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Risky business : the role of risk perception in the Ontario source water protection planning process

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RISKY BUSINESS: THE ROLE OF RISK PERCEPTION IN THE ONTARIO SOURCE WATER PROTECTION PLANNING PROCESS

by

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Abstract

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The purpose of this research was:

1. to investigate whether the perception of drinking water-related risk differs between the public and a Source Protection Committee established under Ontario's new *Clean Water Act* to make decisions about source water protection,
2. to explore how the public makes risk-based decisions about drinking water-related risk, and,
3. to estimate how any differences in drinking water-related risk perception and decision making between the Committee and the public may affect the implementation of the *Clean Water Act*.

Mail and telephone surveys were conducted in a Southern Ontario Region of Study, and were given to samples of the public and the Committee. The two groups had different perceptions of water risk, which could pose challenges for making collective decisions about water risks. Successful source water protection depends on the ability of Committees and the public to make appropriate decisions about risks to drinking water sources.

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1. Introduction

In May 2000, seven residents of Walkerton, Ontario died and approximately 2,300 became ill as a result of exposure to bacterially contaminated drinking water (Hrudey, Huck, Payment, Gillham, & Hrudey, 2002, p.397; Ministry of the Environment, 2006c)[1]. As a result of the severity of this tragedy, the Ontario Government called a public inquiry by Mr. Justice Dennis O'Connor in order to assess the cause of the microbial outbreak, any contribution that government policies may have made to the outbreak, and the implications of this event for drinking water safety across Ontario (Hrudey et al., 2002, p.397). One of the key recommendations made by Justice O'Connor in the *Report of the Walkerton Inquiry* was "to ensure source water protection as part of a multi-barrier approach" to preventing risks to water and ensuring drinking water safety (Elwell, 2006, p.4).

In response to this recommendation, the Ontario Government passed the *Clean Water Act* (S.O. 2006, c. 22) in 2006 (Legislative Assembly of the Province of Ontario, 2006). The Act "establishes each conservation authority and other bodies" as drinking water Source Protection Authorities (Ayres, n.d., p.2). The geographic area of each Source Protection Authority covers the watershed (Ministry of the Environment, 2007f). Under the Act, the area of jurisdiction of each Source Protection Authority is defined as a drinking water Source Protection Area (Ayres, n.d., p.2).[2] While eight Source Protection Areas operate individually, the other Source Protection Areas are amalgamated into Source Protection Regions (Ministry of the Environment, 2007f). There are a total of eleven amalgamated Source Protection Regions, each comprised of two or more Source Protection Areas (Ministry of the Environment, 2007f).

The Region of Study

This research focuses on one particular Region of Study. For the purposes of this study, what will be hereafter referred to as "the Region of Study" is a municipality within a Southern Ontario Source Protection Area. The Source Protection Area within which the Region of Study is located is amalgamated with other Source Protection Areas to form a Source Protection Region. The identity of the Region of Study will not be disclosed for reasons of confidentiality.

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[1] Walkerton, Ontario, Canada is located approximately 175 km northwest of Toronto, Ontario, and has a population of about 4,800 people (Hrudey et al., 2002, p.397). The primarily responsible pathogens were *Campylobacter jejuni* and *Escherichia coli* 0157:H7, although it is likely that other pathogens were present (Hrudey et al., 2002, p.398). Over 2,300 people were afflicted with gastroenteritis, 65 people were hospitalized, 27 people developed hemolytic uremic syndrome (HUS), and seven people died (Hrudey et al., 2002, pp.397-398).

[2] According to the *Clean Water Act*, Source Protection Authority is defined as "a conservation authority or other person or body that, under subsection 4(2) or section 5, is required to exercise and perform the powers and duties of a drinking water source protection authority under this Act" (Legislative Assembly of the Province of Ontario, 2006).

The Source Protection Committee

Under the Act, each Source Protection Authority is required to establish a drinking water Source Protection Committee for the corresponding Source Protection Area (Ayres, n.d., p.2; Legislative Assembly of the Province of Ontario, 2006, §7(1)). Each Source Protection Authority appoints a Source Protection Committee, which is comprised of key local stakeholders who are responsible for making judgments and decisions about risks to municipal drinking water sources (Conservation Ontario, 2007b; Government of Ontario, 2007b, §2; Ministry of the Environment, 2007d). Although it is not explicitly stated, it is implicitly assumed that these individuals appointed to be responsible for making judgments about local water-related risks have expert knowledge that allows them to make informed decisions about source water protection in their area (Conservation Ontario, 2007b; Government of Ontario, 2007b; Ministry of the Environment, 2007d).

For the purposes of this study, the participating members of the Source Protection Committee corresponding to the Source Protection Region within which the Region of Study is located will be hereafter known as "the Committee". Only a sample (i.e. 16 participants out of 22 members and one liaison) of the Source Protection Committee participated in this study, and it is only this sample (i.e. the 16 participants) that will be hereafter referred to as "the Committee". It is important to note that the unit of action for the Committee is the entire watershed, even though this study is of only one municipality within it. The identity of the Committee will not be disclosed in order to protect the confidentiality of its members. However, the educational, occupational and experiential expertise of each of the members of the Committee is listed in Appendix A.

The Study Community

The Committee involves the public through working groups and by broadly consulting across the watershed throughout the source water protection planning process (For further information about the Act, see Section 2; Ministry of the Environment, 2007e; Ministry of the Environment, 2007d). Of particular importance to this research, it is through these working groups and consultations that threats to municipal drinking water and their perceived risk are discussed between Committee members and the public (Ministry of the Environment, 2007e; Ministry of the Environment, 2007d; Ministry of the Environment, 2007f). Therefore, this collaboration between key decision makers and the public is expected to "provide insight that will foster widely supported policy choices reflecting public values, and...build lasting support for those choices" (McDaniels, Gregory, & Fields, 1999, p.499).

In addition to surveying the Committee, this study also surveyed members of the public residing in the Region of Study. For the purposes of this study, those members of the public residing in the Region of Study who participated in the survey[3] will be hereafter referred to as "the Community".

Overview and Relevance of the Clean Water Act, 2006

The *Clean Water Act* is the Province of Ontario's new process for protecting current and future sources of drinking water (Legislative Assembly of the Province of Ontario, 2006, §1). Under the Act, communities are obligated to protect their sources of municipal drinking water (Ministry of the Environment, 2006a, p.1; Ministry of the Environment, 2007g). Through consultations with the public and the municipalities within their jurisdiction, Source Protection Committees are required by the Act to propose Terms of Reference for the preparation of an assessment report and a source protection plan for the Source Protection Area (Ayres, n.d., p.2; Ministry of the Environment, 2007e; Ministry of the Environment, 2007d; Ministry of the Environment, 2007f). Thus, communities must identify and assess existing and prospective threats to local drinking water supplies, as well as develop and carry out the necessary actions to eliminate or reduce critical threats (Ministry of the Environment, 2006a, p.1; Ministry of the Environment, 2007g). Conservation Authorities, municipalities, farmers, property owners, industry, the public and community groups must collaborate in order to achieve common goals (Ministry of the Environment, 2007g).

Therefore, the *Clean Water Act* requires local communities to protect sources of municipal drinking water by identifying and evaluating potential and existing threats to local drinking water supplies, and reducing critical threats by developing source protection plans (Ministry of the Environment, 2006a, p.1; Ministry of the Environment, 2007g). However, this local process of identifying municipal drinking water risks is highly contingent upon the perceptions that both members of the public such as the Community and informed decision makers such as the Committee have of these risks. It is anticipated that there may be negotiation between experts and the public, and there is a concern that local perceptions of water-related risk may influence the outcome. It is therefore crucial to understand the way in which the public perceives and makes decisions about drinking water-related risks, and how these perceptions and decision making processes differ from those of the members of a local Source Protection Committee who are responsible for making judgments about these risks. If the response of the public or of a Source Protection Committee to a specific local drinking water risk is greater or lesser than the particular risk calls for, or if there are discrepancies between the responses of the two groups (e.g.

[3] The term "survey" is used throughout this report. For the purposes of this report, the term "survey" means questionnaire or survey questionnaire. However, it is recognized that the term "survey" typically refers to the entire undertaking.

each group expresses aversions to different individual risks and risk characteristics), there could be considerable differences in municipal source water protection, the prevention of drinking water risk, and ultimately the quality of municipal drinking water and the health of Ontarians.

This research project was designed in relation to the above features of the *Clean Water Act*, as will be outlined in the subsequent subsections of this report. In Chapter 2, the subject matter of this subsection will be discussed in greater detail.

1.1 Problem Statement

How does the public perceive risks related to their drinking water? How do they make decisions about these risks? Are these perceptions and decision making mechanisms different from those of the individuals who are responsible for making judgments about drinking water-related risks? How might these potential differences affect the implementation of the *Clean Water Act*? These questions remain unanswered, primarily due to a lack of knowledge about public risk perceptions and decision making processes, particularly as they pertain to drinking water-related risks (Adamowicz, Dupont, & Krupnick, 2004, p.1842). Although other types of risks and the perception of these risks are adequately addressed in the literature, risks related to drinking water are understudied (Adamowicz et al., 2004, p.1842). Not surprisingly, there is also a lack of information about the effectiveness and implementation of the *Clean Water Act*. This information gap is expected, due to the recency of the legislation.

These knowledge deficits are important given that under the *Clean Water Act*, the process of locally identifying risks to municipal drinking water in the Region of Study is highly contingent upon the risk perceptions of the Community and the Committee. As discussed above, there is a concern that local perceptions of water-related risk may influence the outcome of the anticipated negotiations between experts and members of the public. Local risk perceptions could potentially obscure the scientific basis of a given water risk, resulting in inappropriate responses to the risk. If the response of the public or of the Committee to a specific local drinking water risk is greater or lesser than the particular risk calls for, or if there are discrepancies between the responses of the two groups, there could be important differences in municipal source water protection, the prevention of drinking water risk, and ultimately the quality of municipal drinking water and the health of Ontarians.

The knowledge deficits discussed above are also important given the pervasiveness and future implications of, and renewed public interest in, drinking water risk issues (CELA, 2004). Approximately 82 per cent of Ontarians, or about 8.9 million people, rely on municipal drinking water (CELA, 2004). Furthermore, Ontarians have experienced a renewed interest in drinking water quality issues, incited in part by the May 2000 Walkerton tragedy (CELA, 2004).

This research endeavors to address these knowledge gaps by determining whether the perception of drinking water-related risk differs between decision makers (the Committee) and the public (the Community), how the public makes risk-based decisions pertaining to drinking water-related risk and whether this process differs from that of decision makers and, finally, how any potential discrepancies may affect the implementation of the *Clean Water Act*.

1.2 Purpose

The purpose of this research is threefold. This research seeks to address the knowledge gaps discussed in the previous section. First, the purpose of this research is to establish whether the perception of drinking water-related risk differs between drinking water consumers residing in the Region of Study and the members of the Committee.

Previous risk perception studies suggest that experts and members of the public have very different definitions of risk (Slovic, 1987, p.280-283; Slovic, Fischhoff, & Lichtenstein, 1984, pp.187, 193). When these studies are extended to this research, they suggest that since the Committee members are taking on the role of experts under the *Clean Water Act*, they may perceive risk in the way that is typical of experts, and make decisions accordingly (Hampel, 2006, p.5,8,9; Rowe & Wright, 2001, p.341). It is implied from the literature that, as experts, the Committee members are expected to define drinking water risk as "hazard", the product of magnitude and probability (see Section 3.1.3; Hampel, 2006, pp.7-8; Kasperson et al., 1988, p.177; Slovic et al., 1984, p.193). Similarly, it is implied from the literature that, as members of the public, the Community members are expected to perceive drinking water risks in terms of "outrage factors" and heuristics, as typically characterizes the lay public's more complex perception of risk (Hampel, 2006, pp.7-8; Kasperson et al., 1988, p.177; Slovic et al., 1984, p.193). Thus, based on previous risk perception studies, there is reason to expect that the perceptions of drinking water risk could differ between members of the Community and the Committee members.

Second, the purpose of this research is to explore how drinking water consumers make risk-based decisions pertaining to drinking water-related risk. That is, the way in which members of the public translate complex perceptions of risk into simple decisions that they are able to make will be investigated. This study will also investigate whether this decision-making process differs from that of the Committee members who are responsible for making key judgments and decisions.

The literature implies that not only do experts and laypeople have different risk perceptions, but they also make decisions about risks in different ways (Kasperson et al., 1988, p.177; Slovic, 1987, pp.280, 283). When these studies are extended to this research, it may be anticipated that Community members might make decisions using outrage factors and that are based on their more complex[4] perceptions of risk (Kasperson et al., 1988, p.178; Slovic, 1987, p.283). Another factor that may play a role in the Community's decision making processes is a higher risk aversion, which is characteristic of the lay public (Fischhoff, Slovic, Lichtenstein, Read, & Combs, 1978, p.148; Slovic, 1987, pp.280, 283). Conversely, based on the literature, it may be anticipated that the Committee might make water risk decisions differently (Slovic, 1987, pp.280, 283; Slovic et al., 1984, pp.187, 190, 193). In addition to defining risk in a less complex manner, the Committee is expected to be less risk averse (Fischhoff et al., 1978, p.148; Slovic, 1987, p.283). These characteristics, which are expected to differ between the Community and the Committee, have been shown to affect risk-based decision making (Kasperson et al., 1988, p.178; Slovic, 1987, p.283).

Providing that differences in drinking water-related risk perception and decision making do exist between Committee members and Community members, the third purpose of this research is to estimate how these discrepancies may affect the implementation of the *Clean Water Act*. If there are differences in drinking water-related risk perceptions and decision making processes between the Committee and the Community, these differences could result in inappropriate reactions to water risks and/or discrepancies between the responses of the two groups, which could greatly affect the implementation and even the effectiveness of the *Clean Water Act*.

This research could have both practical and theoretical significance. It is anticipated that the results of this research will be explicitly relevant to the management of drinking water-related risk in general, and the protection of municipal drinking water sources in particular by casting some light on the implementation of the *Clean Water Act*. This research is also expected to add to current knowledge of the perception of water risk characteristics, the local nature of water protection decisions and collective decisions made and actions taken to reduce risks. Thus, it is anticipated that this research will help strengthen the source water protection component of Ontario's multi-barrier approach to ensuring safe municipal drinking water (CELA, 2004).

1.3 Hypothesis

The three null hypotheses listed below correspond to the above listed purposes of this research.

[4] According to the literature, laypeople utilize a number of heuristics, or outrage factors, to help them evaluate risk (Hampel, 2006, pp.7-8; Sly, 2000, p.153; Sly, 2000, p.153). As a result, the average person's perception of risk is more, as opposed to less multifaceted and complex than that of the average expert, who might typically define risk as the product of magnitude and probability (Hampel, 2006, pp.7-8; Kasperson et al., 1988, p.177; Sjöberg, 2000, p.2; Slovic et al., 1984, p.193; Sly, 2000, pp.153-154). See subsection 3.1.3.1 for further information.

$H_0$1. The perception of drinking water-related risk does not differ between the Region of Study's Source Protection Committee members and drinking water consumers living in the corresponding Region of Study.

$H_0$2. There is no difference in the way in which Committee members and the public make decisions about water-related risk.

$H_0$3. There are no differences in drinking water-related risk perception and decision making between Committee members and the members of the public. As such, there are no corresponding ramifications for the implementation of the *Clean Water Act*.

The three alternative hypotheses below correspond to the three null hypotheses listed above.

H_{A1}. The perception of drinking water-related risk differs between the Region of Study's Source Protection Committee members and members of the public residing in the Region of Study, with patterns reflecting expert and lay public risk perceptions in general.

H_{A2}. There is a difference between the way Committee members and the way members of the public make decisions about water-related risk.

H_{A3}. There are important differences in water-related risk perception and decision making between the Committee members and the members of the public, with each group expressing aversions to different individual risks and risk characteristics. These differences are expected to have important ramifications for the implementation of the *Clean Water Act*.

1.4 Overview and Organization

This report will begin by examining the legal context of source water protection planning in Ontario. Subsequently, this report will review the literature for risk perception, risk communication, trust, credibility and deference, collective action theory, decision theory, and finally, other relevant water risk studies. Once the problems of perceiving risk and the problems of collective choice are reviewed, the focus will shift to the research component of this study. The study's research methods will be presented, followed by a discussion of the limitations of this study, the presentation of the research results and an examination of the study's findings. This report will close by presenting the study's conclusions.

2. The Legal Context: Ontario's *Clean Water Act*

This section will discuss the legal context of source water protection in Ontario, focusing on the features of the *Clean Water Act*, 2006 that are most relevant to this research. This section will begin with a brief introduction to the *Clean Water Act*, followed by a discussion of the Act as it relates specifically to source water protection, its main focus (Ministry of the Environment, 2007d). Subsequently, a concise overview of the main features and goals of the *Clean Water Act* will be presented in preparation for the remainder of this section, which discusses the Act in greater detail. The roles and responsibilities of the entities involved in the implementation of the Act will be outlined, followed by a discussion of the three main stages of the source protection process, as dictated by the Act (Ministry of the Environment, 2007f). This section will conclude with a concise discussion of the relevance of the *Clean Water Act* to this research.

The *Clean Water Act* is the province of Ontario's new process for protecting current and future drinking water sources (Legislative Assembly of the Province of Ontario, 2006, §1). The *Clean Water Act* received Royal Assent on October 19, 2006 (Ayres, n.d., p.5). The Act, along with the first phase of regulations[5], came into effect on July 3, 2007 (Ministry of the Environment, 2007g).

The purpose of the Act is to respond to "a key recommendation by Justice O'Connor in the *Report of the Walkerton Inquiry* to ensure source water protection as part of a multi-barrier approach to drinking water safety" (Elwell, 2006, p.4; Ministry of the Environment, 2006d). The Act endeavors to "protect existing and future sources of drinking water" (Legislative Assembly of the Province of Ontario, 2006, §1). According to the Ministry of the Environment:

> The Clean Water Act (Bill 43) is a major part of the McGuinty government's commitment to ensure that every Ontarian has access to safe drinking water. Protecting water at its source is the first step in making that commitment achievable. By stopping contaminants from getting into sources of drinking water –lakes, rivers and aquifers – we can provide the first line of defense in the protection of our environment and the health of Ontarians (Ministry of the Environment, 2006a, p.1).

Source Water Protection and the Clean Water Act

The purpose of drinking water source protection is to keep sources of ground and surface water as clean as possible in order to reduce the risk of contamination (Ayres, n.d., p.1). Source water protection is

[5] The first phase of regulations encompasses five components, including regulations concerning Source Protection Areas and Regions, Source Protection Committees, Terms of Reference, Time Limits and Miscellaneous aspects (Ministry of the Environment, 2007g).

a desirable and effective approach to protecting existing and future drinking water sources because it is more cost effective and judicious to take action to protect the quality and quantity of existing drinking water sources than to remediate or decontaminate a drinking water source once it has become contaminated or impaired (Ayres, n.d., p.1).

Justice O'Connor made a total of twenty-two recommendations pertaining to source water protection in Part Two of the *Report of the Walkerton Inquiry*, twelve of which are actualized by the *Clean Water Act* (Ministry of the Environment, 2003; Ministry of the Environment, 2006d). The main focus of the Act is to help reduce drinking water risks by addressing threats to the quality and quantity of drinking water at its source (Ministry of the Environment, 2007d). The *Clean Water Act* institutes a formal procedure for determining threats to drinking water sources, and establishes regional committees to address those threats (Sierra Legal Media Releases, 2006). Under Section 2 of the *Clean Water Act*, a "drinking water threat" is defined as "an activity or condition that adversely affects or has the potential to adversely affect the quality or quantity of any water that is or may be used as a source of drinking water, and includes an activity or condition that is prescribed by the regulations as a drinking water threat" (Legislative Assembly of the Province of Ontario, 2006, §2).

Additionally, this legislation allows municipalities to more effectively protect waters under their jurisdiction (Sierra Legal Media Releases, 2006). The *Clean Water Act* is comprehensive in that it pertains to all threats to water, including the chemical and biological threats with which this study is concerned (Elwell, 2006, p.4; Ministry of the Environment, 2007d). The Act is involved with, but is not limited to surface and ground water protection, as well as both drinking water quality and quantity (Elwell, 2006, p.4; Ministry of the Environment, 2007d). The Act addresses such prospective threats to drinking water as industrial pollution, bacterial contamination, depletion due to overuse, and urban runoff (Sierra Legal Media Releases, 2006).

Overview of the Clean Water Act

There are two key features of the *Clean Water Act*. The first is the establishment of each Conservation Authority as a Source Protection Authority, whose area of jurisdiction is defined as a Source Protection Area (Ayres, n.d., p.2). The second key feature of the Act is the preparation of locally developed and implemented Terms of Reference, assessment reports and source protection plans (Ministry of the Environment, 2007d). These processes are discussed in greater detail below.

According to the Ministry of the Environment (2007b), in order to reduce treats to the quality and quantity of drinking water sources, the *Clean Water Act*:

- "Requires local communities[6] to look at the existing and potential threats to their water and set out and implement the actions necessary to reduce or eliminate significant threats.
- Empowers communities to take action to prevent threats from becoming significant.
- Requires public participation on every local source protection plan. This means everyone in the community gets a chance to contribute to the planning process.
- Requires that all plans and actions are based on sound science."

2.1 Roles and Responsibilities

The *Clean Water Act* "establishes each conservation authority and other bodies" as drinking water Source Protection Authorities (Ayres, n.d., p.2). The geographic area of each Source Protection Authority covers the watershed (Ministry of the Environment, 2007f). Under the Act, the area of jurisdiction of each Source Protection Authority is defined as a drinking water Source Protection Area (Ayres, n.d., p.2).[7] As set out in *Ontario Regulation 284/07 – Source Protection Areas and Regions*, there are a total of forty Source Protection Areas in Ontario. The corresponding Conservation Authorities are the Source Protection Authorities for thirty-eight of these Source Protection Areas (Government of Ontario, 2007a, §1). The remaining two Source Protection Areas are Northern Bruce Peninsula Source Protection Area for which the Source Protection Authority is the Municipality of Northern Bruce Peninsula, and Severn Sound Source Protection Authority for which the Source Protection Authority is the Severn Sound Environmental Association (Government of Ontario, 2007a, §2).

While eight Source Protection Areas operate individually, the other Source Protection Areas are amalgamated into Source Protection Regions (Ministry of the Environment, 2007f). There are a total of eleven amalgamated Source Protection Regions in Ontario, each comprised of two or more Source Protection Areas (Ministry of the Environment, 2007f). In a Source Protection Region, one of the amalgamated Source Protection Authorities (the lead Source Protection Authority) must "lead and co-ordinate the efforts of all the authorities within the region" (Ministry of the Environment, 2007f).

The Source Protection Authority

The Source Protection Authority is generally the Conservation Authority Board, which is made up of representatives who are appointed by municipal councils (Ministry of the Environment, 2007d).

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[6] In this context, a community is taken to mean all the individuals living within a watershed, the unit of source protection planning under the *Clean Water Act* (Ministry of the Environment, 2007f).

[7] According to the *Clean Water Act*, Source Protection Authority is defined as "a conservation authority or other person or body that, under subsection 4(2) or section 5, is required to exercise and perform the powers and duties of a drinking water source protection authority under this Act" (Legislative Assembly of the Province of Ontario, 2006).

Under the *Clean Water Act*, the Source Protection Authority must establish a Source Protection Committee (Ministry of the Environment, 2007d). The Act also dictates that the Source Protection Authority, with its watershed-based approach, is responsible for providing support to the Source Protection Committee throughout the development of the Terms of Reference, assessment report and the source protection plan by collecting and sharing information, promoting coordination and cooperation among stakeholders and communities, and providing advice and technical support to the Source Protection Committees (Ministry of the Environment, 2007d; Ministry of the Environment, 2007f). While the *Clean Water Act* does not does not grant Conservation Authorities new regulatory or enforcement powers, they are nonetheless required by the Act to provide Source Protection Committees "with local facilitation, coordination and technical support" throughout the assessment and planning process (Ministry of the Environment, 2007d). In a Source Protection Region, the lead Source Protection Authority is responsible for establishing the Source Protection Committee and for providing support to the Source Protection Committee (Ministry of the Environment, 2007f).

The Source Protection Committee

Under the *Clean Water Act*, each Source Protection Authority appoints a Source Protection Committee (Ministry of the Environment, 2007d). After considering any recommendations made by the Source Protection Authority, the Minister of the Environment appoints the Chair of the Source Protection Committee (Legislative Assembly of the Province of Ontario, 2006, §7(2)). The Source Protection Committees have strong municipal representation as well as a range of other key local stakeholders within the watershed (Conservation Ontario, 2007b; Government of Ontario, 2007; Ministry of the Environment, 2007d; Ministry of the Environment, 2007f). According to Section 2 of *Ontario Regulation 288/07 – Source Protection Committees*, the breakdown of membership on a Source Protection Committee is one-third reflecting the interests of the commercial, agricultural and/or industrial sector(s) of the Source Protection Area's or Region's economy, one-third reflecting municipal interests and one-third reflecting other interest groups, such as health groups, environmental groups and the public. There is also the possibility for aboriginal membership if any part of a reserve is located within a Source Protection Area or Region (Government of Ontario, 2007b, §6).

Source Protection Committees are responsible for making judgments and decisions about risks to municipal drinking water sources (Conservation Ontario, 2007b; Government of Ontario, 2007; Ministry of the Environment, 2007d; Ministry of the Environment, 2007f). The Committees are required by the *Clean Water Act* to develop the Terms of Reference, the assessment report and the source protection plan (Conservation Ontario, 2007c; Ministry of the Environment, 2007f).

Through the Source Protection Committee, municipalities across the watershed are working together to identify, assess and address drinking water risks "within their municipal wellhead and intake protection areas" (Ministry of the Environment, 2007d). The Source Protection Committees also involve stakeholders and the public through working groups and by broadly consulting across the watershed throughout the source protection planning process (Ministry of the Environment, 2007e; Ministry of the Environment, 2007d; Ministry of the Environment, 2007f).

Municipalities

Under the *Clean Water Act*, municipalities are building on their current responsibility for municipal drinking water distribution and land use planning through the source protection process (Ministry of the Environment, 2007f). Municipalities have a prominent role in the development and implementation of source protection plans in regions under their jurisdiction (Ministry of the Environment, 2007f). Municipalities are also developing and implementing "policies to reduce risks posed by activities located in areas under their jurisdiction" (Ministry of the Environment, 2007f).

Other Stakeholders and the Public

It is imperative that the public and stakeholders such as farmers, industry, property owners, businesses and community groups become involved in the local source protection planning process (Ministry of the Environment, 2007f). The Source Protection Committees are required under the Act to involve the public and stakeholders through working groups and by broadly consulting across the watershed at the three main stages of the source protection process – the preparation of the Terms of Reference, the assessment report and the source protection plan (Ministry of the Environment, 2007e; Ministry of the Environment, 2007d; Ministry of the Environment, 2007f). Importantly, it is also at these points that threats to municipal drinking water and their perceived risk are discussed between Source Protection Committee members and the public (Ministry of the Environment, 2007e; Ministry of the Environment, 2007d; Ministry of the Environment, 2007f).

2.2 Terms of Reference, Assessment Reports and Source Protection Plans

Terms of Reference

Under the *Clean Water Act*, the Source Protection Committee is required to propose a Terms of Reference that describes the work that the Source Protection Committees must perform in order to prepare an assessment report and source protection plan for the Source Protection Area (Ayres, n.d., p.2; Conservation Ontario, 2008a). The Terms of Reference is a plan that outlines roles and responsibilities, timelines and costs in order to guide the Source Protection Committee through the preparation of the assessment report and source protection plan (Conservation Ontario, 2008b). *Ontario Regulation 287/07* is a general regulation pursuant to the *Clean Water Act* that sets out the criteria for, and details of, the Terms of Reference (Ayres, n.d., p.2).

The Source Protection Committee is required by the Act to consult with municipalities within its jurisdiction throughout the preparation of the proposed Terms of Reference (Ayres, n.d., p.2). The Source Protection Committee is then required to submit the proposed Terms of Reference to its Source Protection Authority/ Authorities and to the municipalities within its jurisdiction (Ayres, n.d., p.3; Legislative Assembly of the Province of Ontario, 2006, §9). The Source Protection Committee must also publish the Terms of Reference on the Internet and invite public comments (Ayres, n.d., p.3; Legislative Assembly of the Province of Ontario, 2006, §9). It is important to note that as of this writing, the Committee in this study is currently at this stage of the planning process; it has submitted the proposed Terms of Reference to the Source Protection Authority/ Authorities and has just completed its public comment period (Conservation Ontario, 2008b). The proposed Terms of Reference are then submitted to the Minister of the Environment for approval or approval as modified (Ayres, n.d., p.3).

Assessment Report

The Source Protection Committee is required under the *Clean Water Act* to complete a proposed assessment report (Ayres, n.d., p.3; Legislative Assembly of the Province of Ontario, 2006, §15(1)). In completing a proposed assessment report, the Source Protection Committee must identify and evaluate risks to the quantity and quality of sources of municipal drinking water (Ministry of the Environment, 2006a, p.1). The Source Protection Committee must also determine which risks are important and require prompt action, which risks require monitoring to make sure they do not become significant, and which risks are insignificant (Ministry of the Environment, 2006a, p.1). Note that this step of the source water protection process is crucial to this investigation.

As outlined by section 15(2) of the *Clean Water Act*, the assessment report:

1. identifies all watersheds within the Source Protection Area
2. characterizes the quantity and quality of water in each watershed
3. specifies a water budget for each watershed
4. identifies all highly vulnerable aquifers and significant groundwater recharge areas located in the Source Protection Area,
5. identifies all wellhead protection areas and surface water intake protection zones located in the Source Protection Area,
6. describes issues with the quality and quantity of drinking water in each of these vulnerable areas,

7. lists for each vulnerable area existing or potential drinking water threats and "conditions that result from past activities that are drinking water threats", and
8. identifies within each vulnerable area the areas where such an activity is or would be a significant threat to drinking water and the areas where such a condition is a significant threat to drinking water.

The Act requires the Source Protection Committee to consult with the municipalities under its jurisdiction, submit the proposed assessment report to these municipalities and to the Source Protection Authority/ Authorities, publish the proposed assessment report for comment and finally submit the proposed report to the Minister of the Environment (Ayres, n.d., p.3; Legislative Assembly of the Province of Ontario, 2006, §15(4), §16, §17).

Source Protection Plan

The *Clean Water Act* requires the Source Protection Committee to prepare a source protection plan that explains how risks identified in the assessment report will be addressed (Legislative Assembly of the Province of Ontario, 2006, §22; Ministry of the Environment, 2006a, p.1). Consultation for the source protection plan is designed to be comprehensive, and should include the public, First Nations, community groups, public health officials, farmers, businesses, industry, property owners, conservation authorities, and municipalities (Ministry of the Environment, 2006a, p.1). Such consultation is expected to result in effective, practicable solutions (Ministry of the Environment, 2006a, p.1).

Under the *Clean Water Act*, the source protection plan must include:

1. "the most recently approved assessment report" (Legislative Assembly of the Province of Ontario, 2006, §22(2))
2. policies that ensure that an activity never becomes a threat to drinking water or where such a threat already exists, policies designed to eliminate such risks or threats to the drinking water supply (Ayres, n.d., p.4), and
3. measures for monitoring conditions or activities that are or would be a threat to drinking water (Ayres, n.d., p.4; Legislative Assembly of the Province of Ontario, 2006, §22(2)).

The source protection plan may designate, regulate or prohibit land uses and activities within the Source Protection Area (Ayres, n.d., p.4). Once the source protection plan is completed, the Act requires the Source Protection Committee to consult with the municipalities under their jurisdiction, submit the proposed source protection plan to these municipalities and to the Source Protection Authority/ Authorities, publish the proposed source protection plan for comment and, finally, submit the proposed plan to the Minister of the Environment (Ayres, n.d., p.4; Legislative Assembly of the Province of Ontario, 2006, §22(15), §22(16), §23, §25). Once the source protection plan is approved and in effect, a municipality, local board or Source Protection Authority must comply with any obligations that are imposed upon it by a significant threat policy or other policy outlined in the source protection plan (Ayres, n.d., p.4; Legislative Assembly of the Province of Ontario, 2006, Parts III and IV).

The source protection plans are implemented "through existing land use planning and regulatory requirements or approvals, or voluntary initiatives" (Ministry of the Environment, 2006a, p.1). However, although the *Clean Water Act* is intended to advance voluntary initiatives, the legislation imposes mandatory action where appropriate (Ministry of the Environment, 2006a, p.1). In extreme cases where significant risks to drinking water exist and threaten the quality and/or quantity of that drinking water, immediate, mandatory action is taken (Ministry of the Environment, 2006a, p.1). This mandatory action is a response to the local perceived risk of the threat to water.

The source protection plans are then followed up with continual monitoring and reporting to determine the effectiveness of the measures taken to protect sources of drinking water, and to ensure future protection (Ministry of the Environment, 2006a, p.1).

Relevance of the Clean Water Act, 2006

The new *Clean Water Act* obligates local communities to assess existing and prospective threats to drinking water, as well as develop and carry out the necessary actions to eliminate or reduce critical threats (Ministry of the Environment, 2006a, p.1). Each step of this process, as well as the resulting decisions and actions, are highly contingent upon the perceptions that the local communities have of drinking water-related risks. Of particular importance to this research are public and stakeholder consultations and the preparation of the assessment report. It is at these crucial points of the planning process that drinking water threats and their perceived risk are discussed between Source Protection Committee members and the public, who together must identify, evaluate and make decisions about drinking water-related risks (Ministry of the Environment, 2006a, p.1; Ministry of the Environment, 2007e; Ministry of the Environment, 2007d; Ministry of the Environment, 2007f). Conservation authorities, municipalities, farmers, property owners, industry, the public and community groups must all collaborate in order to achieve common goals (Conservation Ontario, 2007c; Ministry of the Environment, 2007g).

3. Literature Review

It has already been alluded to in the preceding sections of this report that there are knowledge gaps in the risk perception literature. This study seeks to contribute to the limited investigation of the perception of risks to drinking water. The existing risk perception literature is reviewed in order to build an understanding of what has already been established and how other researchers have addressed similar risk perception problems. The Decision Theory literature will also be reviewed because it is closely related to risk perception, in understanding how the Committee and the Community might translate their water risk perceptions into important decisions that must be made in group situations.

This section will review the way past studies of risk have attempted to investigate risks in general. Whereas this study focuses exclusively on risks to municipal drinking water, the studies discussed in this literature review have largely been focused on risks in general or risks other than water risks. This section will be divided into seven main subsections. The first will focus on risk perception (Subsection 3.1), and will discuss such topics as Starr's Revealed Preferences Model, the Psychometric Paradigm and the Cultural Theory of Risk Perception. The second main subsection to be discussed is Risk Communication (Subsection 3.2), followed by Trust, Credibility and the Decline of Deference (Subsection 3.3). This section will then discuss the Theory of Collective Action (Subsection 3.4), Decision Theory (Subsection 3.5) and other relevant water risk studies (Subsection 3.6), before concluding with a summary of the literature (Subsection 3.7).

3.1 Risk Perception

The way that the Community and the Committee perceive risks to drinking water could impact the implementation of the *Clean Water Act* – from the prioritization of risks to be addressed, to the judgments that are made, and ultimately, to the actions that are taken to mitigate these risks. The pursuit of this understanding will begin with a review of the risk perception literature.

In the past few decades, the development of nuclear and chemical technologies has resulted in the ability to cause enduring and catastrophic harm to the earth and its inhabitants (Slovic, 1987, p.280). The mechanisms that underlie these complicated technologies are incomprehensible and unfamiliar to most people (Slovic, 1987, p.280). The difficult-to-manage and elusive risks associated with modern technologies such as those mentioned just above have forced the establishment of the academic field of risk assessment (Slovic, 1987, p.280). The purpose of this discipline is to facilitate the identification, characterization, and quantification of risk (Slovic, 1987, p.280).

While analysts such as the Committee may evaluate hazards using risk assessment, most non-professionals, such as the Community, tend to rely on intuitive risk judgments, usually called risk perceptions (Slovic, 1987, p.280). Relatively recently, a number of researchers have begun to study the opinions that are expressed by members of the public when they are asked to assess hazardous substances, activities, and technologies (Slovic, 1987, p.280). In fact, risk perception research began during the nuclear debate of the 1960s (Sjöberg, 2000, p.1). This research seeks to determine what people mean when they say that something is risky or is not risky, and to discover what underlying factors shape those perceptions (Slovic, 1987, p.280). This research is fueled by the assumption that those who regulate and promote health and safety – the Committee in this case – must comprehend the ways in which members of the public respond to and understand risk (Slovic, 1987, p.280).

3.1.1 Background

In 1954, Leonard J. Savage, a statistics professor at Yale University, published *The Foundations of Statistics* in which he hypothesized that a rational person should make decisions based on both the "subjective probabilities of possible outcomes and the corresponding utility of those outcomes" (Reid, 1999, p.374; Savage, 1954). Savage also argued that a rational person should attempt "to maximize the subjective expected utility" (Reid, 1999, p.374). However, this decision model was not presented as a model of realistic decision-making behaviour, but rather was intended "as a normative model of behaviour which a rational individual should adopt" (Reid, 1999, p.374). Nonetheless, experiments conducted throughout the 1960s supported Savage's hypothesis (Reid, 1999, p.374). They demonstrated that people did evaluate "subjective probabilities roughly in accordance with the principles of Bayesian statistics and confirmed that individuals did tend to maximize subjective utility" (Reid, 1999, p.374).

In 1955, Herbert A. Simon published an article entitled *A Behavioral Model of Rational Choice*, where he "suggested that the analytical demands of Bayesian probability and utility maximization would often exceed the cognitive capacity of decision-makers faced with complex problems" (Reid, 1999, p.374; Simon, 1955). Simon consequently proposed that in reality, decision-making behaviour is derived from the principles of bounded rationality where individuals represent complex problems in simplified ways using simple decision-making rules, or heuristics (Reid, 1999, p.374; Simon, 1955, p.114).

In the 1960s, growing public interest in environmental risk management and environmental protection lead to an increase in the popularity of the fields of risk perception and risk-based decision-making (Reid, 1999, p.374). Much of this interest resulted from public controversies about the environmental risks related to potentially hazardous technologies, with a particular focus on nuclear power (Reid, 1999, p.374). In response to intense public resistance to nuclear energy, the nuclear energy industry performed quantitative risk assessments of nuclear power plants, which attempted to identify prospective failure modes and estimate the consequences and probabilities of failure (Reid, 1999, p.374).

3.1.2 The Revealed Preferences Model

Along with the nuclear industry's development of quantitative risk assessments for nuclear facilities, a quantitative process was also being developed and was applied to determine socially acceptable risk (Reid, 1999, p.374). This new quantitative method was the method of revealed preferences, and was first used to establish a socially accepted risk for electric power plants (Reid, 1999, p.374).

The revealed preferences model was first described by Starr in his 1969 paper *Social Benefit versus Technological Risk* (Reid, 1999, p.374; Starr, 1969). Here, Starr (1969, pp.1232, 1234, 1237) used historically revealed social costs and preferences to investigate accepted social values in relation to personal risk, with the goal of ultimately determining and understanding social risk acceptance in order to identify the social benefit relative to cost that is required for decision-making. Starr attempted to answer the question "how safe is safe enough?" by comparing historical data on health and accidents for a number of public activities with a general estimation of the corresponding social benefits of these activities (Starr, 1969, p.1233).

Starr's main finding was that the public is generally willing to accept voluntary risks approximately 1000 times greater than involuntary risks, as shown in Figure 1 below (Starr, 1969, p.1237). Figure 1 also demonstrates that "the statistical risk of death from disease appears to be a psychological yardstick for establishing the level of acceptability of other risks" (Starr, 1969, p.1237). Starr also concluded from this figure that risk acceptability is approximately "proportional to the third power of the benefits", irrespective of whether those benefits are perceived or real (Starr, 1969, p.1237).

Additionally, Starr found that the public awareness of an activity's benefits, which can be determined by usefulness, advertising or the number of participants, can influence the social acceptance of the corresponding risk (Starr, 1969, p.1237). This relationship is demonstrated in Figure 2.

Interestingly, when Starr applied his findings to assessing the safety of nuclear power facilities, he found "that an engineering design objective determined by economic criteria would result in a design-target risk level very much lower than the present socially accepted risk for electric power plants" (Starr, 1969, p.1237). That is, Starr found that the risks associated with the generation of nuclear energy were not only acceptable, but the nuclear energy companies' safety standards were higher than those necessary for public safety (Reid, 1999, pp.374-375).

When Starr's work is applied to this study, it is anticipated that the Community may be more willing to accept risks that they perceive to be voluntary, as opposed to risks that are perceived to be involuntary. Furthermore, the Community's awareness of the benefits of any given activity or land use affecting water may influence their acceptance of the associated risk that the activity poses to water.

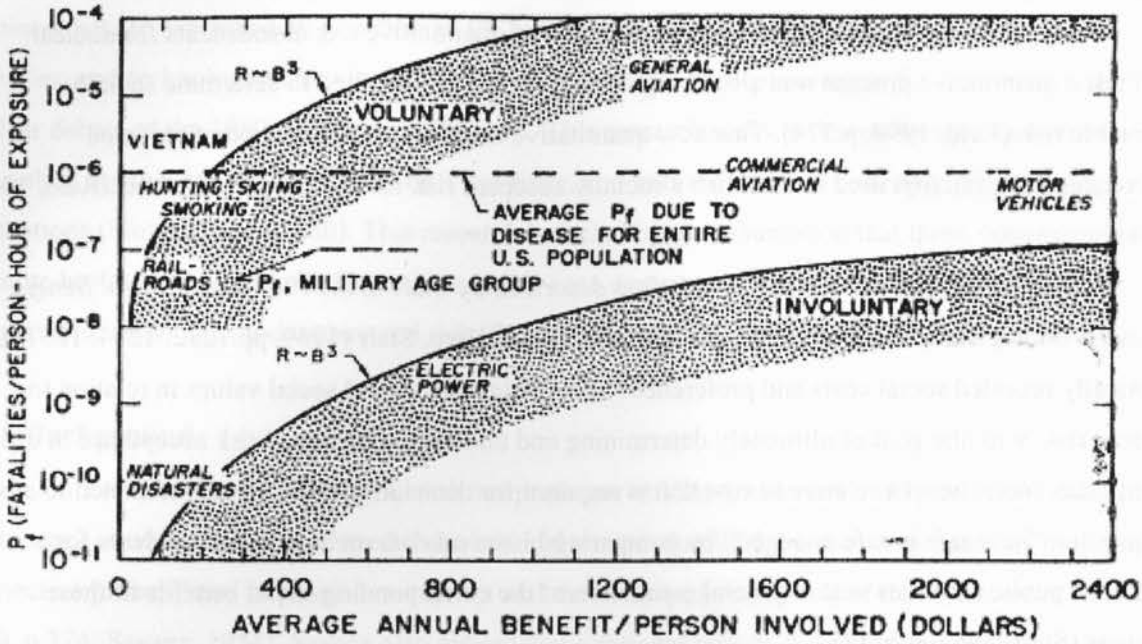

Figure 1: In Starr's seminal 1969 paper, the relationship between risks (R) and benefits (B) for a number of different types of involuntary and voluntary "societal activities" was represented in this figure (Starr, 1969, pp.1234-1235).

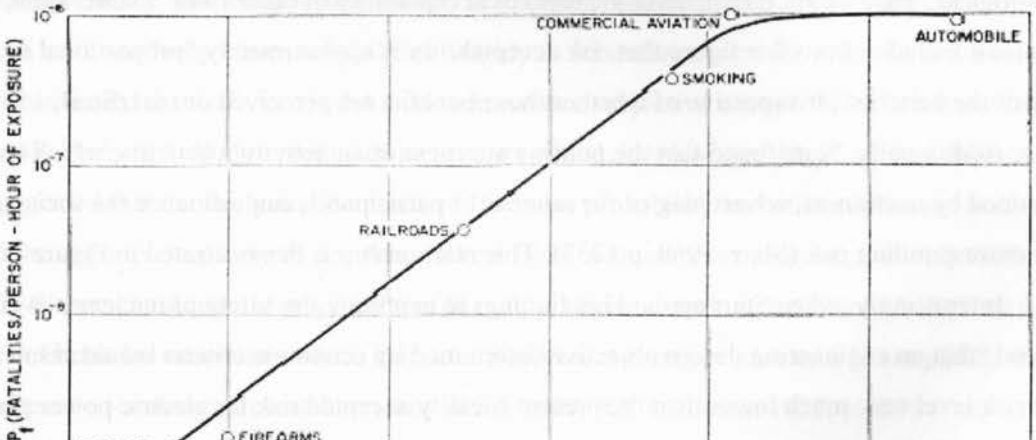

Figure 2: The relationship between socially accepted risk and the public's "benefit awareness", as demonstrated in Starr's seminal paper (Starr, 1969, pp.1236-1237).

3.1.3 The Psychometric Paradigm

Despite the encouraging results of the nuclear industry's probabilistic risk assessments and the favorable findings reported by Starr and other experts, public opposition to nuclear power continued to grow (Reid, 1999, p.375). By the 1970s, risk controversies and the public's reluctance "to accept expert advice on the acceptability of technological risks [was] widely discussed in relation to the concepts of risk perception" (Reid, 1999, p.375). It was at this time that Tversky and Kahneman began to conduct their psychological research, which built upon the earlier work of Herbert A. Simon (Reid, 1999, p.375). In 1974, Tversky and Kahneman first suggested that laypeople depend on simplifying heuristics, or "rules of thumb" that allow them to evaluate subjective probabilities (The identification of heuristics in the field of risk perception will be discussed below in Section 3.1.3.1; Kasperson et al., 1988, p.178; Reid, 1999, p.375; Short, 1984, p.719; Slovic, 1987, p.281; Sly, 2000, p.153).

In 1978, Fischhoff, Slovic, Lichtenstein, Read, and Combs published their seminal paper on the psychometric model. Perceived risk may be studied by creating a hazard taxonomy for predicting and understanding responses to their risks (Slovic, 1987, p.281). Such a taxonomic system may help to explain why members of the public are unconcerned with some hazards, their intense opposition to others, and the differences between expert opinions and these reactions (Slovic, 1987, p.281; Sly, 2000, p.153). Utilization of the psychometric paradigm is the most widespread method of achieving this goal (Slovic, 1987, p.281). It is in part for this reason that this study will be based on the principles of the psychometric paradigm. The psychometric paradigm uses multivariate analysis and psychophysical scaling methods to generate cognitive maps, or quantitative representations of risk perceptions and attitudes (Slovic, 1987, p.281; Slovic et al., 1984, p.187).

Within this paradigm, individuals must make "quantitative judgments about the current and desired riskiness of diverse hazards and the desired level of regulation of each" (Slovic, 1987, p.281). Such judgments are subsequently related to other judgments regarding:

1. The status of the hazard on a number of qualitative characteristics that are thought to account for risk attitudes and perceptions (Slovic, 1987, p.281; Slovic et al., 1984, p.187). Examples include dread, voluntariness, controllability, and knowledge (Slovic, 1987, p.281; Slovic et al., 1984, p.187).
2. The benefits to society that each hazard provides (Slovic, 1987, p.281; Slovic et al., 1984, p.187).
3. The average annual number of mortalities caused by the hazard (Slovic, 1987, p.281; Slovic et al., 1984, p.187).
4. The number of mortalities that result from the hazard in a disastrous year (Slovic, 1987, p.281; Slovic et al., 1984, p.187).

