



**CORE**

Public Health Functions for BC

**Evidence Review:**  
**Water Quality**  
**(Recreational Water)**

**Population Health and Wellness**  
**BC Ministry of Health**

April 2007

*This paper is a review of the scientific evidence for this core program. Core program evidence reviews may draw from a number of sources, including scientific studies circulated in the academic literature, and observational or anecdotal reports recorded in community-based publications. By bringing together multiple forms of evidence, these reviews aim to provide a proven context through which public health workers can focus their local and provincial objectives. This document should be seen as a guide to understanding the scientific and community-based research, rather than as a formula for achieving success. The evidence presented for a core program will inform the health authorities in developing their priorities, but these priorities will be tailored by local context.*

*This Evidence Review should be read in conjunction with the accompanying Model Core Program Paper.*

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## **EXECUTIVE SUMMARY**

Water is used in our society for many purposes, including transport, drinking, bathing, as a receptacle or transport mechanism for wastes, as a source of food, for therapeutic purposes, and—of particular relevance to this paper—recreation. Our society enjoys a high level of leisure time for recreational activities as never before, and the use of water in this role has evolved (i.e., jet skis, etc.) and increased. Along with the obvious and plentiful benefits that people derive in their use of water for recreation, are potential health hazards. As the types of recreation and features of the site where the activities occur are highly varied, so are the hazards and the associated risks. This evidence paper summarizes the body of literature and statistics available regarding these health hazards and their management as they pertain to British Columbia.

Section 1 provides definitions of the recreational water environments to be used herein. These distinctions are important as the literature reviewed, including various World Health Organization reports (1999; 2000a; 2003), consistently present treated and untreated (natural) recreational water in separate papers, reports or books. The mandate of this paper, however, requires the combination of both diverse subject areas into one document. All efforts have been made to maintain clarity as to which environment is being discussed. Section 2 establishes the scope of this document and notes those topics that have been excluded.

Section 3 presents the evidence and literature regarding a variety of microbiological, chemical and physical hazards that may be encountered in recreational water environments. Microbiological and chemical hazards encountered in both environments are addressed separately, reflecting the treatment of these topics in the common literature. Statistics and findings presented for physical hazards apply or refer to pool/spa and beach environments unless otherwise indicated. Where possible, an effort has been made to estimate the burden of recreational water-related diseases, specific to the recreational water environment in BC.

Prüss-Üstün et al. (2003) define the burden of disease as a quantitative figure that represents the amount of disease (or the "health gap") at a defined population level. The standard measure used by the WHO to represent the burden is the disability-adjusted life-year (DALY) (Prüss-Üstün et al., 2003; Kay, Prüss, & Corvalan, 2000); however, data and time constraints prevented the preparation of BC-specific DALY estimates for this paper. Where possible and nationally relevant, estimates on DALY from other sources for recreational water incidents or diseases have been included. Otherwise, the burden of disease is reported as cases, incidence rates or economic costs, or qualitatively as ranges from negligible to high. For some hazards, the estimation of the recreational water burden of disease was not possible due to prohibitive uncertainty regarding the evidence of an exposure-risk relationship in a recreational water environment (Kay et al. 2000; Prüss & Havelaar, 2001).

Section 4 is a point form, tabular summary of the potential health hazards, contributing factors, and options that have been identified in the literature as being effective in preventing or reducing the possibility of a negative outcome. The mitigation options in this table are comprised of standards, suggestions for research, technical options and public awareness campaigns, among other risk management strategies.

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Section 5 presents programs and interventions that draw upon or are comprised of mitigation options highlighted in Section 4. A significant portion of this section refers to the comprehensive recreational water management documents recently published by the World Health Organization and the United States Environmental Protection Agency. Where available, BC-specific examples are highlighted and comparisons are made with respect to the WHO's suggestions. Given the breadth of the topic, not all management aspects are addressed. Additional information on any of the specific topics can be found within the documents and papers cited in the reference section of this review.

## **1.0 OVERVIEW/ SETTING THE CONTEXT**

In 2005, the British Columbia Ministry of Health released a policy framework to support the delivery of effective public health services. The *Framework for Core Functions in Public Health* identifies water quality as one of the 21 core programs that a health authority provides in a renewed and comprehensive public health system.

The process for developing performance improvement plans for each core program involves completion of an evidence review used to inform the development of a model core program paper. These resources are then utilized by the health authority in their performance improvement planning processes.

This evidence review was developed to identify the current state of the evidence based on the research literature and accepted standards that have proven to be effective, especially at the health authority level. In addition, the evidence review identifies best practices and benchmarks where this information is available.

### **1.1 Treated Recreational Water (Swimming Pools, Spas and Wading Pools)**

Treated recreational water consists of all swimming pools, spas, hot tubs, natural hot spring facilities and wading pools.<sup>1</sup> These facilities are accessible publicly, semi-privately (at clubs and hotels) and at private residences. The current BC Swimming Pools, Spray Pools and Wading Pools Regulations (BC Reg. 289/72 O.C. 4190/72) require that all pools (excluding private residential pools) obtain certificates of authorization and operating permits from medical health officers or public health inspectors. This regulation is in place to ensure a minimum standard is met by the facilities and to protect public and semi-private pool and spa users from the various hazards posed in these environments. Data and reporting from these facilities is therefore more readily available, as is the ability to implement specific controls and monitoring programs. Beyond industry standards in pool and spa manufacturing and education programs, the level of involvement that a government agency can have in the management of the residential settings is limited. Public and semi-private treated recreational water will therefore be the focus of this paper. Many of the standards, recommendations and hazards will apply equally to residential water environments, and where clearly applicable, should be extended to this category as well (i.e., educational programs).

The significance of treated recreational water use in the province can be estimated using the 2004 report prepared for the British Columbia Recreation and Parks Association (BCRPA). Based on the BCRPA usage numbers (excluding facility users that are spectators), indoor and outdoor pools comprise 64 per cent of the nearly 28 million total annual visits to all recreational facilities surveyed. The BCRPA study received usage rates from 153 of the 208 pools surveyed. The average annual usage rate per indoor pool was 172,357 visits and per outdoor pool was 21,803. Assuming that these estimates can roughly be applied to all pools in the province, based on data provided by the health authorities on the number of public and semi-private pools in the

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<sup>1</sup> The terms spa and hot tubs refer to the same object and are used interchangeably throughout this paper.

province, the total number of annual visits to pools in BC could be close to 30 million.<sup>2</sup> This figure implies 6 to 7 visits per year per capita.<sup>3</sup>

A key difference between the two types of recreational water environments is the relative ease with which identified public health hazards can be mitigated or managed. The clearly defined physical location and boundaries of pools and spas allow for easier management and enumeration than with untreated sites. Despite the features that facilitate greater control over these sites, serious injury and illnesses still occur. In part, negative outcomes are due to a failure of pool operators to maintain the safety of the environment as indicated by the regulations, but they are also a result of bather practices that put themselves and others at risk. This paper will also provide some evidence that regulations should be constantly reviewed and updated, as new evidence of a risk is sufficient to warrant a revision or amendment.

## **1.2 Untreated Recreational Water (Fresh Water and Coastal Beaches)**

Untreated recreational water is defined by Health Canada in the *Guidelines for Canadian Recreational Water Quality* (Federal-Provincial Working Group on Recreational Water Quality, 1992) as any natural water (coastal or freshwater) that is used for both primary recreation, involving varying degrees of intentional immersion, and secondary recreation, where immersion of the body or head is possible but unintentional. The World Health Organization (WHO, 2003) adds to this definition the characteristic that the site be identifiable based on a substantial number of bathers frequenting the site. The vast number of potential recreation sites and varying degrees of use in BC makes it impossible to enumerate and accurately estimate the risks from all sites. Perhaps a more manageable definition is that employed by the United States Environmental Protection Agency (US EPA), under the *Beaches Environmental Assessment and Coastal Health (BEACH) Act* (2000). This Act constrains the definition further to sites "that states, territories, and authorized tribes officially recognize (or "designate") for swimming, bathing, surfing, or similar activities in the water" (US EPA, 2004).

The management of designated public beach areas falls under the responsibility of the local health regions or health authorities. Within the Vancouver Coastal Health Authority, the Coast Garibaldi currently has 50 designated public beach sites that are sampled for water quality; the North Shore identifies 6 beaches; and the Vancouver area has approximately 20 beaches with 63 sampling sites. The Northern Health Authority lists approximately 80 sites<sup>4</sup> that are routinely monitored. Within the Fraser Health Authority, 60 sites were identified as designated beach sites. The Vancouver Island Health Authority, as of August 31, 2005, monitored 52 designated sites. A figure for the number of beaches sampled in the Interior Health Authority was not made available for this paper; however, during the summer months this region likely experiences the highest levels of freshwater recreation in the province.

