks are the same in all study areas and are above an acceptable risk level of 1 x 10^{-5}. This is due to the fact that background exposures to garden vegetables have not been accounted for in the assessment. Therefore, the incremental ingestion risks are over estimated. .

Figure 2.14: Predicted Intakes of Arsenic (Best Estimate) – Current

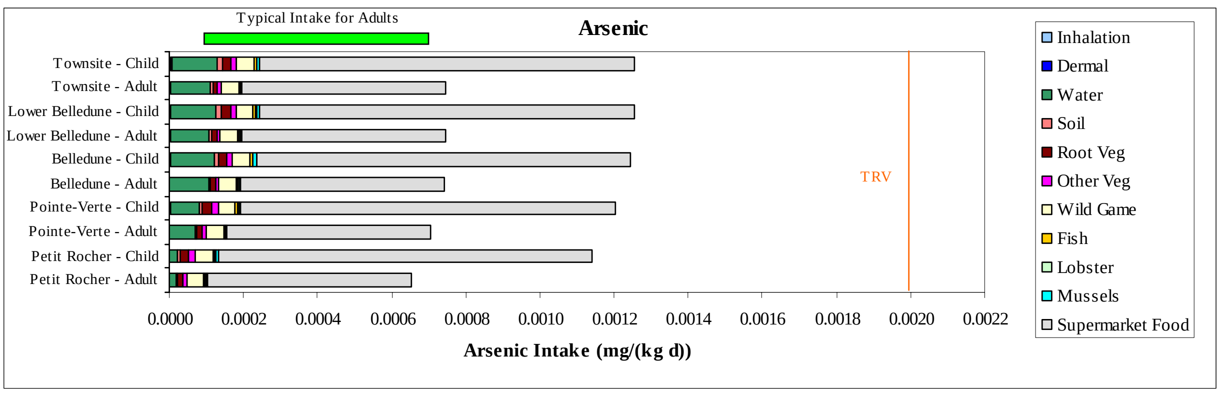
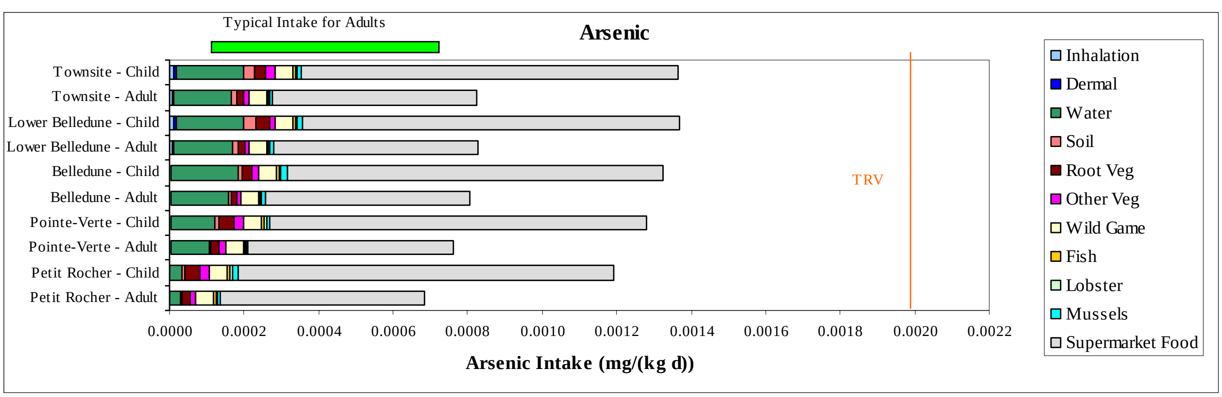


Figure 2.15: Predicted Intakes of Arsenic (Upper Bound) – Current



2.7.2 Current exposure to cadmium

As seen in Figure 2.16, best estimate or average environmental concentrations result in exposures for all locations that are below the oral TRV for cadmium, with the exception of the child in Lower Belledune. Supermarket foods account for the majority of the exposure. The inhalation pathway is insignificant and as such a comparison of the intakes of the oral TRV is appropriate.

At the upper bound estimates (Figure 2.17), exposures for children in Townsite #2 and Lower Belledune exceed the TRV. The primary pathway of exposure is supermarket food. Consumption of wild mussels is also a major pathway. At the upper bound estimates, infants, toddlers and teens do not exceed the oral TRV. As previously mentioned, cadmium is a carcinogen via the inhalation pathway. The predicted air concentrations of cadmium are within baseline and thus there are no incremental inhalation risks associated with cadmium in the air.

Figure 2.16: Predicted Intakes of Cadmium (Best Estimate) – Current

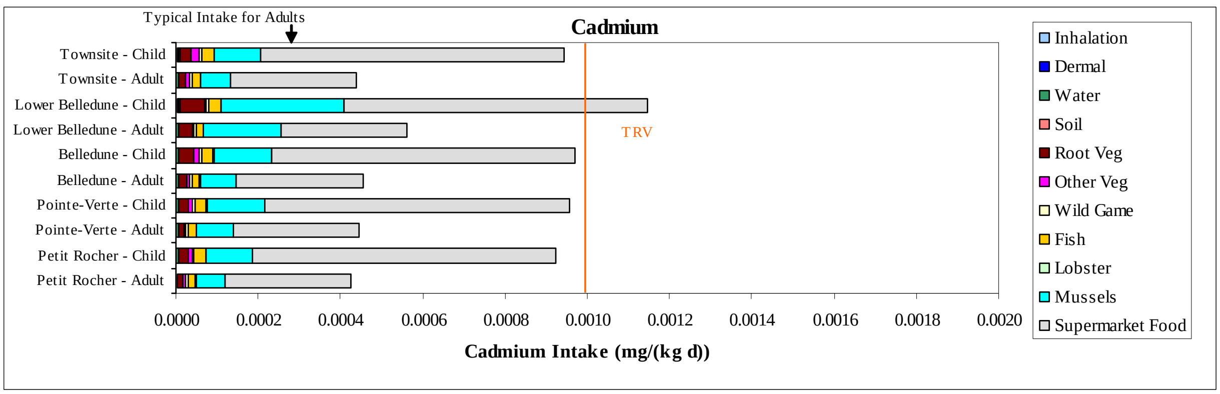
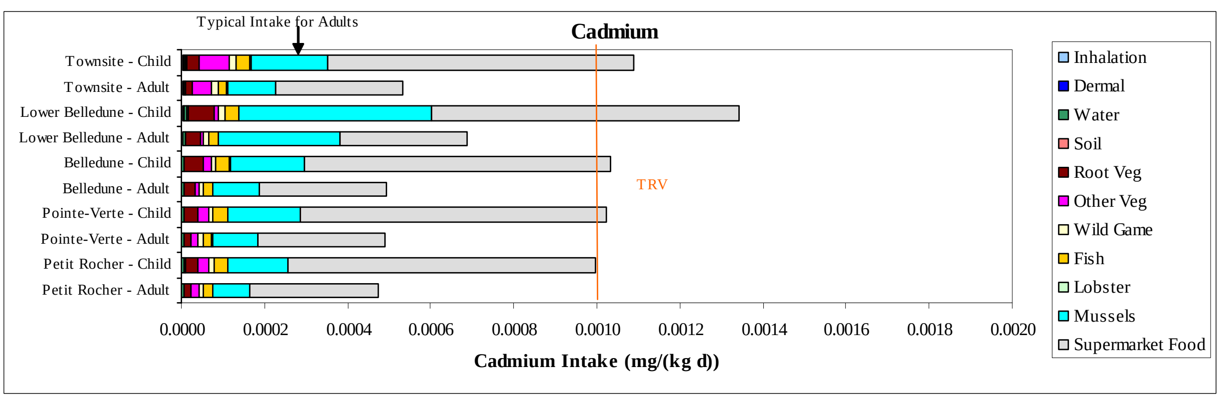


Figure 2.17: Predicted Intakes of Cadmium (Upper Bound) – Current



2.7.3 Current exposure to chromium

Current exposure estimates for chromium were all well below the oral TRV level.

2.7.4 Current exposure to lead

Figure 2.18 demonstrates that the best estimates or average environmental concentrations result in exposures for child and adult receptors that are below the oral TRV with the exception of children in Lower Belledune. The major pathways of exposure for children in Lower Belledune are consumption of local wild mussels and fish. There is large uncertainty surrounding the COPC concentrations in fish due to the use of data that were collected prior to 1985. The uncertainties in the fish data need to be addressed by conducting a fish sampling program in the Baie des Chaleurs.

At the upper bound estimate, there are several more receptors that have exposures that exceed the oral TRV, namely infant, toddler and child receptors in Townsite #2, and the toddler, child, teen and adult in Lower Belledune. The major pathways of exposure for the infant and toddler include garden vegetables and soil. Garden vegetables contribute most to exposure and soil ingestion contributes secondarily. In Lower Belledune, the exposure in the toddlers is mainly due to soil ingestion. Among other age groups, the consumption of local wild mussels and fish dominate the exposures. The supermarket food intakes are not a predominant pathway in the exposure of lead.

Figure 2.18: Predicted Intakes of Lead (Best Estimate) – Current

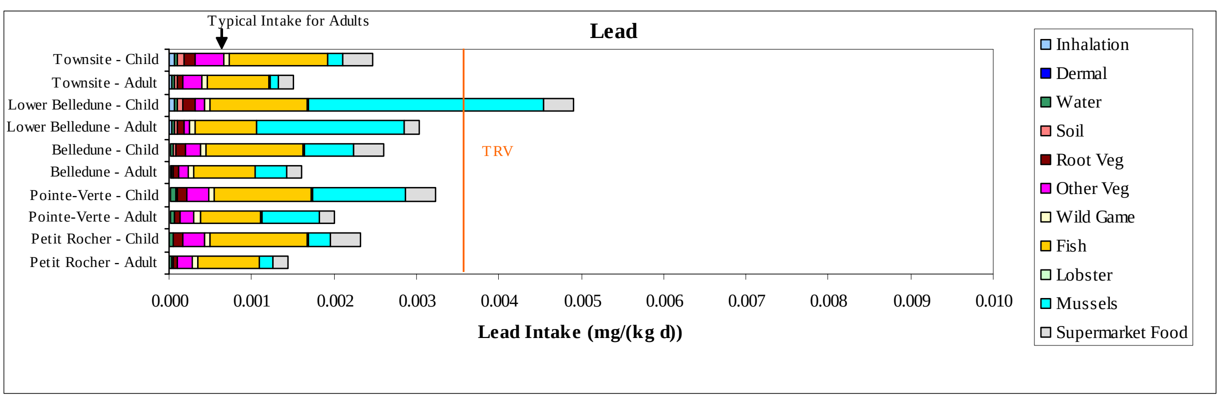
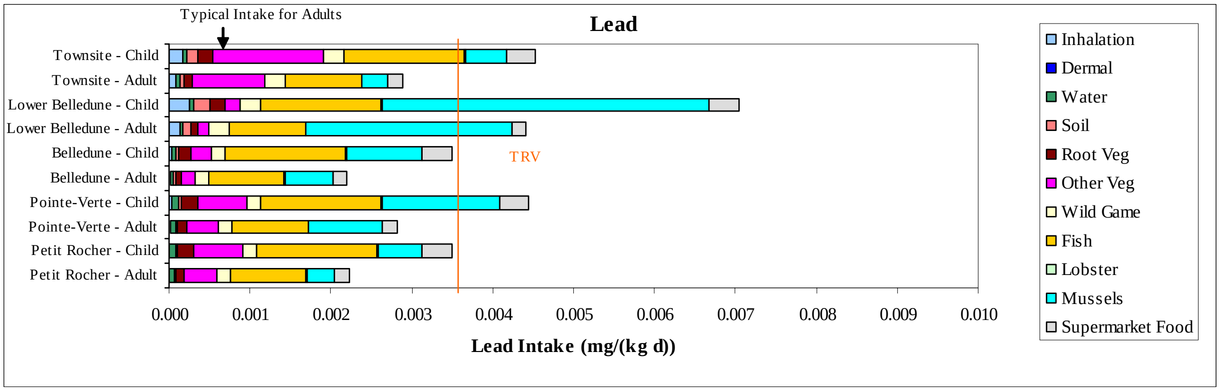


Figure 2.19: Predicted Intakes of Lead (Upper Bound) – Current



2.7.5 Current exposure to mercury

Current exposure estimates based on the best estimate environmental concentrations for mercury were all below the TRV for methyl mercury as seen in Figures 2.20. Methyl mercury which has a high toxicity is the form of mercury that is found in seafood tissue. The predominant pathway is supermarket foods followed by ingestion of fish.

At the upper bound estimate, children in Pointe-Verte and Petit-Rocher meet or exceed the TRV (Figure 2.21). This is due mainly to supermarket food and fish exposure. As previously discussed, the concentrations in fish are highly uncertain since they are based on data that is 20 years old. Supermarket food intakes are uncertain since they are based on the entire Canadian population and not just northern New Brunswick.

Figure 2.20: Predicted Intakes of Mercury (Best Estimate) – Current

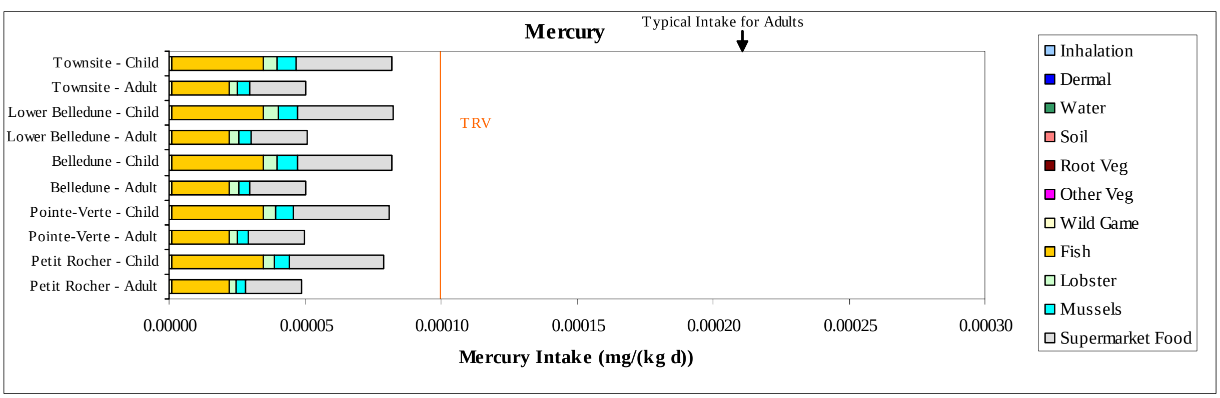
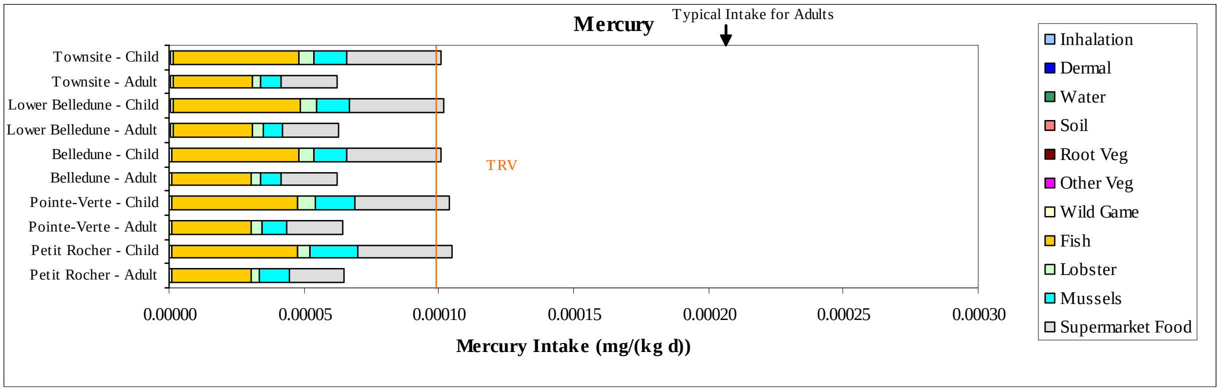


Figure 2.21: Predicted Intakes of Mercury (Upper Bound) – Current



2.7.6 Current exposure to thallium

Current exposure estimates based on best estimate (average) environmental concentrations for thallium are above the TRV for children and toddlers as seen in Figures 2.22. This is due primarily to the consumption of supermarket foods. This data is uncertain and should be considered in this light when reviewing the results for thallium. Intakes of thallium from local sources other than supermarket foods are well below the TRV. Well water is a significant pathway of exposure in Pointe-Verte and Petit-Rocher; however, this is potentially misleading since thallium concentrations were measured below the detection limit in all of the study areas. The differences between Pointe-Verte and Petit-Rocher and the other study areas is that the detection limit is 10 times higher in these two areas (1 μg/L) as compared to the other study areas (0.1 μg/L).

Figure 2.22: Predicted Intakes of Thallium (Best Estimate) – Current

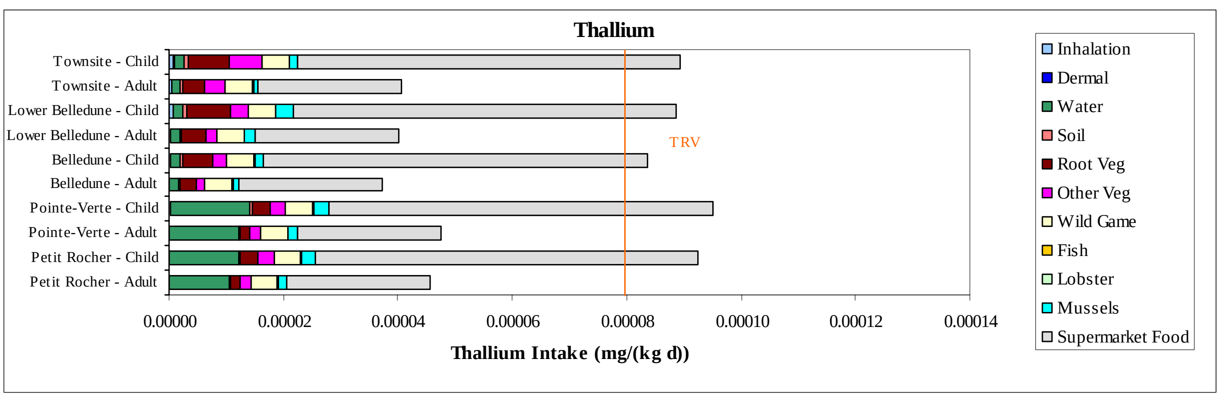
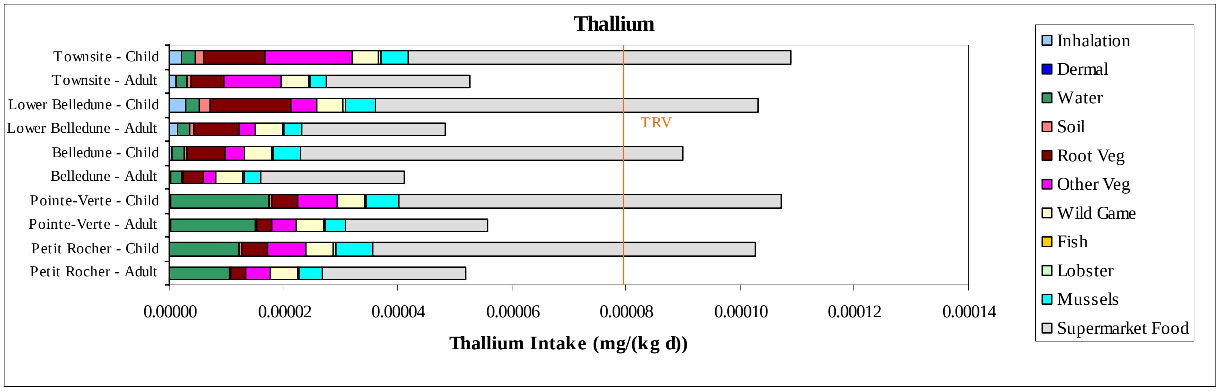


Figure 2.23: Predicted Intakes of Thallium (Upper Bound) – Current



2.7.7 Current exposure to zinc

Current exposure estimates for zinc are totally dominated by the supermarket food pathway and result in exposures for children, toddlers and infants being above the TRV. As seen in Figures 2.24 and 2.25, local intakes of zinc are well below the TRV. As previously mentioned, the supermarket food pathway is uncertain and the figures show that the typical intakes of supermarket foods for children are well above the TRV. This indicates the uncertainty in both the supermarket food estimates and the development of the zinc TRV.