Although each psychometric study contributed to what is known about risk perception, a number of generalizations have become apparent (Slovic et al., 1984, p.187). Those generalizations are as follows:

1. It is possible to predict and quantify perceived risk (Slovic, 1987, p.282; Slovic et al., 1984, p.187). Psychometric methods are able to identify differences and similarities between groups with respect to risk attitudes and perceptions (Slovic, 1987, p.282; Slovic et al., 1984, p.187). It is also for this reason that this study will be based on the principles of the psychometric paradigm.
2. Different individuals have different definitions of risk (Fischhoff, Watson, & Hope, 1984, p.124; Slovic, 1987, pp.282-283; Slovic et al., 1984, p.187). When risk is assessed by experts, their responses are highly correlated with technical approximations of annual fatalities (Slovic, 1987, p.283; Slovic et al., 1984, p.187). Members of the public have the ability to evaluate annual fatalities and generate estimates that are similar to technical estimates (Hampel, 2006, p.8; Slovic, 1987, p.283; Slovic et al., 1984, p.187). However, these risk judgments are also sensitive to other factors (e.g., threat to future generations, catastrophic potential) and, therefore may differ from their own estimates of annual fatalities, or those of experts (Slovic, 1987, p.283; Slovic et al., 1984, p.187-188). Similarly, it is anticipated that the Committee in this study may have water risk perceptions similar to those that are typical of experts, and the Community's water risk perceptions may reflect the more complex risk perceptions that are typical of the public.
3. Although groups may not agree about the overall riskiness of particular hazards, these groups demonstrate significant agreement when rating those hazards on risk characteristics such as catastrophic potential, controllability, dread, and knowledge (Slovic et al., 1984, p.188).
4. Members of the public "tend to view current risk levels as unacceptably high for most activities" (Fischhoff et al., 1978, p.148; Slovic, 1987, p.283). This discrepancy between desired and perceived levels of risk indicates that laypeople are unsatisfied with the way the market and other regulatory mechanisms have balanced benefits and risks (Fischhoff et al., 1978, p.148; Slovic, 1987, p.283). Correspondingly, it is anticipated that the Community might be more risk averse than the Committee in this study, and may be unsatisfied with the current balance between risks and benefits.

It is important to keep in mind that opponents of the psychometric model argue that it only accounts for a small percentage (i.e. ~20%) of the variance of perceived risk (Sjöberg, 2000, pp.1, 5).

3.1.3.1 Heuristics and Biases

The identification of heuristics that people use to make decisions when faced with choices constitutes a significant development in the field of risk perception (Kasperson et al., 1988, p.178; Short, 1984, p.719; Slovic, 1987, p.281; Sly, 2000, p.153). While these mental strategies may be appropriate in some situations, in other circumstances such rules may result in persistent and substantial biases, with important ramifications for risk assessment (Slovic, 1987, p.281). Specifically, research on basic cognitions and perceptions has demonstrated that "difficulties in understanding probabilistic processes, biased media coverage, misleading personal experiences, and the anxieties generated by life's gambles cause uncertainty to be denied, risks to be misjudged…, and judgments of fact to be held with unwarranted confidence" (Slovic, 1987, p.281).

In general, it is believed that laypeople and experts have very different understandings of risk (Hampel, 2006, p.5,8,9; Rowe & Wright, 2001, p.341; Sly, 2000, p.153). When asked how the general public perceives risk, experts frequently employ such adjectives as "emotional" and "irrational" (Covello, Peters, Wojtecki, & Hyde, 2001, p.4; Fischhoff et al., 1984, p.124; Sly, 2000, p.153). The differences in the way experts and laypeople perceive risk may in part be due to differing definitions assigned to the concept of risk (Sly, 2000, p.154). Sandman first argued that experts define risk as "hazard", or the product of magnitude and probability (Kasperson et al., 1988, p.177; Sandman, 1993, pp.6-7; Sandman, Weinstein & Klotz, 1987, p.106). In this study, it is anticipated that the Committee may perceive water risks in this way. However, according to Sandman (1987), the general public perceives risk almost entirely in terms of the outrage factors (see Table 1). When compared, there is only a weak correlation (r = 0.2) between these two definitions of risk (Sly, 2000, p.154).

Table 1: A selection of "outrage factors" (Adapted from Blake, 1995, p.123)

Risk-Decreasing Factors	Risk-Increasing Factors
Control	No Control
Voluntary	Imposed
Ordinary	Memorable
Fair	Unfair
Not Dreaded	Dreaded
Certain	Uncertain
Natural	Artificial/ Technological
Familiar	Unfamiliar
Source is Trustworthy	Source is Untrustworthy
Morally Acceptable	Morally Reprehensible

In general, it is difficult for members of the public to comprehend probabilistic data, and risks expressed in, or otherwise related to, very large and very small numbers (Sly, 2000, p.153). Furthermore, laypeople utilize a number of heuristics to help them evaluate risk (Hampel, 2006, pp.7-8; Sly, 2000, p.153). These outrage factors are quite consistent, and are predominantly independent of gender, class, age, location or political ideology (Sly, 2000, p.153). As a result, the average person's perception of risk is more, as opposed to less multifaceted and complex than that of the average expert (Hampel, 2006, p.8; Sjöberg, 2000, p.2; Sly, 2000, p.154). Sandman attempted to redefine risk by combining the lay and expert concepts of risk into a single equation: Risk = Hazard = Outrage (Sandman, 1993, pp.6-7; Sandman et al., 1987, p.106). Within the context of this study, it is expected that the Community may perceive water risks in this more complex way.

Conversely, some researchers argue that laypeople and experts have similar perceptions of risk (Rowe & Wright, 2001, p.341). Rowe and Wright (2001, p.341) assessed nine empirical studies pertaining to differences in expert and lay risk judgments and concluded that there is minimal empirical support for the premises:

1. that laypeople perceive risk differently than technical experts, or
2. "that experts are more veridical in their risk assessments".

The human dependence on judgmental heuristics results in cognitive biases that arise when people make decisions about risks (Tversky & Kahneman, 1974, p.1130). This heuristic reliance and the pervasiveness of the resulting biases affect not only the risk-based decision-making processes of laypeople, but also impact those of experienced experts when those experts think and make decisions intuitively[8] (Tversky & Kahneman, 1974, p.1130). Thus, while the Community in this study is expected to depend on heuristics to make decisions and judgments about water risk, the Committee is also expected to rely on heuristics and exhibit cognitive biases when they make intuitive water risk perceptions and decisions, particularly for those risks with which they are less familiar (Tversky & Kahneman, 1974, p.1124).

Tversky and Kahneman (1973; 1974) demonstrate three judgmental heuristics –anchoring and adjustment, availability, and representativeness – which determine probabilistic judgments in a number of tasks (Kahneman & Tversky, 1972; Slovic, Fischhoff, & Lichtenstein, 1977, p.4). Although these heuristics are sometimes appropriate and always efficient, they may result in biases that have serious, large, and persistent repercussions for decision making (Slovic et al., 1977, p.4; Tversky & Kahneman, 1974, p.1124). A fourth heuristic, the affect heuristic, will also be discussed (Finucane, Alhakami, Slovic, & Johnson, 2000). Throughout this discussion, it is important to consider that both lay and expert respondents of this current study can be expected to use heuristic devices such as the ones outlined below. Even though the Committee is expected to perceive water risks in a more technical way than the

[8] Experienced experts, however, do not tend to make basic "errors, such as the gambler's fallacy" (Tversky & Kahneman, 1974, p.1130).

Community, they are still expected to rely on such heuristics to some degree when thinking intuitively (Tversky & Kahneman, 1974, p.1130).

Representativeness – A number of probabilistic questions ask "what is the probability that object A belongs to class B? What is the probability that event A originates from process B?" (Slovic et al., 1977, p.4; Tversky & Kahneman, 1974, p.1124). In order to answer these types of questions, individuals generally depend upon the representative heuristic, where probabilities are assessed "by the degree to which A is representative of B, that is, by the degree to which A resembles B" (Slovic et al., 1977, p.4; Tversky & Kahneman, 1974, p.1124). When A is extremely "representative of B, the probability that A originates from B is judged to be high" (Slovic et al., 1977, p.4; Tversky & Kahneman, 1974, p.1124). In support of this hypothesis, Kahneman and Tversky demonstrated that both estimates of posterior probabilities and subjective sampling distributions were not sensitive to sample size, a normatively significant yet psychologically non-representative factor (Slovic et al., 1977, p.4; Kahneman & Tversky, 1972, p.430).

Within the context of this study, it is anticipated that the respondents could also depend on the representative heuristic, and assess probabilities by the degree to which one water risk or hazardous land use is representative of another water risk or hazardous land use. For example, if the study respondents perceive the presence of solvents in source water to be extremely representative of the operation of a local chemical plant, the probability that solvent pollution of drinking water originates from the operation of the chemical plant could be judged to be high.

Availability – The availability heuristic occurs whereby individuals evaluate the frequency, likelihood or probability of an event or class based on how easy it is for them to recall or imagine relevant occurrences or instances (Slovic et al., 1977, p.4; Tversky & Kahneman, 1974, p.1127). In reality, events that occur frequently are generally easier to recollect than are events that are more infrequent (Slovic et al., 1977, p.4; Tversky & Kahneman, 1973, p.207). Similarly, unlikely events are more difficult to imagine than likely events (Slovic et al., 1977, p.4; Tversky & Kahneman, 1973, p.207). Therefore, availability is typically a valid cue for the evaluation of probability and frequency (Slovic et al., 1977, p.4; Tversky & Kahneman, 1973, p.207). However, since availability may also be influenced by subtle factors that are not related to likelihood, such as recency, emotional saliency, and familiarity, dependence on the availability heuristic can give rise to systematic biases (Slovic et al., 1977, p.4; Tversky & Kahneman, 1973, p.207).

The respondents of this current study are also expected to rely on the availability heuristic. Frequent, likely water-related events could be easier for the Community and the Committee to recall, and may thus be judged by these groups to have a higher probability of occurring. Frequency and likelihood are valid indications of the probability of an event occurring, and could result in accurate probability assessments. For example, the Committee and the Community may judge the finding of small amounts of sediment and mud in source water to be more frequent and likely than the finding of many of the other contaminants, and so may accurately judge the probability of finding small quantities of sediment and mud in source water to be high.

However, the availability judgments of the study's respondents may also be affected by factors that are unrelated to the probability of a water risk event occurring, such as emotional significance and recency. In this case, if the Community and the Committee were, for example, to perceive virulent *E. coli* contamination of source water to be highly probable based on the recency of such an event occurring and the emotional saliency of that event, they may incorrectly assess the probability of that event. This might in turn result in systematic biases in water risk perception and decision making among the Committee and Community members.

Anchoring and Adjustment – This heuristic occurs whereby an anchor or starting point is used as an initial approximation to the judgment (Slovic et al., 1977, p.5; Tversky & Kahneman, 1974, p.1128). In order to address the implications of new information, this anchor is subsequently adjusted (Slovic et al., 1977, p.5; Tversky & Kahneman, 1974, p.1128). Individuals tend to remain firmly anchored to their initial perceptions, and the adjustment is typically inadequate and imprecise (Slovic et al., 1977, p.5; Tversky & Kahneman, 1974, p.1128).

The respondents of this current study are also expected to rely on the anchoring heuristic, and are expected to remain firmly anchored to their initial perceptions. This reliance may result in imprecise or inadequate judgments and decisions about water risks on the part of the Committee and the Community. This could, for example, occur if the respondents were basing all of their water risk perceptions and decisions in relation to a single anchored contaminant or land use, such as *E. coli*, chlorine or landfills.

Affect – The significance of affect is being increasingly recognized by decision researchers, regardless of its cognitive emphasis (Finucane et al., 2000, p.2). Finucane et al. (2000, p.3) suggest that affect is a fundamental component in numerous forms of decision making and judgment. They argue that images which are marked by negative and positive affective feelings, guide decision making and judgment (Finucane et al., 2000, p.3). More specifically, individuals employ an affect heuristic to make judgments and decisions (Finucane et al., 2000, p.3).

The study respondents are also expected to employ the affect heuristic, and make water risk judgments and decisions based on images associated with negative and positive affective feelings. For example, the respondents may perceive a grain farm to be less risky because of positive affective feelings or images associated with this land use. Conversely, the respondents may perceive a chemical plant to be more risky as a result of negative affective images or feelings that they associate with this land use.

It must be noted that one relatively legitimate generalization that can be obtained from the above literature is that, with the exception of some Bayesian inference tasks, individuals are inclined to be overconfident in their perceptions and decisions (Slovic et al., 1977, p.6). Similarly, the respondents of this current study are also expected to be overconfident in their water risk judgments and decisions.

3.1.3.2 The Expressed Preferences Model

In their seminal paper on the psychometric model, Fischhoff et al. (1978), based on concerns regarding "the validity of the many assumptions inherent in the revealed preferences approach", conducted "an analogous psychometric analysis of questionnaire data, resulting in "expressed preferences"" (Slovic, 1987, p.282). There have since been a great many expressed preferences studies that have been conducted within the psychometric model (Slovic, 1987, p.282). This is one such study. This research will examine expressed preferences within the framework of the psychometric model.

3.1.3.3 Factor Analysis

Psychometric studies have shown that every hazard has a unique pattern of characteristics that appears to be associated with its perceived risk (Slovic & Weber, 2002, p.9). Several of these qualitative risk characteristics (e.g. "voluntary", "controllable" and "well-known") are significantly correlated with each other, across a vast domain of hazards (Fischhoff et al., 1978, p.149; Slovic et al., 1984, p.188; Slovic & Weber, 2002, p.9). Examination of the relationships through factor analysis has demonstrated that a wide range of risk characteristics may be reduced to a smaller set of higher-order factors or characteristics to create the factor space (Fischhoff et al., 1978, p.149; Slovic, 1987, p.283; Slovic et al., 1984, p.188).

Although the exact method that Slovic and others used to construct the factor space is not made apparent, it is stated that cognitive maps, or quantitative representations of risk perceptions, are generated using multivariate analysis and psychophysical scaling methods (Slovic, 1987, p.281; Slovic et al., 1984, p.187). Slovic et al. (1984, p.188) do not provide the identity or number of research participants used to create the factor space depicted in Figure 3, but only explain that it "has been consistently replicated across groups of laypersons and experts judging large and diverse sets of hazards." However, in a later paper containing this same figure, Slovic (1987, p.281) briefly identifies the League of Women Voters, college students, "Active club members" and "Experts" as participants. In the seminal paper on the psychometric model, Fischhoff, Slovic and Lichtenstein (1978, p.133) create an early version of the factor space with seventy-six (fifty-two women and twenty-four men) members of the Eugene, Oregon, League of Women Voters and their spouses, who participated in two hour long questionnaires.

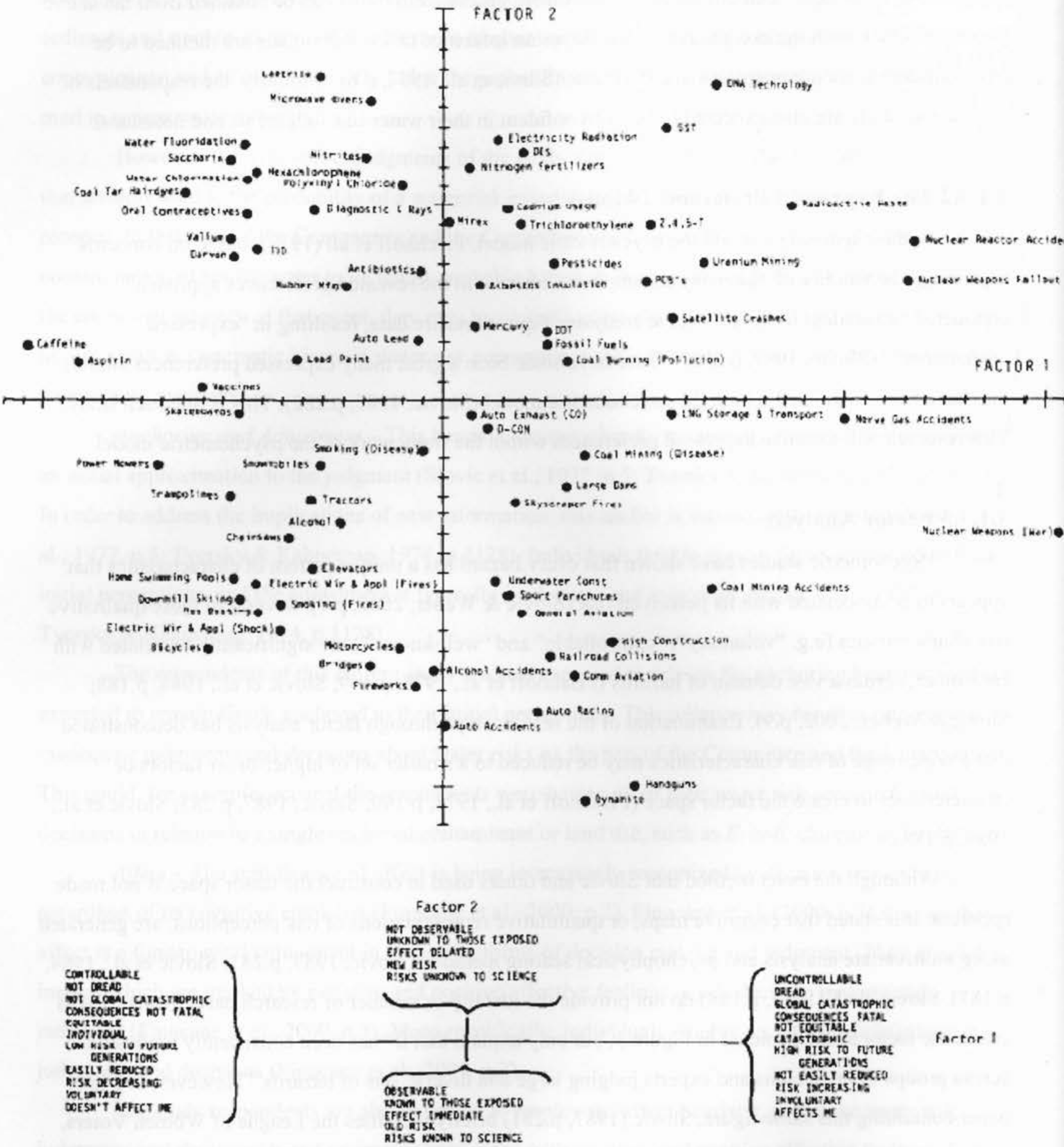

Figure 3: Factor space that has been consistently reproduced across groups of experts and laypeople assessing diverse and large sets of hazards (Slovic et al., 1984, p.189). Factor 1, or "dread risk" is defined at its high end (right-hand) by perceived dread, lack of control, fatal consequences, catastrophic potential, and the unfair allocation of benefits and risks (Fischhoff et al., 1978, p.149; Slovic, 1987, p.283). Factor 2, "unknown risk", is "defined at its high end" by hazards perceived to be unknown, unobservable, novel, and "delayed in their manifestation of harm" (Fischhoff et al., 1978, p.149; Slovic, 1987, p.283).

The two factors shown in Figure 3 demonstrate the degree to which a particular risk is comprehended and the degree to which that risk induces feelings of dread (Slovic & Weber, 2002, p.10). The location of a given risk in the factor space can be identified by calculating "scores on each of these factors" (Gurian, n.d., p.1). Since each risk item plotted on the factor space has a mean score on each of the risk characteristics, a score can be obtained for each risk item on each factor in the factor space (Slovic et al.1978, p.146). The risk items are then plotted in the factor space using the factor scores (Slovic et al.1978, p.146). Increasing the specificity of the set of hazards does not appear to have a significant effect on the factor structure or its connection to risk perceptions (Slovic, 1987, p.283; Slovic et al., 1984, p.188-189). It must be noted that other psychometric techniques (for example, "multidimensional scaling analysis of hazard similarity judgments") that are applied to dissimilar sets of hazards will result in diverse spatial models (Slovic, 1987, p.283). Thus, the method depicted in Figure 3 is not a universal cognitive mapping of the hazard domain (Slovic, 1987, p.283). However, the results obtained from the use of the two factor space are quite consistent, and for the most part are independent of gender, class, age, location or political ideology (Sly, 2000, p.153).

Research has demonstrated that the attitudes and perceptions of members of the public are strongly associated with the location of a hazard within the type of factor space depicted in Figure 3 (Slovic, 1987, p.283; Slovic et al., 1984, p.189). The horizontal dread risk factor is the most important factor (Slovic, 1987, p.283; Slovic et al., 1984, p.189). The greater a hazard scores with respect to the dread risk factor, the greater its perceived risk, the greater the number of individuals who want a reduction in its current risks, and the more people want stringent regulations implemented to bring about the desired risk reduction (see Figure 4; Slovic, 1987, p.283; Slovic et al., 1984, p.189-190). Conversely, the risk perceptions of experts are not strongly correlated to any of the risk factors or characteristics (Slovic, 1987, p.283). As previously discussed, experts apparently perceive risk to be equivalent to expected mortality per annum (Slovic, 1987, p.283). As such, disagreements regarding risk may be due to the fact that laypeople and experts have different definitions of risk (Slovic, 1987, p.283).

This study will examine factors that fall within this framework. Within the context of this study, it is anticipated that the water risk perceptions and attitudes of the Community could be associated with the location of significant hazards in the factor space. Conversely, it is expected that the Committee's water risk perceptions may not be strongly connected to these risk factors or characteristics.

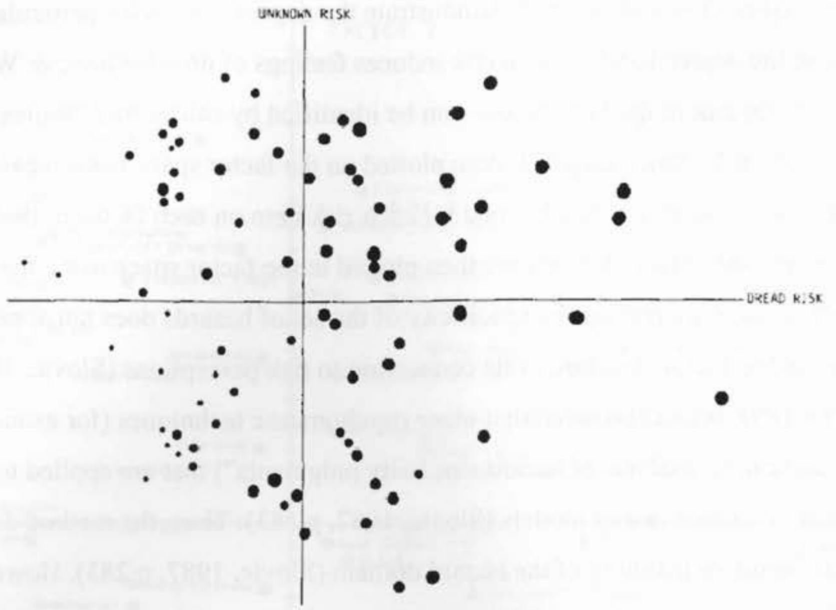

Figure 4: The degree to which members of the public wish to see stringent regulations implemented in order to bring about desired risk reduction (Slovic et al., 1984, p.190).

3.1.4 The Cultural Theory of Risk Perception

The previous subsections of this report suggested that while the Community may perceive risks based on outrage factors, the Committee may perceive risks in a more technical way, as estimates of annual fatalities or as the product of magnitude and probability (Kasperson et al., 1988, p.177; Slovic, 1987, p.283; Slovic et al., 1984, pp.187-188,193). While these elements are important to the risk perception of the Community and Committee, they are not likely the only factors that could influence these two groups' perception of risks to drinking water sources. Other important factors that could affect the Community and the Committee's perception of risks, and perhaps ultimately the implementation of the *Clean Water Act*, are socio-cultural factors.

This subsection focuses on selected works of British anthropologist Mary Douglas (Fardon, 1999, p.xi). Although her work overlaps with a number of disciplines, Douglas' foray into risk perception and analysis is one of her more controversial contributions (Fardon, 1999, p.xii).

In her 1978 article *Cultural Bias*, Mary Douglas argues that risk perception does not depend on preferences, needs, personality traits or the properties of the risk objects (Oltedal, Moen, Klempe & Rundmo, 2004, p.16). Instead, she argues, risk perception is a culturally or socially constructed phenomenon (Oltedal et al. 2004, p.16). Social learning and cultural adherence determine what is perceived as risky and how much risk is accepted (Oltedal et al., 2004, p.16).

In 1980, Douglas co-authored *Risk and Culture: An Essay on the Selection of Technological and Environmental Dangers* with Aaron Wildavsky to develop an ethical, cultural and sociological theory of human judgment (Fardon, 1999, p.153). Douglas and Wildavsky (1982, pp.1,7) introduced a cultural theory of risk perception to explain how, under uncertainty, people choose "which risks to take and which to ignore", and why different people are concerned with different risks. That is, it is not possible to know all risks, and there is considerable disagreement "over what is risky, how risky it is, and what to do about it" (Douglas and Wildavsky, 1982, p.1).

The crux of Douglas and Wildavsky's argument was that specific "risks are socially selected for attention" (Fardon, 1999, p.153). Cultural theory posits that "the perception of risks is culturally constructed" from worldviews or general orientations, thus distinct worldviews and national boundaries will not concur (Boholm, 1998, p.151). Individuals have different risk perceptions "because they have separate world views", not principally because they belong to specific nationalities (Boholm, 1998, pp.151-152).

In their conclusion, Douglas and Wildavsky emphasized the importance of culture by arguing that at the time of writing, the subject of risk was divided between "public, physical science" and "private, subjective perception", with culture lying between the two (Douglas and Wildavsky, 1982, p.194). This division ignores culture, a middle area of common values and beliefs, and is thus self-defeating and arbitrary (Douglas and Wildavsky, 1982, p.194).

Thus, the Committee and Community members' culturally constructed worldviews may play a role in their choices of which threats to water to focus on, how risky these threats are, which risks to water are acceptable and which are unacceptable and ultimately which actions to take in order to mitigate these risks. Furthermore, differences in the Committee and Community members' worldviews could result in disagreement and conflicts regarding these choices.

3.2 Risk Communication

In the late 1970s and early 1980s, interest in the risk controversies related to technological risk assessment peaked, and subsequent risk assessment research has been based mainly on the foundations that were established during this period (Reid, 1999, p.375). From the early 1980s onward, there has been a shift in the focus of psychological research from risk perception to risk communication (Reid, 1999, p.375).

Effective risk communication about water-related risks is important to this study and to source water protection planning. The new *Clean Water Act* not only requires drinking water Source Protection Committees to communicate prospective water-related hazards to the public, but members of the public will be actively involved in developing and implementing a plan to protect municipal drinking water sources (Legislative Assembly of the Province of Ontario, 2006; Ministry of the Environment, 2006a, p.1). As a result, the communication of risks to the public is fundamental to the source water protection planning process. Furthermore, ineffective communication about water-related risk can negatively impact the public's perception and decision-making processes relating to that risk (Fischhoff, 1995, p.137; Sly, 2000, p.154). As such, effective risk communication is fundamental to the successful implementation of the *Clean Water Act* in particular, and effective environmental risk management in general (Wakefield & Elliott, 2003, p.216).

Risk communication is "an interactive process of an exchange of information, involving multiple messages about the nature of risk" (Chartier & Gabler, 2001). The objectives of risk communication include informing, persuading, and consulting. The ultimate goal of risk communication is mutual understanding of the issues.

The risk communication literature discusses a number of principles for the effective communication of risks. In general, the literature advises that all relevant risk information available, as well as any uncertainty, should be communicated to all community members as soon as possible (Fischhoff, 1995, p.140; Thompson, 2002, pp.652-653). The information should be explained in clear, straightforward, comprehensible terms by an individual with both audience and organizational acceptability (Fischhoff, 1995, p.140; Sly, 2000, p.155). Efforts should be made by communicators to create authentic partnerships with the community (Fischhoff, 1995, pp.142-143; Sly, 2000, p.155).

Of all of the constituents of risk communication, trust and confidence in the communicating body are the most significant factors in determining the effectiveness of risk-based messages (Covello et al., 2001, pp.8-9; Frewer, Howard, Hedderley, & Shepherd, 1996, p.473; Peters, Covello, & McCallum, 1997, p.43). Participative, two-way approaches to risk communication may result in improved consensus, but may not guarantee complete concurrence (Chartier & Gabler, 2001; Fischhoff, 1995, pp.142-143). While framing an issue as a voluntary risk may increase public acceptance of that risk, this may be highly dependent upon the objectives of the communicating body (Driedger & Eyles, 2003, pp.1279, 1290).

These nuances of effective risk communication could be important for the Committee to take into account when they are communicating to other experts as well as the Community about water-related risks in the region.

3.3 Trust, Credibility and the Decline of Deference

As mentioned above, confidence and trust in the communicating body are the most important factors in determining the effectiveness of risk-based messages (Covello et al., 2001, pp.8-9; Frewer et al., 1996, p.473; Peters et al., 1997, p.43). Therefore, it is extremely important that the Committee work with the Community to establish trust and confidence. This process is of particular interest because while the public's trust in a number of different information sources is well documented, trust and confidence remains untested for Source Water Protection Committees.

In their investigation into the determinants of credibility and trust, Peters et al. (1997, p.43) found that perceptions of credibility and trust are contingent upon three factors: perceptions of honesty and openness; perceptions of expertise and knowledge; and perceptions of care and concern. Peters et al. (1997, p.43) also found that defying a negative stereotype is fundamental to improving these credibility and trust perceptions.

Frewer et al. (1996, p.473) found that United Kingdom residents view sources with moderate accountability to be the most trustworthy. As can be seen in Figure 5, respondents rated university scientists, medical doctors and consumer organizations as the most trustworthy sources of information about risks to health (Frewer et al., 1996, p.477; Sly, 2000, p.154). Government ministers and ministries were categorized as only marginally more trustworthy than tabloid newspapers (Frewer et al., 1996, p.477; Sly, 2000, p.154).

Burley (2007, p.85) found that members of a Southern Ontario community with drinking water resources that were well managed and low risk not only had "positive perceptions of their drinking water", but also had "high levels of trust in their local government." However, this trust in government

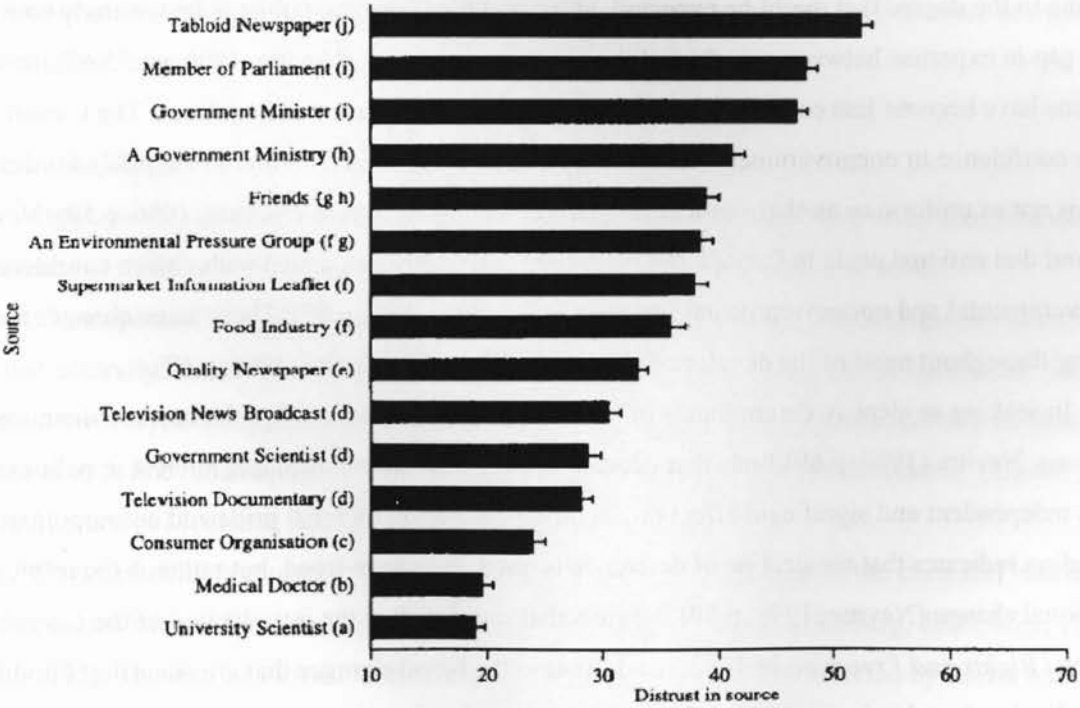

Figure 5: Frewer et al.'s (1996, p.477) findings about public distrust in a number of different health risk information sources.

was local in nature, and did not extend to the provincial government, private water suppliers or the media, which were all assigned a low trust rating by the community members (Burley, 2007, p.85).

This decreased confidence and trust in authoritative bodies, particularly governments, is a trend that is indicative of the decline of deference (Laird, 1989, pp.543-544). The decline of deference is "a situation in which a hostile and alienated public is mobilized primarily through *ad hoc* voluntary organizations, and is increasingly reluctant to defer important decisions to institutional elites" (Laird, 1989, p.543). This phenomenon is evidenced by the decline of the prestige of a number of professions, a decline in the public confidence in leadership, the decline of U.S. political parties and a substantial decline in voter turnout, with a greater proportion of wealthy people voting than poor people (Laird, 1989, pp.544-545). This results in the alienation of the public, particularly those with lower status and income, in terms of both the public's trust in leaders and sense of personal advocacy (Laird, 1989, pp.547-548).

Neil Nevitte, a Professor of Political Science at the University of Toronto, comments on the decline of deference within the Canadian context in his book *The Decline of Deference: Canadian Value Change in Cross-National Perspective* (Nevitte, 1996). Nevitte conducts his analysis by comparing the decline of deference in Canada to the situation in other countries (Nevitte, 1996). Upon examining trends in Canadian political culture and participation, Nevitte discovers that the Canadian public's attachment to traditional political parties is eroding (Nevitte, 1996, pp.55,67). The voter turnout in Canada is not increasing to the degree that might be expected, given that the Canadian public is increasingly educated and the gap in expertise between experts and the public is narrowing (Nevitte, 1996, pp.55,67). In general, Canadians have become less compliant, more assertive and more interested in politics. The Canadian public's confidence in nongovernmental institutions has also declined (Nevitte, 1996, p.59). However this decline is not as uniform or as sharp as it is for governmental institutions (Nevitte, 1996, p.59). Nevitte also found that national pride in Canada and elsewhere is strongly associated with citizen confidence in both governmental and nongovernmental institutions (Nevitte, 1996, p.67). These same changes are occurring throughout most of the developed industrialized world (Nevitte, 1996, p.67).

In seeking to identify determinants of public confidence in national pride, cosmopolitanism and institutions, Nevitte (1996, p.69) finds that education, age, post-materialism and interest in politics all have an independent and significant affect on declining deference, national pride and cosmopolitanism. This finding indicates that the decline of deference is not a short term trend, but rather is the result of generational change (Nevitte, 1996, p.70). Nevitte also suggests that the introduction of the *Canadian Charter of Rights and Freedoms* in 1982, in addition to the broad changes that are occurring throughout the world's developed industrialized nations, may account for Canadian citizens' declining deference, increasing interest in politics, and increasing support of new and unconventional social movements (Nevitte, 2006, pp.104-105).

There is a paradox imbedded in Nevitte's (1996, p.70) findings: although the potential for public participation in public life has apparently increased due to an increased interest in politics and higher education levels, confidence in traditional modes of participation are in decline. However, Nevitte finds that the public is participating more in political life, but is choosing different approaches to political participation (Nevitte, 1996, p.70).

Thus, when the literature is applied to this study, it is apparent that it may be important for the Committee to build trust and establish credibility with the Community. To do so, it is evident that they must be perceived by the Community to be honest and open, knowledgeable and caring and concerned. The Committee must also be perceived as having moderate accountability.

However, this process of building trust and credibility could be especially challenging in this age of declining deference. Since the membership of the Committee reflects the interests of municipalities as well as that of other non-governmental interest groups, the literature suggests that the Committee may, to some degree, encounter challenges as a result of the Canadian public's declining confidence and deference in traditional political institutions and, to a lesser extent, in nongovernmental institutions (Government of Ontario, 2007b, §2; Nevitte, 1996, pp.55,59,67). The Committee is required by the *Clean Water Act* to communicate about risks to water, but it may be likely to underestimate some of these risks, thus undermining trust. Conversely, the public may embrace this new opportunity to participate in public life. This dynamic between the Committee and the public remains to be seen, as deference and trust is as yet untested for Source Protection Committees.

3.3.1 Chemophobia

Although the decline of public trust in traditional institutions may have many ramifications, one consequence of this trend that is particularly relevant to this research is 'chemophobia'.

'Chemophobia' is typically defined as "the fear or chemicals", and often originates from the belief that naturally occurring chemicals are 'good', while manmade, synthetic chemicals are 'bad' (Concise Chemistry, 2007, p.6). Some sources, such as the United States National Library of Medicine, go so far as to define 'chemophobia' as a true phobia, the "[i]rrational fear of chemicals" (United States National Library of Medicine, 2005).

'Chemophobia' is caused in part by the erosion of the public's trust in the chemical industry, following events such as Seveso, Bhopal and the Missouri dioxin incident (Eisberg, 2008; Kay, 1989, pp.1177-1178). The decline of trust in the chemical industry has also been affected by health scares, which are often influenced by environmental groups and the media (Eisberg, 2008). However, according to Bernadette Bensaude-Vincent, the current lack of trust originated with Rachel Carson's book, *Silent Spring*, which depicted chemistry as a vicious enemy of living creatures (Eisberg, 2008).

Since the chemical industry has been particularly concerned about the public's "negative perception of chemicals", many organizations, such as the American Chemistry Council, have attempted to alter the general public's view of chemicals through public education campaigns (Concise Chemistry, 2007, p.6). A survey conducted by a Consumer Information Program[9] established to address the public's fear of agrichemicals asked members of the public about their perceptions of pesticides (Schulze, 1994). The survey found that the public's primary concern relating to chemicals is cancer. One of the survey outcomes was the identification of information that is either effective or ineffective at decreasing the public's anxiety regarding pesticides. Information that helped to reduce 'chemophobia' included statements about the following:

- Pesticides are rigorously tested
- Very few pesticides actually make it to the farm, and monitoring continues even after the chemical is registered
- According to the National Cancer Institute, there is no evidence that cancer in humans is caused by pesticide residues on plants
- The dose required to cause health problems would be enormous (Schulze, 1994)

Information that did not help to reduce public 'chemophobia' included statements about the following:

- Pesticides are required to provide enough food to feed the world's population
- Risk comparisons
- There are many more naturally occurring chemicals that are more dangerous than pesticides
- There are serious shortcomings to organic food production (Schulze, 1994)

This information is potentially crucial for informing public information campaigns and ultimately reducing the public's 'chemophobia'.

'Chemophobia' may have an impact on the source water protection process in that it is a belief that could influence the way that chemical threats to water are thought of, and how these threats are addressed. As members of the public, the Community is expected to be chemophobic to some degree. However, the extent of the Committee's 'chemophobia', if any does in fact exist, remains to be seen. It is not clear whether the Committee, as experts, can be expected to be chemophobic.

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9 The Consumer Information Program was established by the DowElanco company, in association with the agrichemical industry (Schulze, 1994).

3.4 The Theory of Collective Action

The successful implementation of the *Clean Water Act* depends on a variety of factors. Among the most important is the ability of the Committee to not only effectively consult with the public throughout the development of the source protection plan and the risk management plan, but also to make informed, rational decisions about risks to water. This requires the Committee to collectively work towards the common goal of local source water protection. It also requires the Committee members to work with the public in order to reach this goal. To facilitate a better understanding of the complex cooperative processes required to achieve the common goal of source water protection, this section will discuss the theory of collective action, placing special emphasis on the work of Marcur Olson.

"Collective action arises when the efforts of two or more individuals are needed to accomplish an outcome" (Sandler, 1992, p.1). Olson begins his groundbreaking discussion of collective action by stating that the purpose of most groups is to serve "the common interests of their members" by providing a collective or public good for the group (Olson, 1977, p.15). By definition, a collective good is a good from which no group member can be excluded (Olson, 1977, p.15). In this case, the collective good for the Committee and Community members is local source water protection, and the potential for improved water quality and reduced human health risks in the region.

Olson emphasizes the importance of group size for furthering common interests (Olson, 1977, pp.33-52). He argues that the larger the size of the group, the less it will be able to further its common interests, and discusses three factors that are both individual and cumulative (Olson, 1977, p.48). First, Olson states that "the larger the group, the smaller the fraction of the total group benefit any person acting in the group interest receives, and the less adequate the reward for any group-oriented action, and the farther the group falls short of getting an optimal supply of the collective good" (Olson, 1977, p.48). Second, since the larger the size of the group, the smaller the portion of total benefit that any individual member receives, the less likely it is that any individual "will gain enough from getting the collective good to bear the burden of providing even a small amount of it" (Olson, 1977, p.48). Third, the larger the group, the greater the cost of the organization, and thus the greater the hurdle that must be jumped before any of the collective good can be acquired (Olson, 1977, p.48). As a result of these three factors, very large groups will not typically be able to supply themselves with even negligible quantities of a collective good without the use of external incentives or coercion (Olson, 1977, p.48). Thus, a rational member of a large group should theoretically ignore the collective interests of the group and focus instead on his personal interests because he cannot be excluded from the collective goods provided by that group and he is so small relative to the entire group that in any case, his actions will not matter much (Olson, 1977, pp.15,62,106).

Conversely, in very small groups, the common interests of the group members can often be furthered, and any given collective good often can be procured by the self-interested, voluntary action of the group members without the use of positive inducements or coercion (Olson, 1977, pp.33-34). Olson argues that this is because in some small groups, at least one of the members of the group will recognize that the benefit he receives from obtaining the collective good outweighs the entire cost of providing some quantity of that collective good (Olson, 1977, pp.33-34). There are some members of a small group "who would be better off if the collective good were provided, even if they had to pay the entire cost of providing it themselves, than they would be if it were not provided" (Olson, 1977, p.34). Therefore, in small groups where each member of the group receives a considerable share of the total benefit simply because there are few other group members, that small group can often provide a collective good or further common interests by the self-interested, voluntary actions of the group members (Olson, 1977, p.34).

When applied to this current study, Olson's work implies that, as a result of the Committee's small size, the Committee may have a good chance of furthering its common interests and producing the desired collective good – source water protection – without positive inducements or coercion.

Olson then goes beyond economic inducements to discuss social incentives and pressures (Olson, 1977, pp.60,62). He argues that even when there is no economic motivation for a group member to contribute to the realization of a group objective, social incentives for the individual to contribute should still be considered (Olson, 1977, p.60). Since most individuals value self-esteem, personal prestige and social status, these are individual, noncollective goods (Olson, 1977, pp.60-61). Olson concludes by emphasizing that social incentives and pressures only operate in small groups, and are only important for large groups when the large group is a federation of smaller groups (Olson, 1977, pp.62-63).

Olson's discussion of social incentives and pressures implies that even in the absence of economic motivation, the Committee members may be motivated to work towards providing source water protection by social incentives and pressures. Individual noncollective goods that may motivate the Committee include prestige and status both among peers in the Committee and as decision makers within the community.

In his discussion of collective action, Olson briefly touches upon the concept of group consensus (Olson, 1977, p.59). He argues that complete consensus, both about the aspiration for the collective good and the most efficient means of obtaining it, will not always result in the realization of the group's common goal (Olson, 1977, p.59). Perfect consensus is at best an extremely rare phenomenon, and more realistically, consensus is typically incomplete or absent (Olson, 1977, p.60). Thus, if it is not possible for a large group to achieve the common goals of its members under the assumption of perfect consensus, this goal is even less likely in reality, where perfect consensus is at best highly improbable (Olson, 1977, pp.59-60).

This discussion of group consensus emphasizes the importance of differentiating between the barriers to collective action that are attributable to a lack of individual incentives and those that are attributable to a lack of group consensus (Olson, 1977, p.60). Thus, within the context of this current study, Olson's work suggests that the Committee may have an advantage as a small group, both in terms of the presence of individual incentives and the potential for group consensus.

3.5 Decision Theory

The successful implementation of the *Clean Water Act* and the protection of source water in Ontario require complex judgments and decisions about risks to water sources to be made by groups and communities – that is, by the Region of Study's Committee in conjunction with members of the public residing in the Region of Study. These decisions may have important ramifications for the health and safety of the residents of the Region of Study, as well as for the resiliency of the Region's ecosystems. Moreover, these decisions should, at least in theory, reflect the diverse preferences of the Committee members and stakeholders involved in the source water protection process. It is therefore necessary to comprehend the way in which individuals with diverse interests and preferences make fair and representative collective decisions. It is also important to identify some of the problems and pitfalls of collective decision making so that they may be addressed or even avoided throughout the source water protection planning process.

Decision Theory can be defined as theory about decisions, and it focuses on how humans use their freedom (Hansson, 2005, pp.5-6). That is, Decision Theory is the study of "goal directed behaviour in the presence of options" (Hansson, 2005, p.6). Decisions, however, are not made continuously, but rather there are periods of time in which the majority of the decision-making is made and other periods of time in which most of the implementation occurs (Hansson, 2005, p.6). Decision Theory attempts to illuminate this first type of period involving decision making (Hansson, 2005, p.6).

Slovic et al. (1977, pp.1-2) point out a number of trends that were apparent in the Decision Theory literature. First, decision making is diverse and interdisciplinary (Hansson, 2005, pp.5-6; Slovic et al., 1977, p.1). It is being researched from the standpoint of "an increasingly diverse set of disciplines, including" economics, medicine, statistics, education, geography, political science, marketing, engineering, social science, philosophy, management science, and psychology (Hansson, 2005, p.6; Slovic et al., 1977, p.1). "Second, increasing effort is being devoted to the development of practical methods for helping people cope with uncertainty" (Slovic et al., 1977, p.2). Third, the discipline of Decision Theory has rapidly expanded (Slovic et al., 1977, p.1).

Decision Theory may be divided into two distinct types of theories: normative decision theories and descriptive decision theories (Hansson, 2005, p.6). Normative decision theories are theories about how decisions ought to be made, and descriptive decision theories are theories about how decisions are made in reality (Hansson, 2005, p.6; Slovic et al., 1977, p.1). This discussion will focus on the latter type of decision theory, as it may apply to the source water protection planning process.

Decision Theory may also be divided into other types of theories: the theory of decisions made by individuals and the theory of decisions made by groups (Hansson, 2005, p.79). Since this research is concerned primarily with decisions being made by the Committee in conjunction with members of the public residing in the Region of Study, this section will focus mainly on the theory of decisions made by groups, known as Social Decision Theory, Collective Decision Theory or Social Choice Theory. Figure 6 features a brief overview of the major branches of both Individual Decision Theory and Social Decision Theory, with a focus on Social Decision Theory.

3.5.1 Social Decision Theory

The purpose of this section is to build upon the previous discussion of collective action, and attempt to understand and explain the types of choices that need to be made by the Committee in conjunction with the Community. This section also endeavors to understand the way in which these choices will be made.