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<sup>2</sup> Usage rates for semi-public pools have been scaled down. Refer to Appendix A (Table 10) for calculations.

<sup>3</sup> Based on a population of 4,164,043 (Population figure retrieved from BC Stats, at [www.bcstats.gov.bc.ca/data/pop/pop/bcqrtpop.htm](http://www.bcstats.gov.bc.ca/data/pop/pop/bcqrtpop.htm)).

<sup>4</sup> More information is available at: [http://www.healthspace.ca/Clients/NHA/NHA\\_Website.nsf](http://www.healthspace.ca/Clients/NHA/NHA_Website.nsf).



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The guidelines used in the management of beaches in all cases throughout the province are the *Guidelines for Canadian Recreational Water Quality* (Federal-Provincial Working Group on Recreational Water Quality, 1992), which are currently being updated for publication in 2007.

For the purpose of this paper it is assumed that all hazards identified could be present at any potential recreational water site (undesignated or designated) and should therefore be considered as a potential risk to public health. Active management by the health authorities of the health risks posed at undesignated sites is not feasible. In these cases, public education, interest group participation and information-sharing with other branches of government (e.g., BC Ministry of Environment, Environment Canada) will play a vital role in identifying and mitigating potential health risks. Therefore, although all of the hazards identified for untreated recreational water sites may be applicable to both designated and undesignated sites, the total risk at this time is unquantifiable, and the most effective approach for managing risks will differ depending on various factors.

## **2.0 METHODOLOGY**

### **2.1 Excluded Topics**

Exclusions have been made from this paper for a number of reasons. Primarily, the topic of recreational water management can easily be extended to a broad range of topics. Each of these topics is comprised of smaller components with underlying scientific and technical aspects requiring expert knowledge to properly address. Therefore, the scope of this paper is constrained to topics deemed manageable. Secondly, some recreational water management issues are only tangentially related to human health, pose minor health risks to the public or lack any substantial data or literature on which this evidence paper could base any conclusion. Thirdly, the purpose of this paper is to present the hazards and evidence for what (if any) components of a core public health program would be effective at mitigating these risks. Therefore those hazards that have already been widely publicized and addressed were deemed to be outside of the scope, a duplication of effort or redundant (i.e., the hazard of sunburns and the potential for skin cancer). Finally, to keep the scope of the paper reasonable, a broad overview of the literature is presented along with any BC-specific data that was accessible.

The following exclusions have been made:

Although there are significant water-related health risks that have been studied, and many aspects of recreational water and beach management that could be delved into with great detail, this report will focus only on those recreational water-related issues that have been shown to pose a reasonable health hazard to bathers in British Columbia. Topics probed in WHO reports (1999, 2003) such as beach aesthetics, dangerous aquatic organisms, sun, heat and cold hazards (i.e., sunstroke) will not be discussed. Similarly, minor infections or very rarely encountered diseases such as GAE (granulomatous amoebic encephalitis) are noted in Section 4, but do not receive specific attention elsewhere in the document.

Physical hazards in untreated waters (addressed in Section 3.3) exclude hazards outside of those already present at the beach setting, such as recreational watercraft. Also excluded from this report is the significant impact that alcohol consumption has on the potential for physical hazards to result in an incident (Canadian Red Cross Society [CRCS], 2003). Although alcohol consumption is mentioned as a contributing factor to negative health outcomes under Section 4, comparison of incidents where alcohol was a factor or analysis of the success of alcohol prohibition regulations is omitted. Finally, this paper does not address recreational water management with respect to no- or minimal-contact water users. Negative outcomes or hazards posed to people present at a recreational water site for the purposes of engaging in activities such as boating, fishing, hiking, sunbathing or spectating are therefore excluded.

Worth specific mention is the topic of health risks posed by algae or aquatic plants. Several types of algae produce substances that are known to be toxic to humans if ingested in drinking water (fresh water) or consumed in shellfish (saltwater), and worldwide their presence appears to be on the rise (Philipp, 1993; Chorus, 1999). British Columbia is not an exception to this phenomenon, and toxic algae does present serious health and environmental concerns for BC water managers (McPherson, 2004; Warrington, 2001). The water bodies of the highest priority for this hazard

are not primary sites for swimming or full-contact activities. Further to this, fresh water bodies impacted by algae are most often aesthetically repulsive to potential swimmers, and therefore ingestion of water by humans is highly unlikely (Philipp, 1993). In fact, perhaps the only published cases of illness specific to this hazard was in 1959, when 13 people chose to swim in cyano-infected water, despite posted warnings, and became ill with flu-like symptoms (WHO, 2003).

Of course, it is acknowledged that rarely, an unexpected death or illness can occur due to a number of unforeseeable circumstances. This document does not intend to address anomalies and infrequent incidences; however, the mitigation of these events may inadvertently result from the programs discussed in Section 5.

Highly important aspects of pool and spa management are the recommended procedures for disinfection, filtration and facility design (including number of showers, etc.), and protocols for pool and spa cleansing (i.e., shock treatments) in the event of gross contamination by potentially harmful pathogens. Although specific issues will be addressed throughout this paper when relevant to the topic of discussion, for detailed information on all aspects of daily pool and spa management, the reader is referred to one of the many sources on this topic, such as the BC *Health Act* for pools, the WHO report *Guidelines for Safe Recreational Water Environments* (2000a, Chapters 5 and 6), and the Canadian Red Cross Society.

Finally, any estimates of the health risk or health burden of diseases are complicated by the need to consider differences in individual's immune responses to various pathogens or chemicals. People living with HIV/AIDS in the province, along with the elderly, the young and those undergoing treatments for other serious diseases, will obviously be more susceptible to any type of exposures. This paper in general reports on the anticipated response of average individuals. Specific reference to those with weakened or compromised immune systems is made with regard to the increased importance of public health education.

The WHO reports referenced in this paper provide in-depth recommendations and information on all aspects of recreational water management, including areas not addressed in the body of this review. This review aims to provide data specific to BC in relation to the literature, and highlight areas where readers may find the evidence warrants deeper investigation or action.

### **3.0 HAZARDS AND BURDEN OF RECREATIONAL WATER-RELATED ILLNESS AND INJURY IN BC**

Hazards encountered in a recreational water environment can have a variety of outcomes, with some being more measurable than others. Acute and serious physical injury incidents generally have a clear event and outcome, and are often reported by either facilities or health practitioners. Minor injury incidents, illnesses such as acute episodes of gastrointestinal illness, and minor respiratory problems have a variety of sources and are notoriously under-reported. In the case of microbiological hazards, this underestimation is further compounded as exposure incidents are difficult to pinpoint, even if the specific disease-causing agent can be identified via laboratory analysis. Since the 1950s, epidemiological studies have attempted to link specific disease outcomes to exposures to polluted recreational water. More recently, chemical hazards in the form of disinfection by-products are gaining attention as an emerging potential health concern.

Studies on recreational water are specific to the type of hazard, and are also often specific to the outcome (e.g., physical hazards resulting in death, chemical hazards resulting in respiratory illness, specific protozoan exposure resulting in gastrointestinal illness, etc.). The following sections provide a summary of these three groups of hazards found in the recent literature.

#### **3.1 Microbiological**

Providing a definitive assessment of the microbial health hazards and burden of disease associated with recreational water environments is a complicated task, due to a plethora of factors. First, there are a multitude of both predictable and unpredictable variables that constantly influence the presence of a potential pathogen.

This uncertainty is further compounded by differences in bather activities in these recreational waters and their level of susceptibility to these organisms. It may be, in part, due to this complexity, along with the numerous competing public health priorities, that the number of detailed epidemiological studies on microbial diseases encountered in recreational waters have gained attention only recently.

Although significant illness incidences associated with recreational water use have occurred in the past, a direct relationship was only suspected and not investigated (Stanwell-Smith, 1993). Recently, however, improved surveillance data from the United States and Europe show that microbial recreational water-related illnesses are on the rise (de Jong, Allestam, & Knauth, 2004, Barwick et al. 2000; Yoder et al. 2004), and there is a general acceptance that reporting seriously under-represents the burden of disease from both endemic and epidemic gastrointestinal illness (Meinhardt et al. 1996; Gostin et al. 2000). The diseases most widely studied to this point have been bacteria-associated gastrointestinal illness; however, viral and protozoan pathogens are gaining attention as an area of potential concern. Research has also been conducted on other microbial recreational water-related illnesses such as respiratory, ear and skin ailments.