Figure 2.24: Predicted Intakes of Zinc (Best Estimate) – Current

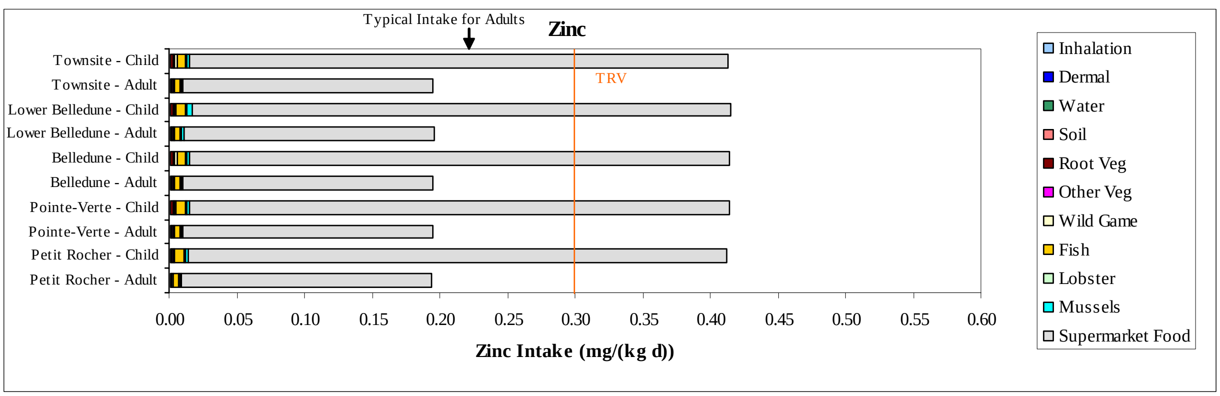
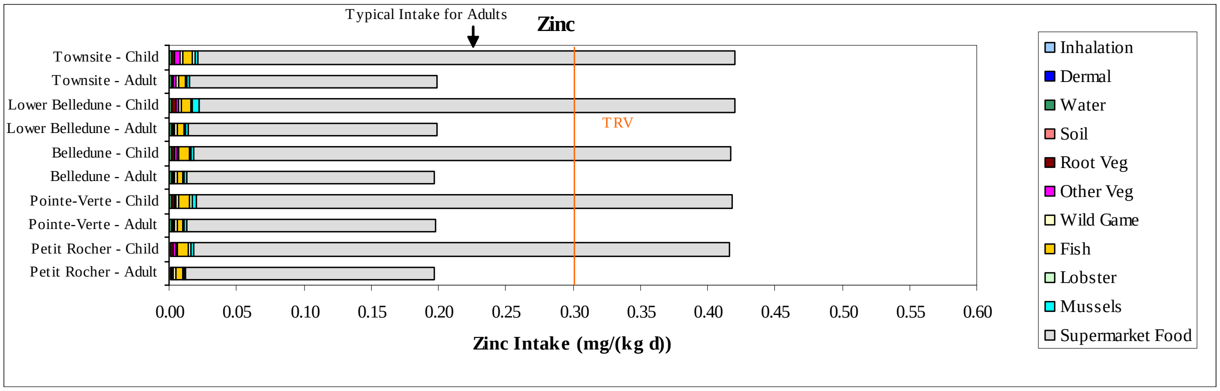


Figure 2.25: Predicted Intakes of Zinc (Upper Bound) – Current



2.7.8 Current exposure to dioxins and furans

None of the estimates for any of the receptor groups for exposure to dioxins and furans met or exceeded the TRV. There is some uncertainty in the estimated concentrations for dioxins and furans due to limited numbers of samples; however, all exposure estimates are at least 2 to 3 orders of magnitude lower than the TRV indicating that dioxins and furans are not a cause for concern currently in the GBA.

2.7.9 Summary of current exposures

Table 2.2 below contains a summary of the findings presented in Section 2.7 for the areas closest to the industrial activities (i.e., Townsite #2 and Lower Belledune).

Table 2.2: Summary of Estimated Current Exposures Exceeding TRVs in Most Exposed Area

	NO LOCAL SEAFOOD		AVERAGE LOCAL SEAFOOD		MAXIMUM LOCAL FISH EATER		MAXIMUM LOCAL LOBSTER EATER		MAXIMUM WILD MUSSELS EATER	
	BEST ESTIMATE	*UPPER BOUND*	*BEST ESTIMATE*	*UPPER BOUND*	*BEST ESTIMATE*	*UPPER BOUND*	*BEST ESTIMATE*	*UPPER BOUND*	*BEST ESTIMATE*	*UPPER BOUND*
Townsite #2										
Arsenic										
Cadmium				Child					Adult	Adult
Chromium										
Lead		Infant Toddler		Infant Toddler Child	Adult	Adult			Adult	Adult
Mercury				Child	Adult	Adult	Adult	Adult	Adult	Adult
Thallium	Toddler Child	Infant Toddler Child	Toddler Child	Infant Toddler Child		Adult				Adult
Zinc	Infant Toddler Child	Infant Toddler Child	Infant Toddler Child	Infant Toddler Child						
Dioxins and furans										
Lower Belledune										
Arsenic										
Cadmium			Child	Child					Adult	Adult
Chromium										
Lead			Child	Toddler Child Teen	Adult	Adult			Adult	Adult
Mercury				Child	Adult	Adult	Adult	Adult	Adult	Adult
Thallium	Infant Toddler Child	Infant Toddler Child	Toddler Child	Infant Toddler Child		Adult			Adult	Adult
Zinc	Infant Toddler Child	Infant Toddler Child	Infant Toddler Child	Infant Toddler Child						
Dioxins and furans										

Note:
- Thallium and zinc exposures for no local seafood and average local seafood eaters are dominated by supermarket food intakes. All local exposures are well below TRV.
- Cadmium and mercury exposure in the child is also primarily due to the supermarket food pathway.
- Maximum local seafood eaters are only considered to be adults since data were not available for children.

Table 2.3 below contains a summary of the findings presented in Section 2.7 for the core study area (i.e., Belledune, Pointe-Verte and Petit-Rocher).

Table 2.3: Summary of Estimated Current Exposures Exceeding TRVs in the Core Study Area

	NO LOCAL SEAFOOD		AVERAGE LOCAL SEAFOOD		MAXIMUM LOCAL FISH EATER		MAXIMUM LOCAL LOBSTER EATER		MAXIMUM WILD MUSSELS EATER	
	BEST ESTIMATE	*UPPER BOUND*	*BEST ESTIMATE*	*UPPER BOUND*	*BEST ESTIMATE*	*UPPER BOUND*	*BEST ESTIMATE*	*UPPER BOUND*	*BEST ESTIMATE*	*UPPER BOUND*
Belledune										
Arsenic										
Cadmium				Child					Adult	Adult
Chromium										
Lead					Adult	Adult			Adult	Adult
Mercury				Child	Adult	Adult	Adult	Adult	Adult	Adult
Thallium	Toddler Child	Toddler Child	Toddler Child	Toddler Child						Adult
Zinc	Infant Toddler Child	Infant Toddler Child	Infant Toddler Child	Infant Toddler Child						
Dioxins and furans										
Pointe-Verte										
Arsenic										
Cadmium				Child					Adult	Adult
Chromium										
Lead				Child	Adult	Adult			Adult	Adult
Mercury				Child	Adult	Adult	Adult	Adult	Adult	Adult
Thallium	Toddler Child	Infant Toddler Child	Toddler Child	Infant Toddler Child					Adult	Adult
Zinc	Infant Toddler Child	Infant Toddler Child	Infant Toddler Child	Infant Toddler Child						
Dioxins and furans										
Petit-Rocher										
Arsenic										
Cadmium									Adult	Adult
Chromium										
Lead					Adult	Adult			Adult	Adult
Mercury				Child	Adult	Adult	Adult	Adult	Adult	Adult
Thallium	Toddler Child	Toddler Child	Toddler Child	Toddler Child					Adult	Adult
Zinc	Infant Toddler Child	Infant Toddler Child	Infant Toddler Child	Infant Toddler Child						
Dioxins and furans										

Note:
- Thallium and zinc exposures for no local seafood and average local seafood eaters are dominated by supermarket food intakes. All local exposures are well below TRV.
- Cadmium and mercury exposure in the child is also primarily due to the supermarket food pathway.
- Maximum local seafood eaters are only considered to be adults since data were not available for children.

2.8 Incremental effects of industrial activities

One aspect of the study was to determine, if possible, the incremental effects that industry has had on the contribution of specific COPC into the environment. This was one aspect of the research question of "*What are the potential types and sources of* *environmental contamination?*". This set of analyses addresses in part the question of sources.

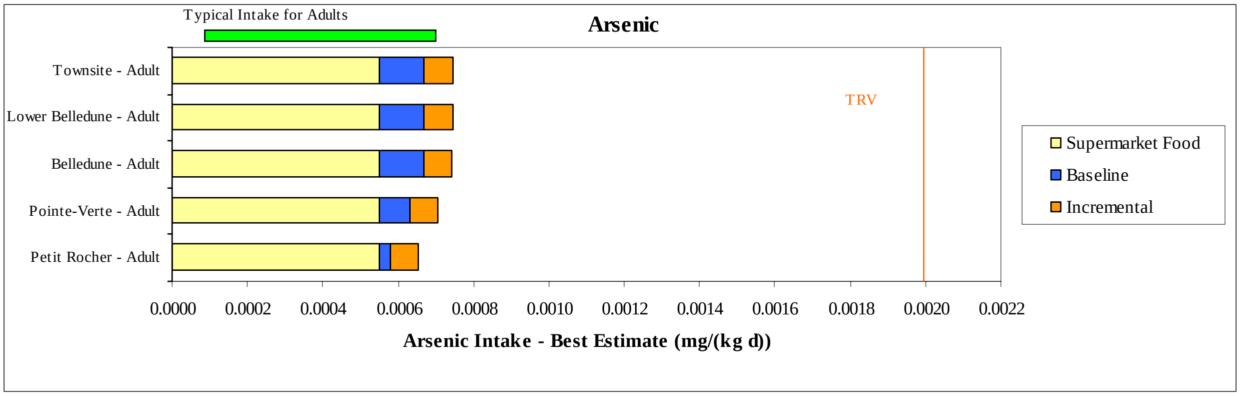
The HHRA divided the estimated *total exposure commitment* of receptor groups according to whether the source of exposure was likely due to:

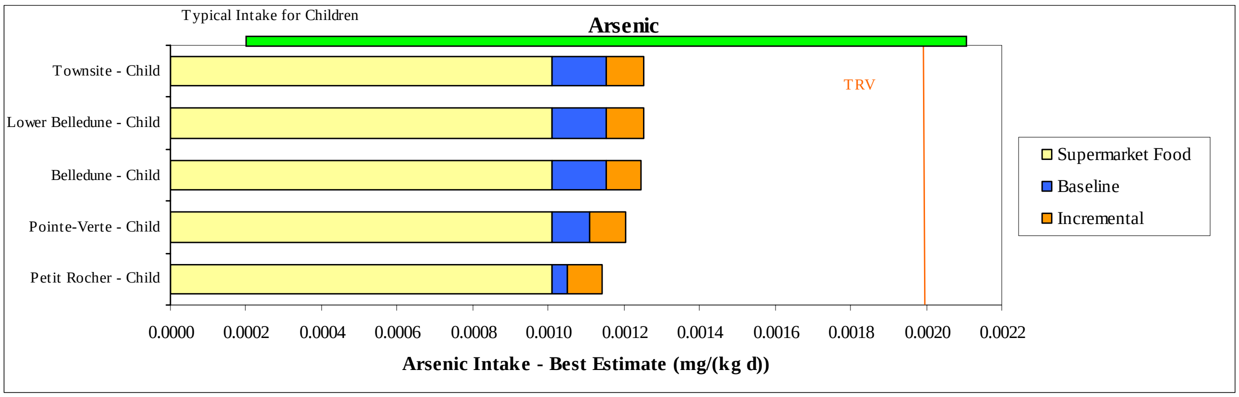
- Belledune area industrial activities;
- Baseline measures (natural and occurring due to human activities other than those related to Belledune area industrial activities); and,
- Supermarket food based on Health Canada models.

A summary of these results provided in Figures 2.26, 2.27 and 2.28 below for three of the COPC: arsenic, cadmium and lead.

Figure 2.26 illustrates the incremental contribution from the industrial facilities due to arsenic exposures.   As seen from this figure, the baseline exposures and supermarket food exposures are the major contributors to arsenic exposure. The exposure due to the industrial facilities is about 1/6 of the total indicating that the industrial facilities are not a significant contributor to arsenic in the surrounding environment. For example, the exposures due to the industrial facilities range from 7% of the total exposure for adults and children in Petit-Rocher to 11% of the total exposures in Townsite #2. In fact the incremental exposures have been over estimated since the incremental exposures are mainly due to exposure to backyard vegetables and there are no baseline concentrations of backyard vegetables.

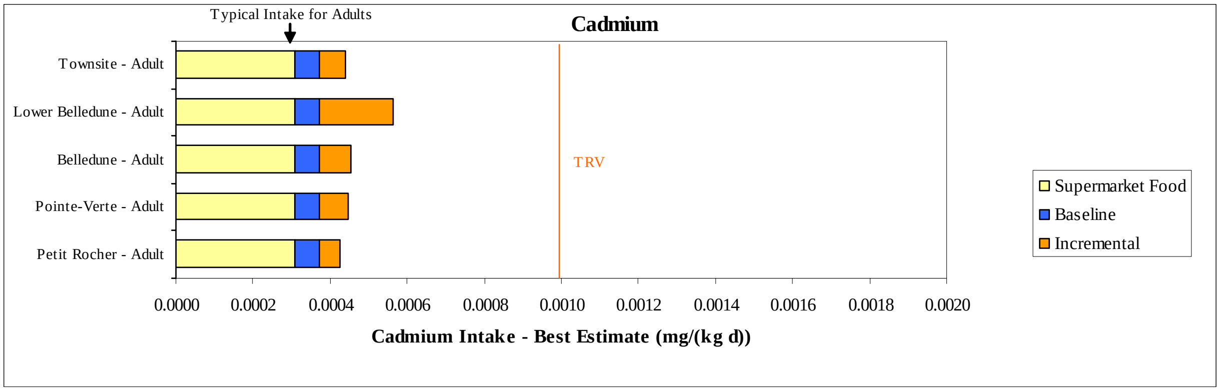
Figure 2.26: Predicted Incremental Contributions for Arsenic Exposure from the Industrial facilities (Best Estimate) – Current

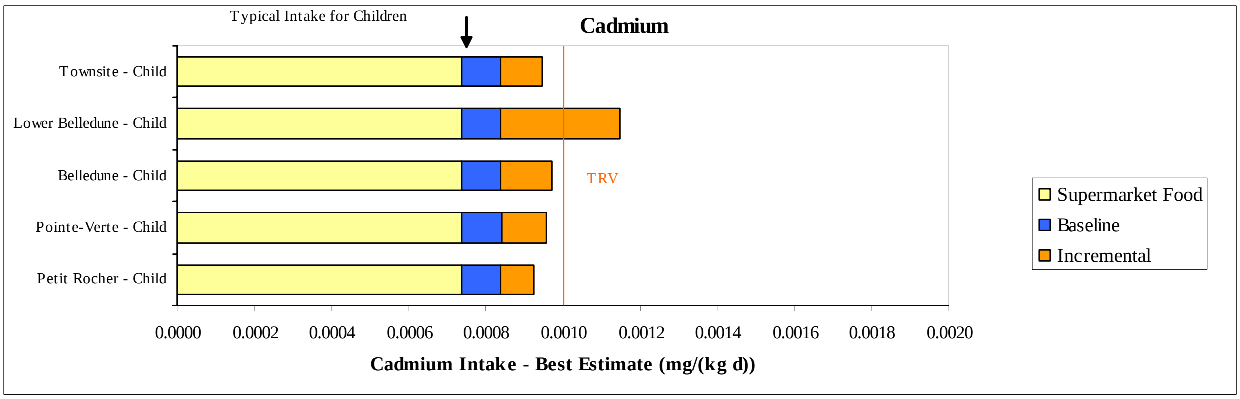




For cadmium exposures (Figure 2.27), baseline and supermarket foods are still a significant contributor to exposure; however, the industrial facilities account for about 1/3 of the total exposure, indicating that cadmium from the industrial facilities contributes to increased environmental concentrations. For example, the exposures attributable to the industrial facilities range from 9% of the exposure in Petit-Rocher to 34% of the total exposure in Lower Belledune.

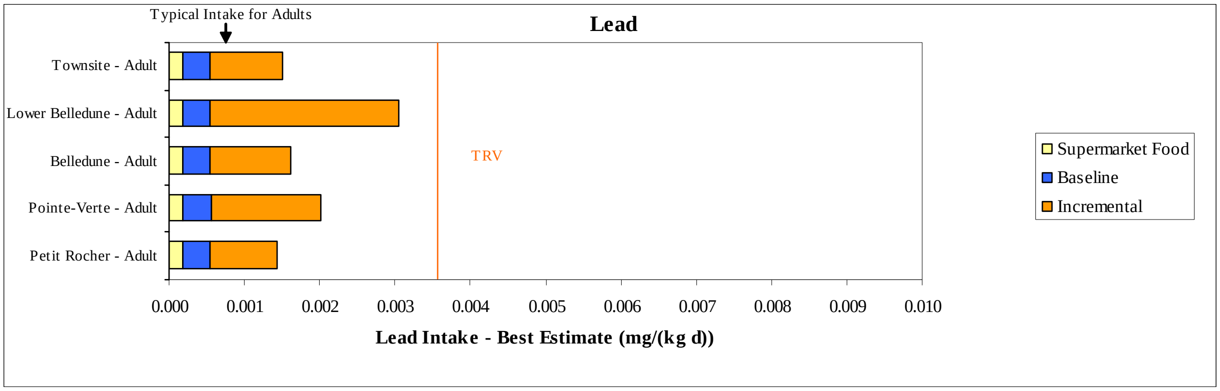
Figure 2.27: Predicted Incremental Contributions for Cadmium Exposure from the Industrial facilities (Best Estimate) – Current

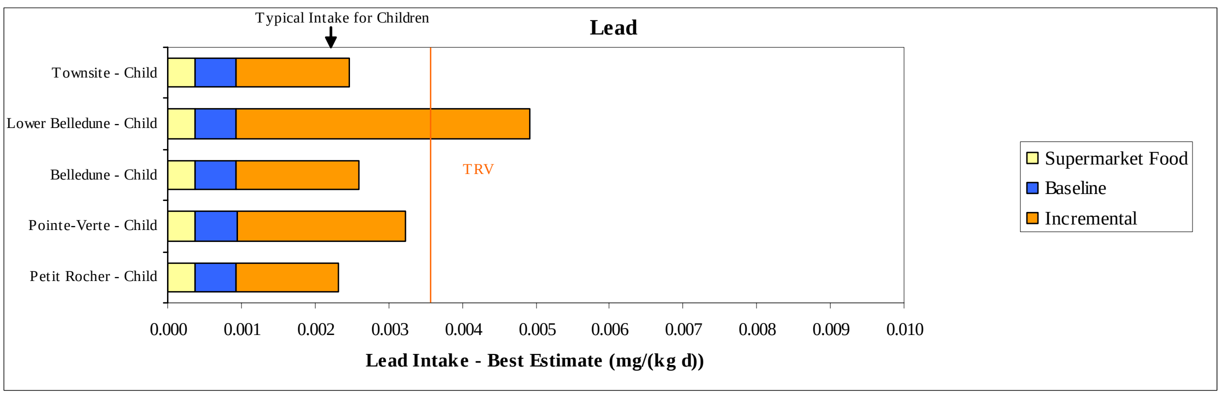




The contributions of lead from the industrial facilities to exposure (Figure 2.28) show an entirely different pattern as compared to arsenic and cadmium. In this case, the contributions of baseline and supermarket foods are very low and the contribution of the industrial facilities to the lead exposure accounts for more than 2/3 of the exposure estimates indicating that the industrial facilities are a significant contributor to lead concentrations in the community. For example, the exposures due to industrial facilities range from 62% of the total exposure in Petit-Rocher to 82% of the total exposure in Lower Belledune.