In some cases, rules that apply to individual decision-making may also be extended to decisions made by groups (Hansson, 2005, p.79). In such instances, it is assumed that the group behaves as though it were a single individual, for example in the case of legal decision-making and corporate decision-making (Hansson, 2005, p.79). Social Decision Theory, however, refers to a theory that models situations in which decisions are made by two or more individuals, who might have conflicting goals or contradictory views on how the goals should be accomplished (Hansson, 2005, p.79). Thus, Social Decision Theory assumes that individuals within a group have contradictory interests which need to be resolved through either compromise or conflict (Hansson, 2005, p.79 quoting Luce & Raiffa, 1957, p.13). Knight and Johnson (1994, p.279) similarly define social choice theory as "a branch of rational choice theory concerned with ways, especially but not exclusively via voting, of aggregating individual interests or preferences into social outcomes." Thus, the central concern of Social Decision Theory is the aggregation of individual choices or preferences into collective choices or preferences (Hansson, 2005, p.79). The main dilemma is thus to identify, "given a set of individual preferences, a rational way to combine them into a set of social preferences or into a social choice" (Hansson, 2005, p.79). However, Social Decision Theory assumes that each individual preference influences the collective decision that is ultimately made (Sager, 2002, p.2). It is also important to note that in the Social Decision theorems, the

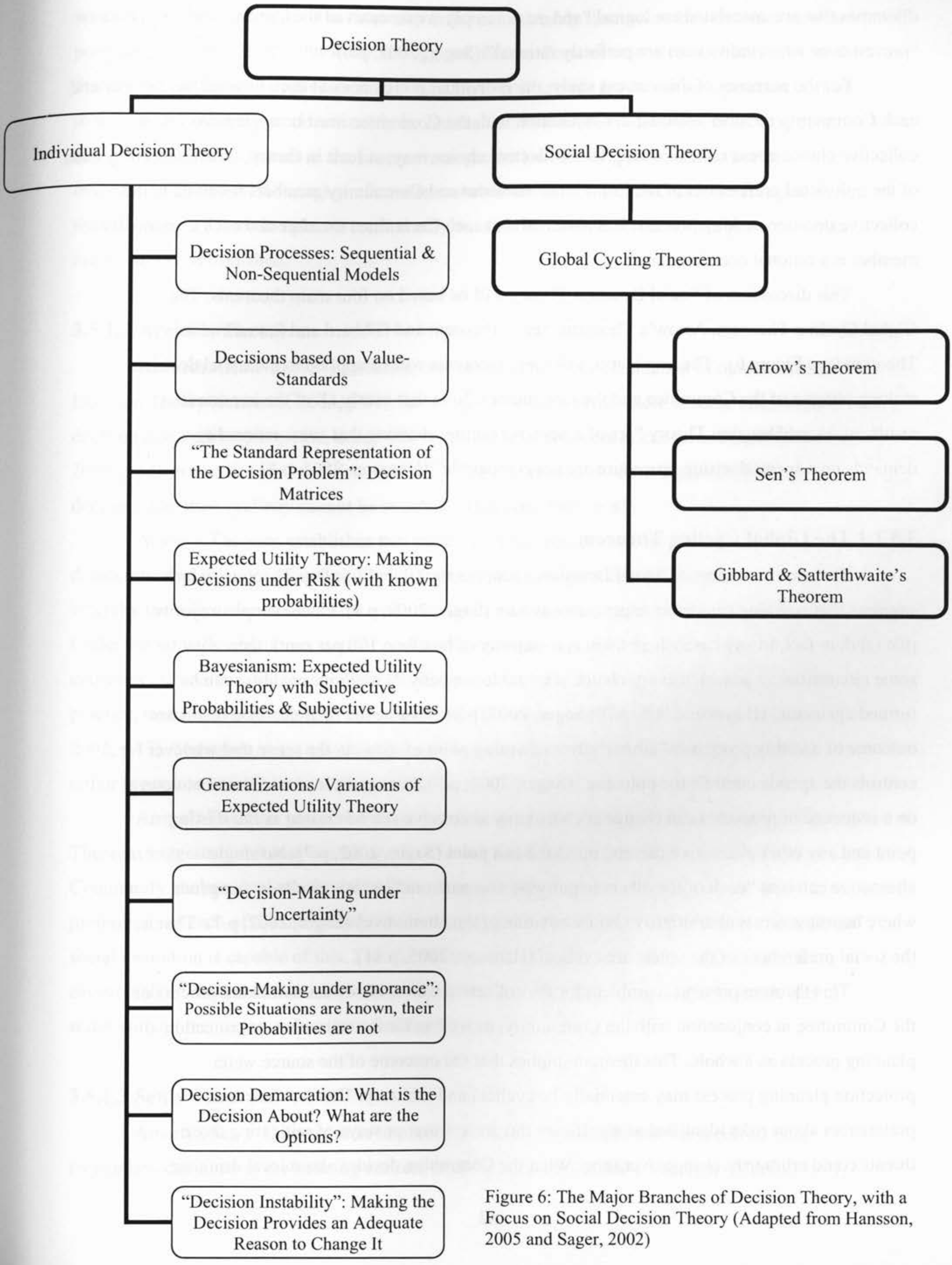

Figure 6: The Major Branches of Decision Theory, with a Focus on Social Decision Theory (Adapted from Hansson, 2005 and Sager, 2002)

dilemmas that are articulated are logical "and do not imply weaknesses of the human mind", and thus "prevail even when individuals are perfectly rational" (Sager, 2002, p.6).

For the purposes of this current study, the individual preferences of each Committee member and each Community member working in conjunction with the Committee must be aggregated into a collective choice about risks to water. This collective choice may, at least in theory, be influenced by each of the individual preferences of the Committee members and Community members involved in the collective decision making process. It is assumed that each Committee member and each Community member is a rational decision maker.

This discussion of Social Decision Theory will be based on four main theorems: The Global Cycling Theorem, Arrow's Theorem, Sen's Theorem and Gibbard and Satterthwaite's Theorem (see Figure 6). The implications of these theorems will be applied to the social decision making process of the Committee and the Community. Note that nearly all of the important results of Social Decision Theory "are of a negative nature, showing that some rationality demands on a social decision procedure are not compatible" (Hansson, 2005, p.81).

3.5.1.1 The Global Cycling Theorem

The central concept of Social Decision Theory is the Global Cycling Theorem, which suggests that anything can occur under majority rule (Sager, 2002, p.7). Under simple majority rule (and, in fact, in any case where there is a majority of less than 100 per cent), there may be some circumstances in which every choice is unstable whereby "a majority coalition can be formed against it" (Hansson, 2005, p.79; Sager, 2002, p.8). That is, the final decision that is an outcome of a voting process is "arbitrary from a voting point of view, in the sense that whoever controls the agenda controls the outcome" (Sager, 2002, p.7). For example, a coalition that votes on a sequence of proposals can change such that any alternative can be chosen as the starting point and any other alternative can end up as the end point (Sager, 2002, p.7). No single alternative can beat "each of the others in pairwise comparisons", which results in an agenda where honest voters will arbitrarily choose any one of the alternatives (Sager, 2002, p.7). That is, the social preferences of the voters are cyclical (Hansson, 2005, p.81).

This theorem presents a problem for the collective water risk decision-making process of the Committee in conjunction with the Community, as well as for the source water protection planning process as a whole. This theorem implies that the outcome of the source water protection planning process may essentially be cyclical and arbitrary. That is, choices or preferences about risks identified as significant threats to water or ways of mitigating those threats could arbitrarily change over time. What the Committee decides about local drinking water-related risks at one point in time may differ considerably from what they decide at another point in time. For example, this theorem suggests that the Committee and the Community – or for that matter, the Committee alone – may be unable to collectively produce a prioritization of risks to water and have that risk prioritization be rational and remain consistent over time. However, any cyclicity or arbitrariness in the source water protection planning process may not be immediately apparent. Although preferences and choices about water risks may be changed over time, the source protection plan is created only once, so no changes in the source protection plan can be observed over time.

3.5.1.2 Arrow's Theorem

Kenneth Arrow's (1951) Theorem is considered to be the foundation of modern Social Decision Theory (Hansson, 2005, p.81). Arrow questioned "whether there is some other social decision rule than majority rule, under which cyclic social preferences can be avoided" (Hansson, 2005, p.81). Arrow found that if four ostensibly logical "rationality criteria are satisfied by the decision rule, then cyclicity cannot be avoided" (Hansson, 2005, p.81).

Arrow's Theorem establishes that there exists no appropriate social institution for making democratic and collective social choices that require the amalgamation of diverse preferences, whereby the collective choice that is made would be both fair and consistent (Sager, 2002, p.17). Under the virtually ubiquitous state of conflicting interests, fair and consistent collective decisions are unattainable (Sager, 2002, p.17). As a result, the decision-making process will, in practice, take place as a result of "various trade-offs between the desired properties" (Sager, 2002, p.17). Therefore, the social decision that is made will inevitably be either the result of unfair procedure or intermediate (Sager, 2002, p.17).

Arrow's Theorem presents another problem for source water protection planning. The Theorem suggests that it may not be possible for the Committee to, in conjunction with the Community, make a democratic and collective social choice that amalgamates the diverse preferences of each of the individuals in the two groups, and that is fair and consistent. Indeed, no social institution is capable of this. The Committee, for example, may not be able to make a decision about risks to water or even be able to produce a prioritized list of significant threats to water without the use of trade-offs or unfair procedure.

3.5.1.3 Sen's Theorem

Amartya Sen's Theorem is as important as Arrow's Theorem, but has received little recognition due to an overwhelming concern with the result of Arrow's Theorem (Aldrich, 1977, p.1). The Theorem addresses the compatibility of a social decision function with three specific conditions (Aldrich, 1977, p.2):

1. The universal domain condition: The social decision function ubiquitously applies "to all possible configurations of individual preferences" (Aldrich, 1977, pp.2-3).
2. The Pareto principle: If each member of a group prefers one option to another, then the group decision should reflect this preference in terms of the social ordering of the social decision function (Aldrich, 1977, p.3).
3. Liberalism: Individual members of a group should be able "to guarantee that the social order reflect some portion of their preferences" (Aldrich, 1977, p.3).

Sen's Theorem states the impossibility of a Paretian liberal and argues that preference sovereignty and liberalism cannot guarantee a cycle-free collective decision procedure (Sager, 2002, p.103). That is, the universal domain condition, the Pareto principle, Liberalism, and the social decision function are all inconsistent (Aldrich, 1977, p.3). Liberalism gives individuals the right to make decisions within their personal spheres, "and preference sovereignty means that the Pareto principle is respected, and thus the institution used for making social decisions respects unanimity" (Sager, 2002, p.103). When individuals in a group are able to come to a favourable decision, it is viewed here as implying that the outcome of the decision is in the public interest (Sager, 2002, p.103).

Sen's Theorem thus demonstrates that it is difficult to combine the control of the individual over their own personal sphere with other advantageous features of the decision-making process (Sager, 2002, p.14). The paradox of Sen's Theorem is that preference sovereignty and privacy can result in decisions or recommendations that are inconsistent (Sager, 2002, p.14).

Sen's Theorem thus presents yet another problem for source water protection planning. The Theorem suggests that it may not be possible for Committee members and Community members to have their individual source water protection planning choices represented while the group simultaneously comes to a fair and democratic consensus. Decisions about water risks and the action plans devised to mitigate them could be inherently inconsistent.

3.5.1.4 Gibbard and Satterthwaite's Theorem

The Theorem independently proven by Mark Satterthwaite and Allan Gibbard outlines that in a democracy, manipulation is incredibly difficult to avoid throughout the process of consistent social decision-making (Sager, 2002, p.14). The Gibbard and Satterthwaite Theorem "implies that every institution for recommending one (of at least three)…alternatives must be either dictatorial or liable to manipulation when it is based solely on individual preference orderings" (Sager, 2002, p.179). When democratic institutions are concerned, there will always be some individuals that are motivated to manipulate by revealing false preferences (Sager, 2002, p.179).

This Theorem implies that the Committee in conjunction with the Community, like all other groups charged with making democratic social choices, may be subject to manipulation or decisions about water risks that are dictatorial in nature. That is, throughout the process of identifying significant threats to drinking water and choosing remediation plans, the decisions made by the Committee and the Community may be based on false preferences or may not reflect the preferences of all members.

3.6 Other Relevant Water Risk Studies

There have been very few studies of specific perceptions about water risks, especially by threats to water. This section identifies and summarizes other water risk studies that are relevant to this research.

In their study of drinking water odours and health risk perception, Jardine, Gibson and Hrudey (1999, p.91) find that drinking water-related health risk perceptions are rated low compared with other types of risks. The study found that only 8.5% of Albertans perceived tap water to be a high risk, compared to approximately 17.6% for moulds in food and 14.6% for bacteria in food (Jardine et al., 1999, p.92). However, tap water was perceived to be more risky than bottled water (Jardine et al., 1999, p.92). Jardine et al. (1999, p.91) assert that water risk perceptions are influenced by the media, which is a main information source. Similarly, the results of this current water risk study are expected to be less extreme due to the nature of the risk, and the water risk perceptions of the participants are expected to be influenced by the media.

Jones et al. (2006, p.1) conducted a survey of Hamilton, Ontario residents with private drinking water supplies in order to determine their water risk perceptions. The study found that while participants perceived their water to be of high quality, 80% were concerned with its safety (Jones et al., 2006, pp.2,6). The Community respondents of this study are also expected to be averse to water risks.

Pushchak, Sly and Hooker's (2005) proposed study, *Risk communication and public confidence in water regulation in Ontario*, seeks to determine the relationship between risk communication and public trust and confidence in government action. The study would survey three Ontario communities – Woodstock, Goderich and Timmins - with varying vulnerabilities to, and successful mitigation of, water risks (Pushchak et al., 2005). Similarly, Burley (2007, p.2) studied trust and drinking water quality in an Ontario community with a "positive drinking water history". While the Community surveyed in this study was proficient, the region has experienced negative drinking water incidents.

3.7 Summary of the Literature

The purpose of this section is to summarize the most important and relevant findings in the risk perception and decision theory literature, particularly as it relates to this study.

First, the risk perception literature suggests that the Community is expected to be more willing to accept drinking water risks that they perceive to be voluntary, as opposed to involuntary risks (Starr, 1969, p.1237). Furthermore, the Community's awareness of the benefits of any given activity or land use that may affect water is expected to influence their acceptance of the risk that the activity poses to water (Starr, 1969, p.1237).

The risk perception literature also implies that a difference in the perception of water risk is expected between the Community and the Committee (Slovic, 1987, pp.280,283; Slovic et al., 1984, p.187-188). The Community is expected to perceive water risks in a more complex way, in terms of outrage factors (Hampel, 2006, pp.7-8; Kasperson et al., 1988, p.177; Slovic et al., 1984, p.193). Conversely, it is anticipated that the Committee may perceive water risks in a less complex, more technical way (Hampel, 2006, pp.7-8; Kasperson et al., 1988, p.177; Slovic et al., 1984, p.193). However, all respondents are expected to rely on heuristics to help them make complex decisions about risks to water (Tversky and Kahneman, 1974, p.1130). This means that even though the Committee is expected to perceive water risks in a more technical way than the Community, they are still expected to rely on heuristics to some degree when thinking intuitively (Tversky and Kahneman, 1974, p.1130). Moreover, the Community is expected to be more risk averse than the Committee (Fischhoff et al., 1978, p.148; Slovic, 1987, p.283). All respondents are expected to be overconfident in their water risk judgments (Slovic et al., 1977, p.6).

This literature review described and discussed the expressed preferences model within the framework of the psychometric paradigm (Fischhoff et al., 1978; Slovic, 1987, pp.281-283). This study will use the expressed preferences model, will examine factors that fall within the factor analytic framework of the psychometric paradigm, and will create a cognitive map of risks to drinking water using the two factor space. It is expected that the water risk attitudes and perceptions of the Community will be associated with the location of hazards within the two factor space (Slovic, 1987, p.283; Slovic et al., 1984, p.189). However, the Committee's water risk perceptions may not be strongly connected to any of the risk factors or characteristics within the two factor space (Slovic, 1987, p.283).

This literature review also examined other factors that could affect the way in which the Community and Committee think about and make decisions about water risks, such as culturally constructed worldviews. Differences in worldviews between Committee and Community members could be a source of conflict (Boholm, 1998, p.151).

The risk communication literature, which was presented in conjunction with the risk perception literature, is important because the Committee will have to communicate to other experts and the public about regional risks to water. The Committee must work with the Community to establish trust and confidence (Covello et al., 2001, pp.8-9; Peters et al., 1997, p.43). It is imperative that the Community perceive the Committee to be honest and open, knowledgeable, and caring, with moderate accountability (Frewer et al., 1996, p.473; Peters et al., 1997, p.43). This is so important because trust and deference remains untested for Source Water Protection Committees (Frewer et al., 1996, p.473; Laird, 1989, pp.543-548). The absence of trusting relationships can have consequences such as 'chemophobia' (Eisberg, 2008; Kay, 1989, pp.1177-1178). Although the Community is expected to exhibit some 'chemophobia', it is not clear whether the Committee can be expected to be chemophobic.

The above discussion of the Theory of Collective Action suggested that the Committee may have an advantage as a result of the small size of the group, both in terms of the presence of individual incentives, including social incentives and pressures, and the potential for group consensus (Olson, 1977, pp.33-34, 60).

This literature review also examined problems with social decision-making processes that may extend to decisions that the Community and the Committee will have to make about water-related risks. It was determined that such social decisions may be cyclical and arbitrary, and that it may not be possible for the Committee and the Community to make a democratic and collective social choice about water risk that amalgamates the diverse preferences of the group and is fair and consistent (Hansson, 1994, p.81; Sager, 2002, pp.7,17). This discussion also indicated that the Committee and Community's collective water risk decisions may be inherently inconsistent and subject to manipulation and dictatorial outcomes (Sager, 2002, pp.14,179). In fact, current members of the Committee have expressed fears of manipulation within the Committee (R. Pushchak, personal communication, July 2008). Thus, the literature suggests that it may ultimately not be possible for the Committee and the Community to make collective democratic social choices about risks to drinking water that are fair and that represent the individual preferences of the group members (Sager, 2002, pp.14,17). Any collective water risk decision made could be inherently inconsistent, cyclical, arbitrary, dictatorial, subject to manipulation, based on trade-offs and the result of unfair procedure (Hansson, 1994, p.81; Sager, 2002, pp.7,14,17,179).

Finally, other relevant water risk studies suggest that since this study is concerned with water risks, the results may be less extreme compared to studies of other risks (Jardine et al., 1999, p.92). Furthermore, the Committee and the Community's risk perceptions may be influenced by the media

(Jardine et al., 1999, p.91). As in Jones et al.'s (2006, pp.2,6) study, the Community surveyed in this study is expected to be averse to water risks.

4. Methods

A qualitative and quantitative research study was designed in response to the three null hypotheses outlined in Section 1.3 (Jalba & Hrudey, 2006, p.38).

Data collection began with a survey of respondents in a Community in Southern Ontario. The survey was given to two distinct groups of people:

1. Randomly selected residents of the Region of Study (i.e. members of the general public) who were 18 years of age or older, who owned property, and who were served by the municipal water supply, and
2. Members of the Region of Study's Source Protection Committee, including the Chair of the Committee and the Committee's Liaison member.

4.1 The Region of Study

This subsection describes the process of selecting the Region of Study, as well as the characteristics of the Region of Study. This subsection will begin with a discussion of the process of selecting the Region of Study, the outcome of which was largely dependent upon the Region's characteristics. This subsection will then go on to describe the Region of Study, including education and employment characteristics, drinking water sources and distribution and recent issues of environmental concern that occurred in the area.

Recall that while the unit of action for the Committee is the entire watershed, this study is of one municipality in it (i.e. for the purposes of this study, the Region of Study is a municipality within a watershed). For the purposes of this study, the term "Region of Study" is used to refer to the municipality being studied.

4.1.1 The Selection Process

In order to identify a Region of Study in Southern Ontario[10], four criteria were used:

1. The region must be characterized by sufficient potential risk to the drinking water supply, as indicated by past events;
2. The region must have sufficient threats to drinking water from industrial activities;

[10] First, Southern Ontario was partitioned along Conservation Authority Boundaries, and an area defined by these boundaries was selected for this research. Then, the largest city in this selected area, the Region of Study, was chosen for sampling.

3. The region must have sufficient threats to drinking water from biological sources;
4. The region must have a reasonably large population.

These criteria were used in the selection of the region of study because it was anticipated that they would elicit more salient responses to drinking water-related issues, as well as positively impact survey response rates. Adverse Water Quality Incidents Reports (2002-2007), Municipal Residential Drinking Water System Convictions (April 1, 2005 – March 31, 2006), and Preventative Orders (2005-2006) were used to identify Southern Ontario regions which have experienced a substantial number of water risk events in the recent past (Ministry of the Environment, 2007b; Ministry of the Environment, 2007c). Industrial Sewage Exceedances (2005) and Pollutant Releases (2005 NPRI data) were used to identify regions with sufficient threats to drinking water from industrial activities (Environment Canada, 2007; Ministry of the Environment, 2007a). Water well inspection data were used to identify regions with sufficient threats to drinking water from biological sources (Ministry of the Environment, 2006b). Finally, population data were used to identify regions in Southern Ontario with a sufficiently large population (Statistics Canada, 2008a).

The three Southern Ontario Regions that best met the four criteria listed above were the Region of Study, the Grand River region, and the Nottawasaga Valley region. The Nottawasaga Valley region was omitted because it did not satisfy the threats from industrial activities criterion and population size criterion (Numbers 2 and 4 above), and because of its proximity to Walkerton, Ontario. The Grand River region was ultimately omitted from this study because the region is already very well studied and is known for its effective source water protection, drinking water treatment, and, when necessary, remediation (Koycheva, 2003).

The Region of Study was ultimately chosen because it best satisfied criteria 1, 2, and 4 and because it is located sufficiently far away from the Walkerton area. The surrounding rural area was excluded from the sample in order to minimize the number of groups used in the study. There were no water well inspection failures in the Region of Study, and thus the region did not satisfy the threats from biological sources criterion (Number 3). However, after researching the region further, it was determined that significant threats to drinking water from biological sources do in fact exist in the Region of Study due to the nature and extent of agricultural activity in the area (see Subsection 4.1.2.1, just below). It should be noted that under Ontario's *Clean Water Act*, a number of Source Protection Areas, including the Source Protection Area corresponding to the Region of Study, were amalgamated to form the Region of Study's Source Protection Region. Consequently, although the Community is the sampling area for this research, the Region of Study's Source Protection Region, which encompasses the watershed in which the Community is situated, is referred to when discussing the *Clean Water Act* and the Committee.

4.1.2 Characteristics of the Region of Study

The Region of Study chosen for this research is located in Southern Ontario, Canada. The Region of Study is a large urban center (Regional Development Corporation, 2007; Regional Development Corporation, 2008b; Statistics Canada, 2008b).

The Region of Study was selected because its characteristics can produce risks to municipal drinking water that may have affected respondents' perceptions. Between the industries that generate chemical risks to water, and those that produce biological risks, there are potentially numerous threats to drinking water in the Region of Study. This section may also describe the potential backgrounds and occupations of some of this study's respondents, as well as the events and experiences that may have shaped the perceptions of those respondents.

4.1.2.1 Education and Industry

The post-secondary education rate in the Region of Study is slightly higher than the provincial average (Statistics Canada 2008b). The Region of Study is also home to a number of post-secondary institutions (Ontario Ministry of Training, Colleges and Universities, 2008a; Ontario Ministry of Training, Colleges and Universities, 2008b). It is thus anticipated that many of the study's respondents could be graduates or even employees of either the local post-secondary institutions or other post-secondary institutions.

The Region of Study's major industries include manufacturing, automotive parts, life sciences, information technology, agriculture and food processing (see Figure 7; Regional Development Corporation, 2008b).

The Region of Study is located near Ontario's automotive cluster (Regional Development Corporation, 2008a). Some of the region's other major employers – chemical companies, brewing, electronics and heavy manufacturing – are industries that may potentially generate several different primarily chemical risks to water in the Region of Study (Confidential Manufacturer, 2008; Canadian Trade Index, 2008; Regional Development Corporation, 2008b).

It is important to also note the nature and extent of agricultural activity in the County in which the Community is located ("the Study County"). Note that since these data were only available at the level of the County, and not at the municipal level, these data must be discussed in terms of the County in which the Region of Study is located. In comparison to other Southern Ontario Counties, the Study County has both a large number of farms and a large number of large (560 acres and over) farms (McGee, 2007b). Furthermore, the Study County has one of the largest numbers of beef cattle farming and ranching operations, and one of the largest numbers of dairy cattle and milk operations and hog farming operations in Southern Ontario (McGee, 2007a). The Study County also has a large number of oilseed and grain farming operations (McGee, 2007a). In the case of large livestock farms, or factory farms, (defined as farms having 300 or more animal units) the Study County has among the highest number of all the regions in Canada (Beaulieu, 2003, p.10). Thus, the nature and extent of agricultural activity in the Region of Study indicates that agriculture is likely a main source of biological risks, and can potentially produce numerous threats to the region's water.

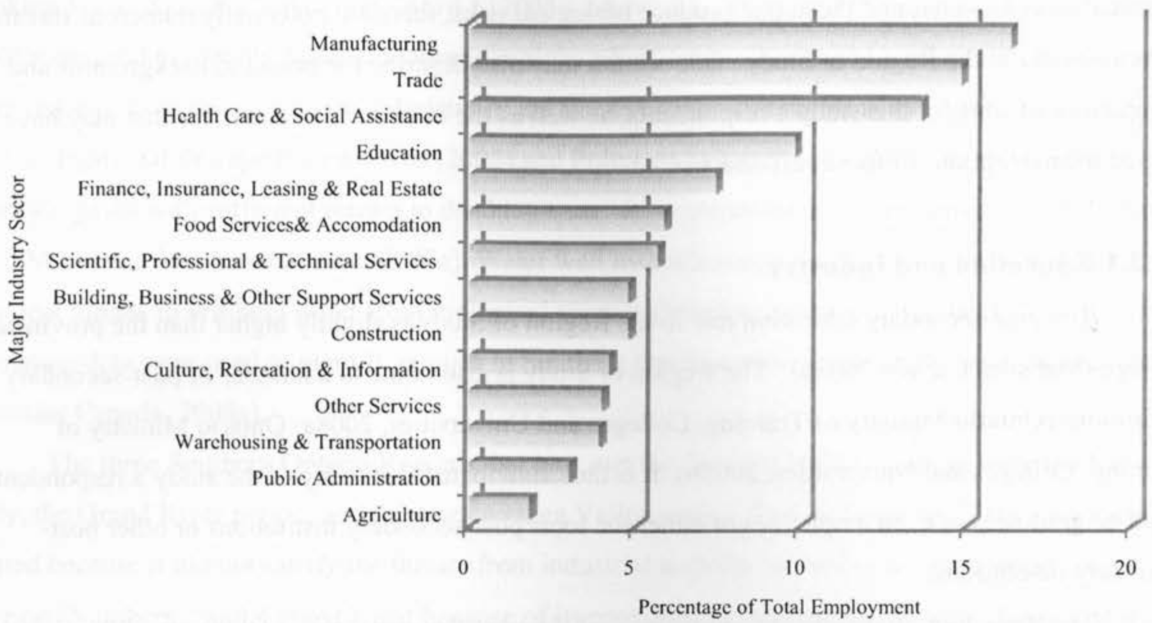

Figure 7: Employment in Region of Study by Major Industry Sector (Adapted from Regional Development Corporation, 2008b). This figure demonstrates that industries in the Region of Study produce potentially numerous threats to municipal drinking water.

4.1.2.2 Drinking Water Sources and Distribution

The Region of Study obtains its treated drinking water from two separate systems (Municipal Report, 2008; Municipal Website, n.d.). Water from one regional (Region 1) Water Supply System comprises most of the water consumed daily, and the remaining drinking water is taken from another regional (Region 2) Water Supply System (Municipal Report, 2008). The Region of Study maintains a network of inactive well fields for emergency purposes (Municipal Report, 2008). The treatment of water from the Region of Study's two main sources falls under the jurisdiction of both the Region 1 Primary Water Supply System Joint Board of Management and the Region 2 Primary Water Supply System Joint Board of Management (Municipal Report, 2008). Water from Region 1 and Region 2 is delivered to two separate pumping stations, at which point the Region of Study assumes responsibility for the water (Municipal Report, 2008).

The Region of Study's water distribution system is comprised of reservoirs, pumping stations, meter houses, wells, pressure reducing valve chambers and main chambers (Municipal Report, 2008). The system is generally comprised of both a high level system and a low level system (Municipal Report, 2008). Staff employed by the Region of Study regularly test for chlorine residuals, microbial indicators, inorganics, organics, pesticides, metals, fluoride, turbidity and other chemical indicators (Municipal Report, 2008).

4.1.2.3 Recent Issues of Environmental Concern in the Region of Study

Beyond agricultural and manufacturing risks to drinking water, there are other risks to water that may have affected the risk perceptions of this study's respondents. This subsection discusses three main water risk issues that are currently of environmental concern in the Region of Study. All three of these issues have received substantial media coverage and have attracted public attention (CWQA, n.d.; Martin, 2006; Martin, 2008; Sher, 2008). However, it is important to note that this section is not exhaustive, and there may be other related issues, reported in the media or otherwise, that are not discussed here. These other issues could also affect the risk perceptions of this study's respondents.

The first issue of environmental concern is a PCB contaminated brownfield site located near the Region of Study. The PCBs are located in earth berms near a former electric systems manufacturing plant (Martin, 2008). In the 2008 Ontario budget, millions of dollars were allocated to the remediation of this site (Martin, 2008).

The second major issue of environmental importance is a large scale municipal solid waste landfill located near the Region of Study (Martin, 2006). The landfill was recently granted approval to expand and accept wastes on a regional scale (Martin, 2006).

The third major issue is the recent finding of unusually high levels of lead in tap water in the area (CWQA, n.d.; Sher, 2008). The lead originated from pipes in older residential homes, and concentrations exceeded Ontario's maximum acceptable level of 10 μg/L (CWQA, n.d.; Sher, 2008). This incident prompted new regulations in Ontario, and as of April 2008, there has been a substantial reduction in lead concentrations (Sher, 2008). However, some of the homes that were tested still exceed Ontario's standard for lead concentrations (Sher, 2008).

It is important to keep these three water quality concerns in mind throughout the subsequent sections of this report. These issues are vitally important because as of this writing they are recent and may alter respondents' perceptions of threats to water, as well as perceptions of the quality of this water.

4.2 Selection of Survey Participants

Study Community Residents

The residents of the Community who were invited to participate in this research were randomly selected by the Institute for Social Research at York University, which provided mailing addresses and phone numbers for each respondent. Only urban residents of the Community who were 18 years of age or older and who owned property were invited to participate.

A sample frame is a list of elements, such as individuals, cities, telephone numbers or institutions, from which a sample will be drawn (e.g. a sample frame could be a subscription list or property tax records; Rigney & Associates, n.d.). The sample frame for this study was a database of listed telephone numbers with appended geographic information. The database was created by randomly generating all telephone numbers within each central office code and area code in Canada. These telephone numbers were then matched against information in telephone directories and other supplementary lists (R. Myles, personal communication, October 2, 2008).[11] When there was a match, the geographic information was then appended to the sample telephone number. Telephone numbers that met the geographic criterion of this study were then selected from the database. That is, the sample ultimately consisted of listed telephone numbers in the sample provider's database that had postal codes[12] locating the telephone numbers within the given boundaries. Forward Sortation Areas (FSAs), census subdivisions, and boundary roads which best approximated city limits were used to define the geographic boundaries that allowed for selection of the telephone numbers comprising the sample (R. Myles, personal communication, October 2, 2008).

A sampling unit can be defined as the elements, such as individuals or institutions, which are available for selection during the sampling process (e.g. a person answering the phone; Rigney & Associates, n.d.). For the mail survey component of this study, the sampling unit was the household member to whom the survey was addressed. For the telephone interview component of this study, the sampling unit was the first member of a household who was 18 years of age or older to answer the telephone.

The sampling method is the way in which potential research participants are chosen from the sample frame. Simple random sampling was the sampling method used in this study. "In simple random sampling, each member of a population has an equal chance of being included in the sample", and each combination of population members has an equal chance of comprising the sample (Statistics Canada, 2006).

[11] Supplementary lists were not disclosed by the Institute for Social Research, but the examples of utility bills and magazine subscription lists were given.

[12] Or, alternately, destination addresses

The required minimum sample size for the Community's population sample was calculated using Cochran's (1963, p.75) equation. A confidence interval of ±5% (or ± 0.05) and a confidence level of 95% were used. A confidence interval is an error rate or margin of error, and sets out "an estimated range of values which is likely to include an unknown population parameter" (Easton & McColl, n.d.). For example, if a confidence interval of ±5% is used and 20% of a sample chooses a specific answer, it can be known for "sure" that if the entire population had been asked that question, between 15% and 25% would have chosen that answer (Godden, 2004, p.1). A "confidence level is the probability value", or degree of certainty, "associated with a confidence interval" (Easton & McColl, n.d.). The confidence level "represents how often the true percentage of the population who would pick an answer lies within the confidence interval" (Godden, 2004, p.1). A confidence level of 95% is typically used by most researchers and means that a researcher can be 95% certain of their result (Godden, 2004, p.1).

The maximum tolerated error, *d*, is defined as the "upper bound for the margin of error" and is set by the researcher (Le, 2003, p.452). Since the equation used to calculate the required minimum sample size for the Community's population sample did not require a *d* value, the maximum tolerated error was not set (Cochran's, 1963, p.75). However, since a confidence interval of ±5% is being used, by definition the maximum tolerated error can be any number greater than or equal to 5%, typically to a maximum of 20% (Le, 203, p.452).

The Z^2 value, or z-score, is the "abscissa of the normal curve that cuts off an area at the tails", and is equal to 1.96 at a 95% confidence interval (Israel, 2008; Paoli, Haggard & Shah, 2002, p.2). That is, the Z^2 value indicates the number of standard deviations a score is from the mean (Kognito, 2007, p.3) Thus, a Z^2 value of 1.96 (i.e. 1.96 standard deviations from the mean) defines the 95% confidence interval (Paoli et al., 2002, p.2).

The p value, "the estimated proportion of an attribute that is present in the population" was equal to 0.5 (Israel, 2008). Since the q value is equal to 1-p, q was also equal to 0.5, which is the maximum variability in a population (Israel, 2008). This is the most conservative estimate of p and q, since these values result in the largest minimum sample size. The e value, representing "the desired level of precision", was equal to 0.5 (Israel, 2008). "Precision is a measure of how close an estimator is expected to be to the true value of a parameter" (Easton & McColl, n.d.).

Since the sample size does not exceed 5% of the population size, N (equal to the approximate 2006 population size for the Region of Study), the finite population correction was not used (Statistics Canada, 2008b; The University of Texas at Austin, n.d.). The required minimum sample size was 384 persons. Adjusting for an estimated 30% response rate, the minimum sample size was increased to 1,280 persons.

The 30% response rate was chosen by assuming a 20% response rate by mail, and an additional 10% response resulting from follow-up telephone conversations. The anticipated 20% response rate for the mail survey was chosen based on the average response rate for mail surveys of approximately 20% (Ipathia Inc., 2005a). The anticipated 10% response rate for the follow-up telephone surveys may appear to be quite conservative. A study conducted in British Columbia by the Public Health Agency of Canada found a 79% response rate among participants who had received an introductory letter prior to participating in a telephone survey, and a 50% response rate among participants who had not (Public Health Agency of Canada, 2004). The overall response rate was 57% (Public Health Agency of Canada, 2004). A similar U.K. study found a response rate of 76% among participants who had received an introductory letter, and a response rate of 60% among those that had not (Smith, Chey, Jalaludin, Salkeld, & Capon, 1995, p.33). The response rate was 68% overall (Smith et al., 1995, p.33). Therefore, even when respondents were not sent an introductory letter in advance of a telephone survey, the response rate for this type of survey was much greater than 10%. All respondents who were contacted for the telephone survey in this study were sent mail surveys prior to telephone contact. However, the 10% response rate was chosen for this study with the knowledge that telephone survey respondents would be members of the Community who had neglected to respond to the mail survey.

The sample size of 1,280 persons was rounded up to 1,300. When the sample arrived, 7 people were already excluded from the sample, presumably because they indicated prior to the purchase of the sample that they did not want to be solicited. Thus, a total of 1,293 surveys were mailed to members of the Community.

Residents chosen to participate were sent mail surveys, which were later followed up with telephone conversations. Only those selected residents who did not return the mail survey and for whom the researcher did not receive a survey returned as 'undeliverable' were contacted by telephone. Telephone calls were made to every resident who fit these criteria, and all telephone interviews were conducted by the researcher. Each mailing address and phone number was assigned a four-digit code. The codes were printed onto the surveys, which allowed the researcher to only contact those residents who did not return the survey by mail and for whom a survey returned as 'undeliverable' was not received.

Out of a total of 1,293 residents of the Community contacted, 180 members of the public (or 13.9% of the sample) responded to the survey. Thus, the number of participants was considerably lower than the anticipated number of 384. Of these, 91 completed surveys (7% of the sample) were mailed back after the initial mailing, 60 responses (4.6% of the sample) were obtained from follow-up telephone conversations, and 29 (2.2% of the sample) completed surveys were mailed back by individuals who requested a second copy of the mail survey during a follow up telephone conversation (see Figures 8 and 9).

The total response rate for this study was 13.9%, a rate considerably lower than the estimated 30% response rate. At a confidence level of 95%, the sample of 180 that was obtained results in a ± 7.3% confidence interval (i.e. margin of error). At a confidence level of 90%, the sample of 180 results in a ± 6.1% confidence interval. Thus, at a 95% confidence level, the final results (in percentage form) may vary by as much as 14.6% (but will vary less than this19 times in 20), and at a 90% confidence level, the final results may vary by as much as 12.2% (but will vary less than this 9 times in 10) . As a result of the small sample size and wider confidence intervals, the sampling error is increased and the statistical significance of this study is considerably weakened (Dillman, 1991, p.227).

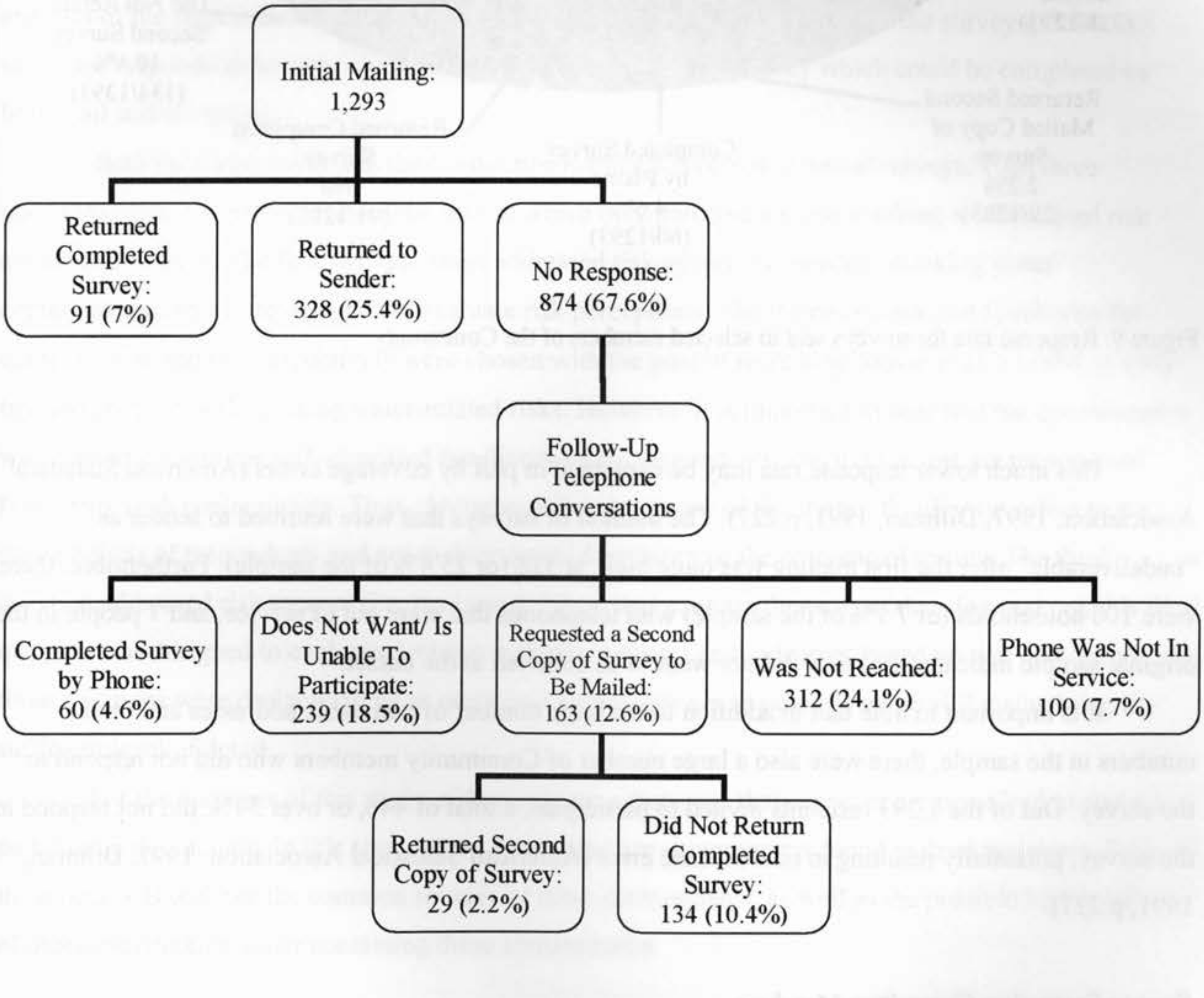

Figure 8: The data collection process and number of responses to surveys sent to selected members of the Community

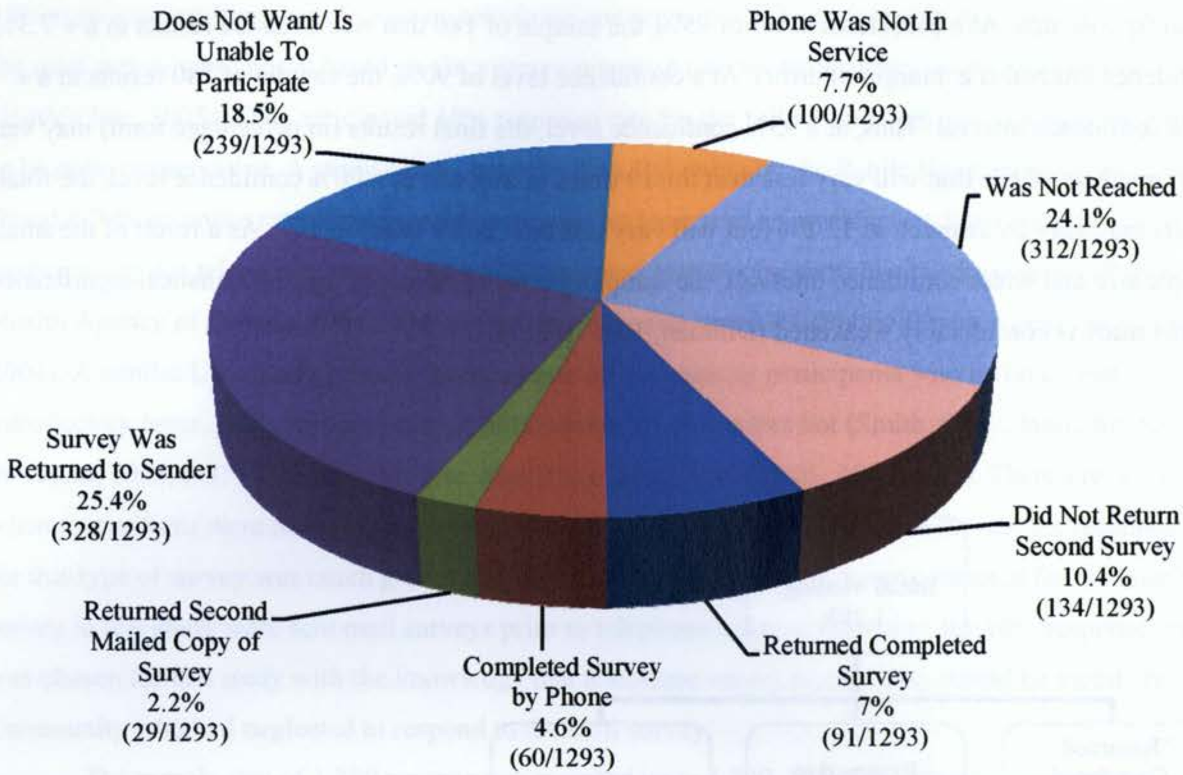

Figure 9: Response rate for surveys sent to selected members of the Community

This much lower response rate may be explained in part by coverage errors (American Statistical Association, 1997; Dillman, 1991, p.227). The number of surveys that were returned to sender as "undeliverable" after the first mailing was quite high, at 328 (or 25.4% of the sample). Furthermore, there were 100 households (or 7.7% of the sample) with telephones that were out of service, and 7 people in the original sample indicated that they did not want to be solicited at the outset.

It is important to note that in addition to the large number of nonviable addresses and phone numbers in the sample, there were also a large number of Community members who did not respond to the survey. Out of the 1,293 residents invited to participate, a total of 446, or over 34%, did not respond to the survey, potentially resulting in nonresponse error (American Statistical Association, 1997; Dillman, 1991, p.227).

Source Protection Committee Members

The choice of the Region of Study dictated the Source Protection Committee that was invited to participate. All members of the Region of Study's Source Protection Committee at the time of mailing were invited to participate in the research. The names of the Committee and the Committee's Liaison were obtained from the Region of Study's Source Protection Region website.

A total of 23 decision makers were invited to participate, including all 22 members of the Committee, and one Committee Liaison. Of these, 16 (or 69.6%) completed and returned the survey. Two (8.7%) Committee members declined to fill out the survey, and the remaining 5 (21.7%) either did not return the survey, or the researcher was unsuccessful at contacting them. Thus, for the purposes of this study, the perceptions of only a sample of the Committee were surveyed.

4.3 Development of the Survey of Drinking Water Risks

The principal research instrument (questionnaire) was a mail-out, mail-back survey comprised of three (3) multiple choice questions. The multiple choice format was chosen to facilitate quantitative analysis of the responses. The multiple choice format was also chosen to make the survey quicker and easier for respondents to complete and to create a more versatile survey which could be completed by both mail and telephone.

Both the Community and the Committee members received identical surveys.[13] All three questions asked respondents about the way in which they perceive various drinking water-related risk agents and sources. The first two questions addressed risk agents (i.e. specific drinking water contaminants), and were designed to evaluate risk perceptions. The themes of risk and familiarity for questions one and two respectively were chosen with the goal of recreating Slovic et al.'s (1984, p.189) two factor space with drinking water-related risks. However, it is important to note that the questionnaire was concerned with the self-identified familiarity of the respondents, and did not test the respondents' familiarity with contaminants. Thus, throughout this discussion of the study, 'familiarity' refers to the stated beliefs of respondents and not to their actual familiarity or the outcome of testing. The third question addressed risk sources (i.e. land uses). Since land uses are the units of decision making, this third question was designed to evaluate decision making processes and outcomes based on risk perceptions. All three questions were designed to be as quick and easy to answer as possible while still maintaining a sufficient level of detail.