In terms of treated recreational water environments, microbial hazards are largely mitigated by the use of disinfection and filtration. Chlorine-resistant protozoa and other bacteria such as *Legionella*, pose additional management challenges for the maintenance of pool and spa water

and air quality. In addition, improper maintenance of public and semi-public facilities frequently fail to adequately protect the public against chlorine-sensitive pathogens (Yoder et al., 2004). These hazards are discussed in more detail in Section 3.1.1.

The hazards presented in sea, estuarine and fresh water beaches are more complex to enumerate and control than those in treated water. In many cases, source control or pathogen removal is not viable. Therefore, preventing exposure to hazards through beach closures or risk communication is the most feasible health protection strategy. First, however, the difficult and still-evasive questions remains regarding the nature of the microbial hazards. For example, epidemiological and biological studies have struggled to define the relationship between various indicators and the incidence of diseases, or the correlation between these same indicators and the presence of pathogens. In the 1980s, some success in this regard was achieved. In response to several large outbreaks, studies were undertaken to quantify the dose-response relationship across varying bather activities and determine the most appropriate indicator organisms for use in setting recreational water quality guidelines (Fewtrell et al., 1993, Kay et al., 1994, WHO/US EPA, 1999). However, there still appears to be a lack of consensus on the most definitive measure for the presence of pathogenic hazards.

Of no doubt is the fact that the majority of the infectious pathogens of concern are those from human feces, introduced to bathing environments from sewage in untreated waters or accidental fecal releases (AFRs) in treated water.<sup>5</sup> The level of pathogens anticipated will be a factor of the rate of illness in the contributing population, and will vary by country, region and season (WHO/US EPA, 1999). For comparison purposes, examples and case studies are drawn from the United States, United Kingdom, Australia and Europe, as the general prevalence of recreational water-associated diseases in these populations should be similar to Canada. It is beyond the scope of this paper to provide an in-depth review of all potential pathogens in all environments; however, a summary is provided in Section 4.

### 3.1.1 Treated Water

With respect to treated water, microbial hazards can be divided into those pathogens that are controlled through disinfection methods and those that are not. Section 4 provides a listing of all pathogens categorized as being either non-chlorine-resistant or chlorine-resistant.

#### *Non-Chlorine-Resistant Pathogens*

As noted in the introduction to this section, if pools and spas are properly maintained, those pathogens removed through disinfection<sup>6</sup> should not present a serious public health concern. The real health risk stems from the possibility that pools and spas do not consistently have adequate water quality. Thus, the question to be answered is how do those responsible for public health protection ensure that the disinfection and filtration mechanisms in pools are well-maintained on an ongoing basis. As permits are required in BC for the operation of any public or semi-private facility, there is a reporting and inspection structure in place that allows for the tracking of information on each facility. Aside from the regular pool and spa water quality testing that

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<sup>5</sup> Important exceptions are Legionnaires' disease, Pontiac fever and mycobacteria.

<sup>6</sup> For details on disinfectant options, refer to the following WHO reports: *Disinfectants and Disinfectant By-products* (2000a), and *Guidelines for Safe Recreational Water Environments* (2000b).

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should be performed by the pool attendant, medical health officers or public health inspectors conduct random inspections, testing for adequate water quality based on parameters such as free chlorine residual, pH and clarity. Several of the health authorities publish the results of these inspections on the Internet (e.g., <http://www.healthspace.ca>). These results show the facilities sampled, the date and a hazard rating (low, moderate or high); some results provide qualitative information on the details of the inspection. While these reports are valuable, the format in which they are posted is not conducive to data analysis or comparison.

The BC Centre for Disease Control (BCCDC) environmental microbiology reports are a source of data that allow for some analysis of what the burden of gastrointestinal illness from treated recreational water may be. The 1999 to 2002 annual reports from Laboratory Services on the levels of total coliform, *P. aeruginosa* and the heterotrophic plate count, indicate that throughout the province, water quality in pools and spas does not pose a significant microbial hazard. For example, in the years 2001 and 2002, the percentage of samples taken exceeding the criteria for total coliforms and *P. aeruginosa* in swimming pools and spas ranged from 1.7 to 2.2 per cent and 2.2 to 2.0 per cent respectively.

The evidence from American pool and spa surveillance (1997–2002) presents another picture. Data from the Centers for Disease Control and Prevention (CDC) suggest that 12 to 25 per cent of gastrointestinal illness in treated waters could be attributed to chlorine-susceptible organisms such as *E. coli O157:H7* and *Shigella* (Castor & Beach, 2004; Yoder et al., 2004). It is an alarming finding that one-quarter of outbreaks were related to pathogens that are controllable through standard proper disinfection. The BCCDC data only refers to total coliforms detected, and not the pathogenic organisms, making a BC comparison with this evidence difficult. Echoviruses, hepatitis A, Norwalk, and adenovirus likewise are controlled through proper chlorination (WHO, 2000b); however, is important to consider the impact that an excess of organic material—contributed by bathers—can have on the efficacy of the disinfectants. Furthermore, persistent levels of free chlorine at 0.5 or 1.0 are not capable of adequately protecting against large volumes of any contamination in a timely manner.

As seen in Table 1, the total reported American cases of viral disease from treated recreational water sites is quite low; it is anticipated, based on a per capita comparison, that the incidence in BC is also negligible.

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**Table 1: Case Numbers from Reported Outbreaks of Illnesses Related to Recreational Water, United States (Treated), 1997-1998, 1999-2000 and 2001-2002**

Etiological Agent	Illness	Number of Cases		
		1997–1998	1999–2000	2001–2002
<i>Shigella</i>	Gastroenteritis	9	6	78
<i>E.coli</i>	Gastroenteritis	26	7	9
Chlorine gas	Acute respiratory	n/a	12*	102
<i>Cryptosporidium</i>	Gastroenteritis	1,61	1,212	1,473
<i>Legionella</i> species**	Pontiac fever	45	20	72
Norwalk virus	Gastroenteritis	n/a	9	60
AGI***	Gastroenteritis	n/a	32	59
<i>P. aeruginosa</i> ****	dermatitis	125	226	408

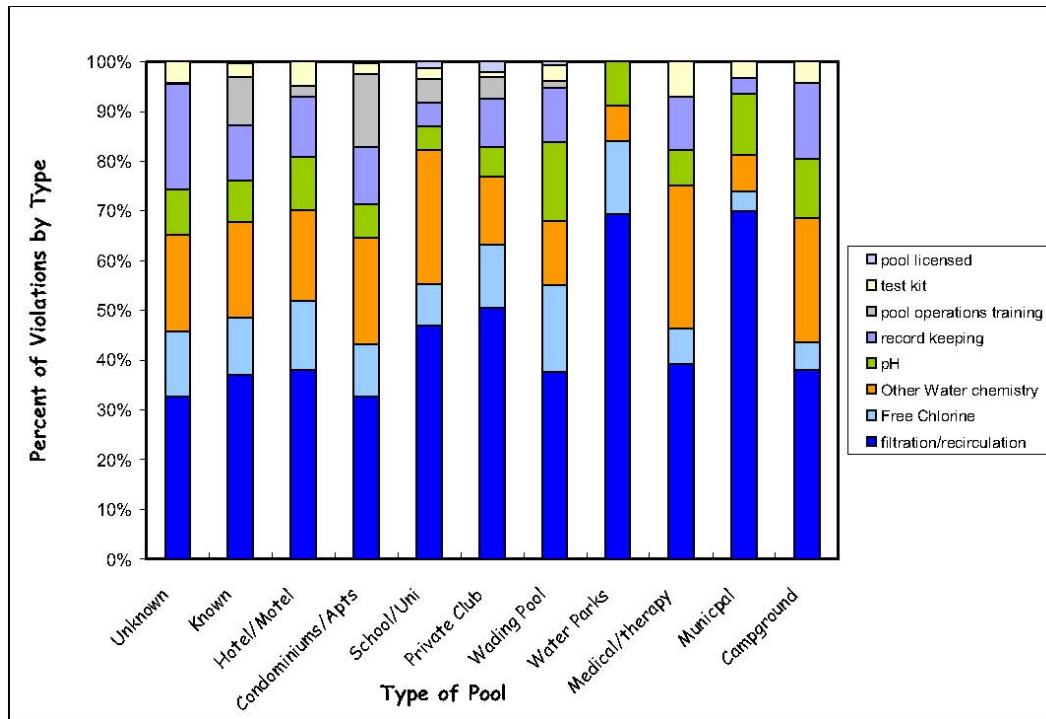
**Notes:**

- \* Cause unknown.
- \*\* Four cases were acute respiratory infections where *Legionella* species was suspected.
- \*\*\* Gastrointestinal Infections – unknown etiology.
- \*\*\*\* 3 cases were due to *Staphylococcus* and 20 to *Bacillus* species.