Figure 2.28: Predicted Incremental Contributions for Lead Exposure from the Industrial facilities (Best Estimate) – Current





3.0 Summary of findings from CHSA

3.1 Overall approach

The CHSA was designed to address the study research question : which follows:

> **CHSA RESEARCH QUESTION**
>
> 4. How does the health status of residents compare with other regions? New Brunswick?

Within the TORs developed for the study, the study team was guided specifically to review existing health status data for the GBA to determine if there are any significant health problems, and if there are significant health problems, determine the most likely factors responsible including environmental exposure, lifestyle, etc.

Measures of the health of a community were derived from a number of assessments of pre-existing data from the Government of NB. The use of population-based data offered the study team an advantageous way of looking at health outcomes without the influence of participation or reporting bias that is often associated with surveys of self-evaluation of health status. The population-based data used for the CHSA are systematically collected, have validated diagnoses, and receive standardized coding.

The data were analysed to examine certain geographic patterns of disease that may be related to geographic patterns of environmental exposures to COPC. This type of analysis provides one dimension of health status for the population being examined, in this case, GBA. The purpose of this study was to initially identify any health problems, generate hypotheses with respect to contributing factors (e.g., environment, lifestyle), and recommend approaches that will be able to directly address cause-effect relationships. Those rates that were found to be higher than expected will require more robust studies to try to explain the identified differences.

3.2 Selection of health status indicators

The initial steps the study team took in deciding which aspects of health status to examine under the CHSA were:

- To consult with GBA residents to determine which aspects of their health they were most concerned about (see Section 1.3);
- To review the scientific literature to determine which health impacts could be linked

coherently to the specific COPC selected for the HHRA component of the study; and,

- To review the available existing health status data for the GBA and NB to determine what health status variables could be addressed.

Of particular importance based on GBA residents' concerns was the incidence of cancer in the GBA. Residents also indicated that they felt concerned about respiratory problems, circulatory problems, child development, gastro-intestinal problems, depression/anxiety, and reproductive problems. In addition, a number of residents mentioned that they were concerned with thyroid disease in their community.

A review of the scientific literature of health impacts related to exposure to COPC tended to support the specific areas of concern expressed by GBA residents during the consultations. A review of epidemiological studies that have attempted to link disease with COPC exposure indicated that the study team should attempt to study cancer incidence, child development issues, respiratory disease, diseases of the digestive system, diseases of the urinary system, diseases of the circulatory system, diseases of the endocrine system, and reproductive issues including birth defects.

The review of existing health status data for NB indicated that the only disease-specific registry available was for cancer. Vital statistics data captured relatively complete information with respect to births (live birth or stillbirth, birth weight, gestational age, birth defect, age of mother), and deaths (cause of death, age, sex) Hospital separation data captured the most "responsible diagnosis" (e.g., respiratory disease, circulatory system disease) for patients discharged from a hospital in NB. All of these data sources used the standardized International Classification of Diseases (ICD-9 and ICD-10) to code disease outcomes. All of these data sources were also able to provide information on place of residence, so that the study team could determine rates for GBA residents and compare them with other areas of NB. The time period that was common to all data sets was 1989-2001 inclusive. As a result, this 13-year time period was used for all sets of analyses.

One of the greatest limitations to this approach was the absence of any reliable population data on child development issues given the GBA residents' specific concerns, and its potential relationship to lead as a COPC. The study team reviewed the NB Early Childhood Initiatives data set (see Appendix D), and it was determined that the data were not adequate for use in this type of study to describe population-level indicators of child development. This explains in part the study team's recommendation to carry out a pilot survey of children's blood lead levels in the potentially most impacted communities. This survey was conducted by the Department of Health and Wellness in the fall of 2004. As a result, the study team had access to biological measures of exposure for the purposes of this study (See section 4.0 for summary results of this pilot survey).

3.3 Selection of comparison populations

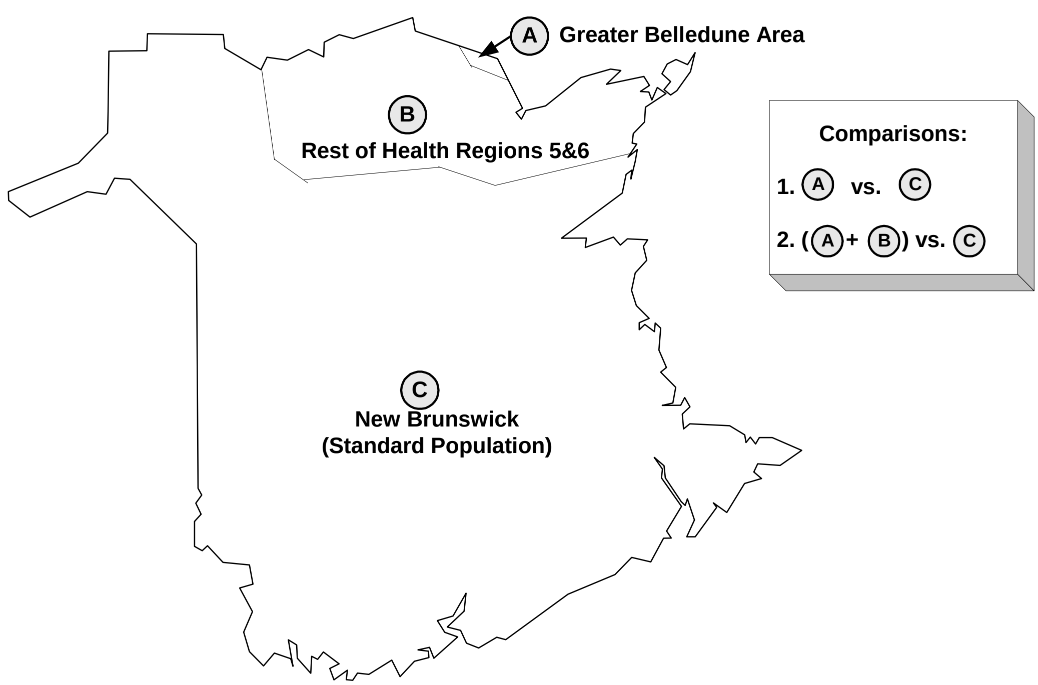
The approach used for this study is comparative to the extent that rates of disease, hospital separation, death, etc. are measured in the GBA, and then compared with rates from another population (called the reference population) to determine whether the GBA is higher, lower or approximately the same as the rate in the reference population.

There were two sets of comparisons that were made with all identified health outcomes (see Figure 3.1). The first comparison was between the GBA and the rest of NB with HR 5&6 removed. The second set of comparisons was between HR 5&6 and the rest of NB. By setting up the comparisons in this manner, the study team were able to achieve two goals:

- Determine which health problems were unique to the GBA and not consistent with the surrounding HR 5&6; and,
- Have a sufficiently large reference population (NB less HR 5&6) to have stable rates to make statistical comparisons.

In Figure 3.1 below, Greater Belledune Area (designated as A) was compared to the referent population that is all of NB (excluding HR 5&6) designated by letter C. For the second comparison, all of HR 5&6 (A+B) was compared to C.

Figure 3.1: Comparisons for CHSA



3.4 Summary of findings for reproductive outcomes

The rate ratio for live birth rates in GBA was slightly higher when compared with NB. The difference in rate ratios was not significant for the comparison between HR 5&6 and NB. There was no difference in stillbirths or birth defects. It is important to note, however, that there were very few cases of stillbirths and birth defects upon which to make this comparison. Low birth weight rates were also similar for all areas. NB has experienced favorable rates of low birth weight children in keeping with the general Canadian trends since 1990[4].

3.5 Summary of findings for mortality

The study carried out this analysis to answer the question:

SPECIFIC QUESTION
What is the mortality experience of the GBA compared to NB?

During the period 1989-2001, overall mortality in the GBA population from *all causes of death* was statistically significantly elevated when compared with what one would expect once we compared them with the number of deaths in the rest of NB (not including HR 5&6), and took into account the differences in age distribution. As illustrated in Figure 3.2 below, when the study team examined specific causes of death, it found statistically significantly more deaths in the GBA were due to *circulatory diseases* and *cancer* than expected.

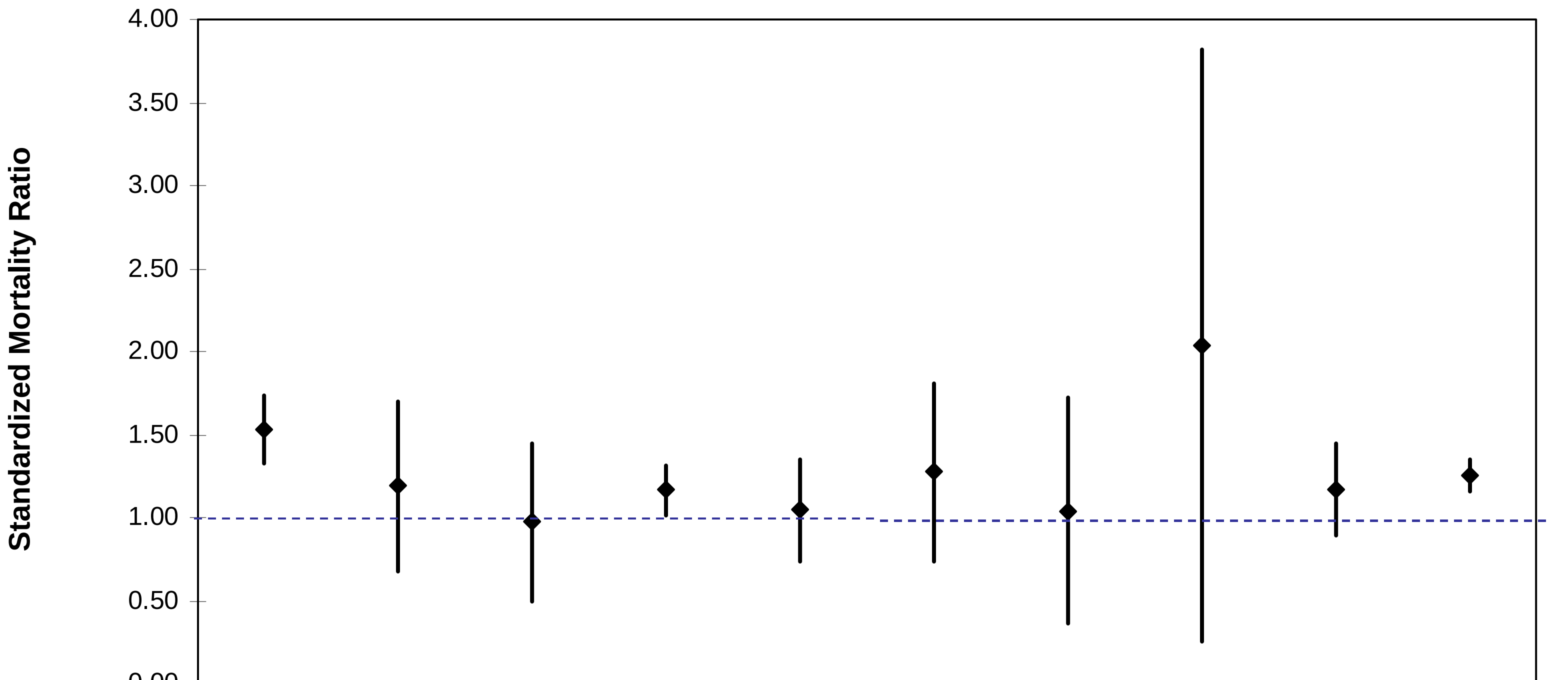
As illustrated in Figure 3.3[5], when the study team examined deaths according to sex, the same pattern as described above emerged for male deaths. One additional cause of death that was statistically elevated for males was “other causes” which include causes of death such as accidents and suicide.

As illustrated in Figure 3.4 below, when the study team examined the number of female deaths in the GBA, it was noted that the GBA male-female mortality pattern differs. Only one category for female residents of GBA, deaths due to cancer, showed results elevated (albeit not statistically significant) over what would be expected when compared to rates of death in NB.

[4] Statistics Canada (1999) and Federal Provincial Committee on Population Health.

[5] The figures used throughout this section contain a graphical depiction of Standardized Mortality Ratios, and/or Standardized Incidence Ratios. Each vertical line on the graph represents one ratio. The diamond symbol represents the exact ratio, while the vertical line on either side of the diamond represents the 95% upper/lower confidence interval for the ratio. The ratio is considered to be statistically significant if neither of the vertical lines touch the horizontal line (ratio =1.00). More details, including p-values, are provided in Appendix D.

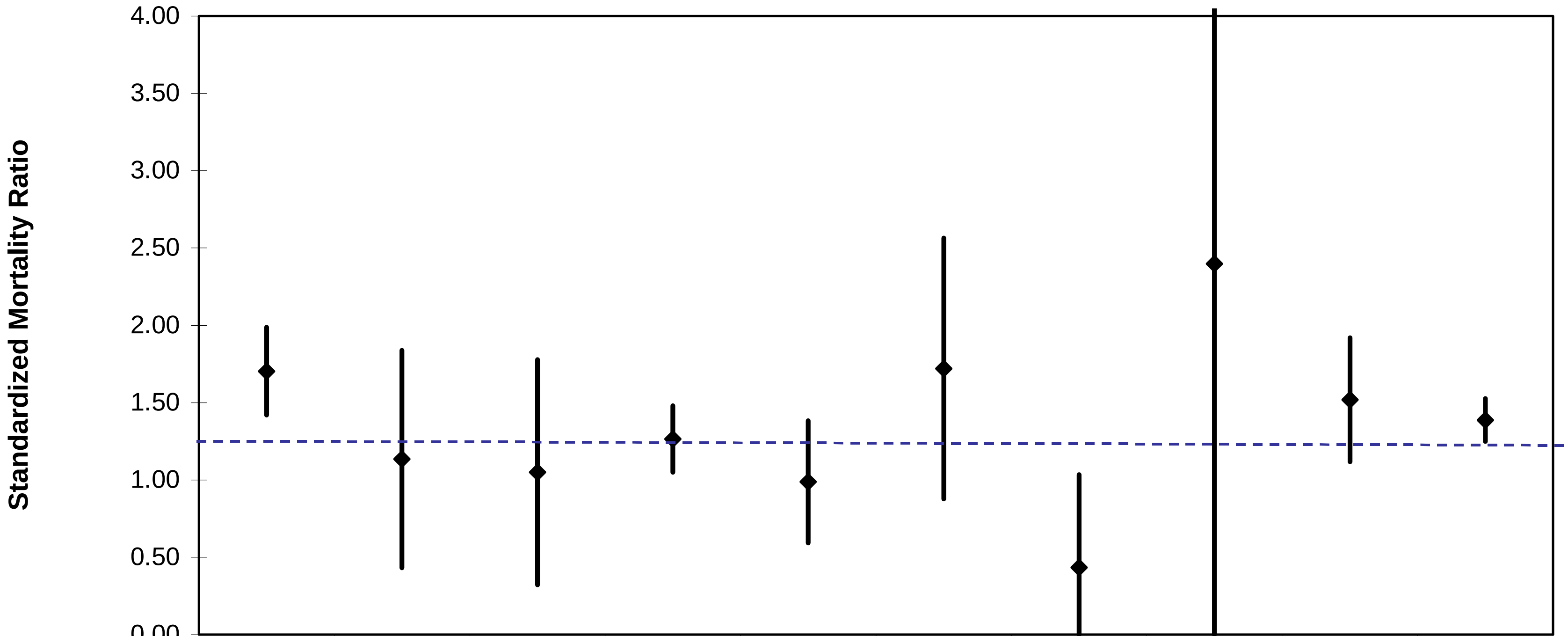
Figure 3.2: Standardised mortality ratio for selected causes of death for Greater Belledune Area, males and females combined, 1989-2001.



	Neoplasm	Endocrine & Metabolic	Nervous & Sense organs	Circulatory	Respiratory	Digestive	Genitourinary	Congenital Anomalies	Other Causes	All Causes
95% LCL	133	0.68	0.50	101	0.74	0.74	0.36	0.25	0.90	116
95% UCL	174	169	145	132	135	180	172	3.82	145	135
◆ SMR	153	119	0.97	116	105	127	104	2.03	117	125

Cause of Death

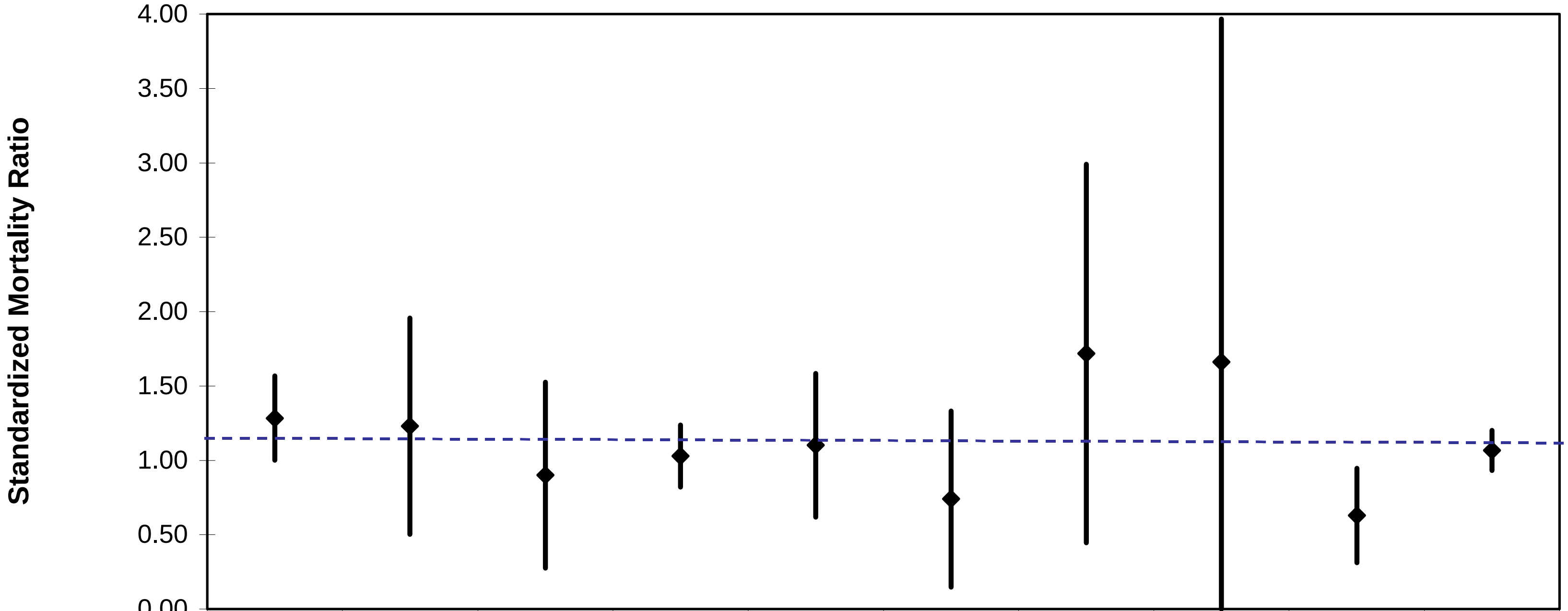
Figure 3.3: Standardised mortality ratio for selected causes of death for Greater Belledune Area, males only, 1989-2001.