For the purposes of this study, risk agents are substances that cause, or are perceived to cause a particular risk outcome. In this study, these substances are contaminants found in drinking water. Table Bi in Appendix B outlines the common sources of these contaminants, as well as the possible health effects of ingesting drinking water containing these contaminants.

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[13] Although the surveys themselves were identical for each group, the cover letter preceding the surveys were different, to ensure compliance with the Ryerson Research Ethics Board.

In this study, risk sources are the land uses that could potentially introduce pollutants to drinking water. Table Bii in Appendix B outlines the drinking water contaminants that are associated with each land use included in the questionnaire, as well as the possible human health effects of those contaminants. This table demonstrates the relationship between risk agents and sources and attempts to rudimentarily approximate some of the factors that must be taken into account when making water risk decisions about land uses.

These descriptions of the human health effects of exposure to the risk agents and sources included in this study are meant to provide an approximation of the "objective" risk associated with the selected drinking water contaminants and the land uses that give rise to them.

The risk agents and sources included in the survey questions were chosen based on the Province of Ontario's inventory of threats to drinking water, also known as the "Threats Inventory" (Fletcher, 2006; Ministry of the Environment Technical Studies, 2006). The risk agents and sources identified using Ontario's inventory of threats to water were then tailored to the Region of Study, based on specific characteristics of the Region of Study. These characteristics included employment and industry in the Region of Study, the type and extent of agricultural activities in the region, and current and historical land uses in the region (see Section 4.1 above).

Both groups of respondents were asked to indicate whether they would like to receive a summary of the research, by checking or declining to check a box on the cover page of the survey. All surveys also included pre-addressed, stamped return envelopes in which the respondents could return their surveys.

The survey and cover letters for both groups received ethical approval from the Ryerson University Research Ethics Board. Although the Research Ethics Board did not require that the Region of Study be confidential, the Committee agreed to take part in the study on the condition that the identity of the Committee remains confidential. This also requires the nondisclosure of the Region of Study and any other identifying information.

The surveys were pre-tested on 24 students enrolled in the Ted Rogers School of Management at Ryerson University. This group was chosen because it was assumed that their familiarity with science-based terminology and themes approximates that of the general public. See Appendix C for a copy of the survey used in this study.

Survey Design and Response Rate

The Community survey was designed to maximize response rate, in an attempt to achieve the 30% response rate goal. The survey was sent from a university (as opposed to a commercial entity), and was sent to a community for which the subject matter of the survey was expected to be relevant and interesting. The cover page of the survey was printed in coloured ink, and the length of the survey was restricted to three questions. Pre-addressed, stamped envelopes were included with the surveys. The survey was also followed up with telephone conversations, and non-respondents were provided with either a second copy of the survey, or the opportunity to complete the survey over the phone.

These characteristics also applied to the survey sent to the Committee members. However, Committee members were given additional options for returning the survey.

According to Edwards et al. (2002, p.1183) who performed a systematic review of methods that affect response rates to mail surveys, all of these characteristics increase response rates. However, Edwards et al. (2002, p.1183) also mentioned a number of other techniques that were not used in this study, but have also been found to increase response rates. These methods include use of monetary incentives, personalized letters and surveys, and contacting respondents prior to mailing the surveys (Edwards et al., 2002, p.1183). These methods were not used in this study, due to temporal and resource constraints.

4.4 Data Collection

The Mail Survey

The mail-out, mail-back approach (as opposed to alternative approaches such as computer-assisted surveys at a centralized location, Internet-based surveys or in-person interviews) was taken because it allowed for random sampling of the Community's population base, and because of cost considerations (Adamowicz et al., 2004, p.1831). This approach reduces interviewer bias and is also less intrusive than other surveying methods, allowing participants to respond at their leisure (Ipathia Inc., 2005a). The use of a mail survey may have also reduced measurement error, since participants often provide more honest, credible responses to mail surveys than to other types of surveys (American Statistical Association, 1997; Dillman, 1991, p.228).

The best available contact information for both Community Members and Committee Members was used at the time of mailing. The residents of the Region of Study who were randomly selected through the Institute for Social Research at York University were all mailed a copy of the survey. The addresses of the Committee members were obtained through internet searches. Business addresses for 6 out of the 23 members could not be identified, so surveys were mailed to them through the corresponding Conservation Authority.

Telephone Surveys and Other Follow-Up Methods

In an attempt to increase the response rate, those members of the public who did not return their completed mail survey and for whom the researcher did not receive a survey returned as 'undeliverable' were contacted via telephone. Telephone calls were made to every resident who fit these criteria, and all telephone interviews were conducted by the researcher, who had not undergone telephone interview training. This method of surveying was chosen because it allowed for quick contact with participants, and it also permitted the researcher to provide clarification to respondents who requested assistance with answering the questions (Ipathia Inc., 2005b). The use of a telephone survey also allowed the researcher to contact and survey individuals who otherwise may not have been able to respond to the mail survey, for example due to scheduling or timing issues, a language barrier, literacy issues or visual impairment (American Statistical Association, 1997; Ipathia Inc., 2005a). However, using two different data collection methods is problematic because this may have increased sample bias.

Each mailing address and phone number was assigned a four digit identification number between 1001 and 2300. The codes were printed onto the surveys, which allowed the researcher to only contact those residents who did not return the survey by mail and for whom a survey returned as 'undeliverable' was not received. The non-respondents were contacted in April and May of 2008. Respondents were defined as the first person who answered the phone over the age of 18. Individuals who were non-residents or visitors were discounted, and where applicable, the homeowner was contacted at a later date. All respondents were contacted between 10:00am and 5:30pm, Monday through Friday. If the resident could not be reached during the day, they were contacted between 7:00pm and 8:30pm on a weekday. Calls were not made between 5:30pm and 7:00pm to avoid contacting respondents during dinner time. Respondents were contacted no later than 8:30pm. Residents who did not answer the phone were called again at a later date, to a maximum of four times.

Community members were given the option to answer the survey over the phone or to be mailed a second copy of the survey. Responses taken over the phone were recorded onto a paper copy of the survey by the interviewer. Individuals who requested a second copy of the survey were assigned a new four digit identification number so that returned second copies of the survey could be differentiated from first copies that were returned late. These individuals were informed about the nature and location of an identifying mark that would help them to recognize the survey. The identifying mark chosen was the name of the researcher hand written in pen below the return address on the envelope containing the survey.

Members of the Committee who did not return their completed survey were also contacted via telephone. Each survey sent to Committee Members was also given a four digit identification number. Telephone contact took place throughout May, June and July of 2008. Telephone calls were made between 10:00am and 5:00pm Monday through Friday. Committee members who could not be reached during the day were contacted on weekdays between 8:00pm and 8:30pm. Committee members were given the option of completing the survey over the phone, or receiving a second survey by mail, email or fax.

4.5 Analysis

Survey Responses from the Study Community

The mail and telephone survey responses were manually entered into three MS Word tables which corresponded to the three questions. Individual risk agents and sources that were not rated due to the respondent either accidentally or purposefully neglecting to check any of the corresponding boxes were omitted from the data entry. Similarly, individual risk agents and sources for which the respondent checked more than one corresponding box, indicating more than one rating, were also omitted. In the event that a respondent neglected to answer an entire question, only that question was omitted from the data entry and subsequent analysis. The remaining questions were included in the analysis. This method resulted in different numbers of total responses for each risk agent and source in each question. Because of this, the data entered into the charts were converted from raw data into percentages. These converted tables were then used in the analysis. Comments included in the surveys were not entered with the survey responses, were secondary to the survey responses, and were taken into account during the quantitative portion of the analysis.

The survey data were analyzed both qualitatively and quantitatively. Analysis began with the generation of a series of bar graphs rating the risk agents and sources based on:

1. Perceived risk of risk agents
2. Self-expressed (i.e. not tested) familiarity with risk agents
3. Degree of perceived threat associated with land uses.

These graphs correspond with survey questions 1 through 3, respectively. Subsequently, graphs depicting the correlation between the risk perception data obtained from Question 1 and the familiarity data obtained from Question 2 were generated. Based on the literature, a linear model was used in an attempt to illustrate any relationship between the two variables (Blake, 1995, p.123). The risk and familiarity data were then used to create a two factor space inspired by Slovic et al.'s (1984, p.189) original version, but comprised only of risks to municipal drinking water. The coordinates on the two factor space were arrived at by independently averaging the risk and familiarity data, respectively, for each contaminant. For example, risk (x-) coordinates were calculated independently of the familiarity (y-) coordinates, and one risk coordinate was calculated for each contaminant. First, the "Almost No Risk" and "Slightly Risky" categories were added together, and the "Moderately Risky" and "Very Risky" categories were added together. This resulted in two dichotomous columns of responses: one high risk column and one low risk column. Then, one column was assigned a negative value, based on the orientation of Slovic et al.'s (1984, p.189) original two factor space (in this case, the low risk category was assigned a negative value because "Low Risk" is located at the negative end of the x-axis in Slovic et al.'s (1984, p.189) two factor space). Finally, the two risk values (one negative and one positive) were added together for each contaminant, to obtain one risk coordinate per contaminant. This method was also used to calculate one familiarity coordinate per contaminant. This resulted in one risk coordinate and one familiarity coordinate per contaminant, which were then plotted onto the two factor space. This two factor space was analyzed on its own, as well as in relation to Slovic et al.'s (1984, p.189) original factor space. Qualitative analysis based on these data as well as the respondents' comments was also conducted.

Survey Responses from the Committee

Techniques for analyzing the survey responses from the Committee were identical to the procedure for analyzing the Community's responses.

Comparison of the Study Community Responses and the Source Protection Committee Responses

In addition to the independent analysis of the Community responses and the Committee responses, the two were compared. This portion of the analysis was integrated into the analysis of the survey responses from the Committee in order to improve efficiency and enrich the analysis of the Committee data. Comparisons of the two groups' responses, as well as the comments made by each group, were analyzed both qualitatively and quantitatively.

The differences between proportions statistical test was used to determine whether the differences observed between the Committee and Community responses are statistically significant or whether these differences can be attributed to chance (Freund, 1973, p.317). Both p values and z-scores were calculated (see the equations just below). As discussed above, the Z^2 value, or z-score, is the "abscissa of the normal curve that cuts off an area at the tails", and is equal to 1.96 at a 95% confidence interval (Israel, 2008; Paoli, Haggard & Shah, 2002, p.2). That is, the z-score indicates the number of standard deviations a score is from the mean (Kognito, 2007, p.3) Thus, a z-score of 1.96 (i.e. 1.96 standard deviations from the mean) defines the 95% confidence interval (Paoli et al., 2002, p.2). The p value is "the estimated proportion of an attribute that is present in the population" (Israel, 2008).

The null hypothesis was that there is no difference between the Committee and Community responses (or $p_1 = p_2$, or proportion 1 = proportion 2). To test the null hypothesis, the p values and z-scores were calculated using the equations below, where x_1/n_1 and x_2/n_2 are two different proportions (in this case, one Committee response and one Community response; Freund, 1973, pp.318-319). More specifically, x_1 and x_2 are the number of observed "successes" (or in this case, responses in a given category of a survey question, for example "Very Risky") for each respective group, n_1 and n_2 are the sample sizes of each group and p_1 and p_2 are "the corresponding probabilities for success on an individual trial" (Freund, 1973, p.318).

$$p = \frac{x_1 + x_2}{n_1 + n_2}$$

$$z = \frac{\frac{x_1}{n_1} - \frac{x_2}{n_2}}{\sqrt{p(1-p)(\frac{1}{n_1} + \frac{1}{n_2})}}$$

If the z-score falls between -1.96 and 1.96, the null hypothesis, that there is no difference between the Committee and Community responses, cannot be rejected (Freund, 1973, p.320). That is, the null hypothesis is rejected for z-scores falling into the right-hand tail, the left-hand tail or both tails of the sampling distribution (Freund, 1973, p.319).

5. Limitations of this Study

Before the results of this research are presented, it is important to identify and examine the limitations of this study. It is also very important that the reader keep these limitations in mind throughout the remainder of this work. This section is comprised of three subsections, first discussing methodological limitations, before going on to address analytical limitations and finally limitations of the discussion.

Methods

This study's methodology is limited by a number of factors. First, there were a number of issues with the design and development of the survey. The two four point Likert scales (Questions 1 and 2) and one seven point scale (Question 3) used to create the survey questions were imprecise and could have affected the results of this study. Using only a four point scale for may not have given respondents enough choice and may have influenced them to respond in certain ways. On the other hand, using a seven point scale may have given respondents too many options which may have been difficult to differentiate between. These imprecise scales may have lead respondents to choose certain answers, artificially clustered the responses of all the participants, forced the participants to make arbitrary choices, and/or created artificial differences between the responses of the first two questions and the third question.

Furthermore, the respondents may have differentially understood the terms in the survey as a result of problems with its design. This may have occurred, for example, in Question 2 of the survey, in which "Unfamiliar" and "Don't Know" are both options. These two options could have been confused or viewed as interchangeable by some or all of the respondents. This may also have occurred with the wording of Question 2. Respondents may have interpreted the question as asking only about their familiarity with the substances, as opposed to asking about their familiarity with the substances in relation to drinking water (e.g. a question about familiarity with mud versus a question about familiarity with the fact that mud may be found in drinking water).

The issue of scale with respect to the contaminants chosen to comprise the survey is also important to consider. While all of the threats in the survey were taken from the Ministry of the Environment's Threats Inventory, some of the contaminants mentioned in the survey are small in scale in that they are single chemicals (e.g. chlorine and arsenic) and some are much larger in scale, such as chemicals that are waste output from entire industries (e.g. acids, auto plant wastewater and paint). The issue of scale is also relevant for the land uses included in the survey. While some of the land uses are small in scale (e.g. house with septic system), others are quite large (e.g. electronics manufacturing). There is also a difference in specificity with respect to the contaminants included in the survey. While some of the contaminants are very general (e.g. acids, microorganisms and solvents) other contaminants are very specific (e.g. Hepatitis A and fluoride). This difference in specificity resulted in the overlap of some of the contaminants (e.g. *E. coli* and microorganisms or metals and mercury). These differences in scale could have caused confusion among respondents and may have decreased response rate or affected the results of the survey.

The method used to pre-test the survey is also problematic. The survey was pretested on a group of students whose familiarity with science-based terminology and themes was assumed to approximate that of the general public. However, this group was not representative of the population chosen for this study. The survey should have been pre-tested on a sample of residents living in the Region of Study chosen for this research. Neglecting to do this may have diminished the effectiveness of the pre-test and ultimately the survey itself. Certain features of the survey which may have been problematic for the Study Community but not for the students may have been overlooked, thus reducing the effectiveness of the survey.

Second, there were issues with sampling. One problem was that the response rate was lower than expected, increasing the sampling error and weakening the statistical significance of the study's results. This was in part due to overestimating the response rate. Although a 30% response rate was assumed, the actual response rate was only 13.9%. Given that most populations are currently over-surveyed, a response rate of even 20% would have been optimistic. This study's response rate indicates serious problems with either the survey or the population sampled. The results of the study could have been strengthened by assuming a lower response rate and contacting more Region of Study residents.

Using two different question response methods, mail surveys and phone interviews, was also problematic and may have increased experimenter bias because one method was more passive and the other method was more intensive. The two groups should have been analyzed separately and subsequently compared to identify potential differences between them.

Another issue was the absence of demographic variables. The survey respondents were not asked about such demographic variables as age, gender or socioeconomic status. Most problematic was the absence of a gender analysis of respondents to ensure that there was equal representation from both genders and to identify any differences in the responses of each group, upon separate analysis of the data. Many of the telephone interviews took place during the day. Although the researcher did not notice any disproportional gender bias, there may be a predominance of female respondents. The survey respondents should have been asked about demographic variables, and knowledge of these variables would have improved the analysis and strengthened the results of the study.

Analysis

There are a number of factors that limit the analysis of this study's results. One of the major issues is that statistical significance should have been reported throughout the study, but, with the exception of the differences between proportions test, was not. Statistical analysis should have accompanied discussions about correlations, negative slopes, weak or strong associations and, where the differences between proportions test does not apply, differing proportions between the two samples studied. An important part of the reporting of statistical significance would have been the calculation and reporting of confidence limits in order to determine the degree to which the study's results deviate from a chance occurrence. Since statistical analysis was not conducted throughout this study, it is not known whether the reported correlations are statistically significant, whether the slopes that were generated differ significantly from zero, whether associations discussed really are weak or strong and, in some cases, whether the proportions discussed truly differ between the two groups. Since confidence limits were not calculated, the degree to which the results deviate from a chance occurrence is not known. The lack of statistical reporting throughout this study is a major limitation.

Another major issue relates to the way in which the data were analyzed. For ease of analysis, the most extreme responses were focused on, with the goal of highlighting the respondents with the most extreme perceptions (e.g. those respondents most likely to be concerned with a particular contaminant). However, this approach is extremely problematic because it results in most of the data being completely ignored. That is, while the survey responses fell into either 5 (Questions 1 and 2) or 8 (Question 3) categories, the discussion only focused on the extreme categories and ignored the others. This selective and inefficient use of the data severely limits the study's analysis.

It is also important to address the issue of causation. Throughout this study, familiarity is discussed in relation to its effect on perceived risk, and this report's analysis in particular focuses on this relationship. However, just as it can be asserted that greater familiarity can decrease the perceived risk among laypeople, it can also be argued that a lower perceived risk can increase familiarity among laypeople. In other words, just as it can be argued that familiarity has an effect on risk perception, it can also be asserted that risk perception can affect familiarity. For the purposes of this study, the focus will be on familiarity as it affects perceived risk. However, it is extremely important to keep in mind this issue of causation throughout the subsequent sections of this report.

One other key issue that may limit the analysis was the design of the survey. Part of the analysis focuses on the fact that respondents may have cognitively clustered most of the water contaminants they were asked about. The explanation that was initially given was that the respondents may be thinking about most of these contaminants in a similar way. However, it is more likely that this clustering effect results from the fact that the survey questions used to generate this study's two factor space required participants to respond by choosing one of only five categories. As a result, the observed cognitive grouping was likely due primarily, if not exclusively, to the extremely limited range of possible participant responses. Thus, the design of the survey may have obstructed and limited the analysis of this study's results.

Finally, the generation of the study's two factor space figures and their comparison with Slovic's (1984, p.189) original two factor space is extremely problematic because the methods used to generate each cognitive map are not the same and not comparable. That is, because different methods were used to generate each cognitive map, any comparison between the two cognitive maps, especially in the detail that they are discussed below, is not valid. However, although the two cognitive maps are not strictly comparable, this study's two factor space will be discussed in relation to Slovic et al.'s (1984, p.189) original version because Slovic et al.'s (1984, p.189) two factor space was the inspiration for this study's two factor space, which was developed to visually represent the data obtained from the surveys on the same axes that Slovic et al. (1984, p.189) used in their studies. Note that confidence limits were not obtained or compared for the two sets of results, which is also problematic.

Discussion

The discussion of the study's results also has a number of limitations. First, any associations made between the results of the study and behavioural outcomes are at best speculative. It is not possible to predict behavioural endpoints or draw conclusions about actual behaviour based on this study's survey results.

Second, a number of theoretical constructs were introduced in the Literature Review section of this study, along with statements linking these theoretical constructs to the study itself. However, in some cases, it is not possible to relate the results of this research back to these theoretical constructs because of the limited nature of the results of this study, as discussed just above. That is, while some links can be appropriately made between the results of this study and some of the theoretical constructs introduced early in this report, some of these constructs cannot be justifiably linked to any of the results. Thus, because of the limited nature of the results of this study, the Discussion section will be limited in terms of the connections that can be made to the literature.

Third, only three environmental issues in the Region of Study that received media attention were identified and discussed. There could have been a number of other events or issues, in the media or otherwise, that may also have affected the survey responses and the outcome of this study. Thus, while the discussion is limited to three main environmental issues, there are many other events that may have shaped or otherwise affected the participants' responses.

Finally, and perhaps most importantly, it is not clear how differences in the degrees of the perception of risk between the two groups translates into conclusions about how different the two groups would be in achieving the goals of the *Clean Water Act*. That is, it is difficult to determine whether the observed differences in the responses of each group translate into major differences in the perceptions of water risks and ultimately the implementation of the Act.

6. Results

Now that this study's methods and analysis have been discussed, the results of the study can be presented. This section begins with a discussion of the Community's results (Section 6.1). The Committee's results are then presented, and are contrasted with those of the Community using the differences between proportions statistical test (Section 6.2). This section concludes with a summary of the results (Section 6.3).

Throughout this discussion of the results of this research, it is very important to keep in mind that the findings that are discussed below are perceptions expressed by respondents of this study, and do not reflect actual, 'real' circumstances or events.

6.1 The Community

Question 1 of the survey asked respondents to rate a number of selected municipal drinking water contaminants according to their perceptions of the risk that these contaminants pose to drinking water. The Community's responses are shown in Table 2 and Figure 10. In general, the participants were

Table 2: The Community respondents' responses to Question 1 of the survey, which asked respondents to rate each contaminant according to riskiness. The numbers (left side of each column) and percentages (right side of each column) represent the total number and percentage of respondents surveyed who chose each risk rating.

Contaminant	Almost No Risk		Slightly Risky		Moderately Risky		Very Risky		Don't Know	
	(No.)	(%)	(No.)	(%)	(No.)	(%)	(No.)	(%)	(No.)	(%)
Chlorine	50	29.1	52	30.2	40	23.3	23	13.4	7	4.1
Metals	10	5.7	22	12.5	52	29.5	76	43.2	16	9.1
E. coli	0	0.0	3	1.7	5	2.8	163	92.6	5	2.8
Mercury	2	1.1	4	2.3	13	7.4	148	84.6	8	4.6
Sediment and Mud	24	13.7	47	26.9	60	34.3	31	17.7	13	7.4
Paint	4	2.3	10	5.7	28	15.9	127	72.2	7	4.0
Acids	5	2.9	14	8.1	36	20.9	106	61.6	11	6.4
Hepatitis A	3	1.7	2	1.1	12	6.8	145	82.4	14	8.0
Arsenic	4	2.3	4	2.3	12	6.8	151	85.3	6	3.4
Nitrates	8	4.5	25	14.2	46	26.1	64	36.4	33	18.8
Industrial Waste	3	1.7	5	2.8	12	6.8	151	85.3	6	3.4
Pesticides	3	1.7	3	1.7	16	9.1	148	84.6	5	2.9
Solvents	1	0.6	6	3.4	20	11.3	141	79.7	9	5.1
Microorganisms	13	7.5	29	15.6	44	25.4	61	35.3	26	15.0
Viruses	3	1.7	13	7.4	30	17.1	119	68.0	10	5.7
Oils	4	2.3	11	6.4	25	14.5	121	70.3	11	6.4
Auto Plant Wastewater	4	2.3	10	5.7	16	9.1	133	76.0	12	6.9
Lead	0	0.0	9	5.1	21	11.9	142	80.7	4	2.3
Fluoride	80	46.0	56	32.2	19	10.9	13	7.5	6	3.4
Fertilizers	4	2.3	20	11.5	42	24.1	101	58.0	7	4.0
Phosphates	7	4.0	27	15.4	47	26.9	60	34.3	34	19.4
PCBs	1	0.6	7	4.0	12	6.8	142	80.7	14	8.0

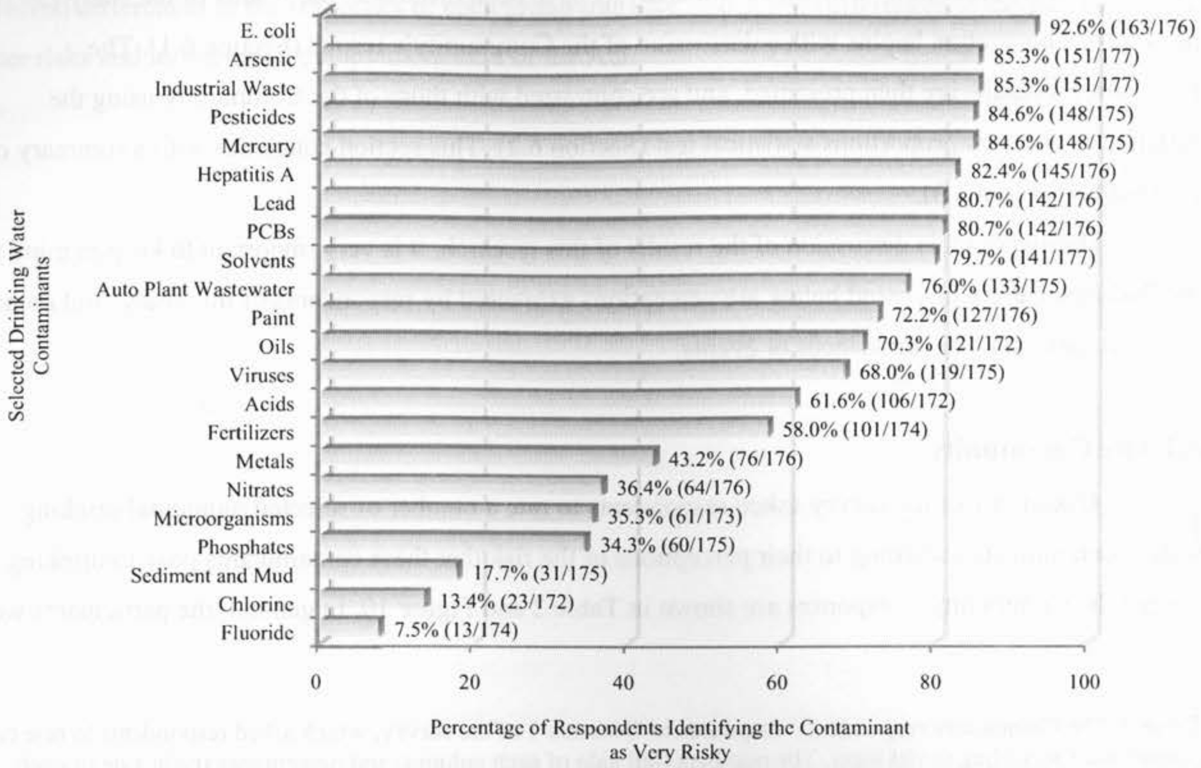


Figure 10: The degree of perceived risk attributed to selected drinking water contaminants by members of the Community who participated in this study

very risk averse. As shown in Table 2, for 19 out of the 22 contaminants (or over 86% of the contaminants), the category with the greatest percentage of responses (with a minimum of 34.3% and a maximum of 92.6% of participants choosing that category) was the "very risky" category. Furthermore, as Figure 10 demonstrates, out of a total of 22 contaminants listed, 15 of the contaminants (or 68% of the contaminants) were identified as being very risky by over 50% of the participants surveyed. That is, most of the Community participants judged most of the contaminants to be very risky to drinking water.

This finding that the Community members appear to be highly risk averse was anticipated, and is supported by the literature. According to Fischhoff et al. (1978, p.148) and Slovic (1987), members of the public typically believe that current levels of risk are intolerably high.

The three contaminants that the participants identified as posing the greatest risk to water were *E. coli*, arsenic and industrial waste. However, the participants believed *E. coli* to be considerably more risky than all of the other contaminants. A total of 92.6% of respondents identified *E. coli* as being very risky, but only 85.3% of respondents identified arsenic, the next most risky contaminant, as being very risky. This finding that the Community considered *E. coli* to be the most risky water contaminant was expected. The May 2000 Walkerton Tragedy, which involved *E. coli* contamination of drinking water in Ontario, was highly publicized and likely remains prominent in the public consciousness. Similarly, lead, which was a recent contaminant of concern in the Community, was rated as the seventh most risky contaminant, with 80.7% of participants identifying it as very risky. However, it is important to note that there are likely many other factors, in addition to those mentioned here, that may have influenced Community responses.

The three contaminants that the participants identified as posing the least risk to water were fluoride, chlorine and sediment and mud. Fluoride was considered to be the least risky contaminant, with only 7.5% of participants identifying it as very risky. A total of 13.4% of participants identified chlorine as very risky and 17.7% of respondents identified sediment and mud as very risky.

In general, very few respondents reported that they did not know how risky they thought the contaminants were. However, three contaminants – phosphates, nitrates and microorganisms – might possibly have been more problematic for the participants to rate. Nearly twenty per cent of participants indicated that they were unable to rate phosphates according to their perception of its riskiness. Similarly, 18.8% of participants were unable to rate nitrates, and 15% were unable to rate microorganisms according to their perception of the riskiness of these contaminants. This may be due to the fact that many of the participants were not sufficiently familiar with the contaminants to be able to rate them. As indicated by some of the Community's comments (see Appendix D), this may also result from some of the participants feeling that some contaminants are too general to be accurately rated, for example in the case of the contaminant "microorganisms". However Slovic noted that increasing the specificity of a set of hazards does not appear to have a significant effect on the structure of the factor space or the relationship between the factor space and risk perceptions (Slovic, 1987, p.283; Slovic et al., 1984, p.188-189). Therefore, the generality or specificity of a given contaminant or the term used to describe a given class of contaminants is not expected to appreciably affect respondents' risk perceptions.

Question 2 of the survey asked respondents to identify their familiarity with the selected municipal drinking water contaminants. In this study, the familiarity responses are stated beliefs and no evidence is presented regarding the actual familiarity of any of the respondents. Thus, this discussion is of the respondents' self-expressed familiarity, and not their actual, tested familiarity. Furthermore, it must be noted that the self-identified familiarity ratings of the Community may be inflated, as the literature indicates that all individuals tend to be overconfident in their judgments (Slovic et al., 1977, p.6).

The Community's responses are shown in Table 3 and Figure 11. The participants were generally reluctant to identify themselves as being very familiar with the contaminants. However, for most of the

Table 3: The Community respondents' responses to Question 2 of the survey, which asked respondents to rate each contaminant according to their self-identified familiarity with it. The numbers (left side of each column) and percentages (right side of each column) represent the total number and percentage of respondents surveyed who chose each familiarity rating.

Contaminant	Unfamiliar (No.)	Unfamiliar (%)	Not Very Familiar (No.)	Not Very Familiar (%)	Familiar (No.)	Familiar (%)	Very Familiar (No.)	Very Familiar (%)	Don't Know (No.)	Don't Know (%)
Chlorine	5	2.9	20	11.5	78	44.8	69	39.7	2	1.1
Metals	24	13.7	41	23.4	66	37.7	38	21.7	6	3.4
E. coli	23	13.2	18	10.3	60	34.5	70	40.2	3	1.7
Mercury	26	14.9	31	17.8	60	34.5	56	32.2	1	0.6
Sediment and Mud	23	13.1	37	21.1	71	40.6	40	22.9	4	2.3
Paint	34	19.3	44	25.0	51	29.0	45	25.6	2	1.1
Acids	35	20.2	48	27.7	56	32.4	30	17.3	4	2.3
Hepatitis A	44	25.3	42	24.1	47	27.0	38	21.8	3	1.7
Arsenic	37	21.3	46	26.4	48	27.6	39	22.4	4	2.3
Nitrates	30	17.3	53	30.6	52	30.1	27	15.6	11	6.4
Industrial Waste	24	13.7	53	30.3	60	34.3	30	17.1	8	4.6
Pesticides	24	13.9	35	20.2	69	39.9	43	24.9	2	1.2
Solvents	35	20.1	45	25.9	55	31.6	38	21.8	1	0.6
Microorganisms	28	16.3	45	26.2	55	32.0	38	22.1	6	3.5
Viruses	33	19.4	50	29.4	50	29.4	31	18.2	6	3.5
Oils	34	19.3	48	27.8	52	29.5	41	23.3	1	0.6
Auto Plant Wastewater	46	26.1	70	39.8	33	18.8	19	10.8	8	4.5
Lead	18	10.2	25	14.2	66	37.5	66	37.5	1	0.6
Fluoride	9	5.1	17	9.7	86	48.9	63	35.8	1	0.6
Fertilizers	28	15.9	31	17.6	65	36.9	51	29.0	1	0.6
Phosphates	35	20.2	55	31.8	59	34.1	16	9.2	8	4.6
PCBs	34	19.2	44	24.9	51	28.8	41	23.2	7	4.0

contaminants (17 out of 22 contaminants, or over 77% of the contaminants), the category with the greatest percentage of responses was the "familiar" category (with a minimum of 27% and a maximum of 44.8% of participants choosing the "familiar" category), indicating that a large percentage of the respondents consider the contaminants to be familiar to them. This trend can be seen in Table 3. Interestingly, *E. coli* is the only contaminant where the greatest percentage of responses is found in the "very familiar" category. Similarly, the greatest percentage of responses for lead is split between the "familiar" and "very familiar" categories.

As shown in Figure 11, the three contaminants that respondents identified as being most familiar to them were *E. coli*, chlorine and lead. A total of 40.2% of participants identified themselves as being very familiar with *E. coli*. Chlorine and lead were just slightly less familiar to respondents, with 39.7% of respondents identifying chlorine as very familiar and 37.5% of respondents identifying lead as very familiar. The Community's stated familiarity with *E. coli* and lead is not surprising, given the publicity that these contaminants have received across the province and in the Region of Study, respectively. However, there are likely many other factors that may have influenced Community responses.

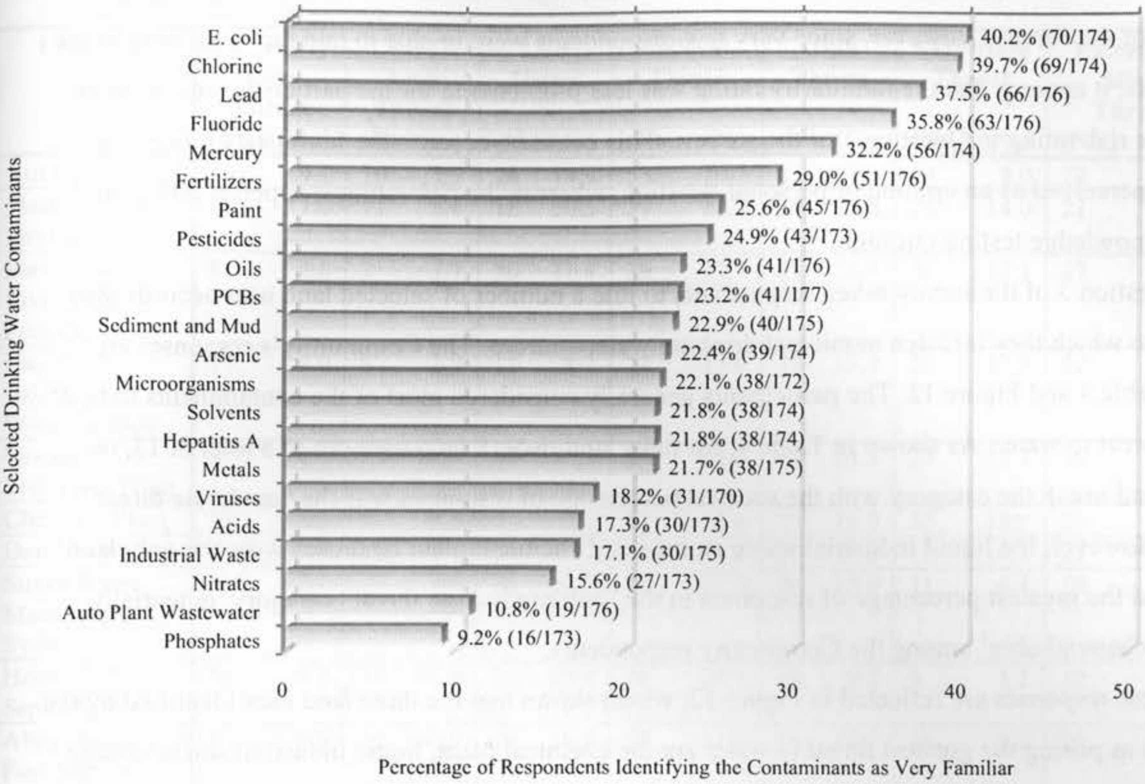


Figure 11: The degree of self-identified familiarity that Community respondents have with selected drinking water contaminants

Phosphates, auto plant wastewater and nitrates were identified by respondents as being the least familiar contaminants. Phosphates were the least familiar contaminant, with only 9.2% of participants identifying it as very familiar. Auto plant wastewater was identified as very familiar by only 10.8% of participants, and nitrates were identified as very familiar by 15.6% of participants. The Community's self declared lack of familiarity with phosphates and nitrates may explain the respondents' difficulty with assessing the riskiness of these contaminants in Question 1 of the survey.

It is interesting to take note of the plateau in the middle of Figure 11. Contaminants judged by respondents to be moderately familiar were not considered to differ drastically in their familiarity to the respondents. That is, the contaminants that were identified as being moderately familiar have familiarity ratings that differ from each other by a maximum of only a few percentage points.

In general, very few respondents reported that they did not know how familiar the contaminants were to them. The contaminant that may have been the most problematic for the participants to rate was nitrates, with 6.4% of participants indicating that they did not know how familiar nitrates were to them. This difficulty with assessing the familiarity of nitrates is not surprising, given the participants' relatively high level of self declared unfamiliarity with this contaminant and similar issues with risk ratings in Question 1 of the survey. However, since very few respondents were unable to rate the familiarity of the contaminants, it appears that the familiarity rating was less problematic for the participants to complete than was the risk rating in Question 1 of the survey. This could be because the familiarity rating was more often perceived as an opinion or personal question, whereas the risk rating was perceived as an objective, knowledge testing question.[14]

Question 3 of the survey asked respondents to rate a number of selected land uses according to the degree to which they threaten municipal drinking water sources. The Community's responses are shown in Table 4 and Figure 12. The participants generally considered most of the contaminants to be a moderate threat to water. As shown in Table 4, for most land uses (8 land uses out of a total of 13, or 61.5% of land uses), the category with the greatest percentage of responses was the "moderate threat" category. However, the liquid industrial waste storage and chemical plant land uses were the only land uses that had the greatest percentage of responses in the "extremely high threat" category, potentially indicating 'chemophobia' among the Community respondents.

These responses are reflected in Figure 12, which shows that the three land uses identified by the respondents as posing the greatest threat to water are the chemical plant, liquid industrial waste storage and landfill land uses. The chemical plant and liquid industrial waste storage land uses were considered by respondents to be much more threatening to water than any of the other land uses. Approximately half of the respondents, specifically 50.9% of the respondents, identified a chemical plant as posing a very high threat or an extremely high threat to water. A total of 48% of respondents identified liquid industrial waste storage as posing a very high threat or an extremely high threat to water and only 33.3% of respondents identified a landfill as posing a very high or an extremely high threat to water.

It is not surprising that the top two land uses identified by the Community as posing the greatest threat to water are chemical risk sources. As discussed in Subsection 3.3.1, it was anticipated that the public would demonstrate 'chemophobia' responses by being more averse to chemical risks than to biological risks or other types of risks (Raats & Shepherd, 1996, p.133). It is also not surprising that the next most threatening land use identified is the landfill. As mentioned above, a large scale municipal solid waste landfill located near the Region of Study was recently granted approval to expand and accept wastes on a regional scale (Martin, 2006). There has been considerable media coverage and opposition in

[14] Although the researcher attempted to avoid this differential interpretation of the survey questions through careful wording of the questions, it is believed that the familiarity rating was intrinsically easier for respondents to understand and complete than was the risk rating.

Table 4: The Community respondents' responses to Question 3 of the survey, which asked respondents to rate each land use according to the degree to which it threatens drinking water. The numbers (left side of each column) and percentages (right side of each column) represent the total number and percentage of respondents surveyed who chose each threat rating.

Land Use	Extremely Low Threat (No.)	(%)	Very Low Threat (No.)	(%)	Low Threat (No.)	(%)	Moderate Threat (No.)	(%)	High Threat (No.)	(%)	Very High Threat (No.)	(%)	Extremely High Threat (No.)	(%)	Don't Know (No.)	(%)
Auto Plant	16	9.1	10	5.7	26	14.9	53	30.3	23	13.1	14	8.0	22	12.6	11	6.3
Plastics Production	12	7.0	11	6.4	18	10.5	39	22.7	34	19.8	24	14.0	21	12.2	13	7.6
Farm with Livestock Feedlot	8	4.6	3	1.7	20	11.4	38	21.7	41	23.4	30	17.1	27	15.4	8	4.6
Liquid Industrial Waste Storage	7	4.0	5	2.9	15	8.7	24	13.9	31	17.9	31	17.9	52	30.1	8	4.6
Sewage Treatment Plant	8	4.6	18	10.4	30	17.3	38	22.0	23	13.3	21	12.1	26	15.0	9	5.2
Chemical Plant	11	6.3	6	3.4	8	4.6	22	12.6	28	16.0	33	18.9	56	32.0	11	6.3
Dairy Farm	11	6.3	16	9.1	28	15.9	46	26.1	27	15.3	18	10.2	22	12.5	8	4.5
Storm Water Management System	5	2.9	27	15.6	42	24.3	38	22.0	26	15.0	11	6.4	16	9.2	8	4.6
House with Septic System	16	9.2	31	17.8	35	20.1	43	24.7	16	9.2	9	5.2	12	6.9	12	6.9
Above Ground Fuel Storage Facility	11	6.3	19	10.9	29	16.7	38	21.8	20	11.5	16	9.2	26	14.9	15	8.6
Landfill	8	4.7	8	4.7	15	8.8	44	25.7	34	19.9	24	14.0	33	19.3	5	2.9
Grain Farm	26	15.0	30	17.3	38	22.0	35	20.2	18	10.4	7	4.0	5	2.9	14	8.1
Electronics Manufacturing	21	12.1	17	9.8	34	19.7	34	19.7	15	8.7	17	9.8	16	9.2	19	11.0

the Region of Study regarding this issue. However, there are likely many other factors, in addition to those mentioned here, that may have influenced Community responses.

The grain farm, house with septic system and storm water management system land uses were identified by respondents as posing the least threat to drinking water sources. Only 6.9% of respondents identified the grain farm as posing a very high threat or an extremely high threat to water. A total of 12.1% of respondents identified the house with septic system land use as posing a very high or an extremely high threat to water, and 15.6% of respondents identified the storm water management system land use as posing a very high or an extremely high threat to water.

In general, relatively few respondents indicated that they did not know how to rate the land uses. Although these percentages were generally higher than the familiarity rating, they were generally lower than the risk rating. This may indicate that Question 3 of the survey was potentially less problematic for the respondents to answer than Question 1, but potentially more problematic for the respondents to

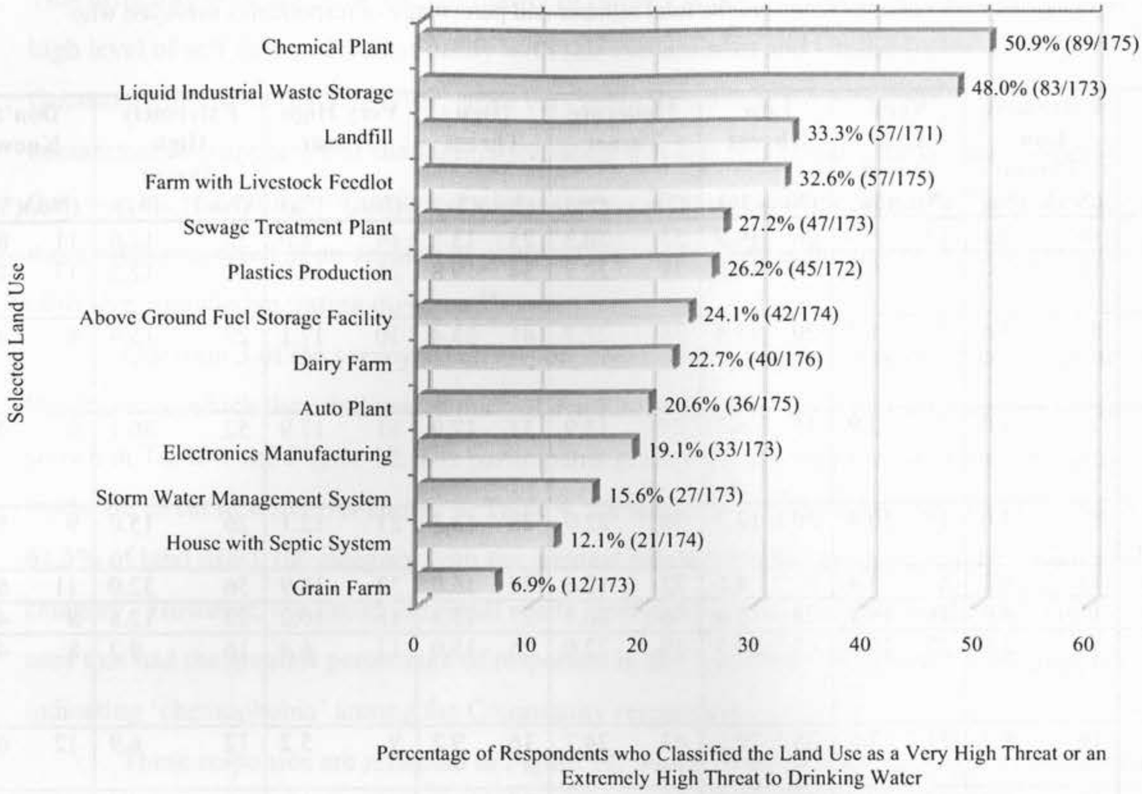


Figure 12: The degree of threat to drinking water sources attributed to selected land uses by members of the Community who participated in this study

answer than Question 2. The most problematic land uses for participants to rate were the electronics manufactuing, above ground fuel storage facility and grain farm land uses. A total of 11% of the respondents were unable to rate the electronics manufacturing land use, compared with 8.6% of respondents who were unable to rate the above ground fuel storage land use and 8.1% of respondents who were unable to rate the grain farm land use.