**Sources:** WHO/US EPA1999; Yoder et al., 2004.

Another comparison can be made with CDC data (2003) that summarizes 22,131 pool inspections from several American states over the period May to September 2002 (see Figure 1). An important finding from these inspections was that the majority of violations could result in poor water quality. The surveillance data also provide some very important insights as to what type of treated recreational water pose the highest hazard to the public. The CDC report (2003) noted that semi-private pool and spa operators (hotels, condominiums, apartments, etc.) were deficient in their accreditation and knowledge in maintaining proper water chemistry. Wading pools were the greatest source of water quality infractions. As children are known to be the most likely source of fecal bacteria, this outcome is not surprising. This evidence does, however, underline the potential need for greater diligence in maintaining these sites in BC. As children have immature immune systems and a propensity to ingest water while wading or swimming, they are an especially vulnerable population.

**Figure 1: Percentage of Pool Inspection Violations by Pool Type, United States, 2002**



**Note:** Total number of violations = 21,561.

**Source:** Adapted from CDC, 2003.

The preceding information indicates that a similar concern regarding recreational water quality protection may exist in BC. As the exact locations of the BCCDC samples were not identified in the annual reports from Laboratory Services (BCCDC, 1999; 2000; 2001; 2002), it is impossible to ascertain any relationship between water quality and pool type. Furthermore, even though nearly 98 per cent of all total coliform and *P. aeruginosa* samples were within the criteria, the selection of pools sampled was not representative of the health authorities' contribution to the total number of pools in the province. For example, although the Vancouver Coastal Health Authority has the highest number of semi-private pools and spas (see Appendix A, Table 6), the BCCDC reports that less than 10 samples per year over the 4-year period were tested for pathogens in this area.<sup>7</sup> Therefore, it is tenuous to draw any specific conclusions regarding the likelihood that inadequate pool management and water quality presents a public health hazard in BC.

The conclusion of the report was that infrequent inspections (less than three per year) by a health official is not sufficient to ensure that pools are consistently compliant with regulations and that the public's health is not compromised. The WHO's minimum sampling recommendations are for fecal indicator sampling weekly at public pools and monthly at semi-public pools (WHO, 2000b).

<sup>7</sup> The specific detail that would be required to replicate the CDC's surveillance inspection data (CDC, 2004b) may be accessible at the health authority level, but it was not available for the purposes of this paper. Should this data become available, it may provide a useful tool in determining the potential health risk due to poor pool maintenance, especially in semi-private facilities.



*Non-Fecally Derived Pathogens*

Spas and hot tubs, because of their temperature, high bather density and the contestant agitation and aeration of water, pose additional hazards that must be managed. *Legionella spp.* and *M. avium* (a species of mycobacteria) are examples of the potentially more serious non-fecally related pathogens. The exposure to *Legionella* that leads to legionellosis (Pontiac fever or Legionnaires' disease) is prolonged inhalation of aerosols. Relatively high doses of *Legionella* are required ( $\sim 10^7$ ) for infection to occur (WHO, 2000b). When the conditions are favourable for infection, the attack rate is between <1 per cent and up to 95 per cent for Legionnaires' disease and Pontiac fever respectively (WHO, 2000b). Luckily the symptoms of Pontiac fever are relatively mild and the illness is not life-threatening. In fact, exposures to *Legionella spp.* and mycobacteria occur in many different environments, and most immunocompetent individuals will not necessarily develop any disease as a result of the exposure (WHO, 2004).

Some concern exists regarding *M. avium* and a group of environmental mycobacteria referred to as MAC (*M. avium-intracellulare*),<sup>8</sup> as they may be more chlorine-resistant than other non-fecal pathogens. To remove these pathogens from recreational water can be a particularly difficult task, as filtration equipment actually supports the growth of MAC and other organisms that can be present in biofilms<sup>9</sup> (Falkinham, 2004). It is difficult to provide an estimate of what the burden of disease might be for recreational water exposures in BC to these pathogens. However, the CDC estimates the overall annual global burden of disease from all mycobacteria (non-AIDS related) to be 110,000 (WHO, 2004). This figure indicates that the risk to immunocompetent individuals in BC is quite low. The WHO report does state that the burden of MAC increases substantially in terms of the population living with AIDS, and has been as high as nearly 50 per cent (WHO, 2004). Considering that over 3,000 people in the province are currently suffering with AIDS, this could represent a burden of 1,500. In general, however, proper maintenance of spas and pools to control *Legionella* address most of the potential risk of exposure to significant levels of MAC (Ford et al. 2004).

*P. aeruginosa* occurs most frequently in spas; as it manifests as a non-serious, self-limiting illness, cases are often not reported (WHO, 2000b). The route of exposure for *P. aeruginosa* is primarily through dermal contact in both spas and pools. However, a case study (Rose et al. 1998) of repeated outbreaks of granulomatous pneumonitis ("lifeguard lung") at a water park illustrates that changes to the standard design features of pools, and the inclusion of recreation features, can introduce a new hazard into the recreational water environment. In this case, the piping system of a spray feature had corroded, allowing for the buildup of an unidentified substance (perhaps biofilm), impairing the disinfection. Subsequently, the material was aerosolized along with the *P. aeruginosa*, which resulted in the observed respiratory symptoms. In this particular case, continued surveillance of the respiratory health of lifeguards before and after physical improvements were made to the facility provided a important discovery.

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<sup>8</sup> Mycobacteria are not specific to spas; they can also be found in and around pools. For a thorough representation of the research and information regarding the health risks of mycobacteria, refer to *Pathogenic Mycobacteria in Water: A Guide to Public Health Consequences, Monitoring and Management* (WHO, 2004).

<sup>9</sup> For recent information on biofilm presence and water quality, refer to an article on amoebae in domestic water systems, by Thomas et al. (2004).

This particular study is important and timely as it demonstrates that reporting and surveillance must continue to be a priority in the management of recreational water. Routine visual inspection of equipment and chemical testing of water is not always sufficient to protect against emerging and previously unknown health risks. As these types of features are becoming increasingly common in public pool facilities, a multiple-barrier approach (or HACCP) to public health protection is required. The number of reported cases in the United States (1997–2002) for illnesses related to *Legionella* and *P. aeruginosa* are provided in Table 1.

The tools to manage these pathogens are standard good disinfection and spa hygiene practices. In Southern Australia the regulations state that this involves maintaining a minimum chlorine residual of 4mg/L within a pH of 7.2 to 7.8, full recirculation of the pool within 30 minutes, a 20 per cent water change per day and/or a full water change weekly, and spa cleansing every week (Department of Human Services, 1998). Other countries, such as Germany, recommend levels of free chlorine as low as 0.3 mg/L (WHO, 2000b). BC does not have a specific regulation for spas; however, the guideline range for pools is between 0.5 and 1.0 mg/L, depending on pH.

#### *Chlorine-Resistant Pathogens*

Effective filtration and disinfection does not guarantee that the microbial hazards have been mitigated, as 50 to 70 per cent of gastrointestinal illness outbreaks in treated venues are attributed to chlorine-resistant pathogens (Yoder et al., 2004; Castor & Beach, 2004). At any time, a bather that is infected with *Cryptosporidium* or *Giardia* can contaminate millions of gallons of water with one accidental fecal release (AFR) in sufficient doses of the oocysts to infect other bathers. The relative ease of disease transmission is such that even a small amount of water taken in orally is considered an infective dose (Castor & Beach, 2004). As AFRs often go undetected, the pathogens can survive in chlorinated pool water for up to two days (Castor & Beach, 2004). The fact that a potentially fatal disease-causing pathogen can exist unknowingly in a pool at any time poses a serious risk to bathers, especially those with compromised immune systems.

Even more alarming is the fact that an average adult can contribute 0.14 g of feces to pool water if proper showering does not precede entry into the pool (Castor & Beach, 2004). For children, this amount can be as great as 10 g (Castor & Beach, 2004). Assuming that the BC population is similar to the United States population, approximately 11 per cent of the population has had diarrhea in the previous month (Castor & Beach, 2004), indicating the potential existence of an intestinal pathogen in this population. Applying this estimate to the approximately 30 million annual visits to BC pools, emphasizes the importance of pre-swim showering, as only 1 g of feces can contain up to  $10^6$  oocysts in an infected individual, and only 140 oocysts qualify as a sufficient dose of the pathogen (DuPont et al., 1995).