	Neoplasm	Endocrine & Metabolic	Nervous & Sense organs	Circulatory	Respiratory	Digestive	Genitourinary	Congenital Anomalies	Other Causes	All Causes
95% LCL	1.42	0.43	0.32	1.05	0.59	0.88	0.00	0.00	1.12	1.25
95% UCL	1.99	1.84	1.78	1.48	1.38	2.56	1.03	5.11	1.92	1.53
◆ SMR	1.70	1.14	1.05	1.26	0.99	1.72	0.43	2.40	1.52	1.39

Cause of Death

Figure 3.4: Standardised mortality ratio for selected causes of death for Greater Belledune Area, females only, 1989-2001.



	Neoplasm	Endocrine & Metabolic	Nervous & Sense organs	Circulatory	Respiratory	Digestive	Genitourinary	Congenital Anomalies	Other Causes	All Causes
95% LCL	1.00	0.50	0.28	0.82	0.62	0.15	0.45	0.00	0.31	0.93
95% UCL	1.57	1.96	1.52	1.24	1.58	1.33	2.99	3.97	0.95	1.20
◆ SMR	1.28	1.23	0.90	1.03	1.10	0.74	1.72	1.66	0.63	1.07

Cause of Death

Once the study team determined that there were statistically significantly elevated death rates in GBA compared to NB, the next step was to attempt to discern whether these rates were characteristic of the surrounding areas as well (i.e., HR 5&6), or were they specific to the GBA. To determine this, the next question that guided the analyses was:

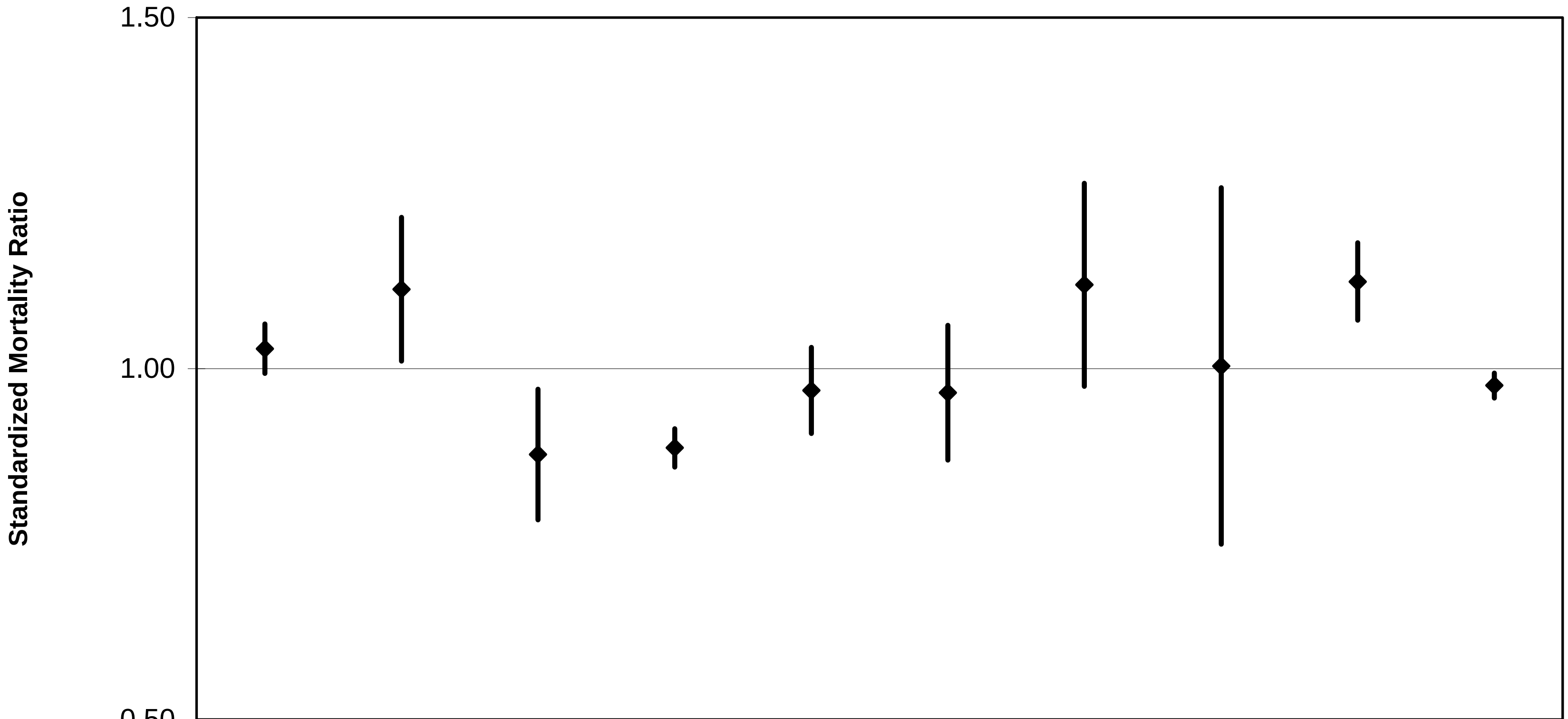
SPECIFIC QUESTION
Is the GBA experience similar to that found in HR 5&6?

The pattern of mortality found in GBA does not appear to match that found for HR 5&6 overall. As demonstrated in Figure 3.5, when compared with the rest of NB, the residents of HR 5&6 (which includes GBA) have statistically significantly elevated numbers of deaths due to *endocrine and metabolic diseases*, and "*other causes*", which is a different pattern from GBA (*all causes*, *circulatory diseases* and *cancer* – see Figure 3.2).

As illustrated in Figure 3.6, when male residents of HR5&6 were compared with the rest of NB males, they had an elevated number of deaths due to "*other causes*", similar to the pattern found in GBA. However, males in HR 5&6 did not have elevated results for deaths from *all causes*, *circulatory*, or *cancer* as was found among GBA male residents.

The pattern for mortality among female residents of HR 5&6 was different from that found among female residents of GBA. As illustrated in Figure 3.7, overall, female residents in HR 5&6 had *fewer deaths* than expected when compared with NB. With respect to specific causes of death, female residents of HR 5&6, compared with the rest of NB females, have an elevated number of deaths due to *endocrine and metabolic diseases* and fewer deaths than expected due to *circulatory* and *respiratory disease.*

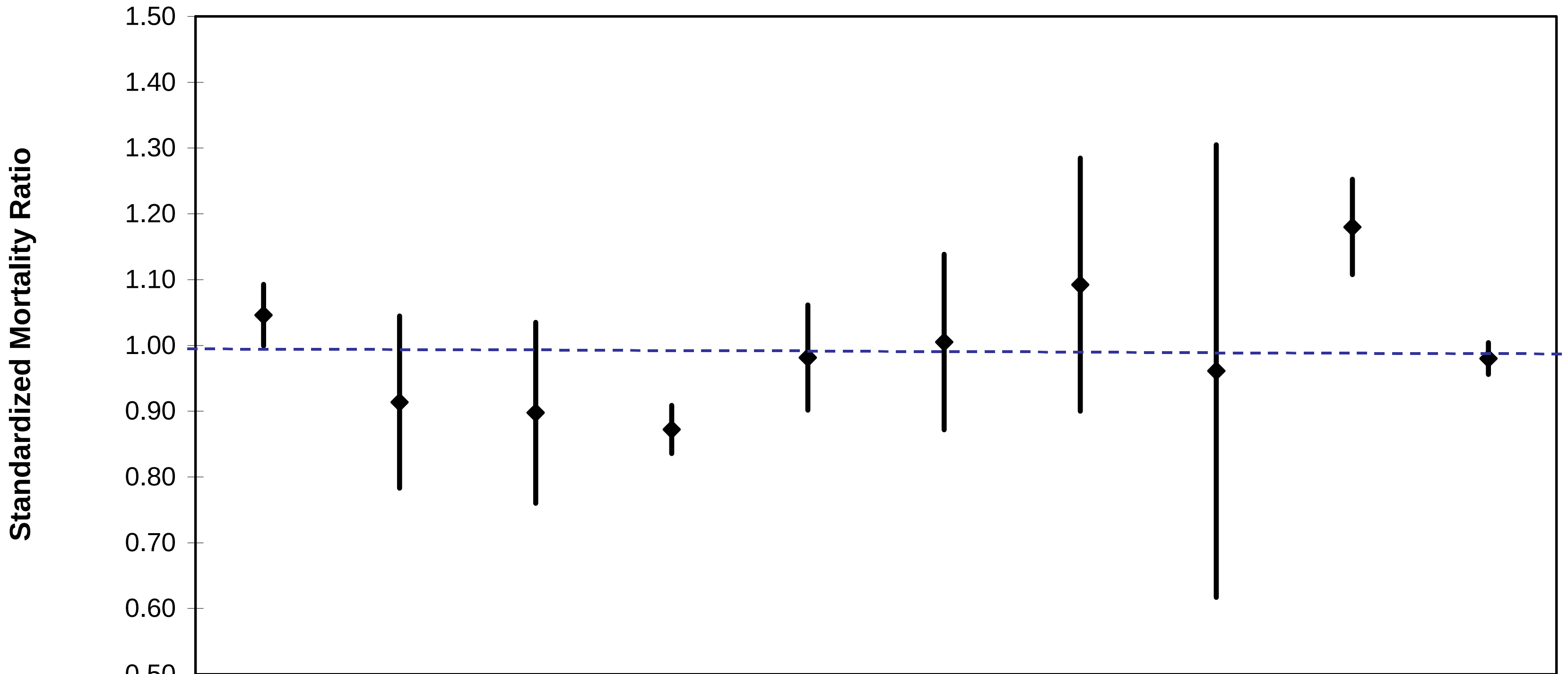
Figure 3.5: Standardized mortality ratios for selected caused of death for HR 5&6 for males and females combined, 1989-2001.



	Neoplasm	Endocrine & Metabolic	Nervous & Sense organs	Circulatory	Respiratory	Digestive	Genitourinary	Congenital Anomalies	Other Causes	All Causes
95% LCL	0.99	1.01	0.78	0.86	0.91	0.87	0.97	0.75	1.07	0.96
95% UCL	1.06	1.22	0.97	0.91	1.03	1.06	1.26	1.26	1.18	0.99
◆ SMR	1.03	1.11	0.88	0.89	0.97	0.97	1.12	1.00	1.12	0.98

Cause of Death

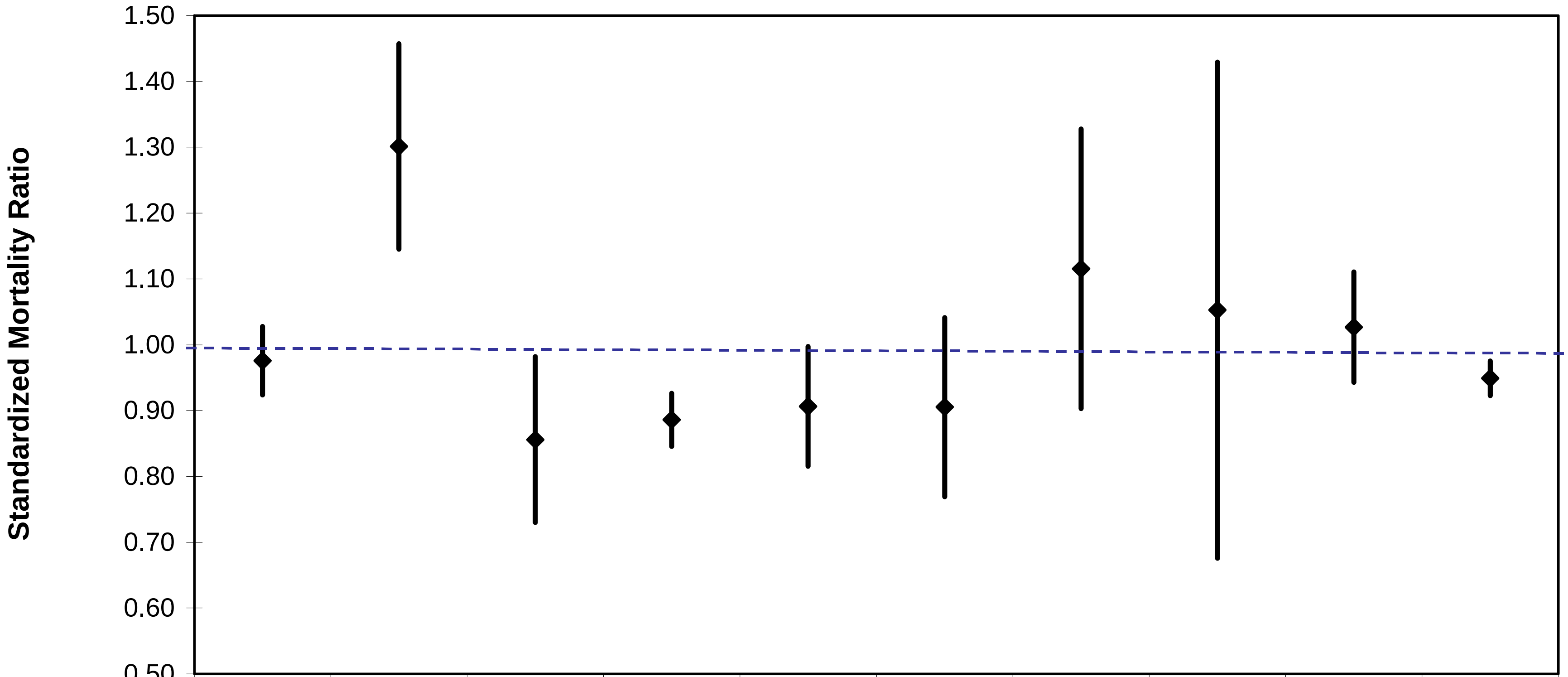
Figure 3.6: Standardized mortality ratios for selected caused of death for HR 5&6 for males, 1989-2001.



	Neoplasm	Endocrine & Metabolic	Nervous & Sense organs	Circulatory	Respiratory	Digestive	Genitourinary	Congenital Anomalies	Other Causes	All Causes
95% LCL	1.00	0.78	0.76	0.84	0.90	0.87	0.90	0.62	1.11	0.96
95% UCL	1.09	1.04	1.03	0.91	1.06	1.14	1.28	1.31	1.25	1.00
◆ SMR	1.05	0.91	0.90	0.87	0.98	1.01	1.09	0.96	1.18	0.98

Cause of Death

Figure 3.7: Standardized mortality ratios for selected caused of death for HR 5&6 for females, 1989-2001.



	Neoplasm	Endocrine & Metabolic	Nervous & Sense organs	Circulatory	Respiratory	Digestive	Genitourinary	Congenital Anomalies	Other Causes	All Causes
95% LCL	0.92	1.15	0.73	0.85	0.82	0.77	0.90	0.68	0.94	0.92
95% UCL	1.03	1.46	0.98	0.93	1.00	1.04	1.33	1.43	1.11	0.98
◆ SMR	0.98	1.30	0.86	0.89	0.91	0.91	1.12	1.05	1.03	0.95

Cause of Death

3.6 Summary of findings for cancer incidence

Cancer incidence is the occurrence of a new case of malignant cancer in a given period. Cancer was one main health concern consistently identified in the community consultations and was also potentially related to exposure to some of the COPC identified in the HHRA component of the study. In order to address this concern, the study team initially studied the question:

> **SPECIFIC QUESTION**
> What is the incidence of cancer in the GBA compared to NB?

As illustrated in Figure 3.8, during the period of 1989-2001, the incidence of *cancer overall* ("all cancer") was found to be statistically significantly elevated among GBA residents when compared with NB once differences in age were taken into account. In addition to all cancers combined, the study team examined incidence of specific cancer sites. The incidence of *respiratory, oral, stomach* and *prostate* cancer were statistically significantly higher than expected for GBA residents when compared with NB. The observed number of *kidney cancer* and *colorectal cancer* were also found to be elevated (although not statistically significant).

When cancer incidence was analysed by sex, incidence among males was generally higher than expected when compared with females. For *all cancers* combined, the standardized incidence ratio among men was higher than that for females. (Males; SIR=1.53, 95%: CI 1.34-1.72, Females: SIR=1.13, 95% CI: 0.95-1.31). Similarly, for *respiratory cancers* in males, cancer incidence was approximately 83% higher than expected (SIR=1.83, 95%:1.39-2.27) while in females, cancer risk was 33% higher (SIR=1.33, 95%:0.79-1.88). Although the point estimate for female respiratory cancer risk was higher than expected, the excess risk was not statistically significant.[6]

For *stomach* and *oral* cancers, the standardized incidence ratios for males were also generally higher than females, however, these analyses were based on very few observations. Therefore, caution must be exercised in interpreting these results due to errors associated with random variation of small sample sizes.

Cancer incidence among children and teens (less than 20 years of age) was not statistically significantly elevated when all cancer sites were considered together. Similarly, the incidence of leukemia or Hodgkin's disease was also not statistically significantly elevated among children and teens residing in the GBA.