In attempt to identify a relationship between familiarity and risk perception, the two variables were plotted against each other (see Figure 13). Based on the literature, an inverse relationship between familiarity and risk perception was expected. It has been established by Slovic and others that the general public's perception of risk is based almost entirely on outrage factors (Slovic et al., 1984, p.193; Sly, 2000, p.154). Familiarity has been established as an outrage factor that can increase or decrease the public's perception of riskiness (Blake, 1995, p.123). Whereas familiarity has been shown to decrease the perceived risk among members of the public, lack of familiarity or unfamiliarity has been shown to

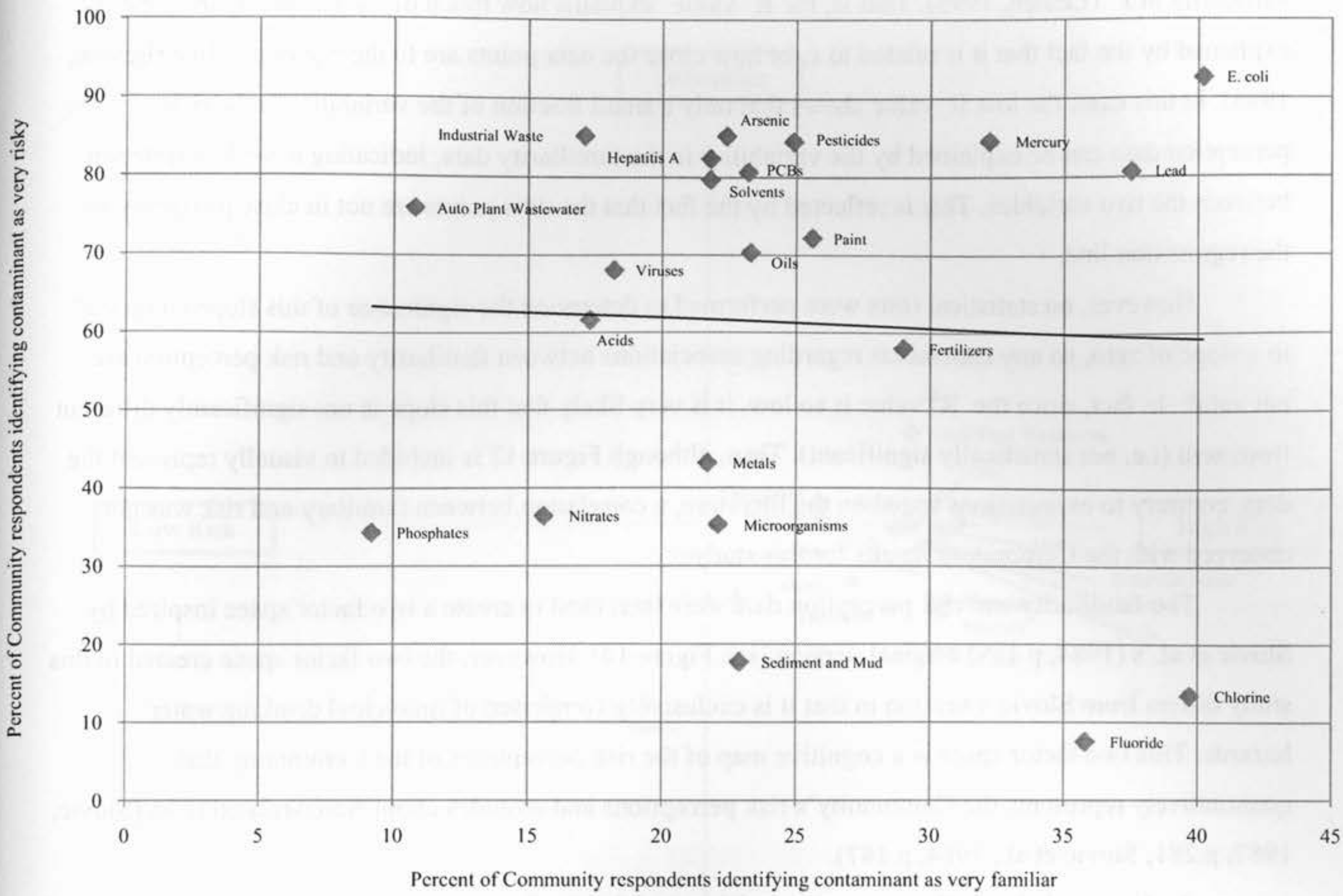


Figure 13: The relationship between the Community respondents' risk perception of selected drinking water contaminants and their self-expressed familiarity with these contaminants.

increase the perceived risk (Blake, 1995, p.123). However, it is extremely important to address the issue of causation at this point in the discussion. Just as it can be asserted that greater familiarity can decrease the perceived risk among laypeople, it can also be argued that a lower perceived risk can increase familiarity among laypeople. Although this study focuses to a greater extent on the effect of familiarity on perceived risk, it is very important to keep in mind this issue of causation throughout the subsequent sections of this report.

A linear model has been used in an attempt to illustrate any relationship between the two variables. The linear model was chosen because the literature suggests a negative linear correlation (Blake, 1995, p.123). The slope (b) of the regression line (or the "line of best fit", used to demonstrate the trend between two data sets more clearly) in Figure 13 is -0.1333 and the square of the correlation coefficient (R^2 value) is 0.0019 (Reed, 2003). Since the R^2 value is quite low, any existing correlation would be weak. The R^2 value is a statistic that is commonly used to determine the goodness-of-fit of the regression (Lethen, 1996). "R^2 represents the fraction of variability in y that can be explained by the variability in x" (Lethen, 1996). That is, the R^2 value "explains how much of the variability in" y can be explained by the fact that it is related to x, or how close the data points are to the regression line (Lethen, 1996). In this case, the low R^2 value shows that only a small fraction of the variability in the risk perception data can be explained by the variability in the familiarity data, indicating a weak correlation between the two variables. This is reflected by the fact that the data points are not in close proximity to the regresssion line.

However, no statistical tests were performed to determine the signicance of this slope compared to a slope of zero, so any statements regarding associations between familiarity and risk percepiton are not valid. In fact, since the R^2 value is so low, it is very likely that this slope is not significantly different from zero (i.e. not statistically significant). Thus, although Figure 13 is included to visually represent the data, contrary to expectations based on the literature, a correlation between familiary and risk was not observed with the Community results for this study.

The familiarity and risk perception data were then used to create a two factor space inspired by Slovic et al.'s (1984, p.189) original version (see Figure 14). However, the two factor space created in this study differs from Slovic's version in that it is exclusively comprised of municipal drinking water hazards. This two factor space is a cognitive map of the risk perceptions of the Community that quantitatively represents the Community's risk perceptions and attitudes about water-related risks (Slovic, 1987, p.281; Slovic et al., 1984, p.187).

As discussed above, the comparison of this study's two factor space with Slovic et al.'s (1984, p.189) original version is problematic because the methods used to generate each cognitive map are not the same and not comparable. However, although the two cognitive maps are not strictly comparable, this study's two factor space will be discussed in relation to Slovic et al.'s (1984, p.189) original version because Slovic et al.'s (1984, p.189) two factor space was the inspiration for this study's two factor space, which was developed to visually represent the data obtained from the surveys on the same axes that Slovic et al. (1984, p.189) used in their studies. Thus, while the two factor space presented below was inspired by Slovic et al.'s (1984, p.189) original version, is in no way methologically related to Slovic et al.'s (1984, p.189) two factor space, and was created for illustration purposes only.

The horizontal "dread risk" factor is the most important factor of the two factor space (Slovic, 1987, p.283; Slovic et al., 1984, p.189). With the exception of fluoride and chlorine, all of the water contaminants are located at the "High Risk" end of the factor space's horizontal axis. This indicates that the Community may perceive most water contaminants to be a high risk to their water and, by extension, to themselves. The Community may consider fluoride and chlorine to be less risky water contaminants.

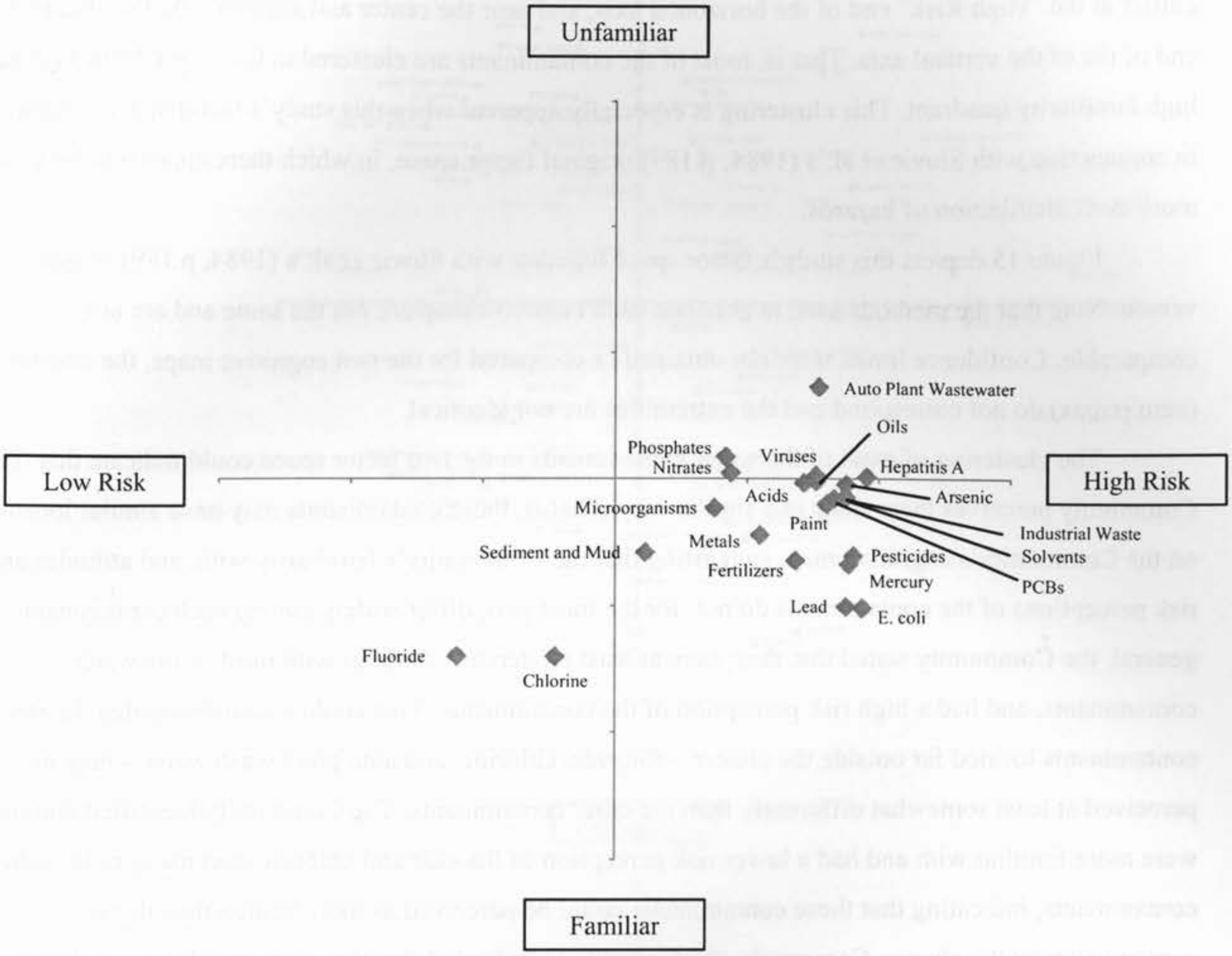


Figure 14: A two factor space comprised only of risks to municipal drinking water, constructed with Community respondents' responses

Many of the water contaminants are located near the middle of the factor space's vertical "Familiarity" axis, with some of the contaminants approaching the "Familiar" end of the axis. Auto plant wastewater is located closest to the "Unfamiliar" end of the vertical axis, and chlorine and fluoride are located closest to the "Familiar" end of the vertical axis. Although lead and *E. coli* were not located at the extreme "Familiar" end of the vertical axis, they were the next most familiar risks after chlorine and fluoride. Thus, in general, the Community indicated that they were moderately to somewhat familiar (as opposed to very or extremely familiar) with most water-related risks, based on their self-expressed familiarity ratings. The self-expressed familiarity data indicated that the Community may have felt considerably less familiar with auto plant wastewater, considerably more familiar with chlorine and fluorine and slightly more familiar with *E. coli* and lead.

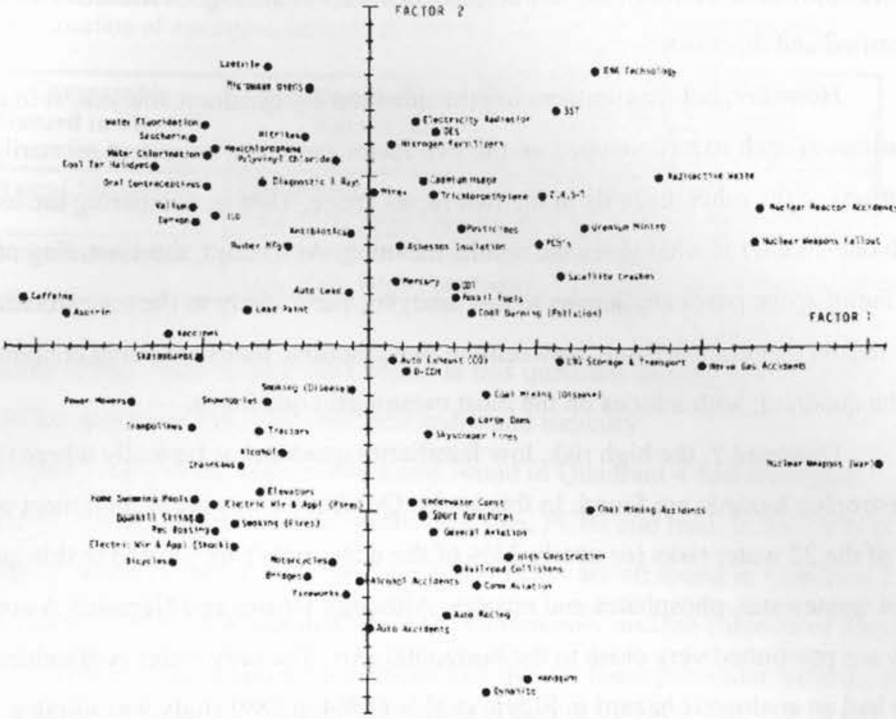
The overall location of the water contaminants in the two factor space can be described as a cluster at the "High Risk" end of the horizontal axis, and near the center and approaching the "Familiar" end of the of the vertical axis. That is, most of the contaminants are clustered in Quadrant 4: the high risk, high familiarity quadrant. This clustering is especially apparent when this study's factor space is viewed in conjunction with Slovic et al.'s (1984, p.189) original factor space, in which there appears to be a much more even distribution of hazards.

Figure 15 depicts this study's factor space together with Slovic et al.'s (1984, p.189) original verson. Note that the methods used to generate each cognitive map are not the same and are not comparable. Confidence limits were not obtained or compared for the two cognitive maps, the origins (zero points) do not correspond and the extremities are not identical.

The clustering of most of the water contaminants in the two factor space could indicate that the Community perceives these risks in a similar way. That is, these contaminants may have similar locations on the Community's cognitive map, suggesting that the Community's familiarity with, and attitudes and risk perceptions of the contaminants do not, for the most part, differ widely among each contaminant. In general, the Community stated that they were at least moderately familiar with most of the water contaminants, and had a high risk perception of the contaminants. This could also indicate that the three contaminants located far outside the cluster – fluoride, chlorine, and auto plant wastewater – may be perceived at least somewhat differently than the other contaminants. The Community identified that they were more familiar with and had a lower risk perception of fluoride and chlorine than many of the other contaminants, indicating that these contaminants could be perceived as more benign than those contaminants in the cluster. Conversely, the Community indicated that they were much less familiar with auto plant wastewater than they were with the contaminants in the cluster, suggesting that auto plant wastewater may be perceived as more harmful or risky than the contaminants in the cluster. In comparing these contaminants, it is important to consider the issue of scale. Fluoride and chlorine are single chemicals and are smaller in scale, while auto plant wastewater consists of the waste output from an entire industry, and is larger in scale. The differences in scale between contaminants is important to consider when such contaminants are discussed and compared.

However, the observed clustering effect may not be caused by trends in the Community's perception, but could instead be attributable to characteristics of the survey itself. The survey questions used to generate this study's two factor space required participants to respond by choosing one of only five categories. Thus, the observed grouping of contaminants was likely due primarily, if not exclusively, to the extremely limited range of possible participant responses.

For the remainder of this subsection, the water risk factor space generated in this study will be discussed in relation to Slovic et al.'s (1984, p.189) original version on a quadrant-by-quadrant basis.



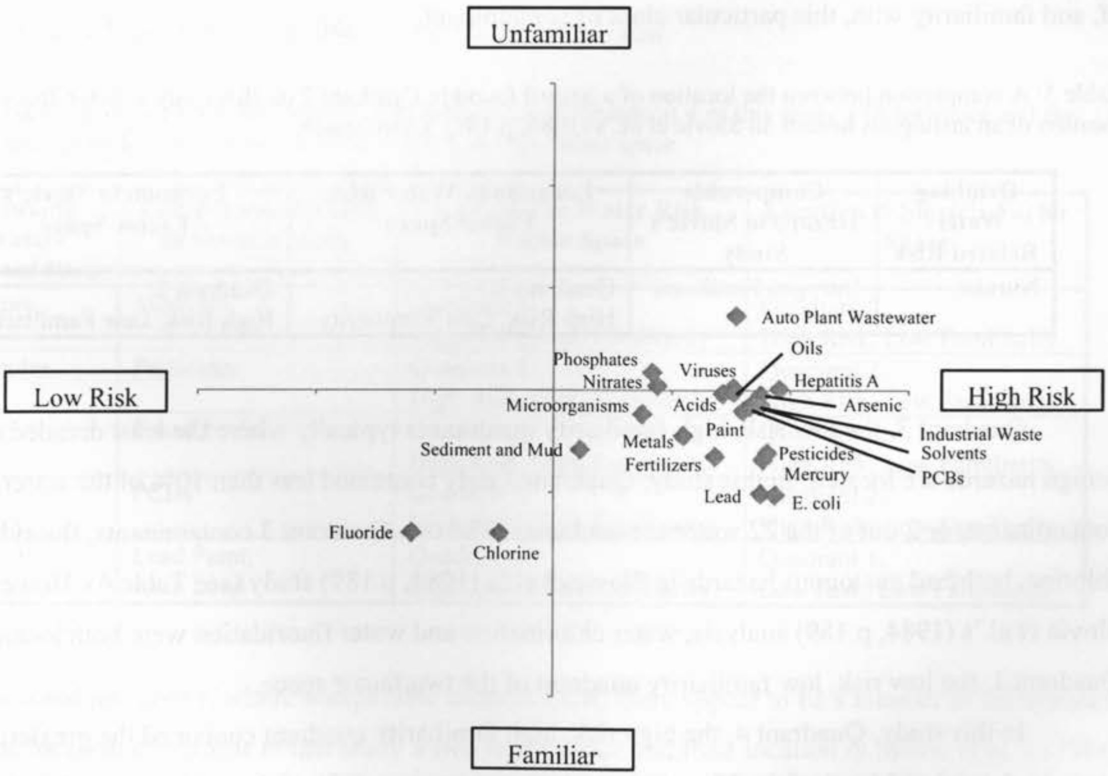


Figure 15: Slovic et al.'s (1984, p.189) original two factor space together with the two factor space comprised of municipal drinking water risks that was generated in this study with Community respondents' responses

Where applicable, similarities between the locations of analogous hazards on each factor space will be identified and discussed.

However, before commencing the quadrant-by-quadrant analysis, it must be noted that the locations of each hazard mapped on the two factor space are important primarily in relation to the positions of the other hazards in the two factor space. That is, comparing the locations of each hazard with one another is what gives the results meaning. As a result, the clustering of the water contaminants in the factor space poses challenges to this analysis, particularly to the interpretation of these data. It is for this reason that comparisions between the two cognitive maps are being conducted principally at the level of the quadrant, with a focus on the most meaningful quadrants.

Quadrant 2, the high risk, low familiarity quadrant, is typically where the most dreaded and catastrophic hazards are found. In this study, Quadrant 2 was the second most populated quadrant. Five out of the 22 water risks (or nearly 23% of the water risks) are located in this quadrant, including auto plant wastewater, phosphates and nitrates. Although viruses and Hepatitis A are located in this quadrant, they are positioned very close to the horizontal axis. The only water contaminant found in this quadrant that had an analogous hazard in Slovic et al.'s (1984, p.189) study was nitrates (see Table 5). In Slovic et al.'s (1984, p.189) study, nitrogen fertilizers were also located in Quadrant 2. This indicates that the Community surveyed in this study and Slovic's study participants may have had similar risk perceptions of, and familiarity with, this particular class of contaminant.

Table 5: A comparison between the location of a hazard found in Quadrant 2 of this study's factor space and the location of an analogous hazard in Slovic et al.'s (1984, p.189) factor space.

Drinking Water-Related Risk	Comperable Hazard in Slovic's Study	Location in Water Risk Factor Space	Location in Slovic's Factor Space
Nitrates	Nitrogen Fertilizers	Quadrant 2: High Risk, Low Familiarity	Quadrant 2: High Risk, Low Familiarity

Quadrant 3, the low risk, high familiarity quadrant is typically where the least dreaded and most benign hazards are located. In this study, Quadrant 3 only contained less than 10% of the water contaminants, or 2 out of the 22 water contaminants. The two Quadrant 3 contaminants, fluoride and chlorine, both had analogous hazards in Slovic et al.'s (1984, p.189) study (see Table 6). However, in Slovic et al.'s (1984, p.189) analysis, water chlorination and water fluoridation were both located in Quadrant 1, the low risk, low familiarity quadrant of the two factor space.

In this study, Quadrant 4, the high risk, high familiarity quadrant contained the greatest number of hazards. A total of 15 out of the 22 water contaminants, or over 68% of the water contaminants, are

Table 6: A comparison between the location of hazards found in Quadrant 3 of this study's Source Protection Committee factor space and the location of analogous hazards in Slovic et al.'s (1984, p.189) factor space.

Drinking Water-Related Risk	Comperable Hazard in Slovic's Study	Location in Water Risk Factor Space	Location in Slovic's Factor Space
Chlorine	Water Chlorination	Quadrant 3: Low Risk, High Familiarity	Quadrant 1: Low Risk, Low Familiarity
Fluoride	Water Fluoridation	Quadrant 3: Low Risk, High Familiarity	Quadrant 1: Low Risk, Low Familiarity

located in this quadrant. Some of the water-related risks found in this quadrant include *E. coli*, lead, arsenic, industrial waste, PCBs, sediment and mud, oils, pesticides and mercury.

As can be seen in Table 7, five of the water contamints found in Quadrant 4 had analogous hazards in Slovic et al.'s (1984, p.189) study: mercury, pesticides, oils, PCBs and lead. In Slovic et al.'s (1984, p.189) two factor space, mercury, pesticides, fossil fuels and PCBs are all found in Quadrant 2, the high risk, low familiarilty quadrant. This indicates that while the Community and the subjects of Slovic et al.'s (1984, p.189) study may generally have similar perceptions of risk for these particular hazards, the Community stated that they were generally more familiar with these hazards. In Slovic et al.'s (1984, p.189) study, lead paint was found in Quadrant 1, the low risk, low familiarity quadrant. Thus, the residents of the Community identified themselves as more familiar with lead and judged lead to be a higher risk than did Slovic et al.'s (1984, p.189) study participants.

Table 7: A comparison between the location of hazards found in Quadrant 4 of this study's factor space and the location of analogous hazards in Slovic et al.'s (1984, p.189) factor space.

Drinking Water-Related Risk	Comperable Hazard in Slovic's Study	Location in Water Risk Factor Space	Location in Slovic's Factor Space
Mercury	Mercury	Quadrant 4: High Risk, High Familiarity	Quadrant 2: High Risk, Low Familiarity
Pesticides	Pesticides	Quadrant 4: High Risk, High Familiarity	Quadrant 2: High Risk, Low Familiarity
Oils	Fossil Fuels	Quadrant 4: High Risk, High Familiarity	Quadrant 2: High Risk, Low Familiarity
PCBs	PCBs	Quadrant 4: High Risk, High Familiarity	Quadrant 2: High Risk, Low Familiarity
Lead	Lead Paint; Auto Lead	Quadrant 4: High Risk, High Familiarity	Quadrant 1: Low Risk, Low Familiarity

As noted just above, where comparable hazards exist, there appear to be a number of differences between the location of hazards in this study's two factor space and their location in Slovic et al.'s (1984, p.189) two factor space. However, the main source of these locational discrepancies appears to be a difference in familiarity with the hazards between the Community and Slovic's participants. In general, the Community and the participants of Slovic et al.'s (1984, p.189) study may have had similar perceptions of risk for the analogous hazards, but the Community indicated that they were more familiar with these hazards, based on self-expressed familiarity ratings. In 6 out of the 7 cases (or 85.7% of cases) where the locations of analogous hazards differed, the Community and Slovic et al.'s (1984, p.189) particpants had similar risk perceptions (i.e. both groups chose either "High Risk" or "Low Risk"). However, in every case where the locations of analgous hazards differed, the two groups had differing familiarity levels, with the Community stating that they were familiar with the hazards, and Slovic's respondents being unfamiliar with the hazards.

The one hazard of which the risk perception differed between the Community and Slovic et al.'s (1984, p.189) participants was lead. This outcome is not surprising, given the Region of Study's recent issues surrounding lead contaminated tap water and the associated media coverage.

Additional Comments from Community Respondents

This subsection will briefly review both the written comments appended to surveys retruned by Community participants and verbal comments made by Community respondents during telephone interviews. Only a selection of the most common and relevant comments will be included in this discussion. However, a list of all the comments that were made can be found in Appendix D.

A total of 36 out of the 120 returned mail surveys (or 30% of the returned mail surveys) included written comments, and a total of 27 out of the 60 respondents who participated in a telephone interview (or 45% of respondents who completed telephone interviews) provided additional verbal comments that were summarized and transcribed by the researcher.

A relatively large number of comments pertained to the source or type of drinking water used within a household, as well as the characteristics of that water. Two mail survey respondents indicated that they choose to drink tap water, and one mail survey respondent and one telephone respondent stated that they do not drink tap water. One mail survey respondent commented that their household only uses bottled water. One mail survey respondent and two telephone respondents stated that they use water filters at home. One mail respondent expressed concern about "cloudy" drinking water, and two telephone respondents expressed concern about off-tasting tap water.

A number of comments related to general concerns about human environmental impacts and associated threats to the sustainability and quality of water resources. A total of three mail survey respondents and two telephone interviewees expressed such concerns.

Many of the comments also pertained to a number of the contaminants and land uses included in the survey. Lead appears to have caused the most concern, with three mail respondents and one telephone interviewee commenting on the contaminant. Additionally, three telephone respondents expressed concern about PCBs, one mail respondent expressed concern about *E. coli*, one telephone respondent was concerned about phosphates and one telephone respondent was concerned about chlorine. Additionally, a number of respondents expressed concerns about farms, with three mail respondents and two telephone interviewees commenting on them.

6.2 The Committee

This subsection will present and discuss the Committee's survey results, and will also compare the Committee's results with the Community's results. The differences between proportions statistical test will be used to determine whether the differences observed between the Committee and Community responses are statistically significant, or whether these differences can be attributed to chance (Freund, 1973, p.317). Although only the most relevant and important statistical results will be reported in this subsection, Appendix E contains all of the statistical results, as well as a brief description of the differences between proportions statistical test.

Throughout this discussion, it is important to keep in mind that the sample sizes of the two groups being compared are very different. While 180 Community members participated in this research, only 16 Committee members participated. Thus, although 90 out of 180 Community members and 8 out of 16 Committee members are frequencies that are both equal to 50% of each respective group, it is possible that each of these frequencies is representatively different. It will be important to consider this difference between the two groups throughout the duration of this discussion.

Question 1 of the survey asked respondents to rate a number of selected municipal drinking water contaminants according to their perceptions of the risk that these contaminants pose to drinking water. The Committee's responses are shown in Table 8 and Figure 16. In general, the Committee appears to have been much less risk averse than the Community. Although the "very risky" category shown in Table 8 has the highest percentage of responses for 10 out of 22 of the contaminants (or 45% of the contaminants), the Committee members appear to have been generally more hesitant to identify the contaminants as "very risky". This is demonstrated by the smaller percentage of Committee members who identified the contaminants as being "very risky", as compared with the higher percentages of Community participants who identified the contaminants as such. As shown in Figure 16, out of a total of 22 contaminants listed, only 8 (or 36% of the contaminants) were identified as being very risky by 50% or more of the Committee members surveyed. In comparison, 68% of the contaminants were identified as being very risky by over 50% of the Community members surveyed (see Figure 17). Furthermore, Figure 17 shows that that the most risky contaminant identified by the Community (*E. coli*) was judged to be very risky by 92.6% of respondents, whereas only 87.5% of the Committee surveyed indentified the most

Table 8: The Committee respondents' responses to Question 1 of the survey, which asked respondents to rate each contaminant according to riskiness. The numbers (left side of each column) and percentages (right side of each column) represent the total number and percentage of respondents surveyed who chose each risk rating.

Contaminant	Almost No Risk		Slightly Risky		Moderately Risky		Very Risky		Don't Know	
	(No.)	(%)	(No.)	(%)	(No.)	(%)	(No.)	(%)	(No.)	(%)
Chlorine	9	56.3	2	12.5	3	18.8	2	12.5	0	0
Metals	1	6.7	6	40	3	20	5	33.3	0	0
E. coli	0	0	2	12.5	2	12.5	12	75	0	0
Mercury	0	0	1	6.3	1	6.3	14	87.5	0	0
Sediment and Mud	4	25	8	50	3	18.8	1	6.3	0	0
Paint	0	0	1	6.3	6	37.5	9	56.3	0	0
Acids	1	6.3	2	12.5	7	43.8	3	18.8	3	18.8
Hepatitis A	0	0	2	12.5	3	18.8	7	43.8	4	25
Arsenic	0	0	4	25	2	12.5	8	50	2	12.5
Nitrates	1	6.3	4	25	6	37.5	4	25	1	6.3
Industrial Waste	0	0	2	12.5	5	31.3	8	50	1	6.3
Pesticides	0	0	2	12.5	7	43.8	7	43.8	0	0
Solvents	0	0	1	6.3	6	37.5	9	56.3	0	0
Microorganisms	0	0	6	37.5	5	31.3	3	18.8	2	12.5
Viruses	0	0	4	25	3	18.8	7	43.8	2	12.5
Oils	0	0	3	18.8	7	43.8	5	31.3	1	6.3
Auto Plant Wastewater	1	6.3	2	12.5	7	43.8	5	31.3	1	6.3
Lead	0	0	4	25	2	12.5	10	62.5	0	0
Fluoride	7	43.8	5	31.3	2	12.5	1	6.3	1	6.3
Fertilizers	2	13.3	3	20	5	33.3	5	33.3	0	0
Phosphates	1	6.3	8	50	5	31.3	1	6.3	1	6.3
PCBs	0	0	1	6.3	4	25	9	56.3	2	12.5

risky contaminant (mercury) as being very risky. As indicated above, this finding that the Committee members appear to be considerably less risk averse than the Community was anticipated, and is supported in the literature (Fischhoff et al., 1978, p.148; and Slovic, 1987, p.283).

As can be seen from Figure 16, the three contaminants that the Committee members identified as posing the greatest threat to water were mercury, *E. coli* and lead. Mercury was identified as being very risky to water by 87.5% of Committee members, while 75% of Committee members identified *E. coli* as being very risky, and 62.5% of Committee members identified lead as being very risky. This rating is interesting because it differs from the Community's prioritization of the contaminants. Although *E. coli* was identified as one of the top three most risky water contaminants by both groups, the Community rated it first with 92.6% identifying it as very risky, while the Committee rated it as the second most risky contaminant, with only 75% classifying it as very risky. Using the differences between proportions statistical test, it was determined that this difference in the responses is statistically significant, with the z-score equal to 2.37. Table 9 lists all the z-scores calculated using the differences between proportions test for the risk data obtained from Question 1 of the survey. The statistically significant results are highlighted in gray. Note that in accordance with the focus of this analysis, only the "very risky" column

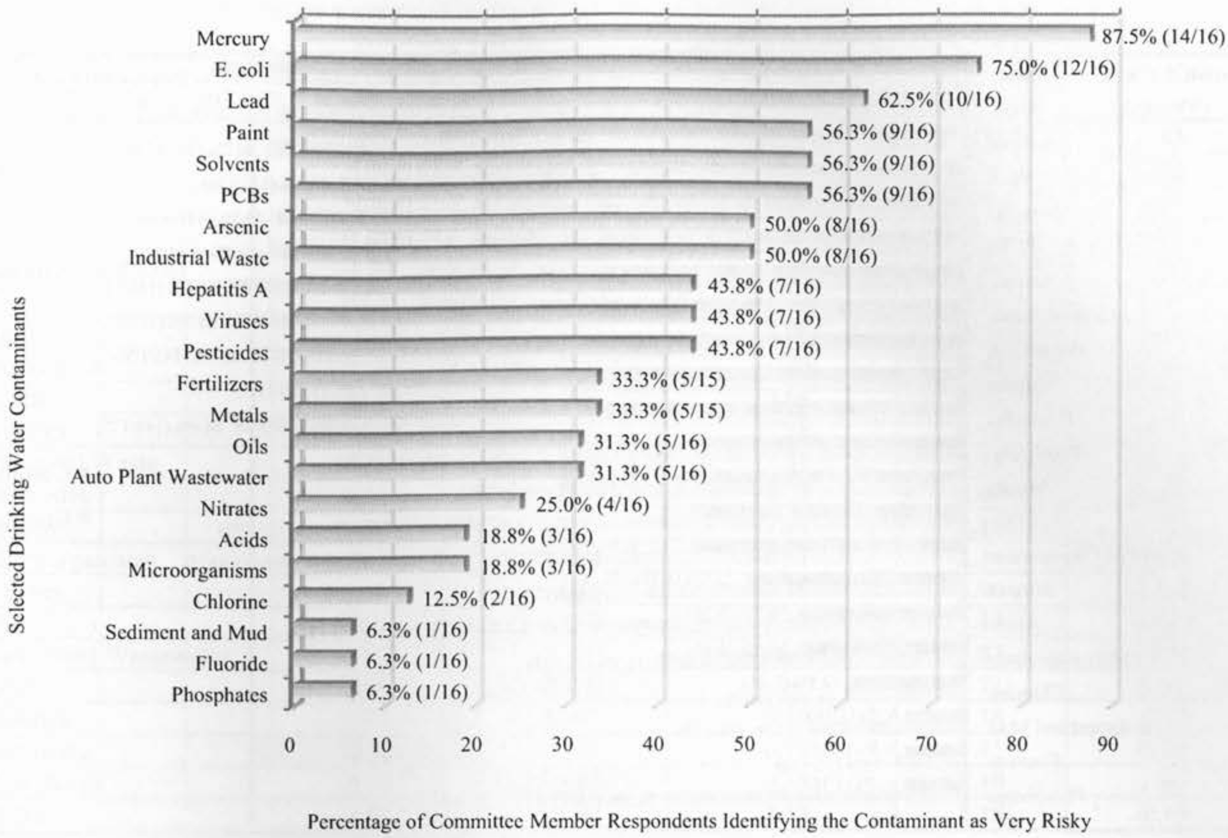


Figure 16: The degree of perceived risk attributed to selected drinking water contaminants by members of the Committee who participated in this study

will be discussed. The other two contaminants that were identified by the Committee as being in the top three most risky contaminants to water, mercury and lead, differed from the Community's choices of arsenic and industrial waste. However, while the differences in the ratings of industrial waste and arsenic are statically significant ($z = 3.55$ for both contaminants), with the Community rating the contaminants as significantly more risky than did the Committee, the differences in the ratings of mercury and lead were not statistically significant. The Community's and the Committee's high risk perception of lead may result at least in part from the recent lead contamination incident that took place in the Region of Study and the resulting media coverage. However, it is important to note that there are likely many other factors, in addition to those mentioned here, that may have influenced both groups' responses.

The three contaminants that the Committee identified as posing the least risk to water were phosphates, fluoride and sediment and mud. It appears that the Committee perceived these three contaminants to pose very similar risks to water. Only 6.3% of the Committee identified each of these contaminants, respectively, as being very risky to water (i.e. all three contaminants received the same risk

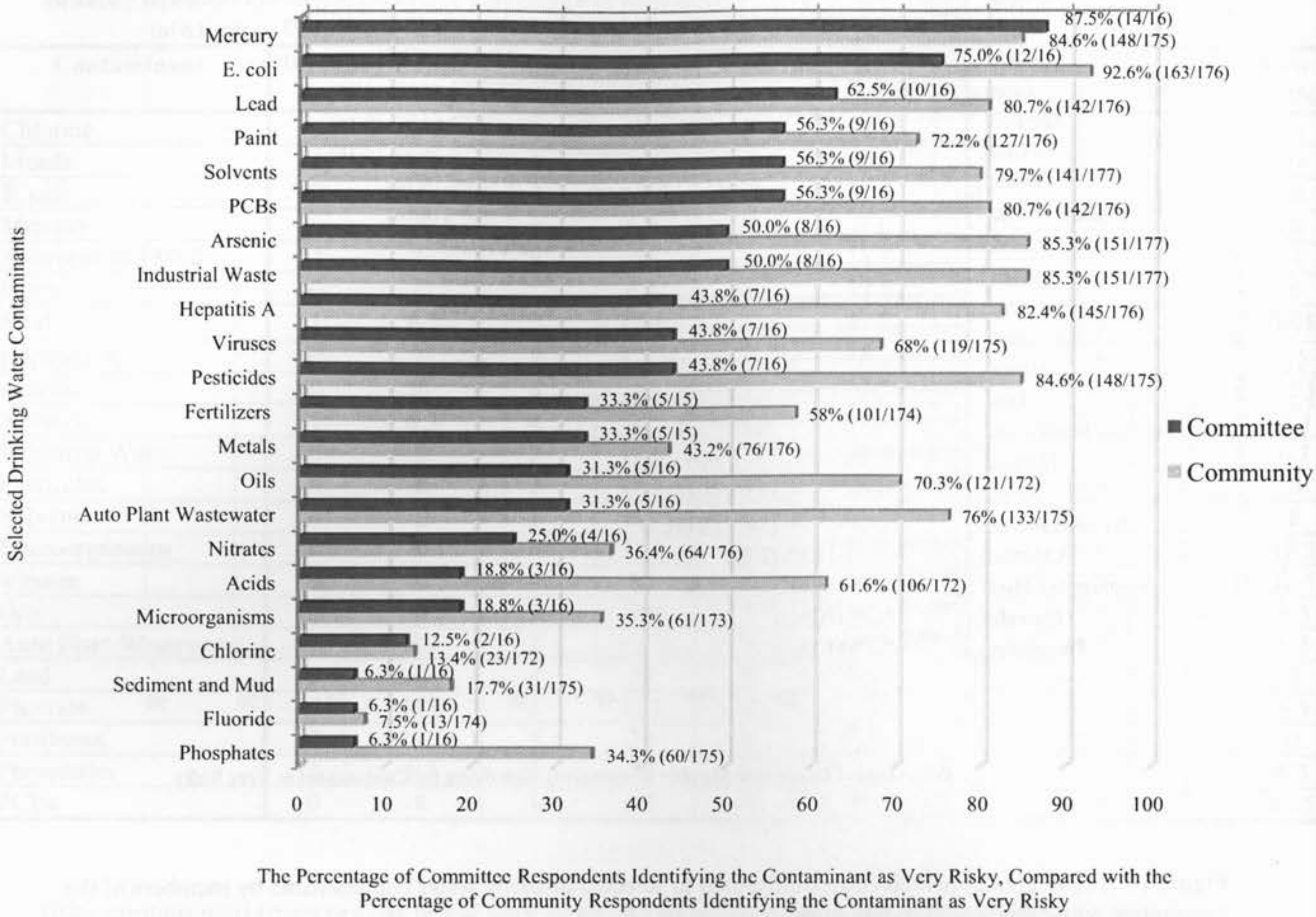


Figure 17: The degree of perceived risk attributed to selected drinking water contaminants by members of the Committee and members of the Community who participated in this study

rating). The next least risky water contaminants, as identified by the Committee, were chlorine, with 12.5% of the Committee identifying it as very risky, and microorganisms and acids, with 18.8% of the Committee identifying each contaminant respectively as very risky. These results were similar to those of the Community (see Figure 17 and Table 10). Both groups identified fluoride and sediment and mud to be among the three least risky water contaminants. However, while the Committee perceived phosphates to be one of the three least risky contaminants, with only 6.3% of Committee members identifying it as very risky, the Community rated phosphates as being the fourth least risky water contaminant with 34.3% of the Community identifying it as very risky. This difference is statistically significant ($z = 2.30$). The only other statistically significant difference in Community and Committee responses for the rating of the least

Table 9: z-scores calculated using the Differences Between Proportions Statistical Test for the risk perception data obtained from Question 1 of the survey

Contaminant	Almost No Risk (z-score)	Slightly Risky (z-score)	Moderately Risky (z-score)	Very Risky (z-score)	Don't Know (z-score)
Chlorine	**-2.25**	1.50	0.41	0.098	0.82
Metals	-0.16	**-2.89**	0.78	0.74	1.22
E. coli	N/A	**-2.60**	**-1.97**	**2.37**	0.68
Mercury	0.43	-0.95	0.17	-0.31	0.87
Sediment and Mud	-1.22	-1.96	1.27	1.18	1.13
Paint	0.61	-0.094	**-2.17**	1.34	0.81
Acids	-0.73	-0.60	**-2.08**	**3.32**	-1.80
Hepatitis A	0.53	**-3.05**	-1.70	**3.64**	**-2.24**
Arsenic	0.61	**-4.37**	-0.84	**3.55**	-1.75
Nitrates	-0.31	-1.15	-0.98	0.91	1.25
Industrial Waste	0.52	**-1.98**	**-3.31**	**3.55**	-0.59
Pesticides	0.53	**-2.59**	**-4.07**	**4.00**	0.69
Solvents	0.30	-0.59	**-2.94**	**2.16**	0.92
Microorganisms	1.14	**-2.04**	-0.51	1.34	0.27
Viruses	0.53	**-2.36**	-0.16	1.96	-1.071
Oils	0.62	-1.80	**-2.97**	**3.18**	0.023
Auto Plant Wastewater	-0.95	-1.071	**-4.071**	**3.83**	0.092
Lead	N/A	**-3.031**	-0.067	1.71	0.61
Fluoride	0.17	0.077	-0.19	0.18	-0.57
Fertilizers	**-2.34**	-0.97	-0.79	1.85	0.79
Phosphates	-0.43	**-3.42**	-0.38	**2.30**	1.30
PCBs	0.30	-0.44	**-2.52**	**2.28**	-0.63

Table 10: Comparison of the three most risky and three least risky drinking water contaminants, as indicated by Community respondents and Committee respondents

	The Community	Percentage identifying contaminant as very risky (%)	The Committee	Percentage identifying contaminant as very risky (%)
Risks perceived to be the most risky to municipal drinking water sources	E. coli	92.6 (163/176)	Mercury	87.5 (14/16)
	Arsenic	85.3 (151/177)	E. coli	75 (12/16)
	Industrial Waste	85.3 (151/177)	Lead	62.5 (10/16)
Risks perceived to be the least risky to municipal drinking water sources	Fluoride	7.5 (13/174)	Phosphates	6.3 (1/16)
	Chlorine	13.5 (23/172)	Fluoride	6.3 (1/16)
	Sediment and Mud	17.7 (31/175)	Sediment and Mud	6.3 (1/16)

risky contaminants listed above was for acids (z = 3.32). While 61.6% of Community members identified acids as very risky, only 18.8% of Committee members did so.

Other contaminants for which there were statistically significant differences between the two groups' ratings pertaining to the very risky category of the survey include Hepatitis A (z = 3.64), pesticides (z = 4.00), solvents (z = 2.16), oils (z = 3.18), auto plant wastewater (z = 3.83) and PCBs (z = 2.28). All of these contaminants were approximately located in the median range of each groups' risk ratings.

In general, few Committee members indicated that they did not know how risky they thought the contaminants were. The Committee members only indicated that they did not know how risky a contaminant was for 12 out of the 22 contaminants, or about 55% of the contaminants. However, some of the contaminants were problematic for the Committee. A total of 25% of the Committee were unable to rate Hepatitis A. In comparison, only 14 out of 176 of the Community (or about 14% of the Community) indicated that they were not sure to what degree Hepatitis A poses a risk to water quality. The difference between these responses is statistically significant (z = -2.24). This result was not expected, and the reason for this outcome is not clear. It could be that at this early stage of the source water protection planning process, the Committee members have not yet had the opportunity or the need to consider the potential threat to water posed by Hepatitis A, and may not come across this contaminant in their respective fields. However, this research does not provide any evidence for this hypothesis, and there are likely many other reasons for this difference between the two groups.

Question 2 of the survey asked respondents to identify their familiarity with the selected municipal drinking water contaminants. In this study, the familiarity responses are stated beliefs and no evidence is presented regarding the actual familiarity of any of the respondents. Thus, this discussion is of the respondents' self-expressed familiarity, and not their actual, tested familiarity. Furthermore, it should be noted that the self-identified familiarity ratings of the Committee may be inflated, as the literature indicates that all individuals tend to be overconfident in their judgments (Slovic et al., 1977, p.6).

The Committee's responses are shown in Table 11 and Figure 18. Although the Committee members were likely reluctant to identify themselves as being very familiar with all of the drinking water contaminants, their self-identified familiarity with the contaminants was greater than was that of the Community. In the case of the Committee, for half of the contaminants (or 11 out of 22 of the contaminants), the category with the greatest percentage of responses was the "very familiar" category. For the contaminant fluoride, the greatest percentage of responses was split between the "familiar" and "very familiar" categories. This degree of familiarity with the contaminants was not reflected in the Community's responses, of which the greatest percentage were located in the "familiar" category.

As shown in Figure 18, the five contaminants that the Committee members identified as being most familiar to them are chlorine, nitrates, pesticides, fertilizers and phosphates. Here, five top rated

Table 11: The Committee respondents' responses to Question 2 of the survey, which asked respondents to rate each contaminant according to their self-expressed familiarity with it. The numbers (left side of each column) and percentages (right side of each column) represent the total number and percentage of respondents surveyed who chose each familiarity rating.

Contaminant	**Unfamiliar**		**Not Very Familiar**		**Familiar**		**Very Familiar**		**Don't Know**	
	(No.)	**(%)**	**(No.)**	**(%)**	**(No.)**	**(%)**	**(No.)**	**(%)**	**(No.)**	**(%)**
Chlorine	0	0	2	12.5	5	31.3	9	56.3	0	0
Metals	0	0	5	31.3	5	31.3	6	37.5	0	0
E. coli	0	0	2	12.5	6	37.5	8	50	0	0
Mercury	1	6.3	1	6.3	8	50	6	37.5	0	0
Sediment and Mud	0	0	2	12.5	6	37.5	8	50	0	0
Paint	1	6.3	5	31.3	6	37.5	3	18.8	1	6.3
Acids	2	12.5	5	31.3	5	31.3	3	18.8	1	6.3
Hepatitis A	2	12.5	6	37.5	5	31.3	3	18.8	0	0
Arsenic	2	12.5	2	12.5	6	37.5	5	31.3	1	6.3
Nitrates	0	0	1	6.3	6	37.5	9	56.3	0	0
Industrial Waste	0	0	7	43.8	6	37.5	2	12.5	1	6.3
Pesticides	0	0	2	12.5	5	31.3	9	56.3	0	0
Solvents	1	6.3	3	18.8	7	43.8	5	31.3	0	0
Microorganisms	2	12.5	5	31.3	4	25	5	31.3	0	0
Viruses	1	6.3	5	31.3	6	37.5	3	18.8	1	6.3
Oils	1	6.3	1	6.3	8	50	6	37.5	0	
Auto Plant Wastewater	2	12.5	8	50	3	18.8	2	12.5	1	6.3
Lead	0	0	2	12.5	6	37.5	8	50	0	0
Fluoride	0	0	2	12.5	7	43.8	7	43.8	0	0
Fertilizers	0	0	1	6.3	6	37.5	9	56.3	0	0
Phosphates	0	0	4	25	3	18.8	9	56.3	0	0
PCBs	0	0	4	25	5	31.3	6	37.5	1	6.3

contaminants are listed instead of usual three because all five contaminants were rated the same, with 56.3% of Committee members identifying that they are very familiar with each respective contaminant. *E. coli*, sediment and mud and lead were identified by the Committee as the next most familiar contaminants, with 50% of the Committee identifying these contaminants as very familiar, followed by fluoride, with 43.8% of the Committee identifying this contaminant as very familiar.