An outbreak of *Cryptosporidium* occurred in a leisure centre in Surrey, BC, during the summer of 2003. A few specific points regarding this outbreak warrant mention. Firstly, two known AFRs occurred in late-June and mid-July, but full remediation of the pool did not occur until after the initiation of the investigation in September. This meant there was a substantial period of time in which visitors to the pool could have been exposed and re-exposed, or could have infected other bathers. Also, shedding of oocysts can continue at a level high enough to cause infection from two to five weeks after the symptoms subside (Stehr-Green et al., 1987).

Secondly, the facility's lifeguards may have been a source of re-contamination of the pool, as at least one lifeguard was confirmed to have the illness. The investigation revealed that many employees suffered from diarrhea during this period but continued to work. As it is fair to assume that lifeguards receive training about the importance of hygiene in pools, it is even more concerning that these behaviours persisted. The *Canadian Communicable Disease Report* (Health Canada, 2004) noted that lifeguards did not receive sick pay and implied that this could have provided a disincentive for employees to stay out of the pool when ill.

Lastly, based on the description of the investigation given in the *Canadian Communicable Disease Report*, the outbreak was identified and subsequently linked to the pool because of the relatively high number of reports to health practitioners. The number of reported cases that instigated the investigation was 9 cases. By the completion of the investigation, 31 cases were associated with the pool (15 laboratory confirmed and 16 clinical), based on self-reporting of the affected individuals to their health practitioners (Health Canada, 2004). This total represented only those individuals who reported symptoms to a doctor; therefore, it underestimates the true burden of illness from this one outbreak. Although a comparable study on the under-reporting of *Cryptosporidium* was not found for Canada, an American study (Perz, Ennever, & LeBlancq, 1998) estimated that for every 3 cases reported, as many as 10,000 go unreported.

A recent meta-analysis of Nordic countries (Horman et al., 2004) revealed similar estimates of between 4,072 and 15,181 cases suspected to every 1 recorded by surveillance or registry systems. This same analysis estimated that the annual incidence of symptomatic *Giardia* and *Cryptosporidium* in these countries is nearly 4,670 and 3,340 per 100,000 population respectively. Applying the estimated annual incidence rate of 3,340 per 100,000 population to BC, it is probable that in one year, there could be 220 cases of recreational water-related cases of *Cryptosporidium*.<sup>10</sup> The estimates based on Mead et al. (1999) and CDC-reported data shown in Appendix B (Table 12) are significantly more conservative at 6.8 cases per year.

It is clear from the examples above that the most effective means to protect public health from disinfection-resistant pathogens is through sustained education, focused on modifying bather practices.

### 3.1.2 Untreated Water

Any discussion of the disease burden related to microbial hazards encountered in recreational water must examine the history of the importance of indicators as a means of identifying the harmful pathogens. The ability to identify the presence of a pathogen at a level that has been proven to have an adverse effect can give recreational water managers the ability to prevent or control exposures leading to an adverse outcome.

The initial studies to quantify this relationship were conducted in the United States and the United Kingdom in the 1950s (Kay & Wyer, 1992). These studies differed significantly in their methodology, with the results of the American studies being used by the US EPA to propose a standard based on the geometric mean of five samples taken for fecal coliforms within a 30-day period. The Canadian standard stated that the geometric mean should not exceed 200 fecal

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<sup>10</sup> Refer to Appendix 2, Table 12 (the calculations for Scenario H).

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coliforms per 100 ml<sup>-1</sup> and that additional sampling would be required in the case of any sample exceeding 400 fecal coliforms. The United Kingdom study was a retrospective study of two specific diseases having a low endemic rate in the population, and it claimed there was negligible health risk to those bathing in sewage-polluted waters. The United Kingdom, in absence of a clear alternative, adopted the European standard, which had a recommended limit of 80 per cent of samples falling below a level of 500 total coliforms/100 ml<sup>-1</sup>, and a mandatory limit of 95 per cent of samples falling below a level of 10,000 total coliforms/100 ml<sup>-1</sup> (Kay & Wyer, 1992; Efstratiou, 2001).

Subsequently, in the 1970s, neither of the early studies were found to be sufficient to dismiss or warrant public concern over the potential health risks posed by microbial-polluted waters.<sup>11</sup> Additional epidemiological studies were conducted in North America in the 1980s by Cabelli et al. (1982, 1983) and Dufour (1984). These studies were the first to present reasonable evidence of a health risk, and became the basis for new fresh and marine beach water quality (Efstratiou, 2001). The current standards shown in Table 2 are a consequence of the knowledge and evidence gathered over the 1980s and early 1990s.

**Table 2: Comparative Microbiological Standards for Untreated Bathing Waters, 2005**

Country/ Organization	Total Coliforms		Fecal Coliforms		<i>E. coli</i>		Enterococci	
	Marine	Fresh	Marine	Fresh	Marine	Fresh	Marine	Fresh
US EPA						126/100 mL	35/100 mL	33/100 mL
Washington State*			14cfu/100 ml	100cfu/100 ml			35/100 mL	
British Columbia		1,000/100 mL	200/100 mL	200/100 mL				
Health Canada			***	**	***	200/100 mL	35/100 mL	
European Union (guide)	500/100 mL	500/100 mL	100/100 mL	100/100 mL				
European Union (mandatory)	10,000/100 mL	10,000/100 mL	2,000/100 mL	2,000/100 mL				

	The indicator is not recommended or not used.
	The indicator is used in practice.
	The indicator is recommended.

**Notes:** The *Guidelines for Canadian Recreational Water Quality* have been revised and will be released in 2007. The “Total and Fecal Coliforms” guidelines will no longer be used. Enterococci will be used as the marine indicator of water quality in the revised Guidelines, as it has a closer relationship to health effects.

\* Indicator levels quoted are for recreational waters where primary contact with water is made.

\*\* The Health Canada guidelines state that where greater than 90 per cent of fecal coliforms are *E. coli*, either fecal coliform or *E. coli* can be used; otherwise *E. coli* must be used.

<sup>11</sup> These studies focused only on microbial hazards introduced through sewage or fecal matter and did not consider viruses or toxic cyanobacteria.

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\*\*\* The Health Canada guidelines state that if it can be demonstrated that *E. coli* or fecal coliforms can adequately demonstrate the presence of fecal contamination in marine waters, the maximum of these indicators for freshwater can be used.

**Source:** Washington State Department of Ecology, 2003.

Cabelli et al. (1983) first estimated the gastrointestinal illness to enterococcus dose-response relationship and defined acceptable illness rates of 8 per 1,000 and 19 per 1,000 for bathers in fresh and coastal sites respectively, based on 200 fecal coliforms per 100 mL (Kay & Wyer, 1992). Also, the concept of tiered single sample allowable densities for indicator organisms that could be applied based on the classification of the beach were introduced.

There have been several criticisms of the epidemiological studies of the 1980s (Kay & Wyer, 1992; Efstratiou, 2001; Wade et al., 2003). Further research continued in this area, employing the use of different protocols, exposure variables, sampling protocols, case definitions for outcome variables and control of confounding variables (Havelaar et al., 2001). One important example was a pilot study conducted in the United Kingdom at several freshwater sites in the early 1990s by Fewtrell et al. (1993). These sites had varying levels of indicator organisms, and the goal of the study was to establish a dose-response relationship between levels of water contamination and the disease attack rates, given different recreational activities. The degree of exposure to the water is determined by the type of activity undertaken by the user, which in turn, will impact the likelihood of symptoms. Another key aim of the study by Fewtrell et al. (1993) was to control for confounding factors such as diet, alcohol consumption and other pre-existing conditions or behaviours. Their study also provides some indication that different standards could be applied in a hierarchical way, based on the type of activity and the associated level of contact with the water.