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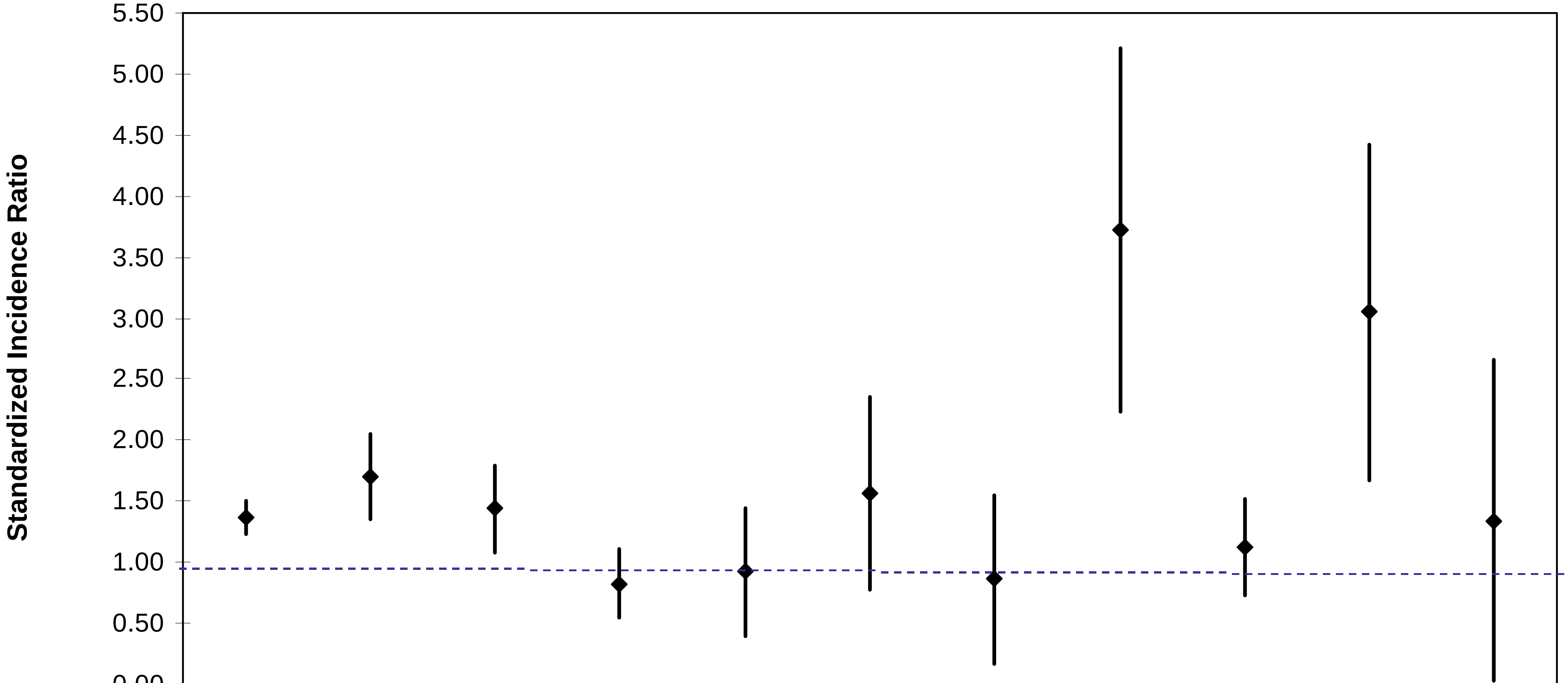
[6] Site-specific respiratory cancer was also examined. Most of the cancer in the "Respiratory Cancer" category were cancer of the trachea, bronchus, and lung (ICD9: 162), therefore, the ratios for those classified as ICD9: 162 were similar to that of the entire respiratory cancer category. Risk estimate for respiratory cancer other than ICD9:162 are not presented for GBA due to very few or no observations.

Figure 3.8: Cancer in GBA – (1989-2001)



	All Causes	Respiratory cancers	Prostate	Breast	Bladder	Kidney	Pancreatic	Stomach	Colorectal	Oral cancers	Thyroid
95%LCL	123	135	108	0.55	0.40	0.77	0.17	2.23	0.73	168	0.03
95%UCL	150	2.05	179	111	144	2.36	155	5.22	152	4.42	2.65
◆ SIR	136	170	144	0.83	0.92	157	0.86	3.72	112	3.05	134

Cancer

The statistically significantly elevated cancer incidence rates in GBA led to the next comparison that assisted the study team in determining whether these elevated rates were characteristic of the surrounding areas as well (i.e., HR 5&6), or were they specific to the GBA. To determine this, the next question that guided the analyses was:

SPECIFIC QUESTION

Is the GBA experience with cancer incidence similar to that found in HR 5&6?

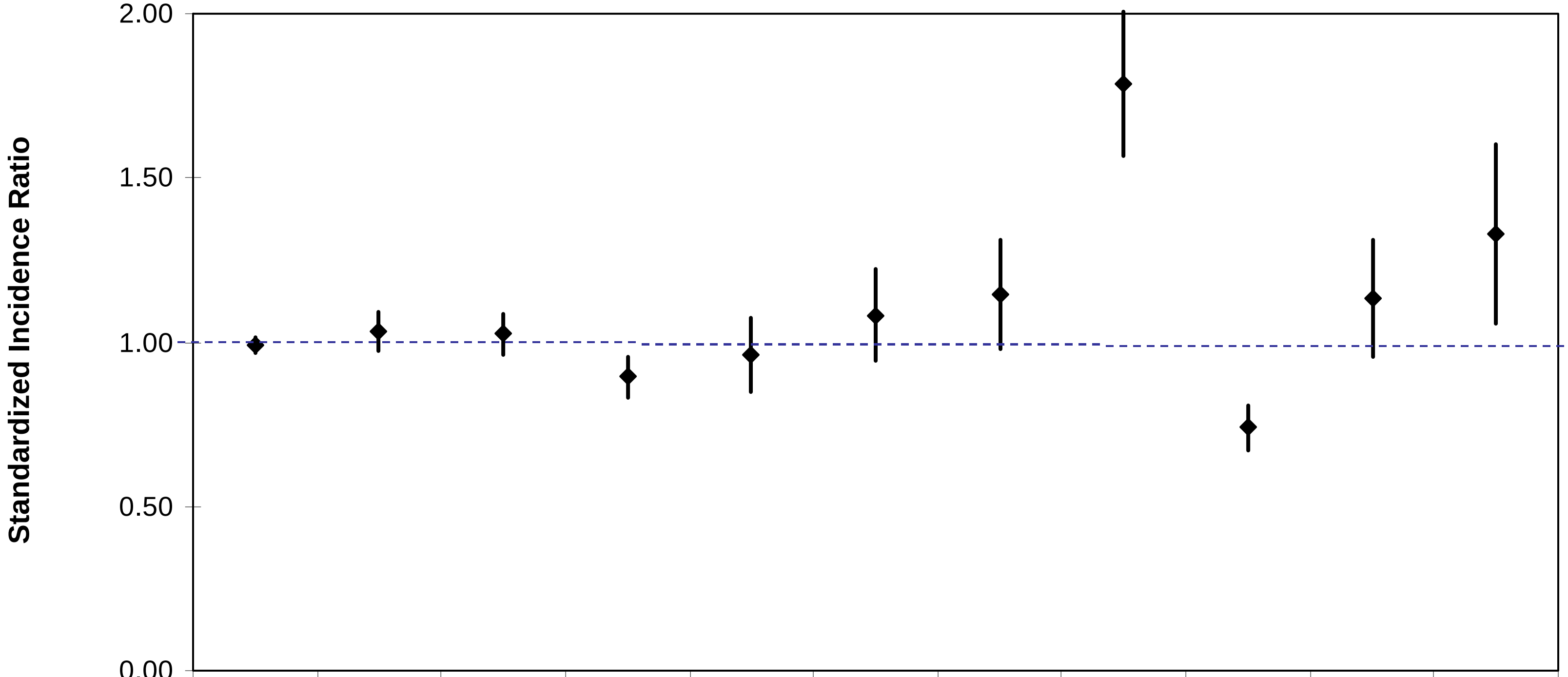
As illustrated in Figure 3.9 below, the pattern of *overall cancer* incidence found in GBA does not appear to match that found for HR 5&6 when "all cancers" were examined. With respect to specific cancer sites, HR 5&6 had statistically elevated standardized incidence ratios of *stomach* and *thyroid* cancer, and statistically lower than expected standardized incidence ratios for *female breast* cancer and *colorectal* cancer.

When stratified by sex, female's thyroid cancers (SIR= 1.42, 95% CI: 1.10-1.75) were significantly higher than expected when compared with male's thyroid cancer (SIR= 1.06, 95% CI: 0.57-1.55).

The standardized incidence ratio for stomach and thyroid cancer are statistically significantly higher in HR 5&6 than in the rest of NB while breast cancer and colorectal cancer is statistically significantly lower in HR 5&6 than in the rest of NB. Stomach cancer rates are higher than NB standard population in both GBA and HR 5&6, a shared pattern.

Similar to the pattern of what was found in the GBA, cancer incidence among children and teens (less than 20 years of age) was not statistically significantly elevated when all cancer sites were considered together. Similarly, the incidence of leukemia or Hodgkin's disease were also not statistically significantly elevated among children and teens residing in HR 5&6.

Figure 3.9: Cancer in HR 5&6 – (1989-2001)



	All Causes	Respiratory cancers	Prostate	Breast	Bladder	Kidney	Pancreatic	Stomach	Colorectal	Oral cancers	Thyroid
95%LCL	0.96	0.97	0.96	0.83	0.85	0.94	0.98	157	0.67	0.95	105
95%UCL	101	109	109	0.96	107	122	131	2.00	0.81	131	160
◆ SIR	0.99	103	102	0.90	0.96	108	114	179	0.74	113	133

Cancer

3.7 Summary of findings for hospital separations

The overall hospital separation rate was higher in both GBA and in HR 5&6 when compared to the rest of NB. Hospital discharges with the "most responsible diagnosis" in the following categories were higher in both GBA and HR 5&6:

- Disease of the respiratory system;
- Disease of the circulatory system;
- Disease of the digestive system;
- Disease of the genitourinary system;
- Endocrine, nutritional and metabolic disorders; and,
- Skin and subcutaneous tissue.

The hospital separation patterns for GBA and HR 5&6 are very similar.

4.0 Pilot survey of blood lead in children

This section describes the approach and findings from a pilot survey of children in the vicinity of the Noranda lead-zinc smelter located in the Belledune industrial park undertaken by the NB Department of Health and Wellness. Additional details are provided in Appendix E. The smelter has been operating since the mid 1960's. The soil lead in Belledune has been examined by Noranda, NB government department of the environment, and by other agencies. The results of these analyses show accumulation of lead in the soil from airborne deposition from the smelter. The objective of this survey was to examine if children in the neighborhoods closest to the smelter indicated levels of blood lead which would inform full scale testing of children in a larger geographic area. Thus, this survey was a pilot project.

The rationale for the use of the two neighborhoods was three-fold: first, these neighborhoods are closest to the smelter; second, there were enough children to test; and third, the community appeared to be interested in participating.

4.1 Overall approach

All children between the ages of 3 and 15 currently residing in Townsite #2 or Lower Belledune (see Figure 1.1) were invited to participate in the survey. A door to door survey carried out by two public health nurses in late September 2004 determined the presence of children of eligible age in the household and the family's willingness to participate in a short interview and in allowing a small blood sample to be taken from the children. Information on the nature of the survey, and a sample of the consent form was also provided on the first visit. Appointments were subsequently set up for the first week of November at a clinic facility away from the areas of potential concern. At this venue, the family signed appropriate consent forms, and a public health nurse conducted a brief interview and collected a blood sample from the participants. Samples were sent to for analysis to the Toxicology Laboratory/ INSPQ; Human toxicology / INSPQ -Trace metals and organic contaminants divisions (Sainte-Foy, Quebec) Individual results were available in late November 2004, and were provided to each participant family and to the family physician[7].

4.2 Findings

The total number of participants in the survey was twenty-three children. As illustrated in Table 4.1 below, ten participants were between three and six years old. The remaining thirteen children were between seven and fifteen years old. Nineteen of the twenty-three children who participated were residents in Townsite #2.

[7] For more details on approach, please refer to Appendix E.

Table 4.1: Survey participants

Age Group	# of Children	# of Children Tested
3 to 6 years	11	10
7 to 15 years	21	12
Total	32	23

As illustrated in Figure 4.1, 21 of the 23 children tested below the generally accepted "medical concern" of 0.48 μmol/L (10 μg/dL). Eighteen of the children tested below 0.20 μmol/L (4μg/dL).

Figure 4.1: Distribution of blood lead levels

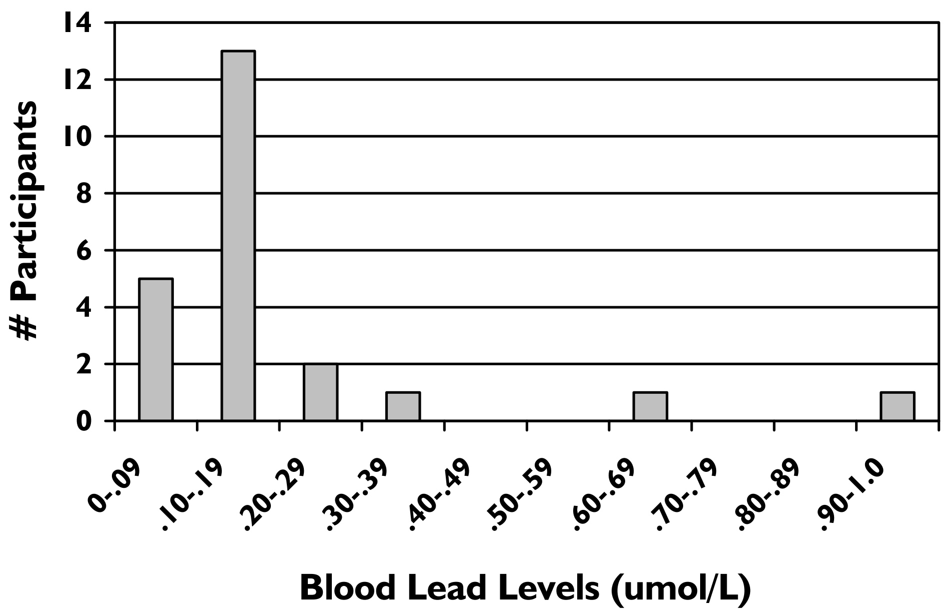


Table 4.2 contains the ranges, arithmetic means, and geometric means according to age groups. Means and ranges are presented in both the standard international units of "μmol/L" and the more common unit in the literature, "μg/dL".

Table 4.2: Average blood lead levels

Age Group	Range (μmol/L)	Range (μg/dL)	Arithmetic Mean (μmol/L)	Arithmetic Mean (μg/dL)	Geometric Mean (μmol/L)	Geometric Mean (μg/dL)
3 to 6 years (n=10)	(0.10-0.60)	(2.1-12.5)	0.21	4.35	0.17	3.54
7 to 15 years (n=13)	(0.07-0.92)	(1.7-19.2)	0.18	3.78	0.13	2.70
Total (n=23)	**(0.07-0.92)**	**(1.7-19.2)**	**0.19**	**3.90**	**0.14**	**2.91**

4.3 Discussion

The average blood lead levels found in the children residing closest to the Noranda Smelter in Belledune are higher than average values reported for urban children in Niagara County, in 2001[8], the last large survey of volunteer urban and suburban children reported, and higher than Ottawa-Carleton children in 2000[9], without unusual sources of exposure (see Table 4.3). They are very similar to those levels found among children in 1991 from urban "control" communities measured as part of the Ontario blood studies[10]. The GBA levels are lower than the levels found in children living in areas of extensive lead contamination from lead reclamation plants (i.e., Trail, BC, 2001; Québec, 1991[11]).

The average levels found among GBA children are below the community or individual intervention level of 0.48 µmol/L or 10 µg/dl. On the other hand, the current pilot survey illustrated that two children (or 9% of participants) were above the intervention level in this small community, which is more than desirable. Investigation of their singular environments will determine if their level is stable and if their exposure is from a known source, an unusual source of lead within the house, or from the general environment.

4.3.1 Current exposure estimates from the HHRA

From the HHRA, the best estimates or average environmental concentrations result in estimated exposures for children in Lower Belledune that exceed the oral TRV. The major pathways of exposure for children in Lower Belledune are consumption of local wild mussels and fish. As noted, there is large uncertainty surrounding the COPC concentrations in fish due to the use of data that were collected prior to 1985.

At the upper bound estimate, there are several more receptors that have exposures that exceed the oral TRV, namely infant, toddler and child receptors in Townsite #2, and the toddler, child, teen and adult in Lower Belledune. The major pathways of exposure for the infant and toddler include garden vegetables and soil. Garden vegetables contribute most to exposure and soil ingestion contributes secondarily. In Lower Belledune, the exposure in the toddlers is mainly due to soil ingestion. Among other age groups, the consumption of local wild mussels and fish dominate the exposures. Without a detailed environmental pathway analysis for each family, it is not possible to tell what the major contributor to lead exposure is for a specific individual.

[8] Decou ML. Blood Lead in Niagara County. Regional Niagara Health Department. 2001
[9] Ellis, E. Blood Lead in Ottawa Carleton. Ottawa-Carleton Regional Health Department. 2001
[10] Langlois P, Fleming S, Smith LF, Gould R, Goel V, Gibson BL. Risk factors for high blood lead in Toronto children: a look at communities with and without abatement. Archives of Environmental Health 1996;51(1):59-67.
[11] Levallois P, Lavoie M, Goulet L, Nantel AJ, Gingras S. Blood lead levels in children and pregnant women living near a lead-reclamation plant. CMAJ. 1991 Apr 1;144(7):877-85.

The children tested represent 70% (23/32) of children ages 3-15 years residing in these two neighborhoods. Inferences about smelter-affected exposure to other children, all things being equal, can be made from the results of this community. If the children closest to the smelter are in the low range of lead exposure, then other children in the GBA may experience similar levels of exposure depending on emissions deposition patterns. Current emissions are not likely to have as strong an impact on exposure from inhalation but soil for historical deposition may still play a role in exposure of children who live further from the smelter. However, this must be ascertained by a larger survey with representative samples of children in the community. The Task Force on blood lead and intervention levels (1994)[12] recommended targeted surveys of children in smelter communities. The 2003 Canadian Task Force on the Periodic Health Examination[13] also recommends (as a B-level recommendation) targeted surveys of blood lead in children living in smelter communities.

Lead is pervasively toxic to developing youngsters and can cause many health effects (see Figure 4.2), and therefore, no matter how low the levels, every effort is warranted to raise awareness about children's exposure to lead and ways to reduce exposure. Recommendations for prevention of exposure include proper iron, calcium and vitamin C intake, correction of iron deficiency anemia, hand washing before eating and good housekeeping, and the removal of specific sources of lead from in and around the home.

[12] Health Canada 1994. Report of the Federal Provincial Committee on Blood lead levels, Interventions and Strategies.
[13] Feldman W., Randel P. Screening children for lead exposure in Canada. In: Canadian Task Force on the Periodic Health Examination. Canadian Guide to Clinical Preventive Health Care, Ottawa, Health Canada, 1994; 268-288.