The Committee's self-identified familiarity with the water contaminants appears to differ from that of the Community. Of the top five most familiar contaminants to the Community, chlorine was the only contaminant also identified as very familiar in the Community's top five most familiar contaminants (see Figure 19). Furthermore, although the Community generally identified themselves as moderately familiar with fertilizers and pesticides, phosphates and nitrates were among the contaminants that appear to be least familiar to the Community. In fact, the Community indicated that phosphates were the least familiar of all the contaminants. The differences in the two groups' responses regarding fertilizers ($z = -2.25$), pesticides ($z = -2.69$), phosphates ($z = -5.31$) and nitrates ($z = -3.96$) were all statistically

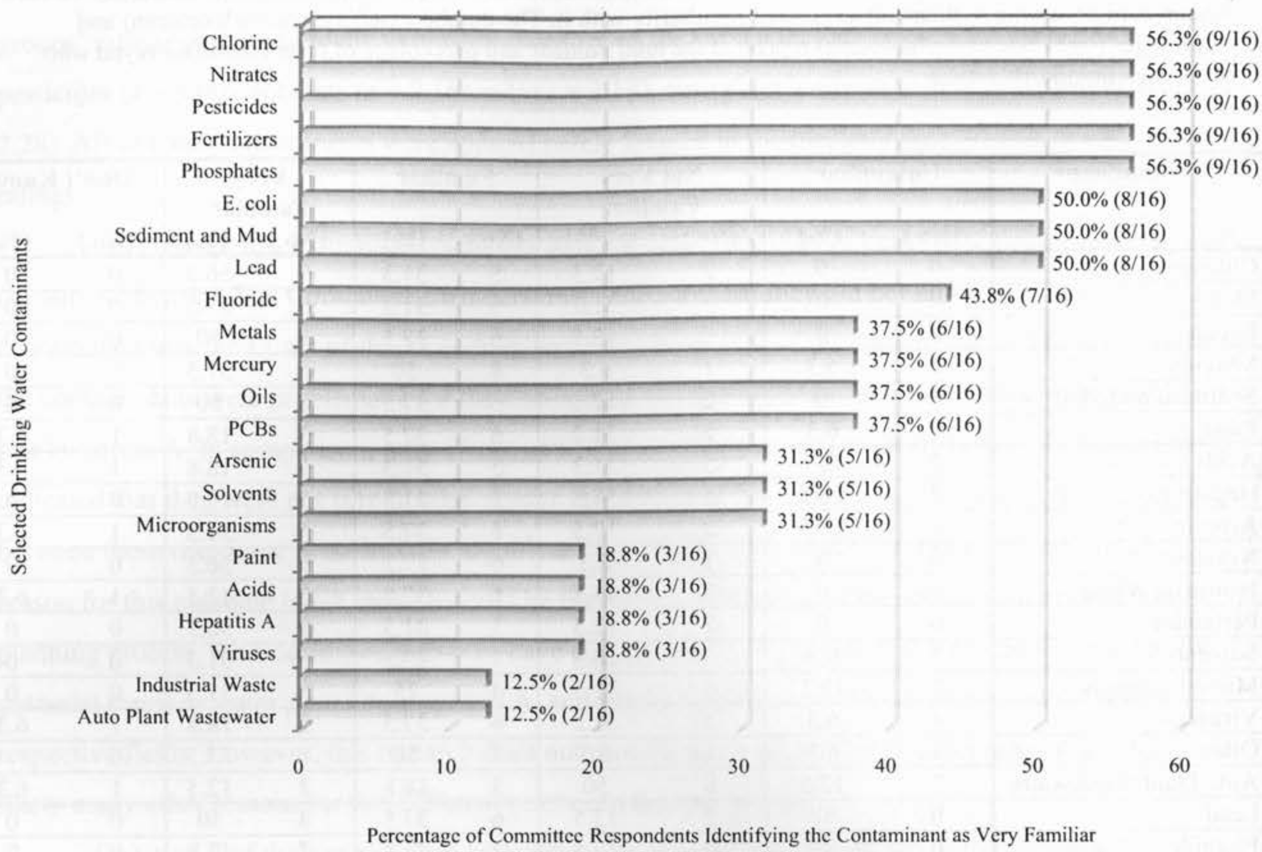


Figure 18: The degree of self-expressed familiarity that Committee respondents have with selected drinking water contaminants

significant, with the Committee rating the contaminants as significantly more familiar to them (see Table 12). The only other statistically significant difference between the two groups' responses in the very familiar category of the survey was for sediment and mud ($z = -2.40$), with the Committee rating the contaminants as significantly more familiar to them. Other than chlorine, the Community included *E. coli* (with 40.2% of respondents identifying it as very familiar) and lead (with 37.5% of respondents identifying it as very familiar) in their top three most familiar contaminants, with *E. coli* being the most familiar contaminant, based on self-expressed familiarity. The Committee identified *E.coli* and lead as the second most familiar contaminants after the first five, with 50% of the Committee members identifiying each respective contamint as very familiar. However, the differences in the two groups' responses pertaining to *E. coli* and lead are not statistically significant.

The water contaminants that were identified by the Committee as being least familiar were auto plant wastewater and industrial waste, with 12.5% of the Committee identifying these contaminants as

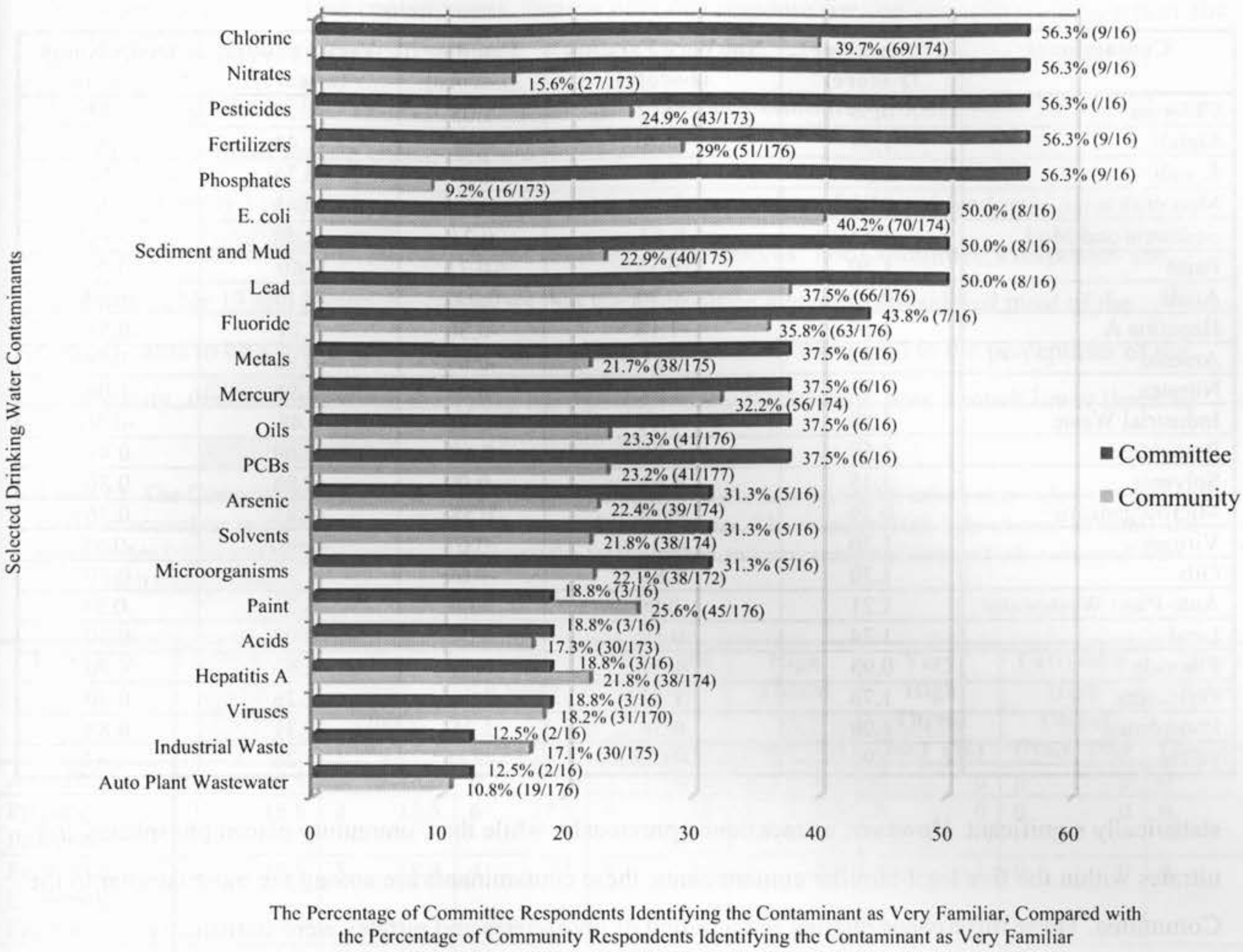


Figure 19: The degree of self-identified familiarity attributed to selected drinking water contaminants by members of the Committee and members of the Community who participated in this study

very familiar, viruses, Hepatitis A, acids and paint, with 18.8% of the Committee identifying these contaminants as very familiar, and microorganisms, solvents and arsenic with 31.3% of the Committee identifying these contaminants as very familiar. These results were somewhat similar to the responses of the Community. A total of 10.8% of the Community identified auto plant wastewater as very familiar, 17.1% of the Community identified industrial waste as very familiar and 17.3% of the Community identified acids as very familiar. The Community placed these three contaminants within the bottom five least familiar contaminants. The similarities between the two groups' responses are supported by the finding that none of the observed differences in responses for any of the contaminants listed above were

Table 12: z-scores calculated using the Differences Between Proportions Statistical Test for the familiarity data obtained from Question 2 of the survey

Contaminant	Unfamiliar (z-score)	Not Very Familiar (z-score)	Familiar (z-score)	Very Familiar (z-score)	Don't Know (z-score)
Chlorine	0.69	-0.12	1.05	-1.29	0.43
Metals	1.58	-0.70	0.51	-1.44	0.75
E. coli	1.55	-0.27	-0.24	-0.76	0.53
Mercury	0.95	1.18	-1.24	-0.43	0.30
Sediment and Mud	1.55	0.82	0.24	**-2.40**	0.61
Paint	1.30	-0.55	-0.71	0.60	-1.58
Acids	0.75	-0.30	0.092	-0.14	-0.94
Hepatitis A	1.14	-1.18	-0.36	0.29	0.53
Arsenic	0.83	1.23	-0.84	-0.80	-0.94
Nitrates	1.82	**2.07**	-0.62	**-3.96**	1.04
Industrial Waste	1.58	-1.11	-0.26	0.48	-0.30
Pesticides	1.59	0.75	0.68	**-2.69**	0.43
Solvents	1.35	0.63	-0.99	-0.86	0.30
Microorganisms	0.39	-0.44	0.58	-0.83	0.76
Viruses	1.30	-0.15	-0.67	-0.051	-0.55
Oils	1.30	1.85	-1.69	-1.27	0.30
Auto Plant Wastewater	1.21	-0.80	0.00	-0.21	-0.31
Lead	1.34	0.19	0.00	-0.98	0.30
Fluoride	0.93	-0.36	0.39	-0.63	0.30
Fertilizers	1.73	1.17	-0.045	**-2.25**	0.30
Phosphates	**1.99**	0.56	1.25	**-5.31**	0.88
PCBs	1.93	-0.013	-0.21	-1.28	-0.44

statistically significant. However, as mentioned previously, while the Community placed phosphates and nitrates within the five least familiar contaminants, these contaminants are among the most familiar to the Committee. These differences relating to the rating of phosphates and nitrates were statistically significant.

Figure 19 shows plateaus for both the Committee and Community familiarity responses, with many contaminants grouped together due to similar or identical familiarity ratings. However, there are more plateaus in the Committee's familiarity responses, likely in part due to the much smaller sample size. The plateaus for both groups' familiarity responses may also be due to the fact that the survey question used to generate this data required participants to respond by choosing one of only five categories. Thus, these plateaus could be due to the extremely limited range of possible participant responses.

In general, very few Committee members indicated that they did not know how familiar the contaminants were to them. Similar to the Community, the Committee appears to have found the familiarity ratings less problematic than the risk ratings, as indicated by the number of respondents who checked the "don't know" column in Questions 1 and 2 of the survey. However, in general, it appears that the Committee found Question 2 less problematic to respond to than did the Community. The Committee members checked the "don't know" box for only 7 of the 22 contaminants (or about 32% of the contaminants), and of those contaminants, there is only one response per contaminant. In comparison, the Community members checked all 22 boxes. Although the difference between these proportions are statistically significant ($z = -4.77$, $p = 0.66$), the much smaller Committee proportion of 7 out of 22 could result from the small sample size of that group.

Question 3 of the survey asked respondents to rate a number of selected land uses according to the degree to which they threaten municipal drinking water sources. The Committee's responses are shown in Table 13 and Figure 20. It appears that the Committee generally considered most of the contaminants to be a low to moderate threat to water. Furthermore, compared to the perceptions of the Community, the Committee members may have perceived the land uses to pose a much lower threat to

Table 13: The Committee respondents' responses to Question 3 of the survey, which asked respondents to rate each land use according to the degree to which it threatens drinking water. The numbers (left side of each column) and percentages (right side of each column) represent the total number and percentage of respondents surveyed who chose each threat rating.

Land Use	Extremely Low Threat (No.)	(%)	Very Low Threat (No.)	(%)	Low Threat (No.)	(%)	Moderate Threat (No.)	(%)	High Threat (No.)	(%)	Very High Threat (No.)	(%)	Extremely High Threat (No.)	(%)	Don't Know (No.)	(%)
Auto Plant	3	18.8	3	18.8	6	37.5	3	18.8	1	6.3	0	0	0	0	0	0
Plastics Production	3	18.8	2	12.5	6	37.5	4	25	1	6.3	0	0	0	0	0	0
Farm with Livestock Feedlot	2	12.5	3	18.8	4	25	4	25	2	12.5	1	6.3	0	0	0	0
Liquid Industrial Waste Storage	2	12.5	2	12.5	3	18.8	3	18.8	3	18.8	3	18.8	0	0	0	0
Sewage Treatment Plant	1	6.3	3	18.8	2	12.5	5	31.3	3	18.8	2	12.5	0	0	0	0
Chemical Plant	2	12.5	2	12.5	3	18.8	1	6.3	5	31.3	2	12.5	1	6.3	0	0
Dairy Farm	1	6.3	4	25	4	25	5	31.3	2	12.5	0	0	0	0	0	0
Storm Water Management System	2	13.3	1	6.7	4	26.7	5	33.3	2	13.3	0	0	1	6.7	0	0
House with Septic System	1	6.3	2	12.5	6	37.5	4	15	2	12.5	0	0	1	6.3	0	0
Above Ground Fuel Storage Facility	1	6.3	6	37.5	4	25	5	31.3	0		0	0	0	0	0	0
Landfill	1	6.3	3	18.8	2	12.5	8	50	1	6.3	1	6.3	0	0	0	0
Grain Farm	3	18.8	6	37.5	5	31.3	1	6.3	1	6.3	0	0	0	0	0	0
Electronics Manufacturing	1	6.3	4	25	1	6.3	4	25	1	6.3	0	0	0	0	5	31.3

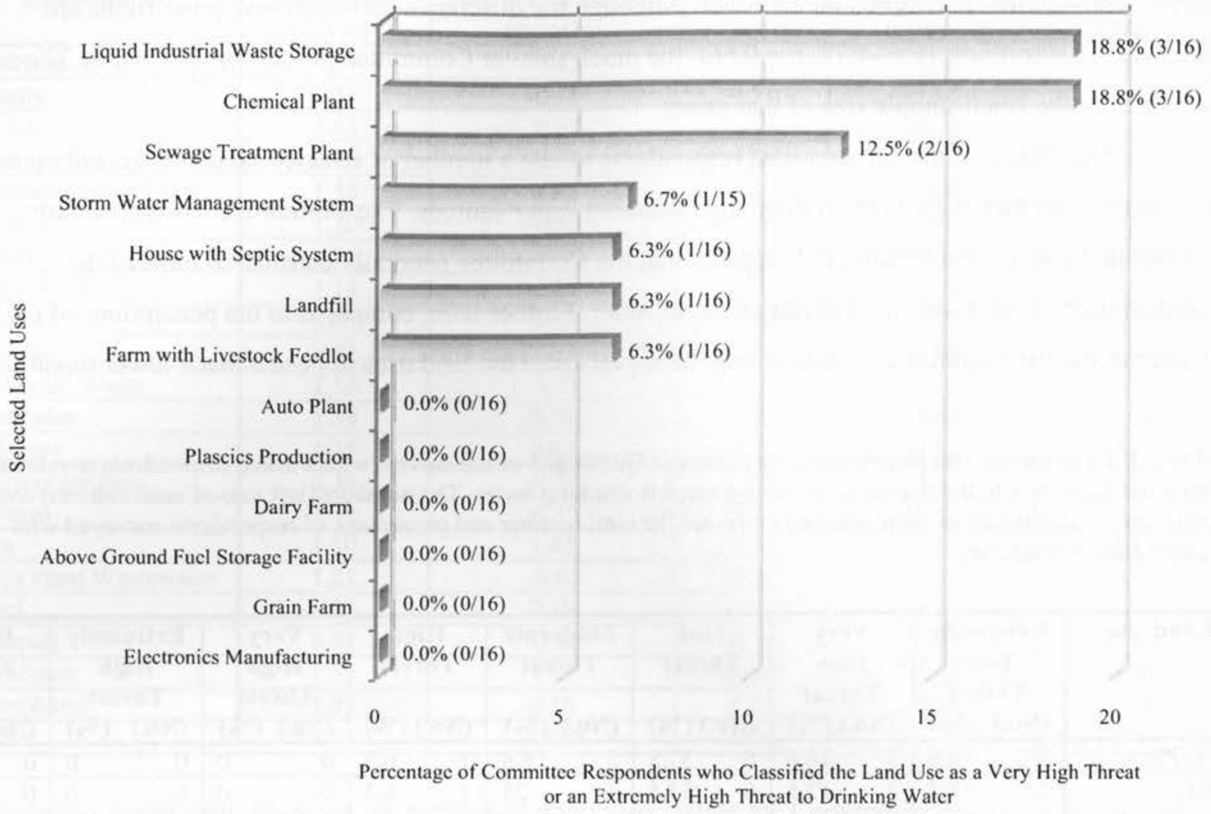


Figure 20: The degree of threat to drinking water sources attributed to selected land uses by members of the Committee who participated in this study. This degree of threat to drinking water sources is represented by the percentage of Committee respondents who classified each land use as a very high threat or an extremely high threat to drinking water.

water, both in general as a group and for each individual land use in pairwise comparisons. The Committee's potentially greater tolerance of the water risk sources included in this study would be consistent with their apparent lower risk aversion to the water contaminants which was discussed above. The Committee's greater risk source tolerance was also expected, and is supported in the literature (Fischhoff et al., 1978, p.148; and Slovic, 1987, p.283).

Similar to the Community's responses, the Committee's responses indicate that the "moderate threat" category has the greatest percentage of responses for the greatest number of land uses (4 out of 13 land uses, or 31% of land uses, in the "moderate threat" category had the greatest percentage of responses of any category for the given land use). However, the next most populated category was the "low threat" category. Moreover, unlike the Community, the Committee appears to have been very reluctant to categorize a land use as posing an extremely high threat to water, as indicated by their responses. Only 3 out of the 13 land uses (or 23% of the land uses) have any Committee responses in the "extremely high threat" category and of those, there is only one response per land use. That is, the chemical plant, storm water management system and house with septic system land uses each have one Committee member response indicating that they are extremely high threats to water.

Figure 20 shows that the three land uses identified by the Committee as posing the greatest threat to water are the liquid industrial waste storage, chemical plant and sewage treatment plant land uses. A total of 18.8% of the Committee members surveyed indicated that liquid industrial waste storage and chemical plants are a very high or an extremely high threat to drinking water. Sewage treatment plants were perceived to be the next most threatening, with 12.5% of the Committee indicating that this land use is a very high or an extremely high threat to water. These responses were similar to those of the Community, who also indicated that the liquid industrial waste storage (with 48% of Community respondents classifying it as a very or an extremely high threat) and chemical plant (with 50.9% of Community respondents classifying it as a very or an extremely high threat) land uses are among the top three most threatening to water (see Figure 21 and Table 14). However, despite these similar ratings, there was a substantial difference in the percentages of respondents in each group who identified the liquid industrial waste storage and chemical plant as either a very or an extremely high threat to water, with the Community identifying these contaminants as a higher threat than did the Committee. In fact, the only significant difference between the responses of the two groups in either the very high threat or extremely high threat category is for the liquid industrial waste storage ($z = 2.58$) and the chemical plant ($z = 2.15$) land uses in the extremely high threat category (see Table 15). When the "very high threat" and "extremely high threat" categories are added together, the only significant differences between responses are the differences between the two groups' responses pertaining to the liquid industrial waste storage ($z = 2.25$, $p = 0.46$) and the chemical plant ($z = 2.46$, $p = 0.48$) land uses.

The responses of the Community and the Committee also differ in that while the Community indicated that the landfill land use was the third most threatening to water, with 33.3% of the Community identifying it as either a very high or an extremely high treat to water, the Committee members perceived landfills to be considerably less threatening, rating them as sixth most risky, with 6.3% of the Committee identifying it as either a very high or an extremely high treat to water. In addition, while the Committee rated sewage treatment plants as the third greatest threat to water, with 12.5% of the Committee identifying it as either a very high or an extremely high treat, the Community rated it as the fifth most threatening, with 27.2% of the Community identifying it as either a very high or an extremely high treat to water. However, these differences in responses were not statistically significant.

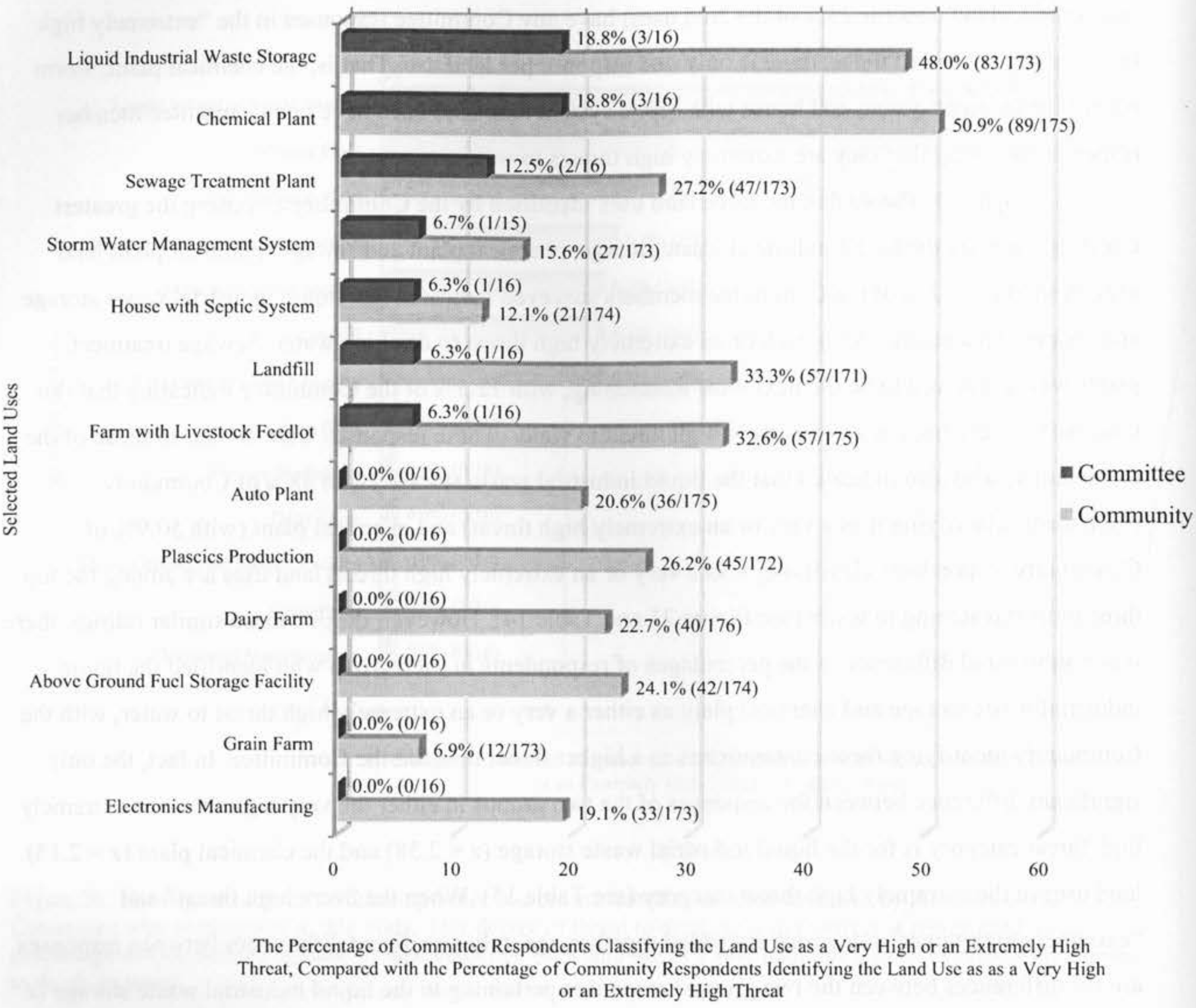


Figure 21: The degree of threat to drinking water sources attributed to selected land uses by members of the Committee and members of the Community who participated in this study

The fact that both groups rated two chemical risk sources - the chemical plant and the liquid industrial waste storage land uses - as the top two most threatening land uses may indicate 'chemophobia' responses among both the Community and the Committee. However, the differences in the Committee and the Community's responses were statistically significant for both the liquid industrial waste storage and the chemical plant land uses in the "extremely high threat" category and in the "very high threat" and "extremely high threat" categories combined, with the Community identifying each of these contaminants as being significantly more threatening to water than did the Committee. This

Table 14: Comparison of the most threatening and least thretening land uses that can affect municipal drinking water sources, as indicated by Community respondents and Committee respondents

	The Community	Percentage identifying contaminant as very high or extremely high threat (%)	The Committee	Percentage identifying contaminant as very high or extremely high threat/ extremely low or very low threat (%)
Risks perceived to be the most risky to municipal drinking water sources	Chemical Plant	50.9 (89/175)	Liquid industrial waste storage	18.8 (3/16)
	Liquid industrial waste storage	40.0 (83/173)	Chemical plant	18.8 (3/16)
	Landfill	33.3 (57/171)	Sewage treatment plant	12.5 (2/16)
Risks perceived to be the least risky to municipal drinking water sources	Grain Farm	6.9 (12/173)	Auto Plant	0.0%
			Plastics Production	0.0%
	House with septic system	12.1 (21/174)	Dairy Farm	0.0%
			Above Ground Fuel Storage Facility	0.0%
	Storm water management system	15.6 (27/173)	Grain Farm	0.0%
			Electronics Manufacturing	0.0%

Table 15: z-scores calculated using the Differences Between Proportions Statistical Test for the land use data obtained from Question 3 of the survey

Contaminant	Extremely Low Threat (z-score)	Very Low Threat (z-score)	Low Threat (z-score)	Moderate Threat (z-score)	High Threat (z-score)	Very High Threat (z-score)	Extremely High Threat (z-score)	Don't Know (z-score)
Auto Plant	-1.23	**-1.98**	**-2.32**	0.97	0.80	1.18	1.51	1.03
Plastics Production	-1.66	-0.92	**-3.10**	-0.21	1.33	1.60	1.48	1.14
Farm with Livestock Feedlot	-1.36	**-3.74**	-1.57	-0.30	1.00	1.13	1.70	0.87
Liquid Industrial Waste Storage	-1.52	-1.95	-1.31	-0.53	-0.083	-0.083	**2.58**	0.88
Sewage Treatment Plant	-0.29	-1.02	0.49	-0.85	-0.61	-0.042	1.67	0.93
Chemical Plant	-0.94	-1.73	**-2.33**	0.74	-1.54	0.63	**2.15**	1.03
Dairy Farm	0.00	0.38	-0.93	-0.44	0.30	1.34	1.50	0.87
Storm Water Management System	**-2.049**	0.93	-0.21	-1.0056	0.18	1.0065	0.33	0.85
House with Septic System	0.40	0.54	-1.62	-0.025	-0.43	0.93	0.098	1.085
Above Ground Fuel Storage Facility	0.011	**-3.010**	-0.84	-0.86	1.43	1.27	1.66	1.22
Landfill	-0.28	**-2.29**	-0.50	**-2.072**	1.34	0.88	1.94	0.69
Grain Farm	-0.40	-1.96	-0.85	1.36	0.53	0.82	0.69	1.18
Electronics Manufacturing	0.70	-1.85	1.32	-0.51	0.33	1.31	1.27	**-2.33**

result could correspond to a much more salient 'chemophobia' response among the Community than among the Committee. However, the reason or reasons for this potential difference in the degree of 'chemophobia' between the two groups is not known. Since 'chemophobia' may be caused in part by the erosion of trust in the chemical industry, it could be that this observed difference may be related to the Community trusting the chemical industry less than does the Committee (Eisberg, 2008; Kay, 1989, pp.1177-1178). However, the reason for this potential difference in trust is not clear. It is important to note that this research does not provide any evidence for this hypothesis and there are likely many different reasons for this potential difference in the saliency of 'chemophobia' between the two groups.

As can be seen from Figure 21 and Table 14, the Committee may have perceived the land uses to be a moderate to low threat to water sources, and it appears that they were especially reluctant to classify them as being a high or an extremely high threat to water sources. Because so few of the Committee members rated the land uses as being considerably threatening to water, there were a number of land uses that were not identified as very high or extremely high threats to water by any of the Committee members (i.e. 0% of the Committee identified these land uses as very high or extremely high threats). These land uses include auto plant, plastics production, dairy farm, above ground fuel storage facility, grain farm and electronics manufacturing. Of these, only the grain farm was present in the Community's rating of the three lowest threats to water.

Since the Committee judged the land uses to be a moderate to low threat to water, and were apparently reluctant to classify them as being a considerable threat to water, the data used to construct Figure 20 are quite sparse. In fact, nearly half of all the land uses (6 out of 13 land uses or 46% of land uses) were not classified as being a very high or an extremely high threat to water, and thus appear as 0.0% in Figure 20. This lack of differentiation between the least threatening land uses illustrates an important problem with this method of analyzing the data, whereby the extreme responses are focused on.

With the exception of the electronics manufacturing land use, none of the Committee members indicated that they did not know how to rate the land uses. However, in the case of electronics manufacturing, the greatest percentage of Committee responses, 31.3%, were located in the "don't know" category. That is, nearly a third of the Committee members were not sure to what degree electronics manufacturing threatens the quality of water sources. In comparison, only 19 out of 173 Community members (or about 11% of the Community) indicated that they were not sure to what degree electronics manufacturing threatens water quality. The difference between these responses is statistically significant ($z = 2.33$). This result was not expected, and the reason for this outcome is not clear. It could be that at this early stage of the source water protection planning process, the Committee members, none of whom appear to be in any way affiliated with the electronics sector, have not yet had the opportunity or the need to consider the potential threat to water posed by electronics manufacturing. However, this research does not provide any evidence for this hypothesis, and there are likely many other reasons for this outcome.

In attempt to identify a relationship between the Committee's familiarity with water contaminants and their risk perception of those contaminants, the familiarity and risk perception variables were plotted against each other (see Figure 22). Based on the literature, an inverse relationship between familiarity and risk perception was expected. However, as mentioned above, just as it can be asserted that greater familiarity can decrease the perceived risk among laypeople, it can also be argued that a lower perceived risk can increase familiarity among laypeople. It is very important to keep in mind this issue of causation throughout this discussion.

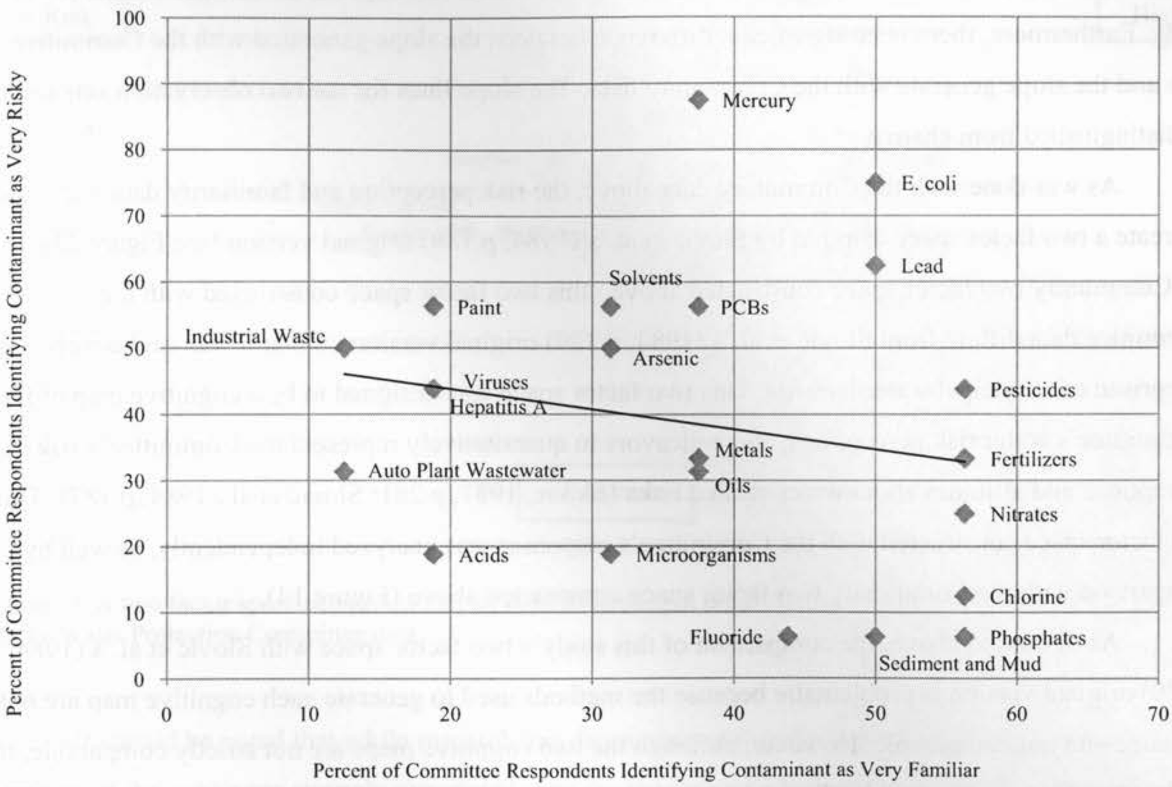


Figure 22: The relationship between the Committee respondents' risk perception of selected drinking water contaminants and their self-expressed familiarity with these contaminants.

As was the case with the analysis of the Community data above, a linear model has been used in an attempt to illustrate any relationship between the two variables. The linear model was chosen because the literature suggests a negative linear correlation (Blake, 1995, p.123). The slope (b) of the regression line in Figure 22 is -0.302 and the square of the correlation coefficient (R^2 value) is 0.043. Since the R^2 value is quite low, any existing correlation would be weak. That is, in this case, the low R^2 value shows that only a small fraction of the variability in the risk perception data can be explained by the variability in the familiarity data, indicating a weak correlation between the two variables. This is reflected by the fact that the data points are not in close proximity to the regresssion line.

However, no statistical tests were performed to determine the signicance of this slope compared to a slope of zero, so any statements regarding associations between familiarity and risk percepiton are not valid. In fact, as was the case with the Community data above, since the R^2 value is so low, it is very likely that this slope is not significantly different from zero (i.e. not statistically significant). Thus, although Figure 22 is included to visually represent the data, contrary to expectations based on the literature, a correlation between familiary and risk was not observed with the Committee results for this study. Furthermore, there is no significant difference between the slope generated with the Committee data and the slope generate with the Community data. The slope lines for the two observation sets cannot be distingiushed from chance.

As was done with the Community data above, the risk perception and familiarity data were used to create a two factor space inspired by Slovic et al.'s (1984, p.189) original version (see Figure 23). Like the Community two factor space constructed above, this two factor space constructed with the Committee data differs from Slovic et al.'s (1984, p.189) original version in that it was exclusively comprised of municipal water hazards. This two factor space was designed to be a cognitive map of the Committtee's water risk perceptions, and endeavors to quantitatively represent the Committee's risk perceptions and attitudes about water-related risks (Slovic, 1987, p.281; Slovic et al., 1984, p.187). This two factor space constructed with the Committee's responses was analyzed independently, as well by comparison with the Community two factor space constructed above (Figure 14).

As discussed above, the comparison of this study's two factor space with Slovic et al.'s (1984, p.189) original version is problematic because the methods used to generate each cognitive map are not the same and not comparable. However, although the two cognitive maps are not strictly comparable, this study's two factor space will be discussed in relation to Slovic et al.'s (1984, p.189) original version because Slovic et al.'s (1984, p.189) two factor space was the inspiration for this study's two factor space, which was developed to visually represent the data obtained from the surveys on the same axes that Slovic et al. (1984, p.189) used in their studies. Thus, while the two factor space presented below was inspired by Slovic et al.'s (1984, p.189) original version, is in no way methologically related to Slovic et al.'s (1984, p.189) two factor space, and was created for illustration purposes only.

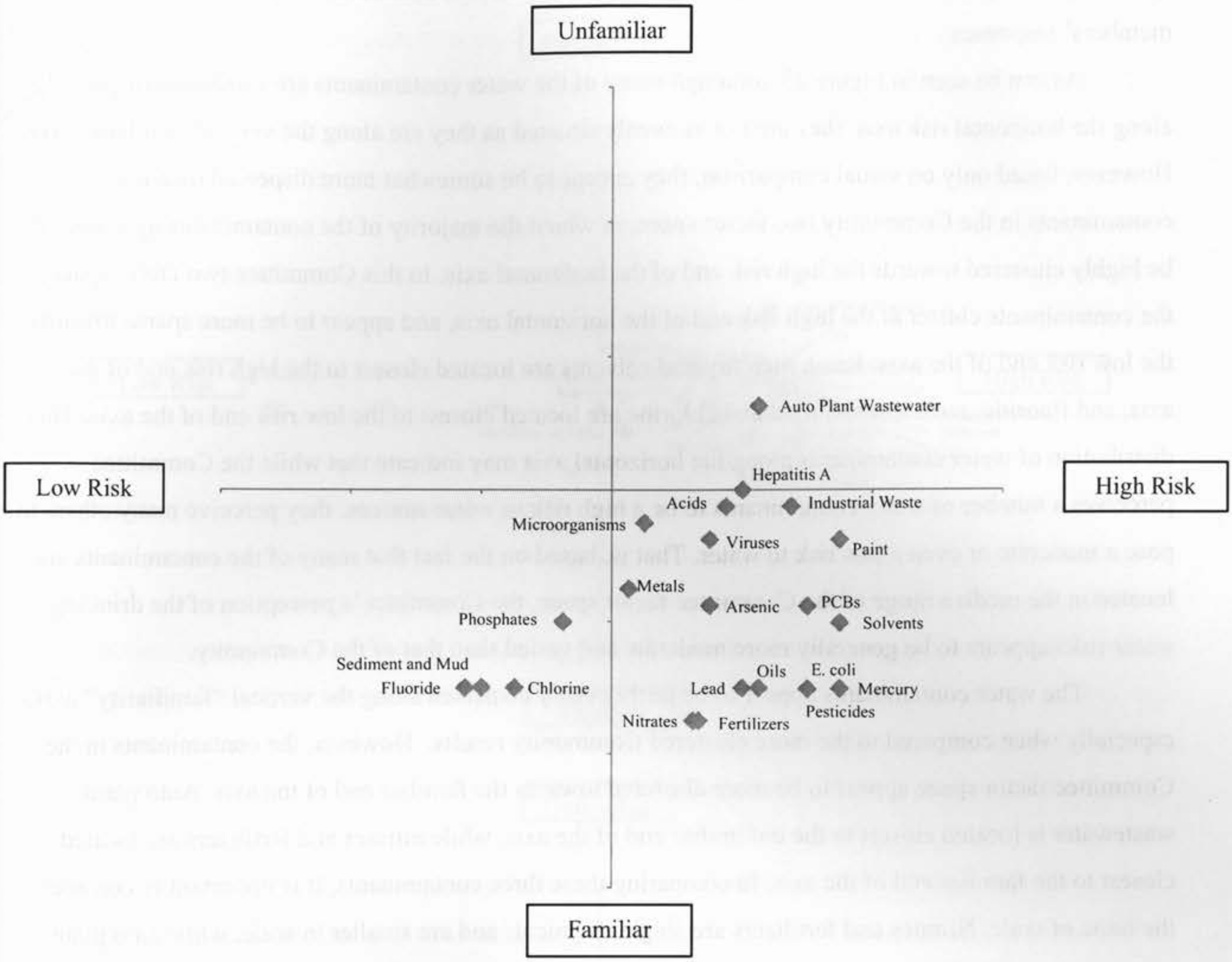


Figure 23: A two factor space comprised only of risks to municipal drinking water sources and constructed with the Source Water Protection Committee data

It should be noted that while research has demonstrated that the attitudes and perceptions of members of the public are strongly associated with the location of a hazard within the factor space depicted in Figure 3, this may not be the case for experts (Slovic, 1987, p.283; Slovic et al., 1984, p.189). Because experts tend to perceive risks in a more technical way, in terms of the product of magnitude and probability or expected annual mortality, the risk perceptions of experts do not tend to be closely related to any of the risk characteristics (e.g. "voluntary" or "controllable") or the factors derived from the characteristics ("dread risk" and "unknown risk"; Kasperson et al., 1988, p.177; Slovic & Weber, 2002, p.10). However, Slovic and Weber (2002, p.10) also state that the factor space depicted in Figure 3 has been replicated consistently across groups of experts as well as groups of laypeople. Thus, a two factor space inspired by Slovic et al.'s (1984, p.189) original version was constructed with the Committee members' responses.

As can be seen in Figure 23, although many of the water contaminants are somewhat dispersed along the horizontal risk axis, they are not as evenly situated as they are along the vertical familiarity axis. However, based only on visual comparison, they appear to be somewhat more dispersed than the contaminants in the Community two factor space, in which the majority of the contaminants appeared to be highly clustered towards the high risk end of the horizontal axis. In this Committee two factor space, the contaminants cluster at the high risk end of the horizontal axis, and appear to be more sparse towards the low risk end of the axis. Paint, mercury and solvents are located closest to the high risk end of the axis, and fluoride, sediment and mud and chlorine are located closest to the low risk end of the axis. This distribution of water contaminants along the horizontal axis may indicate that while the Committee perceives a number of water contaminants to be a high risk to water sources, they perceive many others to pose a moderate or even a low risk to water. That is, based on the fact that many of the contaminants are located in the median range of the Committee factor space, the Committee's perception of the drinking water risks appears to be generally more moderate and varied than that of the Community.

The water contaminants appear to be fairly evenly dispersed along the vertical "familiarity" axis, especially when compared to the more clustered Community results. However, the contaminants in the Committee factor space appear to be more clustered towards the familiar end of the axis. Auto plant wastewater is located closest to the unfamiliar end of the axis, while nitrates and fertilizers are located closest to the familiar end of the axis. In comparing these three contaminants, it is important to consider the issue of scale. Nitrates and fertilizers are single chemicals and are smaller in scale, while auto plant wastewater consists of the waste output from an entire industry, and is larger in scale. The differences in scale between contaminants is important to consider when such contaminants are discussed and compared.

The overall location of the contaminants in the two factor space appears to be a looser cluster towards the high risk end of the horizontal risk axis and the familiar end of the vertical familiarity axis. In other words, most of the contaminants are located in Quadrant 4: the high risk, high familiarity quadrant.

Figure 24 features the Committee and Community factor spaces adjacent to one another for comparison purposes. Although Slovic et al. (1984, p.189) did not include numerical axes in their two factor space, and numerical axes are not included in other two factor space diagrams in this report, numerical axes are included in the Committee and Community factor space diagrams in Figure 24. The purpose of including numerical axes in Figure 24 is to demonstrate that the Committee and Community factor space diagrams were created on the same scale and have identical origins (zero points) and extermities.

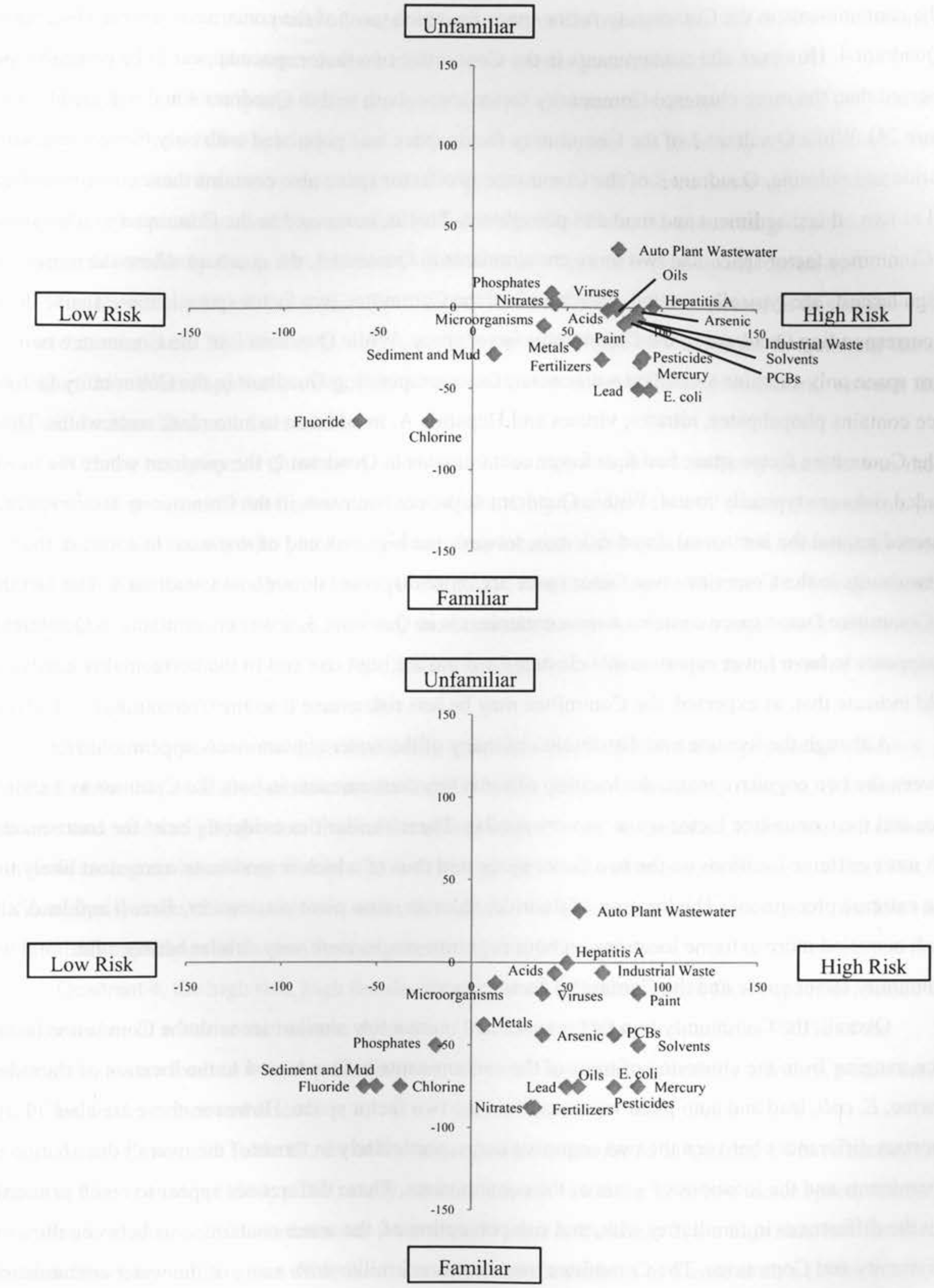


Figure 24: Comparison of the Community two factor space (top) and the Committee two factor space (bottom).