Disagreement internationally regarding what indicators were superior to ensure bacterial water quality prompted another more recent study by van Asperen et al. (1998). This study used a controlled cohort of triathletes to clarify some of the conflicting results different studies had produced. An important result from this work was that even in fresh waters, where the European Union standard for bathing quality was met, swimmers were two times more likely to develop gastroenteritis as the non-swimming control group. This study also clearly demonstrated that different case definitions of gastrointestinal illness commonly used in the United States and United Kingdom literature produced a range of attack rates and burden based on the same indicator organism concentrations. The lack of a universal definition of gastroenteritis clearly complicates the meaningful comparison of studies and can potentially lead to confusion for policy-makers when determining safe standards (Havelaar et al. 2001). In fact, the current *Guidelines for Canadian Recreational Water Quality* (Federal-Provincial Working Group on Recreational Water Quality, 1992) state:

Current microbiological-epidemiological studies are not sufficiently validated to allow calculation of risk levels. However, there is some evidence for increased risk of illness from bathing compared with non-bathing (i.e., wading or remaining on the beach) (p. 21).

The management of recreational water has moved into a new phase with the concepts put forward by the “Annapolis protocol” (WHO/US EPA, 1999). The 2003 WHO report, *Guidelines for Safe Recreational Water Environments: Volume 1, Coastal and Fresh Waters*, widely cited in this review, incorporates the work of the Annapolis Protocol and recent case-controlled studies by Kay et al. (1994). This report clearly recommends *E. coli* as a more reliable predictor for pathogens in freshwater environments, and *enterococci* in marine waters. A recent meta-analysis of the most current and rigorous research (Wade et al., 2003) also recommends the discontinued use of fecal coliforms, finding that *E. coli* is a much more accurate indicator in fresh water. (Kay et al., 1994; Wade et al., 2003; Noble et al., 2003). In general, all indicators are widely questioned for their ability to predict pathogens. More importantly, evidence indicates that the level of viral pathogens present in recreational water may not have a correlation to any of the currently used bacterial indicators (Efstratiou, 2001; Noble et al., 2003; Griffin et al., 2001).<sup>12</sup>

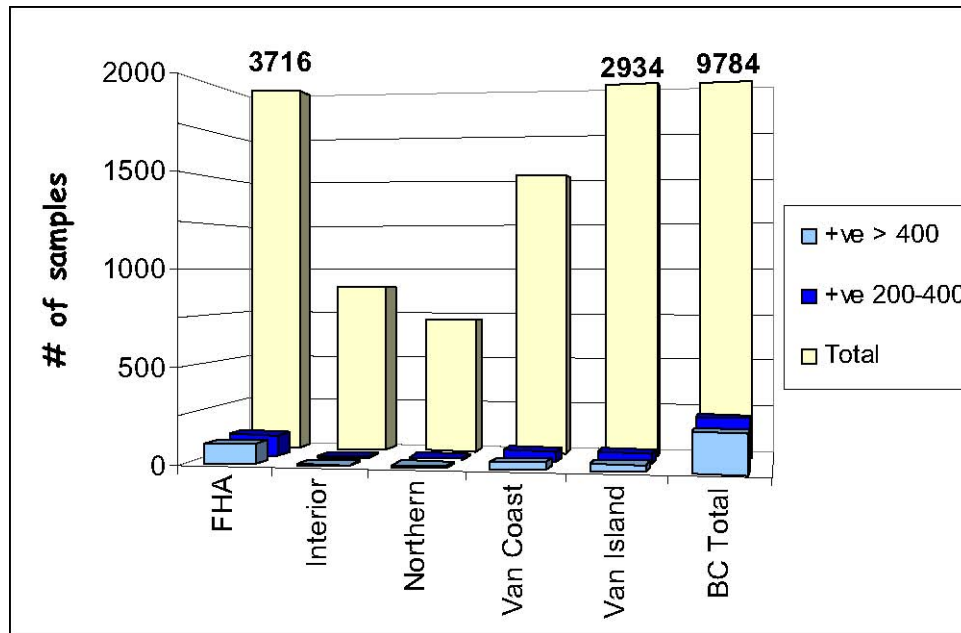
As shown in Table 2, the US EPA now recommends employing *E. coli* as an indicator organism in fresh water environments and *enterococci* for marine waters (Kay & Wyer, 1992). Despite the US EPA and Health Canada recommendations, most states and provinces still use total coliform (TC) or fecal coliform (FC) (Noble et al., 2003). Likewise, marine and freshwater beaches in British Columbia use fecal coliforms as an indicator for water quality. This could potentially pose a health risk to coastal water bathers as microbiological studies have demonstrated the presence of disease-causing pathogens (*Salmonella*) at marine beaches testing at fecal coliform densities above 13 cfu/100 ml (Polo et al., 1998). A report to the Greater Vancouver Regional District by Gibson & Smith (1988), was cited in the *Guidelines for Canadian Recreational Water Quality* (Federal-Provincial Working Group on Recreational Water Quality, 1992) as one of the few Canadian investigations on the use of *enterococci*. They found that only 1.6 per cent of the 30-day geometric mean of 26 beaches sampled exceeded the US EPA-recommended guidelines of 35/100 ml. However, this finding, in itself, does not imply that fecal coliforms are a suitable indicator for marine environments, as these organisms will die off readily in sea water, thereby masking potential pathogen concentrations.

Figure 2 shows BCCDC fecal coliform sampling results from recognized beaches throughout the province over a 4-year period. Vancouver Coastal and Fraser Health Authorities had the highest percentage of fecal indicator bacteria breaches, with approximately 6 per cent of the total samples over this period exceeding the Canadian Recreational Water Quality Guideline of 200 FC/100 mL. It is important to note that the data for the designated beaches (number of samples taken and positive results) was aggregated to produce an overall total for the health authorities. As such, this representation does not show that for some specific areas/beaches within the health authorities, the percentage of samples containing greater than 200 FC ranged between 0 per cent and 16 per cent. More frequently offending beaches may warrant attention of the health authorities to determine the source of the high fecal coliform counts. The results over this period did not indicate an increasing or decreasing trend in the level of coliforms detected.

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<sup>12</sup> For a detailed summary of human pathogenic viruses in marine environments, the reader is directed to Griffin et al. (2003).

**Figure 2: British Columbia Beaches Microbial Water Quality: Fecal Coliform Sampling Results, 1999-2002**



Source: BC Centre for Disease Control, 1999, 2000, 2001, 2002.

Estimating the burden of disease for untreated recreational water exposures has significant obstacles (Prüss and Havelaar, 2001). Unfortunately, the relationship between indicators and pathogenic bacteria in recreational water is not firmly established. Furthermore, epidemiological studies have not proven the exposure-risk relationship between the indicator levels and the probability of disease. It is the establishment of the exposure-risk relationship that would enable the estimate of the burden of disease of the various microbiological hazards present in recreational water (Prüss and Havelaar, 2001). As this is not currently possible, an alternative is to estimate the incidence in the public based on results of controlled case studies and reported outbreaks.

The United States has had a surveillance system in place for tracking and monitoring recreational water illnesses since 1978 (Yoder et al., 2004). Although this system is not entirely standardized and has limitations, it provides a rough means to predict the Canadian circumstances where data is not readily available. Surveillance data 1985–2002 are shown in Table 3 and Figure 3. As in the case with treated water, a compiled list of outbreaks or incidences of recreational water-related illness is not available for Canada or BC, and inferences can only be based on individual case studies or investigations. The data below is difficult to interpret without the additional insight provided within the surveillance reports. However, the information does indicate that the number of outbreaks may be on the rise. Speculative estimates for BC, based on the American data, are provided in Appendix 2 (Table 12).

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**Table 3: Case Numbers from Reported Outbreaks of Illnesses Related to Recreational Water, United States (Untreated), 1985-1994, 1997-1998, 1999-2000 and 2001-2002**

Etiological Agent	Illness	Number of Cases			
		1985- 1994	1997-1998	1999-2000	2001-2002
<i>Shigella</i>	Gastroenteritis	935	-	15	33
<i>E. coli</i>	Gastroenteritis	166	13	52	69
<i>Leptospira</i>	Leptospirosis	14	375	21	
<i>Giardia</i>	Gastroenteritis	65	-	-	2
<i>Cryptosporidium</i>	Gastroenteritis	418	8	220	5
<i>Naegleriafowleri</i>	Meningoencephalitis	-	4	3	8
Norwalk virus	Gastroenteritis	41	48	168	95
Adenovirus 3	Gastroenteritis	595	-	-	-
AGI*	Gastroenteritis	965	939	25	82
Avian Schistosomes	Dermatitis	-	2	2	19

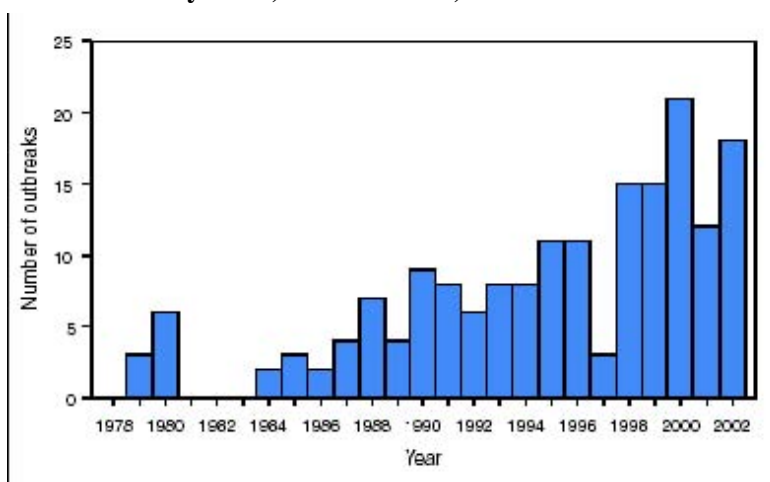
**Note:**

\* Gastrointestinal infections-unknown etiology.