Figure 4.2: Relationship of blood lead level and adverse health outcomes

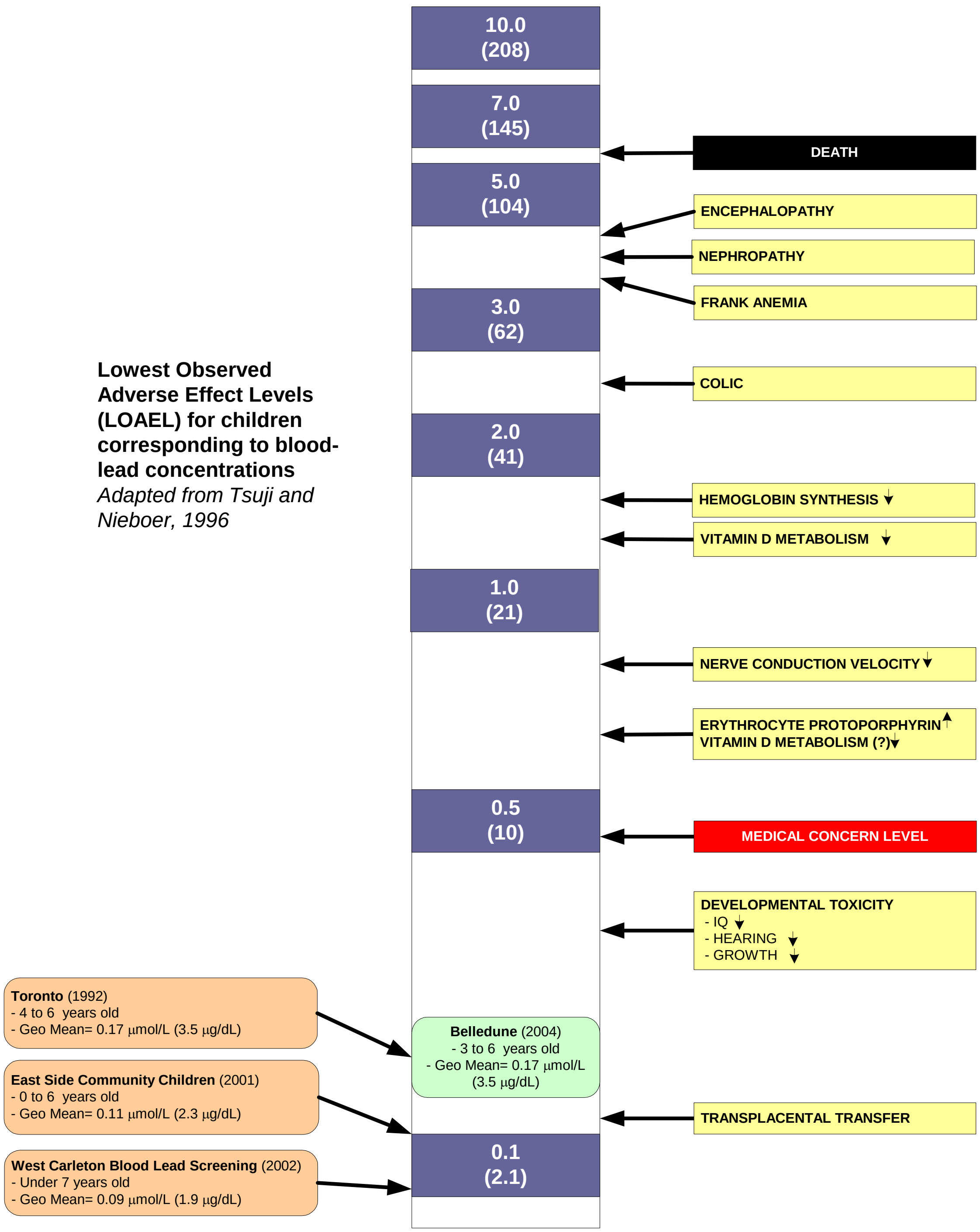


Table 4.3: Blood lead levels in children from selected references

Reference	Place/Emissions	Study Particulars	Number of children /pregnant women	Geometric Mean µmol/L	Range (% at and above 0.48 µmol/L)
New Brunswick Department of Health and Wellness, 2004[14]	• Townsite 2 and Lower Belledune, NB • Community closest to Noranda Lead-Zinc smelter	• Prevalence survey • Pin prick blood	Ages 3 – 15 yrs (N=23)	**0.14**	0.07 - 0.92 (9% above)
			Ages 3 – 6 (N=10)	**0.17**	0.10 - 0.60 (10% above)
			Ages 7 – 15 (N=13)	**0.13**	0.07 - 0.92 (8% above)
Decou 2001[15]	East Side Community, Port Colborne • Community in close proximity to a nickel smelter • Soil lead levels (approximately 1/3 of residential properties' soil exceeded 400µg/g lead)	• Prevalence survey • Pin prick blood	Ages 0 – 6 yrs (N=42)	**0.11**	0.04 - 0.83 no difference between 0-2 yrs and 3-6 yrs
			Ages 7-14 (N=57)	**0.09**	0.04 - 0.61
	Port Colborne Community • outside heavily impacted area • volunteers • variable soil lead		Ages 0 – 6 yrs (N=56)	**0.10**	0.04 – 0.37 no difference between 0-2 yrs and 3-6 yrs
			Ages 7-14 (N=63)	**0.08**	0.04 – 0.40
	Outside Port Colborne • volunteers		Ages 0 – 6 yrs (N=17)	**0.07**	0.04 – 0.16 no difference between 0-2 yrs and 3-6 yrs
			Ages 7-14 (N=19)	**0.07**	0.04 - 0.18

[14] New Brunswick Department of Health and Wellness, 2004. Pilot Study of community closest to Noranda Lead-Zinc smelter
[15] Decou ML. Blood Lead in Niagara County. Regional Niagara Health Department. 2001

Reference	Place/Emissions	Study Particulars	Number of children /pregnant women	Geometric Mean µmol/L	Range (% at and above 0.48 µmol/L)
Ellis 2000[16]	Ottawa-Carleton • Overall - near an old mine site • In and outside "target area" • With and without mine tailings	• Prevalence survey • Pin prick blood	Ages 4 – 6 yrs (N=145)	**0.09**	0.04 – 0.76
	Ottawa-Carleton • In "target area" • With mine tailings on property		Ages 4 – 6 yrs (N=26)	**0.10**	0.04 – 0.51
	Ottawa-Carleton • In "target area" • Without mine tailings on property		Ages 4 – 6 yrs (N=31)	**0.08**	0.04 – 0.24
	Ottawa-Carleton • Outside "target area" • With mine tailings on property		Ages 4 – 6 yrs (N=15)	**0.09**	0.04 – 0.76
	Ottawa-Carleton • Outside "target area" • Without mine tailings on property		Ages 4 – 6 yrs (N=24)	**0.08**	0.04 – 0.32
Ontario Blood Lead Surveys (1990,1992)[17]	Urban "control" neighborhood • Neighborhood used as a control over two periods to serve as "urban background"	• Prevalence survey • Pin prick blood	Ages 4 – 6 yrs (N=227)	**0.17**	• 8% at or above 0.48 µmol/L • 4% above 0.48 µmol/L
	Toronto point source neighborhood • Lead battery recycling plant		Ages 4 – 6 yrs	**0.19**	• 7% above 0.48 µmol/L
Levallois 1991[18]	Quebec • Lead reclamation plant • Higher exposure area	• Prevalence survey • Venous blood	Ages 0 - 5 yrs	**0.49**	Younger children were higher than older children in all areas
	Quebec • Lead reclamation plant • Intermediate exposure area		Ages 0 - 5 yrs	**0.35**	
	Quebec • Lead reclamation plant • lower exposure area		Ages 0 - 5 yrs	**0.28**	

[16] Ellis, E. Blood Lead in Ottawa Carleton. Ottawa-Carleton Regional Health Department. 2001
[17] Langlois P, Fleming S, Smith LF, Gould R, Goel V, Gibson BL. Risk factors for high blood lead in Toronto children: a look at communities with and without abatement. Archives of Environmental Health 1996;51(1):59-67.
[18] Levallois P, Lavoie M, Goulet L, Nantel AJ, Gingras S. Blood lead levels in children and pregnant women living near a lead-reclamation plant. CMAJ. 1991 Apr 1;144(7):877-85.

5.0 Limitations and challenges

The study team endeavoured to address the objectives outlined for the study with the most appropriate methodologies, within the context of the TORs. As with any study, the methods developed for the current study have limitations. These along with specific challenges the study team encountered in conducting the study are outlined below. More details on these are provided within the technical appendices for the various components.

5.1 Limitations identified for the HHRA

5.1.1 Assessing risk rather than actual experience

As previously mentioned in Section 2.0, the HHRA is a tool for determining the risk of health effects. Of particular importance is to note that it does not provide an absolute statement on the experienced health effects measurable in a population. Actual experienced health effects of GBA residents have been the focus of the CHSA component.

5.1.2 Goal to overestimate exposure where there is uncertainty

It should be noted that there is no single “correct” way to conduct a risk assessment. The HHRA framework provides guidance for conducting risk assessment that is usually based on both scientific and professional judgment. Thus, risk assessments generally rely on making inferences, assumptions and models that lead to uncertainties in the estimates. A goal of the risk assessment was to select the assumptions about exposure that are more likely than not overestimations of exposure.

5.1.3 Uncertainties in estimates of risk

As described above, risk assessment is intrinsically an uncertain process with uncertainty arising not only from environmental characterization but also from inter-individual variability and uncertainty associated with exposure point concentrations, exposure factors and toxicity assessment. The inferences and assumptions selected in the risk assessment were such that they are likely to overestimate exposures and hence likely to overestimate risk. For a detailed discussion on the specific uncertainties for the HHRA, the reader is referred to the technical Appendix A. The most notable uncertainties with the HHRA are listed below.

- Historical emissions data – The study team assessed that the most uncertainty exists for the earliest time period studied (namely 1967-1974). Environmental monitoring data for the emissions, soil, and other media during this period for arsenic, cadmium and lead are limited less plentiful. As well, there is likely less accuracy in measurement during this time period due in part to the monitoring technology of the time period.

- **Limited information for some COPC** – Over the various time periods and in current monitoring, some COPC have had less focus than others. The COPC of lead, arsenic, and cadmium have been regularly measured throughout various media and through various time periods. Other COPC such as chromium, dioxins and furans, and mercury have been less of a focus, and as a result have much smaller data sets associated with their measured levels in the environment. However, the findings have indicated that the uncertainty in these COPC does not affect the outcome of the assessment.

- **Current levels of COPC in Baie des Chaleurs fish** – The study team was not able to locate any current data related to metals in local fish from the Baie des Chaleurs. As a result, the HHRA used fish data collected in the 1980's to estimate current exposure to COPC such as lead and arsenic. It is possible that current fish concentrations are lower than these estimates, however, it is impossible for the study team to assume this without some data on actual levels.

- **Current levels of COPC in backyard vegetables** – There are limited data available on current levels of COPC in backyard vegetables. The data are also limited in terms of locations. For example, there were no current backyard vegetable data for Petit-Rocher. This pathway becomes significant for some of the COPC, for example cadmium and lead. The certainty in the significance of this pathway would be greatly improved by the collection of more data.

5.2 Limitations identified for the CHSA

The limitations and challenges identified in conducting the CHSA focus to a certain extent on the design of the component and the availability of data.

5.2.1 Limitations with ecologic designs

The approach used for the CHSA is what is referred to as an *ecologic study*. Ecologic studies are those in which the unit of observation is a group, not separate individuals. . Ecologic studies may be used to generate hypotheses of an association between exposure and disease, but these studies cannot by themselves establish causation. This is because we do not know whether those individuals who died or suffered an illness in a particular geographic area under observation actually had a higher exposure than individuals who remained alive or did not experience the illness.[19] In addition, there may not be information about confounding factors (e.g., smoking) for individuals within an area population, and lack of this information limits the translation of population risks from ecologic studies to individual risks in members of the studied population. The conclusions made here are therefore for the GBA population as a whole, not for individuals therein. While the findings may not necessarily apply to individuals in an area, an ecologic study reveals findings about the population of an area, which may have implications for the individuals in that area.

5.2.2 Child development data

One of the major gaps in addressing community concerns and potential health impacts from the identified COPC was with respect to the absence of data on child development issues, either current or historic. The study team reviewed some potential sources (e.g., Early Childhood Initiative) but concluded that they were not collected in a sufficiently standardized or systematic manner to the extent that population level conclusions could be drawn.

In order to partially remedy this from a current perspective, the study team recommended that a pilot survey be conducted of blood lead levels in children likely to be most impacted from exposure to lead by living in closest proximity to the lead smelter. Given the strong relationship that exists between blood lead levels and health impacts, the study team felt that this type of information would assist the team in drawing at least some preliminary conclusions with respect to exposure levels and potential health impacts for current exposure. Unfortunately, this does not address child development issues potentially related to lead exposure in previous time periods, when the actual exposure levels were likely significantly higher.

5.2.3 Disease specific registries

The only disease specific registry that exists in NB is for cancer. The data for cancer registries in Canada is standardized and relatively complete. As a result, the study team was able to produce solid findings to address many of the residents' concerns with cancer incidence in the GBA. Unfortunately, there are no other disease specific registries, so the study team was unable to go into as much detail with respect to incidence rates for other disease groups. The study team attempted to offset this gap in part by examining mortality and hospital separations. It must be noted that limitations exist with using hospital separation data (e.g., availability of service). Therefore, results based on this data must be interpreted with caution.

[19] http://hsrd.durham.med.va.gov/ERIC/ (Epidemiology Notebook)

5.2.4 Data on determinants of health

As mentioned previously, the health of a population is multi-faceted with many different determinants of health. These include such characteristics as lifestyle factors (e.g., smoking), diet, sex, occupation, biological make-up, physical activity levels, socio-economic status, environment, and medical services. The study team did not have data that provided additional information on these determinants for the populations studied. As a result, it is challenging to attribute causality to the associations found between health status of the study area to any specific health determinant. One way to provide some indication of causality between a health condition in a population and an exposure in that population is to examine diseases or outcomes that have been shown in the scientific literature to be potentially causal. Again, as indicated above, this will generate hypothesis of potential causation, but will not address absolute causality in any way.

6.0 Conclusions and discussion

During the planning stage of the study, a number of research questions were posed that took into account residents' concerns as well as overall study objectives. This section provides the overall conclusions of the study according to these initial research questions. The conclusions are then integrated with the data from the pilot lead survey to provide an overall interpretation of study findings.

6.1 Conclusions according to study research questions

6.1.1 What are the potential types and sources of contamination?

The initial question that was posed to the study team was what were the potential types and sources of contamination. While the study considered eight different COPC as well as combustion products (sulphur dioxide and nitrogen oxide), the findings indicated that the key potential issues in the community were related to concentrations of lead, cadmium and arsenic in the environment. The assessment determined that lead and to a lesser extent cadmium exposures were as a result of the industrial activity in the GBA. The industrial activities contributed only a small portion to arsenic exposures, the majority of the exposure was due to baseline concentrations.

6.1.2 How are residents exposed to the contamination?

The assessment considered both historical and current exposures to arsenic, cadmium and lead. In terms of historical exposure, lead exposure via the inhalation pathway was significant in the 1967 to 1974 time period and has reduced significantly since that time. Another important pathway during that time period was the ingestion of local seafood. It must be pointed out that the assessment considered that residents in the GBA obtained all the seafood that they consumed from local sources. These included the wild mussels along the shoreline, local lobster along the shoreline and fish in the local area in the Baie des Chaleurs. Wild mussels were used as a surrogate for other local shellfish. It is unlikely that the entire seafood diet of residents would be from the local area but this was done to ensure that exposures in the community were not underestimated.

Current exposures are also mainly associated with the consumption of local seafood. The main exposure pathways for cadmium and lead are associated with the consumption of wild mussels along the shoreline. Another important pathway is the consumption of local fish caught in the Baie des Chaleurs in close proximity to the GBA. The exposures due to the consumption of local fish should be viewed with caution, as the fish concentrations used in the assessment were twenty-five years old. Sampling of fish in the Baie des Chaleurs is necessary in order to reduce the uncertainty associated with exposures to local fish.

Another potentially important pathway of exposure for cadmium in Townsite #2 was the ingestion of root vegetables from the backyard garden. The data available for backyard vegetables in Townsite #2 and other areas of the GBA are sparse and efforts need to be made to collect more data to reduce the uncertainty in this pathway of exposure.

One interesting finding from this study was that soil was not a major pathway of exposure at the best estimate concentration. At the upper bound estimate, infants and toddlers exposed to lead in Townsite #2 had exposures that were above the TRV; the backyard vegetable pathway was the major pathway of exposure followed by the soil pathway. In Lower Belledune, the upper bound estimate of lead results in toddler exposure found soil as the dominant pathway.

Environmental concentrations in Lower Belledune are higher than other areas in the GBA. Therefore, residents in Lower Belledune are the highest exposed individuals followed by Townsite #2. Children and toddlers are at potentially higher risks. Residents who consume local mussels from along the shoreline also experience higher risks and it may be prudent to reduce consumption of local mussels to reduce exposures.

Maximum local seafood eaters, such as maximum wild mussel eaters (approximately five ½-pound meals per week all year); maximum local lobster eaters who consume approximately two to three ½-pound meals per week all year, and maximum local fish eaters who consume approximately six to seven ½-pound meals per week all year of local fish from the local shoreline and area are at the highest risk. These individuals would most likely be a small proportion of the population. It is likely that exposures have been overestimated due to the assumptions in the report.

6.1.3 What are the potential health risks for residents as a result of the exposure to the contamination?

The potential health risks associated with exposure to lead, cadmium and the other COPC are outlined below. Both lead and cadmium are considered to be non-cancer causing chemicals via the oral route of exposure. The health effects associated with lead exposure are most severe in children and involve neurocognitive and behavioural developmental effects with exposure *in utero* and in early childhood. The health effect associated with oral ingestion of cadmium is significant proteinurea, a reflection of abnormal kidney function.

For the population in the highest exposed area (Lower Belledune and Townsite #2) the assessment showed that, based on the best estimate, the intakes are below toxicity reference values with the exception of cadmium and lead exposure for a child in Lower

Belledune. The intake for this receptor is influenced by the assumed consumption of local wild mussels and fish. Thallium and zinc exposures for infants, toddlers and children are predicted to be above the TRV; however, supermarket food is the dominant pathway. Local exposures to zinc and thallium are well below the toxicity reference value. The supermarket food intakes are obtained for the Canadian population and may not be appropriate for Northern New Brunswick.

The upper bound estimate for this population suggested that exposures to cadmium, lead and mercury for infants, toddlers and children may exceed the toxicity reference value. These exposures are mainly due to the consumption of local mussels, fish and backyard vegetables. In Lower Belledune, the toddler exposure is due to soil ingestion. Again, thallium and zinc exposure are above the toxicity reference value due to supermarket food consumption.

The best estimate calculations for residents in the core communities of Belledune, Pointe-Verte and Petit-Rocher show that exposures to cadmium, lead and mercury are below predicted to be toxicity reference values. At the upper bound estimate calculations, children exposed to cadmium, lead and mercury in Pointe-Verte are predicted to be above the TRV. In Petit-Rocher, child exposures to mercury are above the TRV. In Belledune, child exposures to cadmium and mercury are above the TRV. This is primarily due to the consumption of local wild mussels and fish. Thallium and zinc exposures are also predicted to be above the toxicity reference values due to the dominance of the supermarket food pathway.

A sensitivity analysis was conducted for individuals who may consume a significant quantity of seafood (fish, wild mussels or lobster) from the local area on a continuous basis. The results show that the intakes for these individuals may be above toxicity reference values for cadmium, lead, mercury and thallium. It should be emphasized that this is an extreme estimate and would apply to only a very small portion of the population.

In summary, the HHRA described above is only a tool for determining the risk of health effects, it is important to note that it does not provide an absolute statement on the experienced health effects measurable in a population. Therefore, the findings from this HHRA need to be considered with the results of the CHSA to determine, where possible, whether adverse health impacts are actually occurring in the community. This is discussed in Section 6.2 below.

6.1.4 How does the health status of residents compare with other regions?

The health status pattern for the GBA is different from that found in the surrounding health regions (HR 5&6) and for NB overall for the time period of 1989-2001. There is a statistically significantly elevated incidence of oral, respiratory and prostate cancer (stomach cancer was found to be statistically significantly elevated in both GBA and HR

5&6); and elevated (albeit not statistically significant) incidence of kidney and colorectal cancer above expected. There is a higher mortality rate than expected, and there are more deaths than expected due to circulatory disease, cancer and to “other causes” such as accidents and suicide . Hospital separations were higher than expected for all disease groups; however, this was found to be the case for the HR 5&6 as well, so is not unique to the GBA.

The population of the study area (GBA) is small compared to the population of Health Regions 5&6, and was actually included in the statistics produced for Health Regions 5&6. Because some disease or mortality rates are much higher in GBA than in Health Regions 5&6, the results for Health Regions 5&6 are influenced by the inclusion of GBA residents. As a result, the differences found between GBA and Health Regions 5&6 are likely slightly underestimated.

As previously discussed above in Section 5.0, ecologic studies may be used to generate hypotheses of an association between exposure and disease, but these studies cannot by themselves establish causation. Further investigation will be required to assist in explaining what factors or characteristics of the residents of GBA are related to their current pattern of health status.