This general location of the contaminants in the Committee factor space is similar to the location of the contaminants in the Community factor space, in which most of the contaminants were also located in Quadrant 4. However, the contaminants in the Committee two factor space appear to be generally more dispersed than the more clustered Community factor space, both within Quadrant 4 and outside of it (see Figure 24). While Quadrant 3 of the Community factor space was populated with only two contaminants: fluoride and chlorine, Quadrant 3 of the Committee two factor space also contains these contaminants, as well as two others: sediment and mud and phosphates. That is, compared to the Community factor space, the Committee factor space had two more contaminants in Quatrant 3, the quadrant where the most benign hazards are typically located. Quadrant 2 of the Committee two factor space is more sparse than the corresponding Quadrant in the Community factor space. While Quadrant 2 of the Committee two factor space only contains auto plant wastewater, the corresponding Quadrant in the Community factor space contains phopshpates, nitrates, viruses and Hepatitis A, in addition to auto plant wastewater. That is, the Committee factor space had four fewer contaminants in Quadrant 2, the quadrant where the most dreaded risks are typically found. Within Quadrant 4, the contaminants in the Community factor space are clustered around the horizontal dread risk axis, towards the high risk end of that axis. In contrast, the contaminants in the Committee two factor space are more dispersed throughout Quadrant 4. The fact that the Committee factor space contains more contaminants in Quadrant 3, fewer contamiants in Quadrant 2, and appears to have fewer contaminants clustered around the high risk end of the horizontal risk axis could indicate that, as expected, the Committee may be less risk averse than the Community.

Although the location and distribution of many of the water contaminants appear to differ between the two cognitive maps, the location of some key contaminants in both the Community factor space and the Committee factor space is very similar. These similarities evidently exist for contamiants with more extreme locations on the two factor space and thus of which respondents were most likely to have extreme preceptions. The location of fluoride, chlorine, auto plant wastewater, *E. coli* and lead, all of which occupied more extreme locations on both cognitive maps, were very similar between the Community factor space and the Committee factor space.

Overall, the Community two factor space had quite a few similarities with the Committee factor space, ranging from the clustering of most of the contaminants in Quadrant 4 to the location of fluoride, chlorine, *E. coli*, lead and auto plant wastewater on the two factor space. However, there are also important differences between the two cognitive maps, particularly in terms of the overall distribution of contaminants and the locations of some of the contaminants. These differences appear to result primarily from the differences in familiarity with, and risk perception of, the water contaminants between the Community and Committee. The Committee may be more familiar with many of the water contaminants, and may be less risk averse for many of these water contaminants (i.e. the Committee may be less likely to identify many of the water risks as being very risky) than the Community. These differences in familiarity with, and risk perception of, water-related risks could translate into the different locations and configurations of the contaminants on each of the factor spaces generated in this study.

Like the Community two factor space, the water contaminants were also clustered in Quadrant 4 of the Committee two factor space, but to a somewhat lesser degree. As discussed above, this clustering was expected because the survey questions used to generate this study's two factor space required participants to respond by choosing one of only five categories. Thus, the observed grouping of contaminants was likely due to the extremely limited range of possible participant responses.

For the remainder of this section, the Committee two factor space generated in this study will be discussed in relation to Slovic et al.'s (1984, p.189) original version on a quadrant-by-quadrant basis (see Figure 25). Where applicable, similarities between the locations of analogous hazards on each factor space will be identified and discussed.

With the exception of Quadrant 1, Quadrant 2, the high risk, low familiarity quadrant was the least populated quadrant in the Committee factor space. Only one out of the 22 water contaminants (or 4.5% of the contaminants), auto plant wastewater, was located in this quadrant. This contaminant does not have an analogous hazard in Slovic et al.'s (1984, p.189) two factor space. The fact that this quadrant only contains one water contaminant indicates that the Committee may not perceive most water contaminants to be negative or particularly harmful. This finding is consistent with the expectation that the Committee may be less risk averse than the Community.

Quadrant 3, the low risk, high familiarity quadrant, was the second most populated quadrant. A total of 4 of the 22 (18.2%) contaminants are located in this quadrant, including fluoride, chlorine, sediment and mud and phosphates. Two of the contaminants found in Quadrant 3, fluoride and chlorine, both have analogous hazards in Slovic et al.'s (1984, p.189) study. However, in Slovic et al.'s (1984, p.189) analysis, water chlorination and water fluoridation were both located in Quadrant 1, the low risk, low familiarity quadrant of the two factor space (see Table 16).

Quadrant 4, the high risk, high familiarity quadrant of the Committee factor space contained the greatest number of water contaminants. A total of 17 out of the 22 contaminants (or 77.3% of the contaminants) were located in this quadrant. Some of these contaminants include mercury, pesticides, oils, PCBs, lead, nitrates and *E. coli*.

As can be seen in Table 17, six of the water contaminants found in Quadrant 4 have analogous hazards in Slovic et al.'s (1984, p.189) study. In Slovic et al.'s (1984, p.189) two factor space, mercury, pesticides, fossil fuels, PCBs and nitrates were are all found in Quadrant 2, the high risk, low familiarilty quadrant. This may indicate that while the Committee and the subjects of Slovic et al.'s (1984, p.189) study may have generally had similar perceptions of risk for these particular hazards, the Committee may

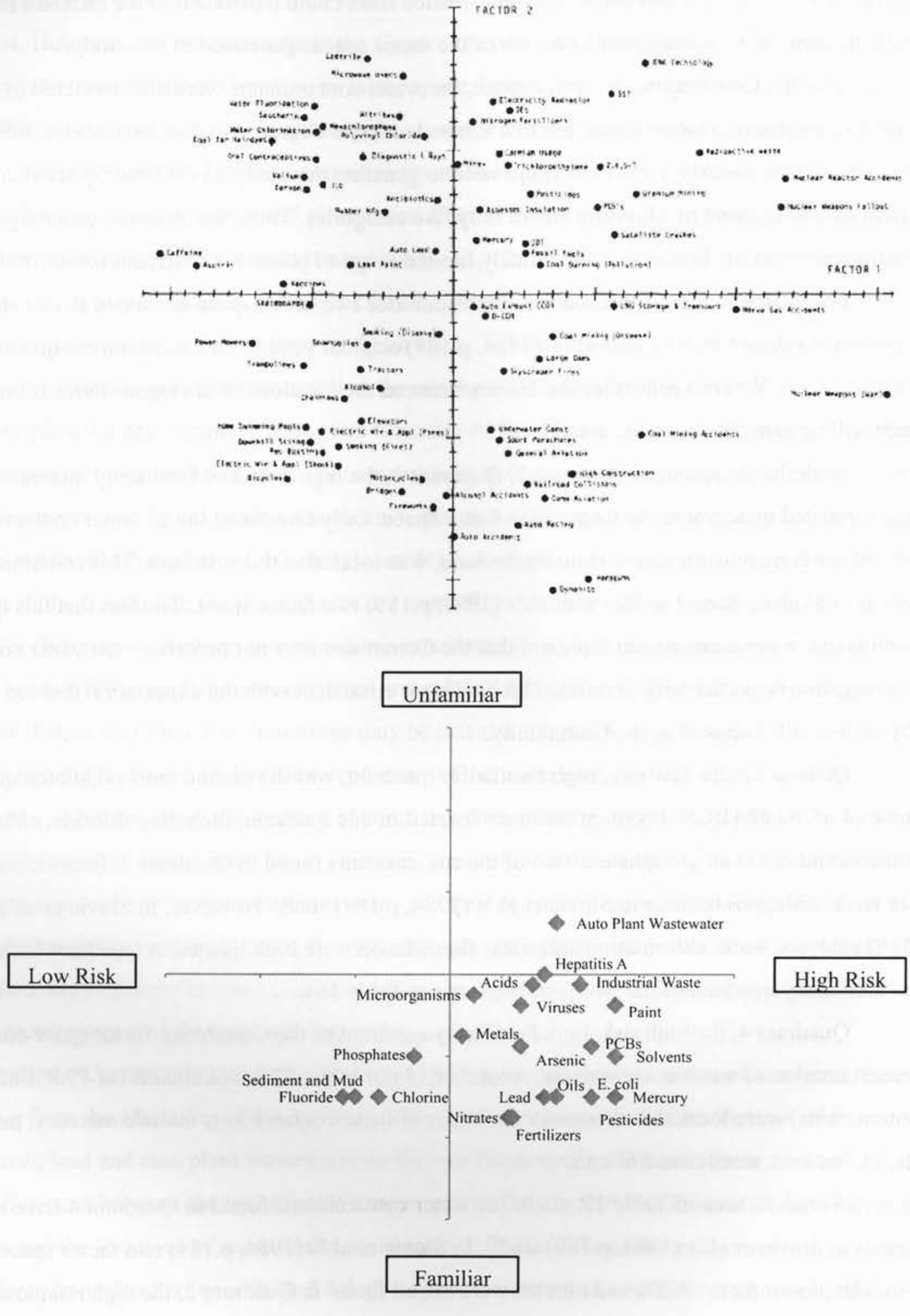


Figure 25: Slovic et al.'s (1984, p.189) original two factor space together with the two factor space comprised of municipal drinking water risks that was generated with the Source Protection Committee in this study

Table 16: A comparison between the location of a hazard found in Quadrant 3 of this study's Committee factor space and the location of an analogous hazard in Slovic's factor space.

Drinking Water-Related Risk	Comperable Hazard in Slovic's Study	Location in Water Risk Factor Space	Location in Slovic's Factor Space
Chlorine	Water Chlorination	Quadrant 3: Low Risk, High Familiarity	Quadrant 1: Low Risk, Low Familiarity
Fluoride	Water Fluoridation	Quadrant 3: Low Risk, High Familiarity	Quadrant 1: Low Risk, Low Familiarity

Table 17: A comparison between the location of hazards found in Quadrant 4 of this study's Committee factor space and the location of analogous hazards in Slovic's factor space.

Drinking Water-Related Risk	Comperable Hazard in Slovic's Study	Location in Water Risk Factor Space	Location in Slovic's Factor Space
Mercury	Mercury	Quadrant 4: High Risk, High Familiarity	Quadrant 2: High Risk, Low Familiarity
Pesticides	Pesticides	Quadrant 4: High Risk, High Familiarity	Quadrant 2: High Risk, Low Familiarity
Oils	Fossil Fuels	Quadrant 4: High Risk, High Familiarity	Quadrant 2: High Risk, Low Familiarity
PCBs	PCBs	Quadrant 4: High Risk, High Familiarity	Quadrant 2: High Risk, Low Familiarity
Lead	Lead Paint; Auto Lead	Quadrant 4: High Risk, High Familiarity	Quadrant 1: Low Risk, Low Familiarity
Nitrates	Nitrogen Fertilizers	Quadrant 4: High Risk, High Familiarity	Quadrant 2: High Risk, Low Familiarity

have been generally more familiar with these hazards, based on self-identified familiarity ratings. In Slovic et al.'s (1984, p.189) study, lead paint was found in Quadrant 1, the low risk, low familiarity quadrant. Thus, it appears that the Committee identified themselves as more familiar with lead and judged lead to be a higher risk than did Slovic et al.'s (1984, p.189) study participants.

This quadrant-based analysis of the Committee two factor space and Slovic et al.'s (1984, p.189) original two factor space has identified that, where comperable hazards exist, there appear to be a number of differences in the location of hazards between the two cognitive maps. Although it is likely that there are a number of reasons for these locational discrepancies, a major source may be a difference in familiarity with the hazards between the Committee, who self-rated their familiarity, and Slovic's participants. In general, the Committee and the participants of Slovic et al.'s (1984, p.189) study may have had similar perceptions of risk for the analogous hazards, but the Committee may have been more familiar with these hazards. In 7 out of the 8 cases (or 87.5% of cases) where the locations of analogous hazards differed, the Committee and Slovic's particpants had similar risk perceptions (i.e. both groups chose either "High Risk" or "Low Risk"). However, in every case where the locations of analgous hazards differed, the two groups had differing familiarity levels, with the Committee identifying that they were more familiar and Slovic's respondents being less familiar with the hazards. This difference in familiarity was anticipated because as experts, the Committee is expected to be more familiar with risks to drinking water than the respondents surveyed in Slovic et al.'s (1984, p.189) study. However, the apparently similar perceptions of the analagous risks between the Committee and Slovic et al.'s (1984, p.189) study participants was not necessarily anticipated. As experts, the Committee is expected to be less risk averse than Slovic et al.'s (1984, p.189) respondents, and thus perceive the water contaminants to be less risky.

The one hazard for which both risk perception and the familiarity differed between the Committee and Slovic et al.'s (1984, p.189) participants was lead. This outcome was not surprising, given the Region of Study's recent issues surrounding lead contaminated tap water, and the media coverage associated with the incident. However, it is possible that there are many other explanations for this outcome.

Additional Comments from Committee Respondents

This subsection will briefly discuss the written comments appended to surveys retruned by Committee participants. A complete list of all the comments that were made can be found in Appendix D.

A total of 7 out of the 16 completed surveys (or 43.8% of the completed surveys) included written comments. Four of the comments expressed dissatisfaction with the survey itself, with three of these comments stating that the survey was too general. One respondent identified septic systems as being the greatest threat to the water supply. Another respondent stated that all of the land uses and contaminants mentioned in the survey are potential threats to raw water quality. Finally, one comment stated that drinking water protection measures taken by property owners that exceed industry standards should be covered for increased operating costs or by compensatory losses.

6.3 Summary of the Results

As anticipated, the Community was generally risk averse, and identified *E. coli*, arsenic and industrial waste as the contaminants that pose the greatest threat to drinking water sources. Fluoride, chlorine and sediment and mud were considered to be the least risky drinking water contaminants. The Community identified that they were relatively familiar with the drinking water contaminants, based on respondents' self-expressed familiarity ratings. The Community identified *E. coli*, chlorine and lead as the most familiar water contaminants, and phosphates, auto plant wastewater and nitrates to be the least familiar contaminants. In general, the Community considered the land uses to be a moderate threat to water sources. They identified the chemical plant, liquid industrial waste storage and landfill to be the greatest threats to water, and the grain farm, house with septic system and storm water management system to be the least threatening land uses.

In an attempt to demonstrate a relationship between risk perception and familiarity with the Community data, the two variables were plotted against each other. Although a negative correlation between familiarity and risk perception was expected, no significant relationship between the two variables was identified.

As expected, the Community two factor space showed a tight cluster at the "High Risk" end of the horizontal axis, and near the center and approaching the "Familiar" end of the vertical axis. Most of the contaminants were clustered in Quadrant 4: the high risk, high familiarity quadrant. The observed clustering of contaminants is very likely attributable to characteristics of the survey itself. The survey questions used to generate this study's two factor space required participants to respond by choosing one of only five categories. Thus, the observed grouping of contaminants was likely due to the extremely limited range of possible participant responses. When analyzed together with Slovic et al.'s (1984, p.189) two factor space, it was apparent that, at least for comparable risks, the Community appeared to have similar risk perceptions to those of Slovic's respondents, but appeared to be more familiar with the hazards, based on the Community's self-expressed familiarity.

Compared to the Community, the Committee appears to have been generally less risk averse than the Community, for at least some of the contaminants. The Committee identified mercury, *E. coli* and lead as most risky to water, and phosphates, fluoride and sediment and mud as being least risky to water. The Committee appears to have been generally more familiar with some of the water contaminants than the Community. The Committee considered chlorine, nitrates, pesticides, fertilizers and phosphates to be most familiar to them, and auto plant wastewater and industrial waste to be the least familiar. The Committee appeared to be less averse to some of the land uses than the Community was, and generally identified them as being a low to moderate threat to water. The Committee identified the liquid industrial waste storage, chemical plant and sewage treatment plant as most threatening to water, and the auto plant, plastics production, dairy farm, above ground fuel storage facility, grain farm and electronics manufacturing as the least threatening land uses. These findings regarding the Committee's risk perception of and familiarity with the water contaminants, as well as judgments pertaining to the land uses were expected.

There was a statistically significant difference between the Committee and the Community's responses pertaining to the identification of contaminants as very risky for half of the contaminants (or 11 out of 22 of the contaminants). These contaminants were *E. coli*, acids, Hepatitis A, arsenic, industrial waste, pesticides, solvents, oils, auto plant wastewater, phosphates and PCBs. The Community had a significantly higher risk perception for all of these contaminants. There was a statistically significant difference between the Committee and the Community's responses pertaining to the identification of contaminants as very familiar for 5 out of 22 of the contaminants (or about 23% of the contaminants). These contaminants included sediment and mud, nitrates, pesticides, fertilizers and phosphates. The Community had a significantly lower self-expressed familiarity with all of these contaminants. There was a statistically significant difference between the Committee and the Community's responses pertaining to the identification of contaminants as an extremely high threat to water as well as either a very high threat or an extremely high threat to water (i.e. the combination of the two categories) for 2 out of the 13 land uses (or 15% of the land uses). The land uses were the liquid industrial water storage and chemical plant land uses. The Community considered both these land uses to be significantly more threatening to water.

Interestingly, 25% of the Committee members indicated that they were not sure to what degree Hepatitis A poses a risk to water, and nearly one third of the Committee members indicated that they were not sure to what degree electronics manufacturing threatens the quality of water sources. The differences between these responses and the corresponding responses of the Community were statistically significant. These results were not expected, and the reason for these outcomes is not clear. It could be that at this early stage of the source water protection planning process, the Committee members have not yet had the opportunity or the need to consider the potential threat to water posed by Hepatitis A and electronics manufacturing, and may not come across these threats in their respective fields.

In an attempt to demonstrate a relationship between risk perception and familiarity with the Committee data, the two variables were plotted against each other. Although a negative correlation between familiarity and risk perception was expected, no significant relationship between the two variables was identified. Furthermore, there is no significant difference between the slope generated with the Committee data and the slope generated with the Community data. The slope lines for the two observation sets cannot be distingiushed from chance.

Like the Community two factor space, the water contaminants in the Committee two factor space were located primarily in Quadrant 4, the high risk high familiarity quadrant. It was also identified that the Committee factor space contains more contaminants in Quadrant 3, fewer contamiants in Quadrant 2, and appears to have fewer contaminants clustered around the high risk end of the horizontal risk axis. This could indicate that, as expected, the Committee may be less risk averse than the Community. The location of some key contaminants occupying extreme locations on the two factor space, including fluoride, chlorine, auto plant wastewater, *E. coli* and lead, were very similar in both cogntive maps. However, as discussed above, any observed clustering of contaminants was likely due to the extremely limited range of possible participant responses in the survey. As expected, the Committee, like the

Community had risk perceptions that were similar to Slovic et al.'s (1984, p.189) research participants, but appear to have been more familiar with the hazards, based on the self-expressed familiarity of the Committee.

7. Discussion

The purpose of this section is to discuss how this study's findings about the risk perceptions and decision making processes of the Community and the Committee, as well as any discrepancies between each group, may affect the implementation of the *Clean Water Act* and source water protection planning in Ontario.

It is very important to keep in mind throughout this discussion that the results of this study being discussed are perceptions expressed by the respondents, and do not reflect actual, 'real' circumstances or events. It is also important to consider the limitations of the research results (outlined in Section 5) throughout this discussion, most notably the low response rate and associated sampling error.

7.1 Risk Perception

As discussed in Section 3, experts and laypeople tend to define risks differently (Slovic, 1987, pp.280,283; Slovic et al., 1984, p.187-188). The risk perceptions of members of the public tend to be sensitive to a number of factors, called outrage factors, and thus tend to differ from estimates of annual fatalities (Slovic, 1987, p.283; Slovic et al., 1984, p.187-188). However, experts typically perceive risks in a more technical way, defining risk based on estimates of annual fatalities or as the product of magnitude and probability (Kasperson et al., 1988, p.177; Slovic et al., 1984, p.193). Additionally, unlike experts, members of the public typically perceive the current levels of most risks as unacceptably high (Fischhoff et al., 1978, p.148; Slovic, 1987, p.283). Thus, not only were the risk perceptions of the Community expected to differ from those of the Committee due to the fact that each group was expected to define risks differently, but, compared with the Committee, the Community was expected to judge the contaminants and land uses in this study as posing a greater risk to water.

As expected, compared to the Committee, the Community appears to have perceived the contaminants in this study as posing a greater risk to water. Also as was expected, the Community perceived the land uses to pose a greater threat to water than did the Committee. The Community's apparent higher risk perception of both the water contaminants and the land uses may indicate that, as expected, the Community may perceive current risks to water as unacceptably high (Fischhoff et al., 1978, p.148; Slovic, 1987, p.283). Similarly, the Committee's lower risk perception of both the contaminants and land uses was also expected (Slovic, 1987, p.283; Slovic et al., 1984, p.187). This may indicate that it is not only possible that the Community and the Committee perceive risks in ways that are different and are typical and expected given each group's professional expertise, but also that the differences in the perception of water risks between experts and the public may be similar to differences in the perception of other types of risks.

This study also found that compared to the Committee, the Community identified themselves as being less familiar with risks to drinking water. However, in this study, the familiarity responses are stated beliefs and no evidence is presented regarding the actual familiarity of any of the respondents. Thus, this finding is based on the respondents' self-expressed familiarity, and not their actual, tested familiarity. Furthermore, it should be noted that the self-identified familiarity ratings of both the Committee and the Community may be inflated, as the literature indicates that all individuals tend to be overconfident in their judgments (Slovic et al., 1977, p.6).

Since the Committee is comprised of diverse local stakeholders who are appointed by the Region of Study's Source Protection Authority, the expertise of the Committee has been called into question (see Appendix A; Conservation Ontario, 2007b; Government of Ontario, 2007b, §2; Ministry of the Environment, 2007d; Ministry of the Environment, 2007f). The literature implies that while laypeople tend to perceive current levels of most risks as unacceptably high, experts do not (Fischhoff et al., 1978, p.148; Slovic, 1987, p.283). The Committee's apparent lower risk perception of threats to water may indicate that, at least in terms of this particular indicator, the Committee members responded to the survey in ways that would be expected of experts. This may also be consistent with the Committee's higher self-expressed familiarity with some of the water contaminants. Statistically significant differences in the two groups' responses pertaining to the identification of contaminants as very familiar include the following contaminants: sediment and mud, nitrates, solvents, fertilizers and phosphates. For these contaminants, there was a statistically significant difference in the two groups' responses, with the Committee identifying each of these contaminants as being significantly more familiar to them than did the Community. However, these self-identified familiarity ratings may be inflated (Slovic et al., 1977, p.6).

Although there were some similarities between the contaminants chosen as most and least risky to water, the public and the Committee did not identify all of the same contaminants as posing the most risk as well as the least risk to water sources. The two groups also showed some similarities in the land uses they chose as most and least threatening. However, as was the case with the risks, not all of the same land uses were perceived as most or least threatening. Statistically significant differences in the two groups' responses pertaining to the identification of contaminants as very risky include the following contaminants: *E. coli*, acids, Hepatitis A, arsenic, industrial waste, pesticides, solvents, oils, auto plant wastewater, phosphates and PCBs. For these contaminants, there was a statistically significant difference in the two groups' responses, with the Community identifying each of these contaminants as being significantly more risky than did the Committee. There were no statistically significant differences in the two groups' responses pertaining to the identifications of contaminants as posing a very high threat to drinking water. There were statistically significant differences in the two groups' responses pertaining to the identification of contaminants as posing an extremely high threat to drinking water for the liquid industrial waste storage and the chemical plant land uses. For these land uses, there was a statistically significant difference in the two groups' responses, with the Community identifying each of these land uses as being significantly more threatening to water than did the Committee.

The differences in some of the specific contaminants and land uses chosen by each group as most or least risky or threatening to water could potentially be explained by differences between experts and the public that are outlined in the literature. As mentioned above, the literature states that while the public typically defines water risks in terms of outrage factors, experts generally define water risks in a more technical way (Kasperson et al., 1988, p.177; Slovic, 1987, p.283; Slovic et al., 1984, p.187-188,193). It is possible that the Community and the Committee define water risks in these characteristic ways, which may account for the observed differences in contaminant and land use judgments. According to Slovic and Weber (2002, pp.10-11), many conflicts that occur between laypeople and experts pertaining to "the acceptability of particular risks are the result of different definitions of the concept of risk and thus often different assessments of the magnitude of the riskiness of a given action or technology, rather than differences in opinions about acceptable levels of risk". Thus, although this research does not provide any evidence for this argument, it could be that the Community and the Committee may be making different judgments about the magnitude of the riskiness of contaminants and land uses because they may be defining risks differently. In other words, it is possible that the Community and the Committee may have different risk perceptions because each group has a different definition of risk, and not because each group has a different opinion about acceptable risk levels. However, since many of the differences in the responses between the two groups were not statistically significant, these differences can be attributed to chance. There may also be a number of other factors that could have influenced the differences in responses, such as the different sample sizes of each group or whether the respondents completed the survey by mail or telephone.

In attempt to identify a relationship between familiarity and risk perception, the two variables were plotted against each other. Based on the literature, an inverse relationship between familiarity and risk perception was expected. It has been established by Slovic and others that the general public's perception of risk is based almost entirely on outrage factors (Slovic et al., 1984, p.193; Sly, 2000, p.154). Familiarity has been established as an outrage factor that can increase or decrease the public's perception of riskiness (Blake, 1995, p.123). Whereas familiarity has been shown to decrease the perceived risk among members of the public, lack of familiarity or unfamiliarity has been shown to increase the perceived risk (Blake, 1995, p.123). Since the literature suggests that only the public typically defines water risks in terms of outrage factors, a strong inverse relationship between familiarity and risk perception would have been expected for the Community data only (Kasperson et al., 1988, p.177; Slovic, 1987, p.283; Slovic et al., 1984, p.187-188,193). However, it is important to take into account the issue of causation. Just as it can be asserted that greater familiarity can decrease the perceived risk among laypeople, it can also be argued that a lower perceived risk can increase familiarity among laypeople.

For both the Committee and the Community data, a linear model was used in an attempt to illustrate any relationship between the two variables. The linear model was chosen because the literature suggests a negative linear correlation (Blake, 1995, p.123). However, no statistical tests were performed to determine the signicance of this slope compared to a slope of zero, and it is very likely that neither slope is significantly different from zero (i.e. the Committee and Community slopes are not statistically significant). Thus, a correlation between familiary and risk was not observed with the Community and Committee results for this study. Furthermore, there is no significant difference between the slope generated with the Committee data and the slope generate with the Community data. The slope lines for the two observation sets cannot be distingiushed from chance.

The Community's and the Committee's two factor space demonstrated both potential similarities and potential differences. Not only did the majority of contaminants in each factor space appear to be clustered in the same general location (i.e. Quadrant 4: the high risk, high familiarity quadrant), but the location of key contaminants on both cognitive maps appeared to be nearly identical. The nearly identical locations of key contaminants occupying extreme positions on the two factor space for both the Community and the Committee is an interesting result, particularly since the Committee's water risk perceptions were not expected to be strongly connected to any of the risk factors or characteristics within the two factor space (Slovic, 1987, p.283). These extreme locations of contaminants on both cognitive maps could potentially represent extreme perceptions about these water risks for both groups. For example, participants generally perceived fluoride and chlorine to pose almost no risk to drinking water, and auto plant wastewater to be very risky to drinking water. However, the distribution of contaminants differed in that the Community's contaminants appeared to be more tightly clustered than those of the Committee. The distribution of contaminants also differed in that the Committee factor space contained more contaminants in Quadrant 3, the quadrant where the most benign risks are typically located, and fewer contamiants in Quadrant 2, the quadrant where the most dreaded risks are typically found. The Committee factor space also appeared to have fewer contaminants clustered around the high risk end of the horizontal risk axis. These findings could indicate that, as expected, the Committee may have lower perceptions of water risks than the Community, as indicated by the location of more contaminants in positions on the factor space where less risky contaminants are typically found.

Both groups had risk perceptions that were similar to Slovic et al.'s (1984, p.189) research participants, but both indicated that they were more familiar with the hazards, based on self-expressed familiarity ratings. There are many potential explanations for observed differences in familiarity. It is possible that this study's respondents perceived the risks that they were asked about to be more familiar to them because they were instructed to consider the risks within the context of municipal drinking water. Thus, the observed differences in familiarity could be a framing issue. Alternately, as Nevitte (1996, pp.55,67) points out, the Canadian public is increasingly educated and the gap in expertise between experts and the public is narrowing. This trend could potentially explain why the respondents of this 2008 study identified that they are more familiar with the water risks than Slovic et al.'s (1984, p.189) respondents were about 24 years ago. However, this is just one of many potential explanations for the observed differences. Since this research provides no evidence or concrete explanations, no conclusions can currently be drawn about these observed differences.

The risk perception literature establishes that the public is generally willing to accept voluntary risks approximately 1000 times greater than involuntary risks (Starr, 1969, p.1237). This suggests that the Community is expected to be more willing to accept water risks that they perceive to be voluntary, as opposed to involuntary risks (Starr, 1969, p.1237). Based on some of the comments made by Community respondents, the public may feel that they have little or no control over the contaminants present in their water, beyond the choice of whether to drink municipal water at all. That is, the Community could perceive nearly all of the contaminants found in their municipal water to be involuntary risks. Since involuntariness is an outrage factor that increases risk perception, this variable may contribute to the potentially higher risk perceptions indicated by the Community's survey responses, and the corresponding distribution of hazards on the Community two factor space (Blake, 1995, p.123).

The risk perception literature also stated that the public awareness of an activity's benefits, which can be determined by usefulness, advertising or the number of participants, can influence the social acceptance of the corresponding risk (Starr, 1969, p.1237). This may indicate that the Community's awareness of the benefits of contaminants and land uses that may affect water is expected to influence their acceptance of the risks (Starr, 1969, p.1237). This may at least partially explain the location of chlorine and fluoride on the Community two factor space, assuming that the public is aware of the benefits of adding these chemicals to water. Interestingly, these are the only two contaminants included in this study that are purposefully added to drinking water, due to the human health benefits that they provide (USEPA, 2008). This may also explain the relatively small percentage of Committee and Community respondents that classified such ostensibly beneficial land uses as grain farms, septic systems and storm water management systems as posing a very high or extremely high threat to drinking water. It is also possible that respondents would be particularly accepting of those contaminants and land uses that are of direct personal benefit to them (e.g. farms for farmers or septic systems), particularly since this may increase benefit awareness.

7.2 Risk-Based Decision-Making

Under Ontario's new *Clean Water Act*, the Source Protection Committees are expected to identify and evaluate risks to municipal drinking water (Ministry of the Environment, 2006a, p.1). The Committee, in conjunction with the Community, must not only create a list of contaminants and land uses that threaten drinking water sources, but must also prioritize these risk agents and sources based on the degree to which they threaten drinking water sources and the remediation required to address them. Committees must also determine which risks are important and require prompt action, which risks require observation to make sure they do not become significant, and which risks are insignificant (Ministry of the Environment, 2006a, p.1).

The prioritization of water risks differed between the Community and the Committee. Although in some cases, one or two of the same risks appeared in the top or bottom three items in the rating, the rating of the risks was different for each group. However, not all of the differences in rating between the two groups were statistically significant. Throughout the source water protection planning process, these discrepancies in risk ratings between the two groups could be important, if only for those differences that were statistically significant, if they ultimately influence the source protection process as a whole, as well as the decisions that are made throughout this process. The Committee, in conjunction with the Community, must complete a proposed assessment report which identifies, evaluates and rates risks to source water based on the magnitude of the risks and the extent of any remediation required to address them (Ministry of the Environment, 2006a, p.1). These risk ratings may be reflected in decisions made by the two groups through the source protection plan, which outlines how risks identified in the assessment report will be addressed (Ayres, n.d., p.4; Legislative Assembly of the Province of Ontario, 2006, §22; Ministry of the Environment, 2006a, p.1). If the rating of risks differs between the Committee and the Community, this could pose challenges to the source water protection process, which requires the cooperation and collaboration of the two groups.

One significant difference in the prioritization of risks was the risk rating assigned to *E. coli* by the Community and the Committee, respectively. While the Community perceived *E. coli* to be by far the most risky water contaminant and rated it accordingly (with 92.6% of Community members identifying it as very risky), the Committee rated *E. coli* to be the second most risky water contaminant, after mercury (with only 75.0% of Committee members identifying it as very risky). The difference between these responses is statistically significant. It seems as though the Walkerton tragedy may not be as prominent in the collective consciousness of Committee experts as it may be in that of the Community. The reason for this difference between the Community and Committee responses is not known. However, discrepancies between the Community and the Committee in the prioritization of key risks such as *E. coli* could lead to contentious situations between Committees and the public throughout the source water protection planning process.

These differences in the priority of risks between the Community and the Committee could indicate that each group has different preferences and may be making different choices about at least some of the risks. This result is consistent with Social Decision Theory, which suggests that in the absence of manipulation or trade-offs, it may not ultimately be possible for a group to make collective democratic social choices that are fair and that represent the individual preferences of the group members (Hansson, 1994, p.81; Sager, 2002, pp.7,14,17,179). Since the rating of some of the risk agents and sources differed significantly between the Community and the Committee, in the absence of manipulation, or at the very least trade-offs, it may not be possible for the Committee and the Community to make a collective social choice about these water risks that amalgamates the diverse preferences of each group and their members, and is fair and consistent (Hansson, 1994, p.81; Sager, 2002, p.17). Any collective decision made about water risks for which there were significant differences in the responses of each group could be inconsistent, arbitrary, subject to manipulation, based on trade-offs and/or the result of unfair procedure (Hansson, 1994, p.81; Sager, 2002, pp.7,14,17,179). However, this may not be the case for the many risk agents and sources for which there was no significant difference in the responses of the two groups. For these risks, it may in fact be possible for the Committee and the Community to make a collective social choice that amalgamates the diverse preferences of each group and their members, and is fair and consistent (Hansson, 1994, p.81; Sager, 2002, p.17). Thus, it is plausible that some risk agents and sources may pose greater challenges to the source water protection planning process than others.

Therefore, it is conceivable that at the very least, trade-offs could be required in order for the Committee, either alone or in conjunction with the Community to make collective decisions about water risks. Although some water risk ratings differ significantly between the Community and the Committee, many of them did not. In fact, one or two of the same risks appeared in the top or bottom three items in each of the ratings (see Tables 10 and 14). For example, both groups chose *E. coli* as one of the top three most risky water contaminants, even though there was a significant difference in the responses, and the Community rated it as first most risky to water while the Committee rated it as second. This indicates that although the actual risk ratings differed between the Community and the Committee, in many cases, the two groups had somewhat similar preferences regarding the riskiness of the contaminants and land uses. Indeed, it is not clear how differences in the degrees of risk perception translate into conclusions regarding the actual effectiveness of the two groups in achieving the goals of the *Clean Water Act*. For example, if both groups rate *E. coli* within the top two most risky contaminants, does it matter that 92.6% of the Community and only 75% of the Committee identified it as very risky, even if this difference was significant? This will remain to be seen throughout the implementation of the *Clean Water Act*. However, despite the fact that collective decision making without trade-offs may not be entirely possible for all risks, the observed similarities in risk ratings may facilitate compromise and lead to water risk decisions that may roughly approximate the preferences of each group, as well as the majority of the members of each group.

One interesting result of the Committee land use rating was that nearly one third of the Committee members (specifically, 31.3% of the Committee members) indicated that they were not sure to what degree electronics manufacturing threatens the quality of drinking water sources. In comparison, only 19 out of 173 of the Community members (or about 11% of the Community members) indicated that they were not sure to what degree electronics manufacturing threatens water quality. The difference between these responses is statistically significant. This result was not expected, and the reason for this outcome is not clear. It could be that at this early stage of the source water protection planning process, the Committee members, none of whom appear to be in any way affiliated with the electronics sector, have not yet had the opportunity or the need to consider the potential threat to water posed by electronics manufacturing. Since the risk agents and sources included in this study were chosen based on the Ministry of the Environment's threats to water inventory, the contaminants and land uses in this study, including the electronics manufacturing land use, closely approximate the risks that the Committee will soon need to consider and address (Fletcher, 2006; Ministry of the Environment Technical Studies, 2006). It is anticipated that by raising awareness of potential issues that could affect the source protection planning process in the Region of Study, such as this finding relating to the electronics manufacturing land use, this research may support the Committee and the Community in preparing for the upcoming stages of the source protection process.

7.3 Implications for Source Water Protection Planning in Ontario

This study's findings and their implications suggest that conflicts about risk may arise throughout Ontario's source water protection process. It appears that the perceptions of drinking water-related risks differ between the Community and the Committee. However, only some of these differences are statistically significant. These differences, particularly those that are statistically significant, may be crucial because the process of locally identifying risks to water may depend on agreement on the water risk perceptions of the Community and the Committee. One consequence of these differences is that local perceptions of water-related risk could influence the outcome of the anticipated negotiations between the Committee and the Community. Local risk perceptions may potentially obscure the scientific basis of a given water risk, resulting in inappropriate responses to the risk. If the response of the Community and/or of the Committee to a specific local drinking water risk is greater or lesser than the particular risk calls for, or if there are discrepancies between the responses of the two groups, there could be important differences in municipal source water protection, the reduction of drinking water risk, and ultimately the quality of water and the health of Ontarians. In particular, based on the lower risk perceptions of the Committee, it is plausible that the Committee may potentially underestimate water risks, a scenario that could have negative consequences for management. However, no direct evidence for this potential underestimation of water risks has been provided by this research.

Observed significant differences in water risk ratings indicate that it may not be possible for the Committee and the Community to make a collective social choice about some water risks that amalgamates the diverse preferences of each group and their members, and is fair and consistent (Hansson, 1994, p.81; Sager, 2002, p.17). Such decisions could be inherently inconsistent and arbitrary (Sager, 2002, p.7). At the very least, trade-offs may be required before any collective decisions are made about the risks (Sager, 2002, p.17). Such compromises could not only be detrimental to the decision-making process, but could also have negative ramifications for the source water protection process in Ontario. Making decisions about which risks to water are most threatening and which are not significant through compromises such as trade-offs could potentially be problematic. However, this may not be the case for the many risk agents and sources for which there was no significant difference in the responses of the two groups. For these risks, it may be possible for the two groups to make a collective social choice that amalgamates the diverse preferences of each group and their members, and is fair and consistent (Hansson, 1994, p.81; Sager, 2002, p.17).

Successful source water protection in the Region of Study and across Ontario will depend on the Community and the Committee making decisions about risks to drinking water sources that are appropriate. As discussed in Subsections 3.2 and 3.3, this will require effective risk communication between the Community and the Committee in order to build trust between the two groups. Since the membership of the Committee reflects the interests of municipalities as well as that of other non-governmental interest groups, the literature suggests that the Committee may, to some degree, encounter challenges as a result of the Canadian public's declining confidence and deference in traditional political institutions and, to a lesser extent, in nongovernmental institutions (Government of Ontario, 2007b, §2; Nevitte, 1996, pp.55,59,67). Conversely, the public may embrace this new opportunity to participate in public life. This process is particularly interesting and important because while the public's trust in a number of different information sources is well documented (see Subsection 3.3), trust and confidence remains untested for Source Water Protection Committees.

8. Conclusion

This study is a first examination of expert and lay perceptions of municipal drinking water-related risks in Ontario. The results of this study have direct policy relevance, and have important implications for the implementation of Ontario's *Clean Water Act*. This study found that there may be differences in the perceptions of risks to municipal drinking water sources. While the Community appears to be highly risk averse and as a result could potentially overestimate water risks, the Committee appears to be less risk averse and thus could possibly underestimate these water risks. Although no evidence for potential overestimation or underestimation of water risks has been provided by this research, it is important to consider these possibilities. While both overestimation and underestimation may be detrimental to the source water protection process, underestimation could be particularly problematic. Acknowledging and addressing these important differences throughout the decision-making process is the first step towards making appropriate decisions about water risks.

These results indicate that there may be sources of conflict in Ontario's source water protection process. These weaknesses could ultimately result in the Committee and Community making collective decisions about water threats that underestimate risks. However, by raising awareness of these potential weaknesses, this study endeavors to provide an advantage to the Committee members and Community members charged with making crucial decisions about water risks. By being conscious of these potential weaknesses at the outset of the source water protection process and before any decisions about water risks have been made, the Committee and the Community can ensure that appropriate decisions are made about risks to drinking water in spite of these weaknesses. Although it may seem that there is little for the Committee to learn about source water protection in the Region of Study given its high self-expressed familiarity with the contaminants and land uses in the survey, it is important to remember that this research pertains to the respondents' self-identified familiarity, and not their actual, tested familiarity. There will likely be many opportunities for both the Committee and the Community to learn about local source water protection as the process unfolds.

Although this study has addressed some of the risk perception and decision-making problems that relate directly to source water protection planning in one Ontario community, many questions remain. Suggestions for future research therefore include a more extensive examination of the similarities and differences in the risk perceptions of the Source Protection Committees and the public across Ontario. A fuller examination of the differences between the risk perceptions of Source Protection Committees and the public is needed. Additionally, it would be useful to examine the role of other important factors that were not directly addressed by this research, such as socio-cultural factors. These factors could affect the Community and the Committee's perception of risks, and perhaps ultimately the implementation of the

Clean Water Act. It would also be interesting to determine whether the risk perceptions of the Committee and the Community in this study correlate with estimates of annual fatalities or some other measure of objective risk, as predicted by Slovic and others (Slovic, 1987, pp.280,283; Slovic et al., 1984, p.187). Furthermore, future research is also needed to establish a better understanding of the decision-making processes of Source Protection Committees and the public, as well as how and why these processes differ. This entails future examination or monitoring of the source water protection decision-making process and the role of public input in this process. Given the shortcomings of this study, notably the low response rate and associated sampling error, this study would be considerably strengthened by any and all of the above suggested future research.

This process of source water protection under the *Clean Water Act* is at its inception. The Source Protection Committees have just submitted the proposed Terms of Reference to the Source Protection Authority/ Authorities and have completed their public comment periods (Conservation Ontario, 2008b). Soon, the Source Protection Committees may be faced with source water risk issues and decisions similar to the ones discussed in this study. While this study is topical and is relevant to current legislative and policy developments, there is little that is currently known about the source water protection process in practice. It is for this reason that it will be fascinating to study the effectiveness of the source water protection process as it matures. It will also be interesting to learn about the levels of trust and deference that the public develops for their regional Source Water Protection Committees. It will be especially informative to learn about the degree to which the public is involved in source water protection decisions, as well as the degree to which differences in risk perceptions and decision-making processes influence the effectiveness of the source water protection process. Perhaps most importantly, although this study determined that conflicts may arise, and gives clues about difficulties with resolving them, it did not explicitly identify the potential conflicts between the Committee and the Community. Thus, it will be important to learn about the future sources, nature and resolution of conflicts between the Committee and Community throughout the source water protection process.

The protection of municipal drinking water sources is fundamental to the integrity of ecosystems, the quality of drinking water and the health and wellbeing of Ontarians. Successful source water protection in the Region of Study and across Ontario will depend on the ability of the Source Protection Committees and the public to collectively make decisions about risks to municipal drinking water sources that are appropriate. Although there are considerable obstacles to making appropriate choices about risks to water, knowledge of these challenges is the first step to overcoming them.

Appendix A: Expertise of each of the members of the Region of Study's Source Water Protection Committee

Table A: Expertise of the Region of Study's Source Water Protection Committee members. The identities of the members of the Source Water Protection Committee, as well as the Committee itself has been made confidential at the request of the Committee.

Source Protection Committee Member	Expertise
Committee Member 1	A member of the Region of Study's Clean Water Program Committee; Farmer
Committee Member 2	Drainage Superintendant; Farmer
Committee Member 3	Municipal Watershed Program Manager ; Planner; Author; Instructor; Bachelors and Masters degrees in science
Committee Member 4	Mayor of a city in the Region of Study
Committee Member 5	Self employed: management consulting and property management; Degree in Geography
Committee Member 6	Municipal Councilor; Conservation Programs Specialist
Committee Member 7	Municipal Manager of Water Treatment and Distribution
Committee Member 8	Prior municipal/ political experience
Committee Member 9	Farmer; Independent Crop Consultant ; Bachelor of Science in Agriculture
Committee Member 10	Farmer; Bachelor of Science in Chemistry
Committee Member 11	Farmer; President of a Federation of Agriculture in the Region of Study
Committee Member 12	General Manager of an Environmental Association in the Region of Study; Bachelors Degree in Environmental Studies
Committee Member 13	Executive member of the Ontario Groundwater Association; Owner of a farming operation; President of a Consulting Company; Bachelor of Arts Degree in Sociology and History
Committee Member 14	Consultant; President of a not-for-profit housing corporation
Committee Member 15	Executive member of the Ontario Petroleum Institute, Inc.; Executive member of the Oil Gas Salt Resources Library
Committee Member 16	Golf course operator
Committee Member 17	Farmer
Committee Member 18	Lawyer
Committee Member 19	Farmer; Chair of a Stewardship Network in the Region of Study; On a committee for stewardship projects
Committee Member 20	Professional Planner for a Municipality in the Region of Study
Committee Member 21	Professor Emeritus of Pharmacology and Toxicology
Committee Member 22	Previously worked as a General Manager of Public Utilities for a Municipality
Committee Member 23	Committee Liaison; No information available

Appendix B: Descriptions of the human health effects of drinking water contaminants and associated land uses included in this study. These descriptions attempt to approximate the "objective" risk associated with the contaminants and land uses.