**Sources:** WHO/US EPA, 1999; Yoder et al., 2004.

As noted earlier, the results of past epidemiological studies estimated that the geometric mean of 200 fecal coliforms would result in 8 illnesses per 1,000 in freshwater and 19 per 1,000 in marine waters.<sup>13</sup> By looking at Figure 3 it could be implied that the potential for illness at beaches in the province during this time was possible. Without estimated numbers of visits, data on the type of water contact and specific fecal coliform data for each beach site, any estimate of the burden of disease would be a tenuous one.

**Figure 3: Number of Water-borne Disease Outbreaks of Gastroenteritis Associated with Recreational Water by Year, United States, 1978-2002**



**Note:** N=76.

**Source:** Yoder et al., 2004

<sup>13</sup>  $R = -11.74 + 9.39 \log_{10}(E)$  where R = swimming-associated gastrointestinal illness per 1,000 swimmers; E is the *E. coli* cfu/100 mL (Dufour, 1984). An alternate approach, quantitative microbial risk assessment, can be found in the 2003 WHO report, *Guidelines for Safe Recreational Water Environments: Volume 1, Coastal and Fresh Waters*.



The WHO recreational water guidelines now place less importance on the ability of past epidemiological studies to accurately quantify the risks of swimming at beaches, as this has been shown to be an impossible task (Efstratiou, 2001). Instead, the focus is on combining the knowledge of the sources of the pollution with the level of fecal indicator bacteria detected along with other specifics regarding the type of recreational water environment and the users of the site (WHO, 2003). Part of this strategy is a commitment to effective, goal-oriented sampling programs to establish a baseline of water quality and No Observed Effect Level(s) (NOELS). Through continued sampling and monitoring, a body of evidence will emerge that will greatly improve the understanding of how accurately indicator organisms predict pathogen presence in a wide variety of environments.

#### *Non-Human Sources of Pathogenic Bacteria*

The source of pathogens that has been most studied is human sewage; however, other point and non-point sources may also pose risks (e.g., urban runoff, especially during periods of intense rainfall (Dwight et al., 2004; WHO, 2003). At British Columbia lakes and beaches, a common source of coliforms is birds and other wildlife. For example, the Vancouver Island Health Authority attributed past beach closures at Prospect Lake to local waterfowl (Vancouver Island Health Authority, 2001). Recent studies highlight the importance of accurately determining what portion of the high fecal coliform readings are attributable to bird feces (Kirschner et al., 2004), and whether these feces carry virulent forms of the pathogens that pose an authentic risk to health (Kassa, Harrington, & Bisesi, 2004; Kullas et al. 2002; Waldenström et al., 2003; Zhou et al., 2004). With respect to *Cryptosporidium*, no human cases have been linked to exposure to bird feces, and generally the overall health risk is considered to be very low from this source (Kullas et al., 2002; Zhou et al., 2004).

Several of the papers warn, however, that evidence has emerged indicating further study is required and that complacency regarding the potential that protozoan parasites are zoonotic is not totally warranted (Waldenström et al., 2003; Kullas et al. 2003; Monis & Thompson, 2003; Zhou et al., 2004; Kassa et al., 2004). For example, the infection of children by *Giardia lamblia*, another intestinal parasite, has been correlated with a high presence of domestic animals in and around homes (Ali & Hill, 2003). Canine-originating species of *Cryptosporidium* have also recently been detected in the feces of infected humans (Chappell & Okhuysen, 2002).

This confounding factor, that indicator organisms detected may be related to wildlife or other non-human feces, has been noted as a weakness in the use of fecal indicator bacteria (WHO, 2003). In answer to this, indicators such as fecal sterols, caffeine, male-specific bacteriophage, enteric virus and enteric bacteria have been considered (Ashbolt, Willie, & Snozzi, 2001; Boehm et al., 2003).<sup>14</sup> All of these alternatives are still relatively unstudied, however, and currently the most reasonable indicators are fecal bacteria. Monitoring agencies and health authorities should be diligent and knowledgeable in assessing the most likely source of the fecal bacteria—be it wildlife, urban runoff or bathers themselves. Kirschner et al. (2004) have attempted to develop a model that would assist beach managers in more confidently making this assessment by establishing the relationship between fecal indicator bacteria (*E. coli* and *enterococci*) and the

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<sup>14</sup> For a listing of the potential indicators and their advantages and disadvantages for use in recreational water environments, refer to Bartram & Rees (2000, pp. 169–216).

portion of contamination that is from wildfowl, based on bird abundance and several easily measurable environmental variables.

In reference to non-gastrointestinal infections, a few studies have looked at allergic reactions or infections due to parasites; the primary examples being swimmer's itch (cercarial dermatitis) and swimmer's ear (otitis externa) (van Asperen et al., 1998; Springer & Shapiro, 1985; Seyfried & Cook, 1984). These studies did find evidence to suggest that prolonged swimming exposure in very warm freshwater lakes did increase the risk of developing otitis externa. This finding was true even when the lake water quality was within the bacteriological guidelines (Seyfried & Cook, 1984; van Asperen et al., 1998). As some of the heavily used lakes during the summer months in BC can reach temperatures in excess of 20°C, the risk of developing otitis externa may increase. While BCCDC does publish the results of *P. aeruginosa* detected in pools and spas in the province, there is no similar sampling for marine or freshwater sites.

### 3.1.3 Associated Costs of Related Risks

In taking an economic approach, Rabinovici et al. (2004) provide estimates of the dollar cost/benefit of beach closures to swimmers using 1998 to 2001 beach data from a popular beach on Lake Michigan in the Northern United States. The study focused on determining if management decisions to close a beach in response to fecal indicator bacteria levels provided a net economic benefit to swimmers. A key issue that they identified was the time delay from when the samples of an indicator were taken to the subsequent action of closing the beach (generally 24 hours later). Because of this delay, beaches may have been open when there was a potential for disease, and closed to the public when this threat had passed.

Willingness to pay (WTP) values for swimming and for the avoidance of gastrointestinal illness were estimated using previous economic studies. From their analysis it appears that beach closures can forfeit a net benefit to swimmers of nearly \$35,000 per day (2000 USD), even when the closure was warranted. The avoidance of a small number of people contracting gastrointestinal illness did not appear to outweigh the benefits of a large number of swimmers. The authors of the paper stressed that the case definitions for gastrointestinal illness were mild to moderate and they did not address life-threatening cases due to immunocompromised individuals.

Appendix 2 displays the rationale for hypothetical estimates of the cost of gastrointestinal-related water illness in BC, based on data from the United States, European Union, United Kingdom, and British Columbia. While these estimates are very imprecise, they could provide insights into the importance that surveillance and reporting can have on evaluating the burden of disease, and the efficacy of any program aimed at lowering this burden.

Most of the data on the number of cases is from American data collected by the CDC. Although Canadian and American populations are similar in their standard of living, significant climate differences (i.e., much warmer beaches for a greater portion of the year), clearly equate to a much larger population participating in full-contact water activities, with an increased exposure to these hazards. The estimated case numbers for BC may be overstated. A focused review of American states most similar to BC could prove more accurate.