From the DHW pilot survey, children’s average blood lead levels in the potentially most impacted communities indicate that, even though they are well below the the community or individual intervention level of 0.48 µmol/L (geometric mean was 0.14 µmol/L), they are higher than what have been recently measured in other communities. In addition, there were two children (or 9% of participants) above the intervention level in this small community. This indicates that there is likely exposure occurring at such a level that it warrants additional investigation on a community level given the concerns expressed by the community and the pervasive toxicity of lead to young children.

6.2 Overall discussion of study findings

This section presents the overall discussion of study findings structured according to findings from the CHSA with HHRA findings woven throughout. The health status findings are explored and discussed according to likely contributing factors.

6.2.1 Reproductive outcomes

None of the measures of reproductive outcomes was different for GBA, HR 5&6 and NB.

6.2.2 Mortality

GBA males experienced statistically higher mortality than expected for cancer, circulatory system diseases and "other causes" such as accidents and suicide. GBA females experienced elevated mortality rates for cancer (albeit not statistically significant). This mortality pattern may be related to a combination of many risk factors.

<u>Associated Factors – tobacco use</u>

Because smoking alone can contribute significantly to cancer and circulatory disease[20], it would be extremely important to know the historical smoking rates in this population as well as current patterns before attributing elevated mortality to any specific risk factors or sets of risk factors. Socioeconomic status has generally been accepted as related to smoking rates[21].

<u>Associated Factors – environmental exposures</u>

It has been suggested that background arsenic exposure could be related to health outcomes in GBA such as the metabolic and circulatory disease mortality experience. The scientific literature indicates that in areas of high arsenic exposure from drinking water there is a higher prevalence and mortality of diabetes (a metabolic disease), hypertension and cardiovascular disease.[22]

We would not expect to see arsenic-related adverse outcomes in GBA because the estimated average levels of exposure are low as per calculations carried out in the HHRA (see Section 3.0). As well, it should be noted that where effects have been seen in other populations, the exposure to arsenic is from extremely high levels of arsenic in drinking water, a condition that does not appear to exist in GBA as judged from results of distributed municipal and well water. Where arsenic effects are documented well, population effects result from long term exposure through drinking water containing highly available dissolved inorganic arsenic from natural sources. Soil arsenic is not as available and ingestion is variable and can be controlled.

The HHRA demonstrated that potential arsenic exposure for GBA residents are below the TRV of 0.002 mg/kg/day. This is well below the exposure levels of populations that have experienced a higher prevalence and mortality of diabetes, hypertension and cardiovascular disease. These reasons combined with the different mortality rates for circulatory diseases between men and women which would be expected to be similar if there were an arsenic exposure effect, do not support an association between arsenic exposure and circulatory disease, but do point to other differential risk factors between men and women in the GBA.

[20] Ezzati M, Lopez AD. Regional, disease specific patterns of smoking-attributable mortality in 2000. Tob Control. 2004 Dec;13(4):388-95.
[21] Gilman SE, Abrams DB, Buka SL. Socioeconomic status over the life course and stages of cigarette use: initiation, regular use, and cessation. J Epidemiol Community Health. 2003 Oct;57(10):802-8.
[22] Tchounwou PB, Patlolla AK, Centeno JA. Carcinogenic and Systemic Health Effects Associated with Arsenic Exposure-A Critical Review. Toxicologic Pathology 32003;31:575-588.

6.2.3 Cancer Incidence

6.2.3.1 Prostate Cancer

The causes of prostate cancer are not known, but there are some risk factors that have been shown in studies to increase the risk of prostate cancer: age, family history, race (Caucasians at lower risk than African Americans or Asians and American Indians), and diet (lower risk from fruits, vegetables and higher risk from animal fat and meats). Many studies are currently taking place examining the role of other risk factors and interventions. [23,24,25]

The age standardized incidence rate of prostate cancer in Canada has increased from 73.1 in 1975 to 121.2 in 2004 while mortality has remained about the same (about 27 per 100,000) with a minor rise preceding and then falling in the 1990s. The increased incidence rate has been attributed to earlier detection through the use of prostate specific antigen testing. In NB, the prostate cancer incidence rate is 140 per 100,000.[26]

<u>Associated Factors – environmental exposures</u>
An environmental cause for prostate cancer has not been postulated.

<u>Associated Factors – occupational exposures</u>
Occupational cadmium exposure has been considered in a number of studies as a potential risk factor. However, recent reviews of the literature do not support an association. [27] Arsenic exposure has not been associated with prostate cancer. Lead is not carcinogenic.

Within the limitations of the current study, it is not possible to state that there is any relationship between the industrial emissions in GBA, environmental exposure and the incidence of prostate cancer in the GBA.

6.2.3.2 Respiratory and oral cancers

Respiratory cancers consist of cancer of the lung, bronchus, trachea, and larynx. Oral cancers are a heterogeneous group consisting of cancers of the oral cavity, pharynx and nasopharynx, salivary glands, and gums. Respiratory and oral cancers are

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[23] Bostwick DG, Burke HB, Djakiew D, Euling S, Ho SM, Landolph J, Morrison H,Sonawane B, Shifflett T, Waters DJ, Timms B.Human prostate cancer risk factors. Cancer. 2004 Nov 15;101(10 Suppl):2371-490
[24] Carter BS, Carter HB, Isaacs JT.
Epidemiologic evidence regarding predisposing factors to prostate cancer. Prostate. 1990;16(3):187-97
[25] Mettlin C.Recent developments in the epidemiology of prostate cancer. Eur J Cancer. 1997 Mar;33(3):340-7.
[26] Canadian Cancer Statistics, 2004. Canadian Cancer Society (www.cancer.ca)
[27] Verougstraete V, Lison D, Hotz P. Cadmium, lung and prostate cancer: a systematic review of recent epidemiological data. J Toxicol Environ Health B Crit Rev. 2003 May-Jun;6(3):227-55.

discussed here together because of the concordance of evidence pointing to associated factors for these cancers.

GBA experienced higher rates of respiratory and oral cancers as compared to NB while HR 5&6 did not. One must posit risk factors in GBA that are not shared by HR 5&6 and the rest of NB.

Of all the provinces, the incidence of lung cancer in NB males is exceeded only by Quebec (95 vs. 97 per 100,000 population). This is not the case for NB females whose lung cancer incidence rate is less than half the NB male rate (46 vs. 95 per 100,000 population) and lower than the Quebec female rate (46 vs. 55 per 100,000 population). The pattern for oral cancer is different, with the NB incidence rate in males exceeded by NS, NL and MB. For females, the rates are similar among all Canadian provinces.[28]

Associated Factors – tobacco and alcohol use

As a group, respiratory and oral cancers are associated with tobacco use, either smoking (lung, larynx, trachea, bronchus), or chewing (gums, lip, tongue). In addition, oral cancers are associated with alcohol consumption. No discussion of respiratory and oral cancer can ignore the impact of tobacco use on population health. Tobacco use is associated unequivocally with death due to respiratory cancer, oral cancer, other internal cancers, respiratory disease, and cardiovascular disease in regions around the world.[29] Premature death due to lung cancer, in particular, takes a special toll from tobacco use.[30]

Associated Factors – occupational exposures

Other factors may include the role of occupational exposures sustained in mining and industry that cannot be categorically excluded as contributing to the respiratory cancer rate. Some COPC (arsenic, cadmium and chromium) may be inhaled in the course of work and could, in specific circumstances, contribute to respiratory cancer rate.

Associated Factors – environmental exposures

The COPC that could potentially be related to these types of cancers are arsenic and cadmium. It should be noted that according to the HHRA, the estimated environmental exposure commitment for arsenic and cadmium are below their respective TRVs. The environmental exposure commitment for arsenic is relatively large, but attributable to primarily background levels, and not to GBA industrial emissions. Arsenic environmental exposure commitments are also primarily oral (ingestion of food stuffs), and not inhaled, which would be the route associated with lung cancer.

[28] Canadian Cancer Statistics, 2004. Canadian Cancer Society (www.cancer.ca)
[29] Ezzati M, Lopez AD. Regional, disease specific patterns of smoking-attributable mortality in 2000. Tobacco Control. 2004 Dec;13(4):388-95.
[30] Peto R, Lopez AD, Boreham J, Thun M, Heath C Jr. Mortality from tobacco in developed countries: indirect estimation from national vital statistics.Lancet. 1992 May 23;339(8804):1268-78.

Within the limitations of the present study, it is not possible to attribute the GBA's increased incidence of lung cancer, or the higher incidence of oral cancer, to any factor or set of factors such as environmental exposures, tobacco use, or to alcohol use in the case of oral cancer. Of particular importance for next steps will be the determination of past and current tobacco use rates, alcohol consumption, and occupational exposures of GBA residents to find potential associations with the elevations of oral and respiratory cancers among GBA residents. Considerations should also include issues such as changes in tobacco and alcohol use rates over the past 20 to 30 years, and changes in occupational exposure given that there is a latency period of decades for cancer.

6.2.3.3 Stomach cancer

Stomach cancer is second in frequency to lung cancer around the world. In Canada, however, stomach cancer places about 13th overall, with lung, colorectal, breast, prostate, non-Hodgkin's lymphoma, leukemia, pancreas and uterine cancer among those more prevalent.[31] About 800,000 cases of stomach cancer are identified every year worldwide.[32] Canada identified about 2800 stomach cancer cases in 2003 (1800 in men and 1000 in women). Of these, about 50 in males and 25 in females were estimated for NB in 2003.[33]

Stomach cancer incidence has been declining in the last few decades and this pattern has been observed in Canada and in NB. In Canada, the overall decline in stomach cancer has been about -2.3% among males and -2.6% among women.[34] Known associated factors include *Helicobacter pylori* (*H. pylori*) infection, cigarette smoking, diet, being male, and familial genetic abnormalities. The causes for the decline are not known but there are several candidates reported in the literature that may be responsible: improvements in diet, improved food storage and a decline in the prevalence of *Helicobacter pylori* (*H. pylori*) infection.[35]

Associated Factors – *H. pylori infection*

Epidemiological studies have shown that areas with high gastric cancer rates often have a correspondingly high prevalence of *H. pylori* and prospective studies have shown that subjects with serological evidence of *H. pylori* infection were significantly more likely to go on to develop gastric cancer than those who did not.[36] Several investigators have found similar findings in clinical control trials.[37] *Helicobacter pylori*

[31] Canadian Cancer Statistics, 2004. Canadian Cancer Society (www.cancer.ca)
[32] Plummer M, Franceschi S, Munoz N. Epidemiology of gastric cancer. IARC Sci Publ. 2004;(157):311-26
[33] Canadian Cancer Statistics, 2004. Canadian Cancer Society (www.cancer.ca)
[34] Ibid.
[35] Hunt RH. Will eradication of Helicobacter pylori infection influence the risk of gastric cancer? Am J Med. 2004 Sep 6;117 Suppl 5A:86S-91S.
[36] Shogo Kikuchi Epidemiology of Helicobacter pylori and gastric cancer. Gastric Cancer. 2002;5(1):6-15.
[37] Wong BC, Lam SK, Wong WM, Chen JS, Zheng TT, Feng RE, Lai KC, Hu WH, Yuen ST, Leung SY, Fong DY, Ho J, Ching CK, Chen JS; China Gastric Cancer Study Group. Helicobacter pylori eradication to prevent gastric cancer in a high-risk region of China: a randomized controlled trial. JAMA. 2004 Jan 14;291(2):187-94.

infection is a risk factor for gastric cancer and most epidemiological studies have estimated a relative risk associated with infection in the order of two to four-fold.[38] Control of *H. pylori* infection may also offer great potential for prevention of stomach cancer.[39] *H. pylori* infection may be controlled by improving general sanitary conditions, case finding and direct treatment of infections, or, in the future, immunization.
The prevalence of *H. pylori* infection is estimated at 50% in some countries. No Canadian prevalence rates were published as of 2004.

Associated Factors – Diet

Carcinogens as potential causes for gastric cancer include N-nitroso compounds. Many N-nitroso compounds, which come from nitrites, which in turn come from nitrates in food following bacterial transformation in a low-acid stomach environment, are established cancer causing agents in animals, but their risk for human gastric cancer is still uncertain.

Other risk factors for stomach cancer include salt and salted food intake. Diet high in salt carries a relative risk of up to 6, and a highly significant correlation between 24-hour urinary salt content and incidence of gastric cancer has been shown in 24 countries.[40]

Dietary modifications remain potentially one of the most important tools for the prevention of stomach cancer. Overall, the observed reduction in stomach cancer risk can reasonably be considered to be the result of a trend related to widespread improvements in socioeconomic conditions. Domestic refrigeration, increased availability of fresh fruits and vegetables, and a reduced use of salt in salted and preserved foods, are considered to be the most relevant factors in explaining the decreasing temporal trend and the geographical patterns of stomach cancer. Fruits and vegetables, green tea, alpha-tocopherol (vitamin E) and other micronutrients such as selenium have been shown to reduce the risk for gastric cancer. A diet consisting of vegetables and fruits, low in salt, together with the avoidance of cigarette smoking has been estimated to be able to prevent some two-thirds to three-quarters of gastric cancer.

Associated Factors – environmental exposures

Arsenic exposure is associated with a number of internal cancers, including stomach cancer. The HHRA presented in Section 3.0 of this report, demonstrated potential exposure from arsenic, with the major part arising from background or baseline sources, not from the contributions of industrial emissions. The exposure commitments did not exceed the Toxicity Reference Values for arsenic in any age group. The impact

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[38] Lam SK. 9th Seah Cheng Siang Memorial Lecture: gastric cancer--where are we now? Ann Acad Med Singapore. 1999 Nov;28(6):881-9.
[39] Shogo Kikuchi Epidemiology of Helicobacter pylori and gastric cancer. Gastric Cancer. 2002;5(1):6-15.
[40] Hunt RH. Will eradication of Helicobacter pylori infection influence the risk of gastric cancer? Am J Med. 2004 Sep 6;117 Suppl 5A:86S-91S.

of industries with respect to the COPC would not be considered an important risk factor in this type of cancer.

The prevalence of risk factors for the Belledune population in the last 30 years may be considered to have been similar to those favouring a higher stomach cancer incidence diet low in fresh fruits and vegetables and rich in salted, preserved foods, etc.) We have no quantitative data on the prevalence of these risk factors, and in particular, the prevalence of *H. pylori* infection. Improvements in socio-economic status with the concomitant improvement in variety of fresh foods in the diet, the lowering of smoking rates, and improvement of medical interventions in diagnosing *H. pylori* infection may promise a decrease in the incidence of stomach cancer in Belledune as has been observed in other areas. However, the prevalence of *H. pylori* infection in Belledune or the potential contribution of infection to Belledune stomach cancer cases is not known.

6.2.3.4 Colorectal cancer

Colorectal cancer ranks as the third most common cancer among men and women. In 2004, it is expected that approximately 510 New Brunswickers will be diagnosed with colorectal cancer. In Canada, there appears to be an east-west gradient with higher rates found in the east and lower rates found in the west. For example, the highest rate for colorectal cancer in 2004 is found in Newfoundland and Labrador and the lowest is found in British Columbia with the age-standardized incidence rate of 80 and 56 per 100,000 population respectively. The in age-standardized incidence rate for New Brunswick in 2004 is 64 per 100,000.[41]

Associated Factors – Diet

Known risk factors for colorectal cancer include high dietary fat and meat, and low fibre, fruits and vegetable intake.[42]

Associated Factors – Other factors

Other risk factors include family history, physical inactivity, obesity, history of diabetes, tobacco smoke, and heavy use of alcohol.[43]

Associated Factors – environmental exposures

There is no specific association noted in the literature with any COPC and colorectal cancer.

[41] Canadian Cancer Statistics, 2004. Canadian Cancer Socity (www.cancer.ca)
[42] Schottenfeld D, Winawer SJ. Cancer of the large intestine. In: Schottenfeld D, Fraumeni JF, eds, Cancer Epidemiology and Prevention, Second Edition. New York: Oxford University Press 1996: 813-40.
[43] American Cancer Society

6.2.3.5 *Kidney cancer*

The kidney is the 6th most common cancer site among men and ranks 11th among women.[44] In 2004, it is expected that New Brunswick will have a total of 135 cases of kidney cancer, of which, 75 cases will be males and 60 females. It is not clear what causes kidney cancer, however, a number of risk factors have been identified.

Associated Factors – cigarette smoking

Cigarette smoke is strong risk factor for kidney cancer for both males and females. The risk can be as high as 2-fold among active cigarette smokers.[45] Cigarette smoking will provide considerable inhalation exposure to cadmium, so that most studies which have suggested a possible role for cadmium in kidney cancer cannot separate the effect of cigarette smoke as a separate risk factor.

Associated Factors – occupational exposures

Increased risk for kidney cancer has also been reported for various occupations with exposures to petroleum products[46]

Associated Factors – environmental exposures

Ingested cadmium is not associated with kidney cancer, although it is associated with kidney disease. No other COPC has been implicated in the scientific literature with kidney cancer.

6.2.4 Hospital Separations

Hospital separations reflect the most responsible diagnosis each time a person is admitted and discharged from a hospital. These data are captured at the provincial level and then collated and analysed in a national information system (Hospital Medical Records Institute and Canadian Institute for Health Information). Each separation (i.e. discharge) is counted as an independent event, so that separations by one individual in two circumstances will be counted as two events. In order to aggregate events to individuals, a personal identification number or a statistical algorithm must be used to merge events to individuals. The present study did not aggregate separations to individuals, as personal identifiers were not available for the data received by the study team.

Community consultations revealed that there was considerable concern about the high number of cancer hospitalizations from GBA residents. The analysis of these data are

[44] National Cancer Institute of Canada: Canadian Cancer Statistics 2004, Toronto, Canada 2004.
[45] Kreiger N, Marrett LD, Dodds L, et al. Risk factors for renal cell carcinoma: results of a population-based case-control study. *Cancer Causes & Control* 1993; 4:101-10.
[46] Boffetta B, Dosemeci M, Gridley G et al.. Occupational exposure to diesel engine emissions and risk of cancer in Swedish men and women. *Cancer Causes & Control* 2001; 12:365-74.

thus in response to community concerns. Hospital discharge information is a good reflection of diseases or services such as surgical interventions (i.e. gall bladder removal, hysterectomy) which require single hospitalizations. When considering chronic conditions such as cancer or respiratory diseases such as asthma, which may require multiple admissions for diagnosis and treatment, hospital separations do not reflect as precisely the population rates of disease, but rather the use of hospital services.

In 1999-2000, NB experienced the highest rate of hospital discharges in Canada, except for the Northwest Territories and Nunavut.[47] Average length of stay in hospital is about the same as the overall Canadian rate.[48]

The patterns of elevated rates of hospital discharges were very similar for both GBA and HR 5&6 as compared to NB which itself has a high rate of this measure. The patterns reflect medical practice in particular areas. Hospital admissions may be higher where there are no alternative ways of caring for sick people outside a hospital setting. Possible explanations may include but are not limited to fewer practicing physicians (high case load), fewer out patient facilities or home care, larger distances between residence and hospital (dispersed cachement area), or that the population is actually sicker and requiring more hospital-based health care. The study team did not have data upon which to make a valid inference on these elevated rates.

The mortality statistics for GBA (increased SMR for “all causes”, “all cancer” and circulatory system disease) and for HR 5&6 (increased SMR for endocrine and metabolic diseases and “other causes”) can together indicate that there is higher need for hospital services. However, without a more detailed analysis of these patterns, an explanation for the higher hospital separation rates across the board for both GBA and HR 5&6 cannot be confirmed.