Table Bi: The sources and possible human health effects of ingesting the drinking water contaminants that comprise the survey

Drinking Water Contaminant	Possible Health Effects (Oral Route)	Sources of the Drinking Water Contaminant
	Microorganisms	
E. coli	Indication of presence other possibly harmful bacteria	Animal and human fecal waste
Hepatitis A	Appetite loss; tiredness; fever; abdominal pain; nausea; dark urine; jaundice. The virus does not cause chronic damage and typically is not fatal	Feces of infected individuals; more prevalent "under poor sanitary conditions and when good personal hygiene is not practiced"
Microorganisms	Gastrointestinal illness and associated headaches	Exist naturally in the environment; animal and human fecal waste
Viruses	Gastrointestinal illness	Animal and human fecal waste
	Disinfectants[15]	
Chlorine (Cl_2)	Stomach discomfort; irritation of the eyes and/or nose	Added to water in order to control microorganisms
	Inorganic Chemicals	
Arsenic	Circulatory system malfunction; skin problems; possible increased cancer risk	Runoff from electronics production wastes, glass production wastes and orchards; natural deposit erosion
Fluoride	Mottled teeth in children; bone disease	Added to drinking water to increase the strength of teeth; discharge from aluminum and fertilizer factories; natural deposit erosion
Lead	Physical and mental developmental delays and minor deficits in learning ability and attention span in children; high blood pressure and kidney problems in adults	Corrosion of water distribution system; natural deposit erosion
Mercury	Damage to kidneys	Cropland and landfill runoff; factory and refinery discharge; natural deposit erosion
Metals	Kidney damage; blood pressure increase; circulatory problems; intestine or liver problems; etc.	Discharge from industrial processes; leaching from distribution systems and natural formations
Nitrates	Blue-baby syndrome and shortness of breath in infants younger than six months of age	Fertilizer runoff; septic tank leaching; natural deposit erosion
Phosphates	In concentrations above 1.0 mg/L, may disrupt water treatment plant coagulation processes, thus obstructing the removal of microorganisms which may be potentially harmful (see "Microorganisms" above)	Runoff from agricultural lands where fertilizers have been applied; manufacturing and other industrial processes; natural deposit erosion and overland runoff
	Organic Chemicals	
Oils	Various, including: diarrhea; vomiting; drowsiness;	Leaks in storage tanks; spills

[15] Also, see "Acids" for a discussion of the disinfection by-products Haloacetic acids

	coughing; restlessness; irritability; cramps; stomach swelling; breathing problems; coma; death; leukemia (due to long term benzene exposure). "High level" or long-term exposure can cause: damage to liver and kidneys; damage to nervous system; decreased blood clotting; increase in blood pressure	
PCBs	Problems with skin, thymus gland, nervous system, reproductive system and immune system; increased cancer risk	Waste chemical discharge; landfill runoff
Pesticides	Increased cancer risk; reproductive difficulties; liver, adrenal gland, kidney problems; problems with cardiovascular system; cataracts; gastrointestinal problems; nervous system problems; etc.	Runoff from crops and other agricultural operations
	Other	
Acids	Water with a low pH can leach metal ions from aquifers and distribution systems (see "Metals" above). There are a variety of different acid contaminants which have different corresponding health effects. The only acids identified by the EPA as a drinking water contaminants are the disinfection byproducts Haloacetic acids which increase cancer risk	Haloacetic acids are drinking water disinfection byproducts
Auto Plant Wastewater	Various[16], including: cancer; damage to nervous system and liver; kidney damage; damage to blood cells; damage to circulatory system; diarrhea; vomiting; drowsiness; coughing; restlessness; irritability; cramps; stomach swelling; breathing problems; coma; death; decreased blood clotting; increase in blood pressure	Runoff/ discharge from automotive factories, repair shops and body shops
Fertilizers	Various[17], including: Thyroid problems; nerve damage; bone disease; "blue-baby syndrome"; shortness of breath; mottled teeth in children	Factories; agricultural application; runoff
Industrial Waste	Various[18], including: increased cancer risk; liver damage; kidney damage; damage to circulatory system; anemia; blood changes; spleen damage; stomach problems; problems with immune system; damage to the nervous system; irritation of the gastrointestinal system; dental and skeletal fluorosis	Discharge from industrial processes

[16] Auto plant wastewater contains a number of different contaminants, including paints, solvents, acids and oils. The health effects of these substances have been used to approximate the health effects of auto plant wastewater (Oregon Department of Environmental Quality, n.d.)

[17] Fertilizers include a number of ingredients, including Fluoride, Cyanide, Nitrite, and Nitrates. The health effects of these substance have been used to approximate the health effects of fertilizers (USEPA, 2008; Wilkes University, n.d.a)

[18] Discharge from industrial activities includes a wide variety of contaminants, including Carbon Tetrachloride, o-Dichlorobenzene, p-Dichlorobenzene, 1,2-Dichloroethane, 1,1-Dichloroethylene, cis-1,2-Dichloroethylene, trans-1,2-Dichloroethylene, 1,2-Dichloropropane, Epichlorohydrin, 1,1,2-Trichloroethane, lead, copper, Fluoride and Benzene. The health effects of these substances have been used to approximate the health effects of industrial waste (USEPA, 2008; Wilkes University, n.d.a)

Paint	Various[19], including: cancer; damage to nervous system and liver; kidney damage; damage to blood cells	Spills and leaks; industrial processes
Sediment and Mud	Associated with higher levels of pathogenic microorganisms which may cause gastrointestinal illness and associated headaches	"Soil runoff"
Solvents	Various[20], including: cancer; liver damage; damage to the kidneys, circulatory system and nervous system	Industrial processes; chemical plant discharge

(Adapted from Canadian Centre for Occupational Health and Safety, 2008; Oregon Department of Environmental Quality, n.d.; USEPA, 2008, Wells, 2008; Wilkes University, nd.a.; Wilkes University, n.d.b.; Wisconsin Department of Health Services, 2004)

Table Bii: The drinking water contaminants that are associated with the land uses comprising the survey, and possible human health effects of ingesting those contaminants

Land Use	Drinking Water Contaminants Associated with Land Use	Possible Health Effects (Oral Route)
		Agricultural
Farm with Livestock Feedlot	*E. coli*	Indication of presence other possibly harmful bacteria
	Microorganisms	Gastrointestinal illness and associated headaches
	Viruses	Gastrointestinal illness
	Nitrates	Blue-baby syndrome and shortness of breath in infants younger than six months of age
	Phosphates	In concentrations above 1.0 mg/L, may disrupt water treatment plant coagulation processes, thus obstructing the removal of microorganisms which may be potentially harmful (see "Microorganisms" above)
	Pesticides	Increased cancer risk; reproductive difficulties; liver, adrenal gland, kidney problems; problems with cardiovascular system; cataracts; gastrointestinal problems; nervous system problems; etc.
	Fertilizers	Various, including: Thyroid problems; nerve damage; bone disease; "blue-baby syndrome"; shortness of breath; mottled teeth in children
Dairy Farm	*E. coli*	Indication of presence other possibly harmful bacteria
	Microorganisms	Gastrointestinal illness and associated headaches
	Viruses	Gastrointestinal illness
	Nitrates	Blue-baby syndrome and shortness of breath in infants younger than six months of age
	Phosphates	In concentrations above 1.0 mg/L, may disrupt water treatment plant coagulation processes, thus obstructing the removal of microorganisms which may be potentially harmful (see "Microorganisms" above)
	Pesticides	Increased cancer risk; reproductive difficulties; liver, adrenal gland, kidney problems; problems with cardiovascular system; cataracts; gastrointestinal

[19] Paint includes a number of ingredients, including Benzene, 1,2-Dichloroethane, 1,1-Dichloroethylene, 1,1,1-Trichloroethane, Cadmium, o-Dichlorobenzene and Xylenes. The health effects of these substances have been used to approximate the health effects of paint exposure (USEPA, 2008; Wilkes University, n.d.a)

[20] There are a number of different types of solvents, including Carbon Tetrachloride, cis-1,2-Dichloroethylene, trans-1,2-Dichloroethylene, 1,2-Dichloropropane and Tetrachloroethylene. The health effects of these substances have been used to approximate the health effects of solvents (USEPA, 2008; Wilkes University, n.d.a)

		problems; nervous system problems; etc.
	Fertilizers	Various, including: Thyroid problems; nerve damage; bone disease; "blue-baby syndrome"; shortness of breath; mottled teeth in children
Grain Farm	Pesticides	Increased cancer risk; reproductive difficulties; liver, adrenal gland, kidney problems; problems with cardiovascular system; cataracts; gastrointestinal problems; nervous system problems; etc.
	Fertilizers	Various, including: Thyroid problems; nerve damage; bone disease; "blue-baby syndrome"; shortness of breath; mottled teeth in children
	Nitrates	Blue-baby syndrome and shortness of breath in infants younger than six months of age
	Phosphates	In concentrations above 1.0 mg/L, may disrupt water treatment plant coagulation processes, thus obstructing the removal of microorganisms which may be potentially harmful (see "Microorganisms" above)
Above Ground Fuel Storage Facility	Oils	Various, including: diarrhea; vomiting; drowsiness; coughing; restlessness; irritability; cramps; stomach swelling; breathing problems; coma; death; leukemia (due to long term benzene exposure). "High level" or long-term exposure can cause: damage to liver and kidneys; damage to nervous system; decreased blood clotting; increase in blood pressure
		Industrial
Auto Plant	Oils	Various, including: diarrhea; vomiting; drowsiness; coughing; restlessness; irritability; cramps; stomach swelling; breathing problems; coma; death; leukemia (due to long term benzene exposure). "High level" or long-term exposure can cause: damage to liver and kidneys; damage to nervous system; decreased blood clotting; increase in blood pressure
	Solvents	Various, including: cancer; liver damage; damage to the kidneys, circulatory system and nervous system
	Acids	Water with a low pH can leach metal ions from aquifers and distribution systems (see "Metals" above). There are a variety of different acid contaminants which have different corresponding health effects. The only acids identified by the EPA as a drinking water contaminants are the disinfection byproducts Haloacetic acids which increase cancer risk
	Paint	Various, including: cancer; damage to nervous system and liver; kidney damage; damage to blood cells
	Auto Plant Wastewater	Various, including: cancer; damage to nervous system and liver; kidney damage; damage to blood cells; damage to circulatory system; diarrhea; vomiting; drowsiness; coughing; restlessness; irritability; cramps; stomach swelling; breathing problems; coma; death; decreased blood clotting; increase in blood pressure
Plastics Production	Solvents	Various, including: cancer; liver damage; damage to the kidneys, circulatory system and nervous system
	Oils	Various, including: diarrhea; vomiting; drowsiness; coughing; restlessness; irritability; cramps; stomach swelling; breathing problems; coma; death; leukemia (due to long term benzene exposure). "High level" or long-term exposure can cause: damage to liver and kidneys; damage to nervous system; decreased blood clotting; increase in blood pressure
	Paint	Various, including: cancer; damage to nervous system and liver; kidney damage; damage to blood cells
	Acids	Water with a low pH can leach metal ions from aquifers and distribution systems (see "Metals" above). There are a variety of different acid contaminants which have different corresponding health effects. The only acids identified by the EPA as a drinking water contaminants are the disinfection byproducts Haloacetic acids which increase cancer risk
	Industrial Waste	Various, including: increased cancer risk; liver damage; kidney damage;

		damage to circulatory system; anemia; blood changes; spleen damage; stomach problems; problems with immune system; damage to the nervous system; irritation of the gastrointestinal system; dental and skeletal fluorosis
Liquid Industrial Waste Storage	Industrial Waste	Various, including: increased cancer risk; liver damage; kidney damage; damage to circulatory system; anemia; blood changes; spleen damage; stomach problems; problems with immune system; damage to the nervous system; irritation of the gastrointestinal system; dental and skeletal fluorosis
Chemical Plant	Solvents	Various, including: cancer; liver damage; damage to the kidneys, circulatory system and nervous system
	Metals	Kidney damage; blood pressure increase; circulatory problems; intestine or liver problems; etc.
	Industrial Waste	Various, including: increased cancer risk; liver damage; kidney damage; damage to circulatory system; anemia; blood changes; spleen damage; stomach problems; problems with immune system; damage to the nervous system; irritation of the gastrointestinal system; dental and skeletal fluorosis
Electronics Manufacturing	Solvents	Various, including: cancer; liver damage; damage to the kidneys, circulatory system and nervous system
	Arsenic	Circulatory system malfunction; skin problems; possible increased cancer risk
	Oils	Various, including: diarrhea; vomiting; drowsiness; coughing; restlessness; irritability; cramps; stomach swelling; breathing problems; coma; death; leukemia (due to long term benzene exposure). "High level" or long-term exposure can cause: damage to liver and kidneys; damage to nervous system; decreased blood clotting; increase in blood pressure
	Acids	Water with a low pH can leach metal ions from aquifers and distribution systems (see "Metals" above). There are a variety of different acid contaminants which have different corresponding health effects. The only acids identified by the EPA as a drinking water contaminants are the disinfection byproducts Haloacetic acids which increase cancer risk
	Paint	Various, including: cancer; damage to nervous system and liver; kidney damage; damage to blood cells
	PCBs	Problems with skin, thymus gland, nervous system, reproductive system and immune system; increased cancer risk
	Industrial Waste	Various, including: increased cancer risk; liver damage; kidney damage; damage to circulatory system; anemia; blood changes; spleen damage; stomach problems; problems with immune system; damage to the nervous system; irritation of the gastrointestinal system; dental and skeletal fluorosis
		Other
Sewage Treatment Plant	Chlorine (Cl_2)	Stomach discomfort; irritation of the eyes and/or nose
	E. coli	Indication of presence other possibly harmful bacteria
	Viruses	Gastrointestinal illness
	Microorganisms	Gastrointestinal illness and associated headaches
	Nitrates	Blue-baby syndrome and shortness of breath in infants younger than six months of age
	Phosphates	In concentrations above 1.0 mg/L, may disrupt water treatment plant coagulation processes, thus obstructing the removal of microorganisms which may be potentially harmful (see "Microorganisms" above)
	Oils	Various, including: diarrhea; vomiting; drowsiness; coughing; restlessness; irritability; cramps; stomach swelling; breathing problems; coma; death; leukemia (due to long term benzene exposure). "High level" or long-term exposure can cause: damage to liver and kidneys; damage to nervous system; decreased blood clotting; increase in blood pressure
	Pesticides	Increased cancer risk; reproductive difficulties; liver, adrenal gland, kidney problems; problems with cardiovascular system; cataracts; gastrointestinal problems; nervous system problems; etc.

	Metals	Kidney damage; blood pressure increase; circulatory problems; intestine or liver problems; etc.
	Paint	Various, including: cancer; damage to nervous system and liver; kidney damage; damage to blood cells
	Acids	Water with a low pH can leach metal ions from aquifers and distribution systems (see "Metals" above). There are a variety of different acid contaminants which have different corresponding health effects. The only acids identified by the EPA as a drinking water contaminants are the disinfection byproducts Haloacetic acids which increase cancer risk
Storm Water Management System	Oils	Various, including: diarrhea; vomiting; drowsiness; coughing; restlessness; irritability; cramps; stomach swelling; breathing problems; coma; death; leukemia (due to long term benzene exposure). "High level" or long-term exposure can cause: damage to liver and kidneys; damage to nervous system; decreased blood clotting; increase in blood pressure
	Solvents	Various, including: cancer; liver damage; damage to the kidneys, circulatory system and nervous system
	Pesticides	Increased cancer risk; reproductive difficulties; liver, adrenal gland, kidney problems; problems with cardiovascular system; cataracts; gastrointestinal problems; nervous system problems; etc.
	Lead	Physical and mental developmental delays and minor deficits in learning ability and attention span in children; high blood pressure and kidney problems in adults
	Mercury	Damage to kidneys
	Metals	Kidney damage; blood pressure increase; circulatory problems; intestine or liver problems; etc.
	Nitrates	Blue-baby syndrome and shortness of breath in infants younger than six months of age
	Phosphates	In concentrations above 1.0 mg/L, may disrupt water treatment plant coagulation processes, thus obstructing the removal of microorganisms which may be potentially harmful (see "Microorganisms" above)
	Auto Plant Wastewater	Various, including: cancer; damage to nervous system and liver; kidney damage; damage to blood cells; damage to circulatory system; diarrhea; vomiting; drowsiness; coughing; restlessness; irritability; cramps; stomach swelling; breathing problems; coma; death; decreased blood clotting; increase in blood pressure
	Industrial Waste	Various, including: increased cancer risk; liver damage; kidney damage; damage to circulatory system; anemia; blood changes; spleen damage; stomach problems; problems with immune system; damage to the nervous system; irritation of the gastrointestinal system; dental and skeletal fluorosis
	Fertilizers	Various, including: Thyroid problems; nerve damage; bone disease; "blue-baby syndrome"; shortness of breath; mottled teeth in children
	Paint	Various, including: cancer; damage to nervous system and liver; kidney damage; damage to blood cells
	Sediment and Mud	Associated with higher levels of pathogenic microorganisms which may cause gastrointestinal illness and associated headaches
	Viruses	Gastrointestinal illness
	Microorganisms	Gastrointestinal illness and associated headaches
	E. coli	Indication of presence other possibly harmful bacteria
	Hepatitis A	Appetite loss; tiredness; fever; abdominal pain; nausea; dark urine; jaundice. The virus does not cause chronic damage and typically is not fatal
	Acids	Water with a low pH can leach metal ions from aquifers and distribution systems (see "Metals" above). There are a variety of different acid contaminants which have different corresponding health effects. The only acids identified by the EPA as a drinking water contaminants are the disinfection byproducts Haloacetic acids which increase cancer risk

House with Septic System	*E. coli*	Indication of presence other possibly harmful bacteria
	Microorganisms	Gastrointestinal illness and associated headaches
	Viruses	Gastrointestinal illness
	Hepatitis A	Appetite loss; tiredness; fever; abdominal pain; nausea; dark urine; jaundice. The virus does not cause chronic damage and typically is not fatal
	Nitrates	Blue-baby syndrome and shortness of breath in infants younger than six months of age
	Metals	Kidney damage; blood pressure increase; circulatory problems; intestine or liver problems; etc.
	Oils	Various, including: diarrhea; vomiting; drowsiness; coughing; restlessness; irritability; cramps; stomach swelling; breathing problems; coma; death; leukemia (due to long term benzene exposure). "High level" or long-term exposure can cause: damage to liver and kidneys; damage to nervous system; decreased blood clotting; increase in blood pressure
	Pesticides	Increased cancer risk; reproductive difficulties; liver, adrenal gland, kidney problems; problems with cardiovascular system; cataracts; gastrointestinal problems; nervous system problems; etc.
	Paints	Various, including: cancer; damage to nervous system and liver; kidney damage; damage to blood cells
	Chlorine (Cl_2)	Stomach discomfort; irritation of the eyes and/or nose
	Phosphates	In concentrations above 1.0 mg/L, may disrupt water treatment plant coagulation processes, thus obstructing the removal of microorganisms which may be potentially harmful (see "Microorganisms" above)
	Mercury	Damage to kidneys
Landfill	Solvents	Various, including: cancer; liver damage; damage to the kidneys, circulatory system and nervous system
	Nitrates	Blue-baby syndrome and shortness of breath in infants younger than six months of age
	Metals	Kidney damage; blood pressure increase; circulatory problems; intestine or liver problems; etc.
	Mercury	Damage to kidneys
	Oils	Various, including: diarrhea; vomiting; drowsiness; coughing; restlessness; irritability; cramps; stomach swelling; breathing problems; coma; death; leukemia (due to long term benzene exposure). "High level" or long-term exposure can cause: damage to liver and kidneys; damage to nervous system; decreased blood clotting; increase in blood pressure
	PCBs	Problems with skin, thymus gland, nervous system, reproductive system and immune system; increased cancer risk

(Adapted from Canadian Centre for Occupational Health and Safety, 2008; Oregon Department of Environmental Quality, n.d.; USEPA, 2008, Wells, 2008; Wilkes University, nd.a.; Wilkes University, n.d.b.; Wisconsin Department of Health Services, 2004)

Appendix C: The Survey[21] of Drinking Water Risks Given to Both Community Members[22] and Experts[23]

RYERSON UNIVERSITY

IT'S YOUR WATER. WHAT DO YOU THINK?

Consent to participate in the survey

Data collected from this private and confidential survey will be used for the completion of a master's thesis in Environmental Applied Science and Management at Ryerson University. Your mailing address was accessed through the Institute for Social Research at York University. In this survey, you will be asked about your feelings about, and your familiarity with, potential drinking water risks in your area. There is a potential psychological risk to you in answering questions about potential water-related risks in your area. It may make you feel uncomfortable or anxious to think about risks to your water supply when reading the examples in this survey, but please remember that they are entirely hypothetical, and are not in any way related to your present water supply. The potential benefits of your participating in this research include improved knowledge of the public's awareness of water quality, and a contribution to implementing Ontario's Clean Water Act.

You can choose whether or not you want to participate, but you must be 18 years or older to do so. You are free to not complete the survey if you so choose, you can answer only those questions you feel comfortable answering, and you can stop at any time. If you don't want to participate, simply don't return the survey. If you do participate, completion and return of the survey indicates your consent to the above conditions, and for your responses to be used in the study.

Please do not put your name on this form. This survey has 3 questions and takes about 15 minutes to complete. Please return this survey using the stamped, self-addressed envelope enclosed. You will be informed about the results after the survey has been completed. If you would like a summary of the research, please check this box ❑

Any questions or concerns should be directed to the principal investigator, Mary Lorimer, at mrollins@ryerson.ca or (416) 655-0911, or the research supervisor, Professor Ron Pushchak at pushchak@ryerson.ca. If you have concerns or complaints about your rights as a research participant, you may contact the Ryerson Research Ethics Board, Office of the Vice President, Research and Innovation, 1 Dundas Street West, Suite YDI-1100, Toronto, Ontario, M5G 1Z3, (416) 979-5283. Thank you very much for your time. Your prompt response is appreciated.

Mary Lorimer
Environmental Applied Science and Management
Ryerson University

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[21] Note that the formatting and font sizes have been changed slightly from the original version distributed to the respondents
[22] The first cover page was sent to Community Members
[23] The second cover page was sent to members of the Region of Study's Source Protection Committee

RYERSON UNIVERSITY

IT'S YOUR WATER. WHAT DO YOU THINK?

Consent to participate in the survey

Data collected from this private and confidential survey will be used for the completion of a master's thesis in Environmental Applied Science and Management at Ryerson University. Your information was accessed through the source protection committee membership listing on the [Region of Study's] Drinking Water Source Protection website. In this survey, you will be asked about your feelings about, and your familiarity with, potential drinking water risks in your area. There is a potential psychological risk to you in answering questions about potential water-related risks in your area. It may make you feel uncomfortable or anxious to think about risks to your water supply when reading the examples in this survey, but please remember that they are entirely hypothetical, and are not in any way related to your present water supply. The benefit of your participating in this research is a contribution to understanding the implementation of Ontario's Clean Water Act.

You can choose whether you want to participate. You are free to not complete the survey if you so choose and you can answer only those questions you feel comfortable answering. If you don't want to participate, simply don't return the survey. If you do participate, completion and return of the survey indicates your consent to the above conditions, and for your responses to be used in the study.

Please do not put your name on this form. This survey has 3 questions and takes about 15 minutes to complete. Please return this survey using the stamped, self-addressed envelope enclosed. You will be informed about the results after the survey has been completed. If you would like a summary of the research, please check this box ❑

Any questions or concerns should be directed to the principal investigator, Mary Lorimer, at mrollins@ryerson.ca or (416) 655-0911, or the research supervisor, Professor Ron Pushchak at pushchak@ryerson.ca. If you have concerns or complaints about your rights as a research participant, you may contact the Ryerson Research Ethics Board, Office of the Vice President, Research and Innovation, 1 Dundas Street West, Suite YDI-1100, Toronto, Ontario, M5G 1Z3, (416) 979-5283. Thank you very much for your time. Your prompt response is appreciated.

Mary Lorimer
Environmental Applied Science and Management
Ryerson University

1. If the below substances were found in drinking water in your area, how would you feel about it? Please rank each substance according to how risky you feel it is (Is it potentially fatal? Can it be controlled?). Rate the presence of each substance in drinking water from having almost no risk (1) to being very risky (4) by checking the appropriate box. **Please check only one box for each substance**.

	Almost No Risk	Slightly Risky	Moderately Risky	Very Risky	Don't Know
Chlorine	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
Metals	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
E. coli	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
Mercury	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
Sediment and Mud	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
Paint	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
Acids	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
Hepatitis A	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
Arsenic	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
Nitrates	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
Industrial Waste	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
Pesticides	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
Solvents	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
Microorganisms	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
Viruses	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
Oils	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
Auto Plant Wastewater	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
Lead	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
Fluoride	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
Fertilizers	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
Phosphates	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
PCBs	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5

2. How familiar are you with the following substances that might be in your drinking water? Please rank each of the same substances below according to your familiarity with each substance, from being unfamiliar (1) to being very familiar (4) by checking the appropriate box. **Please check only one box for each substance.**

	Unfamiliar	Not Very Familiar	Familiar	Very Familiar	Don't Know
Phosphates	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
Fluoride	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
Auto Plant Wastewater	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
Viruses	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
Microorganisms	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
Pesticides	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
Nitrates	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
Hepatitis A	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
Paint	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
Mercury	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
Metals	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
Fertilizers	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
Lead	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
Oils	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
Solvents	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PCBs	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
Industrial Waste	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
Arsenic	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
Acids	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
Sediment and Mud	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
E. coli	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
Chlorine	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

3. The operations listed below may potentially exist in your area and could affect your drinking water. Please indicate the level of threat that you feel each operation poses to your drinking water. Rank each operation from being an extremely low threat to drinking water (1) to being an extremely high threat to drinking water (7) by checking the appropriate box. **Please check only one box for each operation.**

	Extremely Low Threat	Very Low Threat	Low Threat	Moderate Threat	High Threat	Very High Threat	Extremely High Treat	Don't Know
Auto Plant	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5	❑ 6	❑ 7	❑ 8
Plastics Production	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5	❑ 6	❑ 7	❑ 8
Farm With Livestock Feedlot	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5	❑ 6	❑ 7	❑ 8
Liquid Industrial Waste Storage	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5	❑ 6	❑ 7	❑ 8
Sewage Treatment Plant	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5	❑ 6	❑ 7	❑ 8
Chemical Plant	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5	❑ 6	❑ 7	❑ 8
Dairy Farm	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5	❑ 6	❑ 7	❑ 8
Storm Water Management System	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5	❑ 6	❑ 7	❑ 8
House with Septic System	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5	❑ 6	❑ 7	❑ 8
Above Ground Fuel Storage Facility	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5	❑ 6	❑ 7	❑ 8
Landfill	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5	❑ 6	❑ 7	❑ 8
Grain Farm	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5	❑ 6	❑ 7	❑ 8
Electronics Manufacturing	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5	❑ 6	❑ 7	❑ 8

COMMENTS

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THANK YOU

Appendix D: Community and Committee Respondents' Comments

Written Comments Obtained from Mail Surveys

These comments are listed in no particular order. They are direct quotes of the written comments appended to the surveys sent in by the respondents.

Table Di: Written Comments from Community Respondents

Comment No.	Comment
1	"Interesting and easy to understand until For a Francophone. thank you."
2	"I use city piped in water almost exclusively."
3	"Q.1 – Hard to answer since the risk depends on the concentrations: i.e, a little arsenic is not much of a threat, a lot could be fatal. microorganisms – too vague. Some are harmless, some, e.g., giardia, are a real hazard. industrial waste – what industry? what waste? treated or untreated Q3 I am not aware of any threat to my water supply from any of these, but it wasn't clear to me from any of the wording of the question if that is what you wanted to know. This doesn't seem to me to be a very well-thought-out questionnaire"
4	"Thank you for my participation."
5	"I prefer tap water & am aware there might be some contamination but don't know what & don't care enough to find out. I just have faith I won't die. Cloudy water makes me feel like it's dirty. ☺"
6	"OUR DRINKING WATER IS PROVIDED BY 2 OF THE GREAT LAKES AND I FEEL THAT ALL OF THE ABOVE CAN SOMEHOW BE OR BECOME A RISK TO OUR WATER SUPPLY."
7	"The question of "how familiar" is probably deliberately vague. Compared to a biochemist I would say I am very unfamiliar with most substances!"
8	"As reflected by my ratings I am much more familiar with threats associated with agriculture and soil sciences. My medical background allowed me to assess risk with more confidence with regard to several areas, for example, viruses, microorganisms. Question – how was my address on record with York University?"
9	"I DON'T DRINK TAP WATER…[followed by illegible writing, possibly a signature]"
10	"I'm afraid my knowledge on this matter is not good. But I thank you for the chance to comment…[a signature]"
11	"Make explanation page briefer"
12	"A very timely survey! Thank you! We take our water supply <u>TOO</u> much for granted! <u>We are already in trouble!</u>"
13	"Interesting survey :s" "to you too!" [in response to "THANK YOU" at the end of the survey]
14	"It is good to carry out research in this interesting topic. I am very interested to work as a team member in your future research activities. Please feel free to contact me, if you have any opportunity in near future."
15	"Too little is known – therefore the possible "threat" is extremely high. e.g. If you live in an <u>old</u> home in [municipality removed], you are at an extremely high risk of having lead in your drinking water but if you live in a brand new home with all new, modern pipes you are at an extremely low threat level = both extremes in the same city. * This survey gets a failing grade."
16	"THE ABOVE THREATS ARE ONLY POSSIBLE WHEN THERE IS A PATHWAY. TO THE AQUIFER OR PIPELINE. THE SURVEY IS OVERSIMPLIFIED TO THE POINT OF NEAR-IRRELEVANCE."
17	"You are welcome!" [in response to "THANK YOU" at the end of the survey]
18	"Electronics could be Moderate threat depending on how it is disposed."
19	"Our household uses only bottled water for both cooking and drinking however it would interest me to know how safe our city water is. Also any literature on the substances in the survey and it's effect on the water we use would be of interest to me."
20	"Why have you sent this questionnaire to me? What factors determined this questionnaire be sent to the

	[municipality removed] area? The recent incidents of lead + E coli in our water system?"
21	Proper regulations reduces risk of the operation. Process and procedures can be regulated but politics and blind sightedness can not. Opinion gathering for political purpose without proper knowledge always leads to confusion and mis-information."
22	"Your research is very important and I appreciate the opportunity to participate. The public needs to know from a scientific perspective what they are doing to the water supply."
23	"- I am/was a professional scientist (biology/environmental sciences) - It's the levels rather than mere presence that matters for many water contaminants - There was no attempt by survey authors to address issues of hazard + risk - Where will survey results be posted?"
24	"Most conditions depend on concentrations involved + or length of exposure Industrial depends on age of facility + how they treat their wastewater – do they follow latest regulations Farms have to follow safe practices to eliminate unsafe runoff"
25	"Thank you for sending me the survey. I hope I have been helpful. Thanks for your hard work."
26	"We do not have any problem here"
27	"Your questionnaire might have benefited from questions asking how the respondent's water is made available. For example a municipal system that sources its water from a Great Lake will be less vulnerable to threats than one that sources its water from an aquifer. Respondents on private systems have greater threats. It is likely that you will be unable to get a clear picture of peoples' perceptions if you are unable to cross-reference to the type of their water source."
28	"This is too vague but in general, major changes should be made to all discharges with proper materials recovery systems. Rivers and lakes should not be used for waste removal. There are far too many people to continue these practices."
29	" *difficult to answer this question because the risk is associated with level of concentration. i.e. chlorine is not risky but can be if very high concentration?" [comment pertains to Question 1] "I found this survey difficult to fill out! Activities and agents can have varying influences on drinking water depending upon many parameters (concentrations, proximity – location, treatment). As stated earlier, there may exist Maximum Acceptable Concentrations (MAC's) for substances so depending upon concentration it can be negligible or highly critical. Perhaps more clarification needed for background information."
30	"My name is [name removed], please use! Not [name removed]. thank you"
31	"Question should be: Do you know if these factors are affecting water quality area yes or no? I am not sure exactly what level of threat each of these poses, since I am not familiar with all the industry/farming activity in my area. You could get a job writing referendum questions is Ottawa."
32	"LIVESTOCK FEEDLOTS ARE HIGH THREAT BECAUSE OF LIQUIFIED HANDLING OF MANURE, DAIRY FARMS USUALLY HAVE FEWER COWS AND HAVE BEEN ☑ MODERATE THREAT"
33	"WE HAVE INSTALLED WATER TREATMENT FACILITY IN OUR HOUSE. HAVE HAD THIS UNIT FOR SEVERAL YEARS (10+)"
34	"ON [water bodies removed] WATER SUPPLY IN [municipality removed] CONCERNED ABOUT AG RUNOFF AT [location removed] !"
35	"I am concerned about "lead" pipes inside house - some have been replaced by previous owner to copper I have had some indoor pipes replaced to copper - I have no storm drains on street, concerned about this"
36	"HIGH FOR KILLS ARE NOT REMOVED" [comment pertains to "Chlorine" in Question 1] "PRETTY MUCH ALL THESE IN SOLUTION ARE PUTTING US AT RISK." [comment pertains to Question 1] "DRAINAGE TO A RECEIVING BODY OF WATER CAN CAUSE PROBLEMS" [comment pertains to "Farm With Livestock Feedlot" in Question 3] "IF IT LEACHES OUT WILL CAUSE PROBLEMS" [comment pertains to "Liquid Industrial waste Storage in Question 3] "CAN CAUSE ALL SORTS OF PROBLEMS" [comment pertains to "Sewage Treatment Plant" in question 3] "ALL THE ABOVE CAN POSE A HIGH THREAT A) NOT KEPT IN GOOD REPAIR B) DO NOT HAVE SKILLED PERSONNELL C) OPERATE AT HIGHER CAPACITIES THAN AE RATED FOR & ALLOWED TO LEACH INTO OUR POTABLE WATER SYSTEMS. I BELIEVE THAT ALL THIS IS TAKING PLACE AS WE SPEAK SORRY FOR THE POOR PENMANSHIP."

Table Dii: Written Comments from Committee Respondents

Comment No.	Comment
1	"Measures taken to protect drinking water that cause property owners to use practices that are above industry standard should be covered by compensatory losses or for increased operating costs!"
2	"The survey is too vague. Is this treated water or raw water? Is there a multi-barrier system in place with appropriate treatment and monitoring? Is there a source water protection system in place? Is this surface water or a secure ground water system? The survey should be reworked."
3	"Local village creates most threat to water supply 300+ septics. Big concern for Board of Health."
4	"This survey is extremely general. Caution should be used in using this information, assumptions made in the absence of more scientific data can be misleading."
5	"difficult to ans questions – you didn't speak to amount ie, [actual rates/ concentrates?] – greater than 10 ppm etc didn't speak to type of pesticides – didn't speak to type of plastic production – Bio vs petro"
6	"poorly constructed questions"
7	"My confidence in water treatment capabilities influence my position on actual threats. [All of these?/ All the…] are a possible threat to raw water quality."

Verbal Comments Obtained from Telephone Interviews

These comments are listed in no particular order. They are summaries of comments made by the respondents and recorded by the researcher during telephone interviews.

Table Diii: Summaries of Verbal Comments made by Community Respondents

Comment No.	Comment
1	Concerned about amount of lead in the water supply
2	Uses a water filter
3	Stated that the answers to the survey depend on the effluent being discharged and are area-specific. Expressed concern about farms and rainfall in the Great Lakes. The effect of auto manufacturing depends on the quality control of each company
4	This respondent was concerned about drinking water because they lived in Walkerton during the *E. coli* outbreak
5	Is concerned about drinking water when it tastes different
6	Is interested in the water situation in Southern Ontario and expressed that all the contaminants in the survey have the potential to be slightly risky
7	Concerned with PCBs in breast milk and is also concerned about tap water
8	Concerned about farms and cottages as they relate to the quality of drinking water. Believes that in the city, the distribution system is more of a concern than the drinking water itself. Expressed that the topic of drinking water quality is broad.
9	Was not able to complete the written survey sent in the mail because it was too difficult and science-based
10	Expressed that the risks to water depend on individual farms or methods and effectiveness of purification
11	Stated that they grew up using a septic system, currently lives near a sewage treatment plant, and has friends who are farmers
12	Expressed that responses to the questionnaire depend on the concentrations of the contaminants in water
13	Concerned about phosphates and the link between PCBs in water and cancer incidence
14	Extremely concerned about the environment and believes that we have pushed the limits too far
15	Was concerned and confused about chlorine in drinking water
16	Appreciated not being cut off when responding to the survey questions
17	Believes that water research is important. Had trouble responding to Question 3 because they were concerned about giving opinions without facts to base them on. Was concerned about cancer as well as the media.
18	Stated that their drinking water was "fine"
19	Stated that responses to the survey questions depended on a lot of different factors, and knowing more about these factors would result in clearer opinions
20	Concerned about living in an old building because of bad tasting tap water
21	Expressed that they do not drink tap water and that they sterilize water that they use for cooking and drinking
22	Stated that they were not aware of many of the contaminants included in the survey
23	Stated that they did not understand the written copy of the survey that was sent to them by mail due to a language barrier
24	Stated that they previously worked at a local industrial facility and constantly came into direct contact with PCBs. Stated that it never occurred to them that a house with a septic system could affect water quality. Stated that they use a water filter. Stated that they were not sure what to say for some of the survey responses.
25	Expressed the belief that the contaminants in the survey were either a concern or not a concern, and that they were unable to see how the questions in the survey could help solve any problems
26	Stated that one "can't care too much" about water quality issues
27	Wanted to know the number of potential respondents to whom the researcher had to make telephone calls

Appendix E: Results of the Differences Between Proportions Statistical Test

This Appendix outlines the results of the differences between proportions statistical test that was used to determine whether the differences observed between the Committee and Community responses are statistically significant or whether these differences can be attributed to chance (Freund, 1973, p.317). Tables Ei, Eii and Eiii below contain the results of the differences between proportions test for the survey results for Questions 1, 2 and 3 of the survey, respectively. The tables below include both the p values and z-scores that were calculated for each set of responses. As discussed above, the Z^2 value, or z-score, is the "abscissa of the normal curve that cuts off an area at the tails", and is equal to 1.96 at a 95% confidence interval (Israel, 2008; Paoli, Haggard & Shah, 2002, p.2). That is, the Z^2 value indicates the number of standard deviations a score is from the mean (Kognito, 2007, p.3) Thus, a Z^2 value of 1.96 (i.e. 1.96 standard deviations from the mean) defines the 95% confidence interval (Paoli et al., 2002, p.2). The p value is "the estimated proportion of an attribute that is present in the population" (Israel, 2008).

In this case, the null hypothesis is that there is no difference between the Committee and Community responses (or $p_1 = p_2$, or proportion 1 = proportion 2). To test the null hypothesis, the p value and z-score are calculated using the equations below, where x_1/n_1 and x_2/n_2 are two different proportions (in this case, one Committee response and one Community response; Freund, 1973, pp.318-319). More specifically, x_1 and x_2 are the number of observed "successes" (or in this case, responses in a given category of a survey question, for example "very risky") for each respective group, n_1 and n_2 are the sample sizes of each group and p_1 and p_2 are "the corresponding probabilities for success on an individual trial" (Freund, 1973, p.318). However, it must be noted that this study's low response rate and associated sampling error could compromise the results of this statistical test because n_1 and n_2 are defined as the sizes of "large independent random samples" (Freund, 1973, p.318).

$$p = \frac{x_1 + x_2}{n_1 + n_2}$$

$$z = \frac{\frac{x_1}{n_1} - \frac{x_2}{n_2}}{\sqrt{p(1-p)(\frac{1}{n_1} + \frac{1}{n_2})}}$$

If the z-score falls between -1.96 and 1.96, the null hypothesis, that there is no difference between the Committee and Community responses, cannot be rejected (Freund, 1973, p.320). That is, the null hypothesis is rejected for z-scores falling into the right-hand tail, the left-hand tail or both tails of the sampling distribution (Freund, 1973, p.319). The statistically significant differences between Committee and Community responses, where the z-score does not fall between -1.96 and 1.96, are highlighted in gray in the tables below.

Table Ei: Results of the Differences Between Proportions Statistical Test for the risk perception data obtained from Question 1 of the survey

Contaminant	Almost No Risk		Slightly Risky		Moderately Risky		Very Risky		Don't Know	
	(p)	(z)	(p)	(z)	(p)	(z)	(p)	(z)	(p)	(z)
Chlorine	0.31	**-2.25**	0.29	1.50	0.23	0.41	0.13	0.098	0.037	0.82
Metals	0.058	-0.16	0.15	**-2.89**	0.29	0.78	0.42	0.74	0.084	1.22
E. coli	0.00	N/A	0.026	**-2.60**	0.036	**-1.97**	0.91	**2.37**	0.026	0.68
Mercury	0.010	0.43	0.026	-0.95	0.073	0.17	0.85	-0.31	0.042	0.87
Sediment and Mud	0.15	-1.22	0.29	-1.96	0.33	1.27	0.17	1.18	0.068	1.13
Paint	0.021	0.61	0.057	-0.094	0.18	**-2.17**	0.71	1.34	0.036	0.81
Acids	0.032	-0.73	0.085	-0.60	0.23	**-2.08**	0.58	**3.32**	0.074	-1.80
Hepatitis A	0.016	0.53	0.021	**-3.05**	0.078	-1.70	0.79	**3.64**	0.094	**-2.24**
Arsenic	0.021	0.61	0.041	**-4.37**	0.073	-0.84	0.82	**3.55**	0.041	-1.75
Nitrates	0.047	-0.31	0.15	-1.15	0.27	-0.98	0.35	0.91	0.18	1.25
Industrial Waste	0.016	0.52	0.036	**-1.98**	0.088	**-3.31**	0.82	**3.55**	0.036	-0.59
Pesticides	0.016	0.53	0.026	**-2.59**	0.12	**-4.07**	0.81	**4.00**	0.026	0.69
Solvents	0.0052	0.30	0.036	-0.59	0.13	**-2.94**	0.78	**2.16**	0.047	0.92
Microorganisms	0.069	1.14	0.19	**-2.04**	0.26	-0.51	0.34	1.34	0.15	0.27
Viruses	0.016	0.53	0.089	**-2.36**	0.17	-0.16	0.66	1.96	0.063	-1.071
Oils	0.021	0.62	0.074	-1.80	0.17	**-2.97**	0.67	**3.18**	0.064	0.023
Auto Plant Wastewater	0.026	-0.95	0.063	-1.071	0.12	**-4.071**	0.72	**3.83**	0.068	0.092
Lead	0.00	N/A	0.068	**-3.031**	0.12	-0.067	0.79	1.71	0.021	0.61
Fluoride	0.46	0.17	0.32	0.077	0.11	-0.19	0.074	0.18	0.037	-0.57
Fertilizers	0.032	**-2.34**	0.12	-0.97	0.25	-0.79	0.56	1.85	0.037	0.79
Phosphates	0.042	-0.43	0.18	**-3.42**	0.27	-0.38	0.32	**2.30**	0.18	1.30
PCBs	0.0052	0.30	0.042	-0.44	0.083	**-2.52**	0.79	**2.28**	0.083	-0.63

Table Eii: Results of the Differences Between Proportions Statistical Test for the familiarity data obtained from Question 2 of the survey

Contaminant	Unfamiliar		Not Very Familiar		Familiar		Very Familiar		Don't Know	
	(p)	(z)	(p)	(z)	(p)	(z)	(p)	(z)	(p)	(z)
Chlorine	0.026	0.69	0.12	-0.12	0.44	1.05	0.41	-1.29	0.011	0.43
Metals	0.13	1.58	0.24	-0.70	0.37	0.51	0.23	-1.44	0.031	0.75
E. coli	0.12	1.55	0.11	-0.27	0.35	-0.24	0.41	-0.76	0.016	0.53
Mercury	0.14	0.95	0.17	1.18	0.36	-1.24	0.33	-0.43	0.0053	0.30
Sediment and Mud	0.12	1.55	0.20	0.82	0.40	0.24	0.25	**-2.40**	0.021	0.61
Paint	0.18	1.30	0.026	-0.55	0.30	-0.71	0.25	0.60	0.016	-1.58
Acids	0.20	0.75	0.28	-0.30	0.32	0.092	0.17	-0.14	0.026	-0.94
Hepatitis A	0.24	1.14	0.25	-1.18	0.27	-0.36	0.22	0.29	0.016	0.53
Arsenic	0.21	0.83	0.25	1.23	0.28	-0.84	0.23	-0.80	0.026	-0.94
Nitrates	0.16	1.82	0.29	**2.07**	0.31	-0.62	0.19	**-3.96**	0.058	1.04
Industrial Waste	0.13	1.58	0.31	-1.11	0.35	-0.26	0.17	0.48	0.047	-0.30
Pesticides	0.13	1.59	0.20	0.75	0.39	0.68	0.28	**-2.69**	0.011	0.43
Solvents	0.19	1.35	0.25	0.63	0.33	-0.99	0.23	-0.86	0.0053	0.30
Microorganisms	0.16	0.39	0.27	-0.44	0.31	0.58	0.23	-0.83	0.032	0.76
Viruses	0.18	1.30	0.30	-0.15	0.30	-0.67	0.18	-0.051	0.038	-0.55
Oils	0.18	1.30	0.26	1.85	0.31	-1.69	0.24	-1.27	0.0052	0.30
Auto Plant Wastewater	0.25	1.21	0.41	-0.80	0.19	0.00	0.11	-0.21	0.047	-0.31
Lead	0.094	1.34	0.14	0.19	0.38	0.00	0.39	-0.98	0.0052	0.30
Fluoride	0.047	0.93	0.099	-0.36	0.48	0.39	0.36	-0.63	0.0052	0.30
Fertilizers	0.15	1.73	0.17	1.17	0.37	-0.045	0.31	**-2.25**	0.0052	0.30
Phosphates	0.19	**1.99**	0.31	0.56	0.33	1.25	0.13	**-5.31**	0.042	0.88
PCBs	0.18	1.93	0.25	-0.013	0.29	-0.21	0.24	-1.28	0.041	-0.44

Table Eiii: Results of the Differences Between Proportions Statistical Test for the land use data obtained from Question 3 of the survey

Land Use	Extremely Low Threat		Very Low Threat		Low Threat		Moderate Threat		High Threat		Very High Threat		Extremely High Threat		Don't Know	
	p	z	p	z	p	z	p	z	p	z	p	z	p	z	p	z
Auto Plant	0.099	-1.23	0.068	**-1.98**	0.17	**-2.32**	0.29	0.97	0.13	0.80	0.073	1.18	0.12	1.51	0.058	1.03
Plastics Production	0.080	-1.66	0.069	-0.92	0.13	**-3.10**	0.23	-0.21	0.19	1.33	0.13	1.60	0.11	1.48	0.069	1.14
Farm with Livestock Feedlot	0.052	-1.36	0.031	**-3.74**	0.13	-1.57	0.22	-0.30	0.23	1.00	0.16	1.13	0.14	1.70	0.042	0.87
Liquid Industrial Waste Storage	0.048	-1.52	0.037	-1.95	0.095	-1.31	0.14	-0.53	0.18	-0.083	0.18	-0.083	0.28	**2.58**	0.042	0.88
Sewage Treatment Plant	0.048	-0.29	0.11	-1.02	0.17	0.49	0.23	-0.85	0.14	-0.61	0.12	-0.042	0.14	1.67	0.048	0.93
Chemical Plant	0.068	-0.94	0.042	-1.73	0.058	**-2.33**	0.12	0.74	0.17	-1.54	0.18	0.63	0.30	**2.15**	0.058	1.03
Dairy Farm	0.063	0.00	0.089	0.38	0.17	-0.93	0.27	-0.44	0.15	0.30	0.094	1.34	0.11	1.50	0.042	0.87
Storm Water Management System	0.037	**-2.049**	0.15	0.93	0.24	-0.21	0.23	-1.0056	0.15	0.18	0.059	1.0065	0.090	0.33	0.043	0.85
House with Septic System	0.089	0.40	0.17	0.54	0.22	-1.62	0.25	-0.025	0.095	-0.43	0.047	0.93	0.068	0.098	0.063	1.085
Above Ground Fuel Storage Facility	0.063	0.011	0.13	**-3.010**	0.17	-0.84	0.23	-0.86	0.11	1.43	0.084	1.27	0.14	1.66	0.079	1.22
Landfill	0.048	-0.28	0.059	**-2.29**	0.091	-0.50	0.28	**-2.072**	0.19	1.34	0.13	0.88	0.18	1.94	0.027	0.69
Grain Farm	0.15	-0.40	0.19	-1.96	0.23	-0.85	0.19	1.36	0.10	0.53	0.037	0.82	0.026	0.69	0.074	1.18
Electronics Manufacturing	0.12	0.70	0.11	-1.85	0.19	1.32	0.20	-0.51	0.085	0.33	0.090	1.31	0.085	1.27	0.13	**-2.33**

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