[47] CIHI data: www.CIHI.ca

[48] CIHI data: www.CIHI.ca Average Length of Inpatient Hospital Stay (in Days) for Canada (Provinces and Territories), 1995–1996, 2001–2002 and 2002–2003

7.0 Recommendations

The study team has a number of recommendations emerging from the results of this study. As requested in the TORs for the study, these focus on directions for future research. To assist stakeholders in decision-making, the study team indicates from their perspective whether the specific recommendation is of higher or lower priority.

7.1 Biological monitoring recommendations

Of high priority would be to conduct an expanded survey of blood lead among child residents and pregnant women for the GBA. Given the results from the pilot survey combined with the HHRA findings and concerns of the community, an expanded blood lead survey of a representative sample from the other communities within the GBA is warranted. *(Higher Priority)*

7.2 Environmental monitoring recommendations

Based on the above discussion, uncertainties surrounding the concentrations of COPC in fish from the Baie des Chaleurs and in backyard garden vegetables are large enough to influence the outcome of this assessment. Therefore, it is recommended that:

- programs be implemented in the GBA to collect data (metal concentrations) on fish from the Baie des Chaleurs (Higher priority); and,
- to obtain additional data (metal concentrations) on garden vegetable produce across the GBA (Higher priority).

Local wild mussel consumption was a significant pathway of exposure for a number of the COPC and there are enough data collected on local mussels to be confident in the results of this analysis. Local wild mussels were used as a surrogate for other local shellfish in the study area. Limited data are available on clams and the concentrations of COPC were lower in clams than in the wild mussels. There were no data available on oysters. It is recommended to collect data on other shellfish such as clams and oysters to confirm that the local wild mussels contained the highest concentrations of COPC. It may also be prudent for individuals who consume local wild mussels to limit their intakes.

The side bar analysis on specific sites in the GBA, for example, the Soil 9 location from the Noranda EMP and the school indicate that further studies should be conducted on both of these sites. It is understood that the DELG is currently investigating the property identified with Soil 9 location, and remedial action for soil has occurred at the school site.

7.3 Research on health determinants

In order to further understand the findings from the CHSA, it will be necessary to conduct research on some of the factors associated with the disease patterns characteristic of the GBA. This is of *higher priority* because it will help to better explain the findings for a community with elevated disease patterns. This research should focus on:

- What are the current (and if possible) past smoking rates?
- What is the prevalence of diabetes? Hypertension? Obesity?
- What is the family history of cases of cancer?
- What foodstuffs are/were eaten regularly such as pickled meats, fish and vegetables?
- What are/were the rates of fresh vegetable consumption?

Of *lower priority* would be a study addressing *H. pylori* infection in stomach cancer cases and in the population in the region (HR 5&6).

Glossary

This glossary contains terms and definitions that may not be in common use among the general public. The definitions presented are the manner in which the terms are used in the current report.

Sources for definition of terms include:

New York State Department of Health, Health Canada, and Federal Drug Administration (USFDA).

Last, J. A Dictionary of Epidemiology, 3rd Ed. Oxford University Press New York, 1995.

ATSDR Glossary of TERMS

Absorption
The process of taking in, as when a sponge takes up water. Metals can be absorbed into the bloodstream from the lung (after inhalation), the skin (after skin contact), the stomach and intestine (after ingestion) and transported to various body organs. Skin absorption is not a common source of exposure to metals, while eating and breathing are more likely sources of exposure.

Acute
Occurring over a short time, usually a few minutes or up to about 24 hours. An acute or short-term exposure can result in short term or long-term health effects. An acute effect happens within a short time after an exposure.

Adverse health effect
A change in body function or cell structure that might lead to disease or health problems

Age-specific rate
A rate for specified age group. The numerator and denominator both refer to the same age group. The multiplier (usually 100,000) is chosen to produce a rate that can be expressed as a convenient number.

Age standardisation
A procedure for adjusting rates, designed to minimise the effects of differences in age composition when comparing rates for different population.

Atmospheric dispersion
The dispersion into the atmosphere of particulate matter and gases that can be carried by air currents.

Ambient
Surrounding. Ambient air is usually outdoor air (as opposed to indoor air).

Background level
Naturally occurring level or concentration of a chemical or substance in the environment. Background often refers to naturally occurring or uncontaminated levels, and it should be noted that these vary from one location to another.

Baseline Level
Concentration or level of a chemical or substance present in the environment due to human-made, non-site sources (e.g., automobiles, industries).

Bioaccumulation
All chemicals are excreted from the body at a rate that varies among different chemicals. If the rate of absorption exceeds the rate of excretion, then the chemical will build up in the body. This is known as “bioaccumulation”.

Biological monitoring
Measuring chemicals in the body either by sampling body tissues or by sampling fluids (blood, urine, nails, hair, and breath, etc.). For example, the blood lead level is a reflection of exposure to lead.

Births
Infants born alive excluding still-births.

Body burden
The total amount of a chemical in the body at any one time.

Cancer risk
A theoretical risk for getting cancer if exposed to a substance every day for 70 years (a lifetime exposure). The true risk might be lower.

Carcinogen
A chemical that can increase the risk of cancer.   A few chemicals are known to be carcinogens in humans ; however, some other chemicals are considered suspect carcinogens.

Case control study
An observational retrospective epidemiology study in which people with a disease (cases) are compared to people without the disease (controls) to see if frequency of chemical exposures or other factors were different for the two groups.
The "disease" in question usually has to be clearly defined in a standard way such as lung cancer, or liver cancer, etc.

Central nervous system (CNS)
The part of the nervous system that includes the brain and the spinal cord.

Chemical of Potential Concern (COPC)
Any chemical that is shown to pose possible risk at a site. A Chemical of Potential Concern (COPC) is generally a chemical which may or may not be causing risk or adverse effects to humans at a site.

Chronic
Exposures that occur over a long period of time; several weeks, months or years or health effects that persist for a long time or that occur after chronic exposures.

Cohort study
An observational epidemiologic study of a group of people in which subsets of a defined population can be identified who are, have been, or in the future may be exposed or exposed to different degrees to a factor(s) hypothesised to influence the probability of occurrence of a given disease or other outcome. This generally implies study of a large population, studied for a long period of time.A cohort is any group of people sharing a similar characteristic such as neighborhood where they reside, or school they attended, or a common birth year, etc.

Composite sample
A sample of water, soil or other medium, which is made by combining samples differing from each other in depth, time, or location.

Concentration
The amount of one substance dissolved or contained in a given amount of another. One part per million means that there is one part in a million parts, for example, one kilogram of a chemical in a million kilograms of soil.

Conceptual site model
A "model" of a site developed at scoping using readily available information. Used to identify all potential or suspected sources of contamination, types and concentrations of contaminants detected at the site, potentially contaminated media, and potential exposure pathways, including receptors. This model is also known as "conceptual evaluation model."

Confidence Interval (CI)
The computed interval with a given probability (e.g., 95%) that the true value of a variable such as a proportion or rate is contained within the variable.

Confounding
A situation in which the effects of two processes are not separated.
A relationship between the effects of two or more causal factors as observed in a set of data such that it is not logically possible to separate the contribution that any single causal factor has made to an effect. A situation in which a measure of the effect of an exposure on risk is distorted because of the association of exposure with other factors(s) that influence the outcome under study.

Confounder
A variable that can cause or prevent the outcome of interest, is not an intermediate variable, and is associated with the factor under investigation. Unless it is possible to adjust for confounding variables, their effects cannot be distinguished from those of factors(s) being studied.

Conservative
As used in the term conservative estimates, this is considered a pessimistic or an overestimate of the level, effect or hazard, as the case may be.

Contaminant
Any substance that enters a system (the environment, human body, food, etc.) where it is not normally found or at levels above the natural concentrations. Contaminants are usually referred to in a "negative" sense and include substances that spoil food, pollute the environment or potentially cause other adverse effects.

Contaminant migration
The movement of contaminants from one location to another.

Crude Rate
Crude rates per 100,000 (per annum) are obtained be dividing the number of cases in a given population by that population multiply by 100,000. Crude rates do not account for differences in age distribution of the population.

Dermal
Referring to the skin. For example, dermal absorption means absorption through the skin. Some substances are not absorbed though the skin at all, such as some metals, unless they are dissolved in water or other solvents (that is they are made soluble).

Detection limit
The lowest amount of substance that a laboratory can detect using a specific analytic technique.

Dose
The amount of substance to which a person is exposed. Dose often takes body weight into account. For example, to receive equivalent doses of medicine, children are given smaller amounts than adults.

Dose-response relationship
The relationship between the amount of exposure [dose] to a substance and the resulting changes in body function or health (response).

Environmental media
Soil, water, air, biota (plants and animals), or any other parts of the environment that can contain contaminants.

Environmental media and transport mechanism
Environmental media include water, air, soil, and biota (plants and animals). Transport mechanisms move contaminants from the source to points where human exposure can occur. The environmental media and transport mechanism is the second part of an exposure pathway.

Epidemiology
The study of the occurrence of health effects or disease in human populations. An epidemiological study often compares two or more groups of people who are as alike as possible, except for the factors being investigated. The factor could be exposure to a chemical or the presence of a health effect. The investigators try to determine if any factor is associated with the health effect.

Ecological fallacy
The bias that may occur because an association observed between variables on an aggregate level does not necessarily represent the association that exists at n individual level.

Exposure
Exposure is any contact with a chemical by swallowing, by breathing it or by direct contact (such as through the skin or eyes). We often refer to internal exposure, which is how much gets into the body, and external exposure, which is how much is “presented” to the body but may not be absorbed.

Exposure assessment
A process that estimates or measures the amount of a chemical or substance that enters or comes into contact with a person. An exposure assessment also takes into consideration the length of time and the nature and size of a population exposed to a chemical.

Exposure pathway
The pathway a chemical, substance or agent may take to reach or cause exposure of humans or other living organisms. Pathways link a source of a chemical, substance or agent (i.e. soil) to its eventual entry into the body.

Exposure Point Concentration (EPC)
The value that represents a conservative estimate of the chemical concentration available from a particular medium or route of exposure.

Exposure Route
The way a chemical comes in contact with a person (e.g., by ingestion, inhalation, dermal contact).

Gradient
The change in concentrations of a chemical, substance or agent over distance. For example, with a source of the chemical, substance or agent (i.e. a smokestack), its concentration will decrease as distance away from the source increases, resulting in a gradient.

Groundwater
Water beneath the earth's surface in the spaces between soil particles and between rock surfaces

Guideline
Recommended limits for some parameter. For example, health guidelines are upper limits of exposure, below which adverse health effects are absent or minimized.

Hazard
Potential for radiation, a chemical or other pollutant to cause human illness or injury. Hazard identification of a given substances is an informed judgment based on verifiable toxicity data from animal models or human studies.

Hazard Assessment
Evaluating the effects of a contaminant or determining a margin of safety for an organism by comparing the concentration which causes toxic effects with an estimate of exposure to the organism.

Health outcome
Any health condition associated with or possibly resulting from an exposure.

Health assessment
An ongoing process to determine, if possible, the health impacts related to particular events or circumstances, such as the release of a hazardous substance into the environment. It includes a health interpretation of all the information known about the situation. The information may include some or all of the following: site investigation (environmental sampling and studies), exposure assessment, risk assessment, biological monitoring and health effects studies. The information is used to advise people how to prevent or reduce their exposures, to determine remedial actions are necessary, or the need for additional studies.

Sometimes there are other terms used such as:

Community-based health assessment
Community health risk assessment
Site-specific health risk assessment
Community health study

The types of studies carried out in the service of these terms can be studies of the environment (soil measurements, contaminant availability, etc.) or studies of the people living in the environment (epidemiological studies or biological monitoring studies).

Health effects studies
Studies that examine historical health impacts may result from particular events, such as exposure to hazardous or other substances. Health effects studies may include, but are not limited to, epidemiological studies and exposure and disease registries.

Health registry
A record of people known to have been exposed to a specific substance (such as a virus, bacteria, heavy metal), or a record of people displaying a specific health effect (such as cancer or a communicable disease). Exposure registries are used primarily in occupational settings where workers may be exposed to relatively high levels of hazardous substances (i.e. National Radiation Dose Registry).

ICD-9 CODES
The World Health Organization's *International Classification of Diseases, Ninth Revision.*

Incremental
Small increase.

Infant Death
Death under one year of age.

Ingestion
Eating or drinking.

Inhalation
Breathing or inhaling air, and the substances it contains, into the lungs. Exposure may occur from inhaling contaminants because they can be deposited in the lungs, taken into the blood or both.

Latency period
The period of time between exposure to an agent, such as a virus, bacteria or toxic chemical, and the onset of any health effect. For solid tumours, the latent period can be more than 20 years.

Media
Soil, water, air, plants, animals or any other parts of the environment that can contain chemicals, agents or substances. Body tissues or fluids such as blood, bone or urine may also be media. The singular of "media" is "medium."

Metabolism
All the naturally occurring chemical reactions within the body that enable the body to work. For example, food is metabolized (chemically changed) to supply the body with energy. Chemicals can be metabolized and made either more or less harmful by the body. In general, metabolism makes chemicals less harmful (detoxifies substances). Occasionally, metabolism can activate a chemical to increase its potential to do biological harm.

mg/kg
Milligram per kilogram.

mg/m^3
Milligram per cubic meter; a measure of the concentration of a chemical in a known volume (a cubic meter) of air, soil, or water.

Modelling
The process by which scientists consider many scenarios of exposure for the purpose of determining the associated risk (of adverse health effect). A selected scenario may be preferred for a given site when information is known about the site and about the behavior of the chemical or substance.

In most cases modelling involves the use of mathematical equations to inter-relate the factors critical to the process being studied. These mathematical equations have been developed through studies of factor inter-relationships. Models are used to predict events expected in the future, or that have occurred in the past, when direct measurements are not available or feasible.

Morbidity
Illness or disease. Morbidity rate is the number of illnesses or cases of disease in a population per 100,000 (or other multiplier) per annum.

NPRI – National Pollutant Release Inventory
The National Pollutant Release Inventory (NPRI) is the only legislated, nation-wide, publicly-accessible inventory of its type in Canada. It is a database of information on annual releases to air, water, land and disposal or recycling from all sectors - industrial, government, commercial and others.

P-value
The p-value is the probability of rejecting the null hypothesis when a specified test procedure is used on a given data set. This probability is the smallest level of significance at which the null hypothesis would be rejected. Once the p-value has been determined, the conclusion at any particular level alpha
results from comparing the p-value to alpha (e.g., 0.05):
(a) p-value ≤ alpha; reject null hypothesis at level á,
(b) p-value > alpha; do not reject the null hypothesis at level alpha,
and we call the data statistically significant when the null hypothesis is rejected and not significant otherwise.

Plume
An area of increased concentrations of chemicals, substances or agents moving away from its original location in a long band or column. Subsurface plumes are in groundwater. Airborne plumes come from air emissions. See gradient.

Proportional Mortality Ratio (PMR)
The proportion of observed deaths from a specified condition in a defined population, divided by the proportion of deaths expected from this condition in a standard population.

Protocol
The detailed plan for conducting a scientific procedure. A protocol for measuring a chemical in soil, water or air describes the way in which samples should be collected and analyzed.

Quality assurance and quality control (QA/QC)
A system of procedures, checks and audits to judge the quality of measurements and reduce the uncertainty of environmental data.

Receptor
A human exposed to a contaminant released to the environment.

Remediation
Correction or improvement of a problem, such as work that is done to clean up or stop the release of chemicals from a hazardous waste site (or other contaminated site). After investigation of a site, remedial work may include removing soil and/or drums, capping the site or collecting and treating the contaminated fluids.

Renal
To do with the kidney

Risk
Risk is the probability, chance or likelihood of something happening. In the current context, the likelihood of injury, disease or death that will be caused by an action or condition. For example, for a person who has measles, the risk of death is one in one million.

Relative risk
The ratio of the disease rate among exposed people and the disease rate among unexposed people.

Risk assessment
A process that estimates the likelihood or chance that people may have adverse health effects from a particular series of events or circumstances, such as exposure to chemicals or substances. The four steps of a risk assessment are:

hazard identification (Can this substance damage health?);
dose-response assessment (How much of this substance must be ingested or absorbed to observe an effect?)
exposure assessment (How, and how frequently do people contact it?); and
risk characterization (The act of combining the other three steps to quantify risk: "one in a million").

Most risk assessments also have a "Problem Formulation" phase to clearly specify or define the issues to be addressed by the risk assessment.

Likelihood is a quantitative term related to "probability", "chance" or to "risk".

Route of exposure
The way in which a person may contact a chemical, substance or agent. For example, drinking (ingestion) and bathing (skin contact) are two different routes of exposure to contaminants that may be found in water. See "Exposure."

Safe
In common language, safe means free from harm or risk. In scientific language, any exposure to most chemicals, substances or agents have some risk, although that risk may be extremely small. Therefore, scientifically, safe means at very low or negligible risk. Safety is the complement of risk. As risk increases, safety decreases, and vice versa. Safety is rarely 100%, and risk is rarely zero.

Sample
A portion or piece of a whole. A selected subset of a population or subset of whatever is being studied. For example, in a study of people the sample is a number of people chosen from a larger population [see population]. An environmental sample (for example, a small amount of soil or water) might be collected to measure contamination in the environment at a specific location.

Sample size
The number of units chosen from a population or an environment.

Screening
A preliminary stage of the assessment process for quick evaluation of relatively simple and routine activities, or for determining the level of effort required for evaluating more complex projects.

Standard Population
A reference population of known age distribution used in the calculation of standardized indicators to adjust for variations in population age structures in different geographic areas or time periods. For SMR/PMR calculations the standard population is the entire New Brunswick population excluding Health Regions 5&6 for the year(s) concerned.

Standardized Mortality/Morbidity/Incidence Ratio (SMR/SIR)
The ratio of the number of deaths/illness observed in the study group or population to the number that would be expected if the study population had the sample specific rates as the standard population.

Stillbirths
Fetal deaths of at least 500 grams or at least 20 weeks gestation.

Target organ
An organ (such as the liver or kidney) that is more sensitive to the toxic effects of a chemical, substance or agent.

Threshold
The dose or exposure below which an adverse effect is not expected. Significance is a statistical term that describes the medical or scientific confidence for a prediction (describes the limits of uncertainty).

Toxicological profile

A document that examines, summarizes, and interprets information about a hazardous substance to determine harmful levels of exposure and associated health effects. A toxicological profile also identifies significant gaps in knowledge on the substance and describes areas where further research is needed.

Toxicity Reference Value(TRVs)

An estimate of a rate of exposure of people, animals or plants that is likely to be without appreciable risk of deleterious effects. There are two types of TRVs. For threshold acting or non-carcinogenic chemicals the TRV is an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily oral exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime. Uncertainty factors are generally applied to reflect limitations of the data used. For carcinogens, the TRV is an upper bound, approximating a 95% confidence limit, on the increased cancer risk from a lifetime exposure to an agent. This estimate, usually expressed in units of proportion (of a population) affected per mg/kg/day, is generally reserved for use in the low-dose region of the dose-response relationship, that is, for exposures corresponding to risks less than 1 in 100.

Uncertainty

A lack of knowledge about certain factors in a study which can reduce the confidence in conclusions drawn from data in that study; it is opposed to variability which is a result of true variation in characteristics of the environment.

Uncertainty factor

Mathematical adjustments for reasons of safety when knowledge is incomplete. For example, factors used in the calculation of doses that are not harmful (adverse) to people. Uncertainty factors are used to account for variations in people's sensitivity, for differences between animals and humans. Scientists use uncertainty factors when they have some, but not all, the information from animal or human studies to decide whether an exposure will cause harm to people [also sometimes called a safety factor].

Weight of evidence

The extent to which all of the available scientific information supports the concept of concern; for example, the available evidence on the relationship between an exposure to a substance and cancer in humans.

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