In contrast to this point, it is important to note that the estimates of BC cases are based on reported American cases over the period 1997–2002. Averaging the percentage of reported gastrointestinal illness that could be attributed to recreational water environment over this time period could result in overly conservative estimates. This point is illustrated by Figure 3 (Yoder et al., 2004). It is clear that including data from the periods 1997–2002 in the average may incorrectly represent the burden from recreational water, especially if the rising trend in recreational water gastrointestinal illness continues. Furthermore, reported cases can be multiplied by 38-fold (for non-bloody diarrhea) and 20-fold (for bloody diarrhea) causing illness (Mead et al., 1999) to account for under-reporting. By applying these multipliers to the figures derived from American data, the burden would more closely match that of the Nordic country estimates (Appendix 2, Table 12, Scenario H), and could then be seen as significantly more serious. Even so, this relatively low number, in comparison to the burden of other diseases prevalent in our society, would indicate that although American surveillance shows disease from this source is on the rise, it will still remain a relatively low priority on the public health agenda.

In summary, what the evidence and available data on the burden of disease attributable to recreational water in BC demonstrates is that there is a lack of clear evidence and data. There are several diseases or ailments for which a cause-effect relationship between bathing in polluted, untreated water and their occurrence is biologically plausible (e.g., hepatitis A, eye infections, skin ailments) (WHO, 2003). However, with the exceptions of gastroenteritis and ear infections, the evidence does not prove the associations of most of the suspected outcomes with certainty (WHO, 2003). As is the case worldwide, the opportunity for improvement exists in the management of BC's recreational waters, including a review of the effectiveness of current monitoring and surveillance practices. Undoubtedly, the costs of any recreational water management strategy must be in balance with the health risks posed by competing health priorities. A summary of some of the recommendations of the WHO (2003) and others to improve fresh and marine recreational water management is provided throughout Section 5 of this paper.

## **3.2 Chemical**

Chemical hazards posed by recreational water environments, relative to the physical and microbiological hazards, have not received a great deal of attention until fairly recently; as such, the risks of a negative health outcome are not well understood (Stanwell-Smith, 1993; WHO, 2003). In lakes and marine environments, the primary sources of potentially harmful chemicals are industry and effluent discharges and urban runoff. In treated recreational water, swimmers and non-swimmers may be exposed to chemical hazards that are by-products of disinfection agents commonly used to treat against microbiological hazards.<sup>15</sup>

### **3.2.1 Treated Water**

Safety protocols for disinfectants used in the treatment of pools are well-established, and many of them have been used for decades. It is well-known that ingestion, inhalation or physical contact with undiluted concentrations of the disinfection chemicals used in pools can have serious negative health outcomes (WHO, 2000a). Less well-established are the health effects of

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<sup>15</sup> For detailed information on disinfectants and by-products, refer to WHO 2000a & 2000b.

the disinfection by-products in pool and spa water, and their impact on the air quality of a facility. Disinfection by-products are the compounds that result when disinfectants such as chlorine and bromine, react with organic matter, constituents of toiletry products and urea under different conditions of temperature and turbidity (Thacker & Nitnaware, 2003).

There are several groups of disinfection by-products; the ones that have been most studied and are associated with swimming are trihalomethanes (THMs) and chloramines (Bernard et al., 2003; Nieuwenhuijsen, Toledano, & Elliott, 2000; Whitaker, Nieuwenhuijsen, & Best, 2003; WHO, 2000b). The most studied THM is chloroform, which is suspected to play a role in the development of bladder, kidney and other forms of cancer and adverse birth outcomes (Whitaker et al., 2003; WHO, 2000a). Swimming pools and spas are only one way that people are exposed to chloroforms, and research has been conducted to determine the relative contributions that drinking water, showering and swimming make to the levels of chloroform in the blood (Whitaker et al., 2003). Recent epidemiological studies have been able to determine with some degree of confidence the level of uptake of disinfection by-products into the body via the three routes of exposure; dermal, inhalation or ingestion (Nieuwenhuijsen et al., 2000; Whitaker et al., 2003; WHO, 2000b). The WHO (2000a) summarizes these studies, and concludes that the health risks of cumulative exposures to disinfection by-products as a result of chlorinated drinking and bath water pose a greater concern than infrequent exposures to pool water. The WHO report (2000a) suggests several methods for minimizing the risks, focusing on dilution, alternate disinfection methods (pre-ozonation), pool air ventilation and enforcement of thorough pre-swim showering.

Chloramines—and in particular, nitrogen trichloride (NCL<sub>3</sub>)—have been the focus of study by researchers in France. They have noted that NCL<sub>3</sub> may induce eye, nose and respiratory irritation for lifeguards working in indoor pools (there is no identified health risk from NCL<sub>3</sub> in outdoor pools or spas) (Massin et al., 1998). This 1998 study was unable to establish any chronic effects of long-term occupational exposures to NCL<sub>3</sub>; however, a recent study (Bernard et al., 2003) has found evidence to suggest that sufficient childhood exposure to indoor chlorinated pools may increase a child's risks for developing asthma. As this is very recent information, further studies are needed. Furthermore, from Table 1, the 102 cases in 2001–2002 reported by the CDC for chemical exposures, were attributed to chloramine exposures in an indoor pool setting. There appears to be both scientific and anecdotal evidence warranting continued research on disinfection by-products in the interest of public health protection.

As a final note, the WHO (2000a), in their assessment of chemical hazards, concluded that even though disinfection by-products may pose a health risk, the benefit the chemicals provide against pathogens was far more significant, and disinfection should never be compromised. They recommended not greater than 5 mg/L residual chlorine with levels always below 2 mg/L for public pools and 3 mg/L for semi-private pools. Lower residual levels may be acceptable in cases where the pool is ozonated (0.5); however, for spas, the free chlorine should be maintained at 2-3 mg/L because of higher bather loads. This type of information is not currently stated in the BC *Health Act*; however, it is the commonly accepted guideline used by pool/spa managers and medical health officers/public health inspectors.

### 3.2.2 Untreated Water

The WHO (2003) report regarding both organic and inorganic chemical hazards in recreational water states the following:

In general, the potential risks from chemical contamination of recreational waters, apart from toxins produced by marine and freshwater cyanobacteria and algae, marine animals or other exceptional circumstances, will be very much smaller than the potential risks from other hazards outlined in [other] chapters. It is unlikely that water users will come into contact with sufficiently high concentrations of most contaminants to cause adverse effects following a single exposure. Even repeated (chronic) exposure is unlikely to result in adverse effects at the concentrations of contaminants typically found in water and with the exposure patterns of most recreational water users. However, it remains important to ensure that chemical hazards and any potential human health risks associated with them are recognized and controlled and that users can be reassured as to their personal safety (WHO, 2003).

The *Guidelines for Canadian Recreational Water Quality* (Federal-Provincial Working Group on Recreational Water Quality, 1992) support this conclusion. Sections 5.4.1 and 5.4.2 of the guideline acknowledge that chemicals could cause a health hazard in recreational water, but that based on nationwide water quality samples, no sufficient evidence exists to warrant concern at this time. Accidental spills of hazardous chemicals at or near a water body are of course a serious potential hazard; however, these types of events would be dealt with through emergency response mechanisms. Should such an event occur, an appropriate monitoring and testing program of the affected water would ensue to ensure the public's health was protected.

There is no evidence at this time to believe that chemical contaminants in untreated recreational water pose any significant health risk in BC. This statement is based on Ministry of Environment water quality monitoring and objective reports.<sup>16</sup> Some chemicals, such as selenium and arsenic (associated with mining), have been detected in parts of the province; however, their concentrations have not exceeded safe bathing limits and are declining due to reclamation efforts. Phosphorus is the only chemical that has raised some concern. In Quamichan Lake and Prospect Lake on southern Vancouver Island, values of phosphorus were detected that exceed the criterion (0.01 mg/L) for recreational use and drinking water during several years in the 1980s and 1990s. Warnings were posted at each of these lakes declaring them unsafe for swimming. High levels of phosphorus are more an indicator of poor water quality in general and not a determinate of a health risk. Therefore, the closure was most likely due to the concurrent levels of fecal coliforms (>200/100 ml) in these lakes.

### 3.2.3 Associated Costs of Related Risks

Currently there is a lack of information available to calculate the burden from chemical hazards. Should evidence emerge that a causal relationship exists between swimming and diseases such as

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<sup>16</sup> Reports are available at <http://www.env.gov.bc.ca/wsd/>.

cancer and asthma, it may be reasonable to attribute some of this burden of disease for these illnesses to recreational water.

### **3.3 Physical**

Treated and untreated waters pose a variety of physical hazards that can result in similar outcomes. The more serious outcomes that are possible as a consequence of these hazards are drowning, near-drowning, spinal injuries (quadriplegia, paraplegia), brain injuries, retinal dislocation and fractures. This section of the paper reviews the literature on the basis of outcomes, rather than on a hazard-by-hazard basis, with the exception of entrapment or entanglement hazards (Section 3.3.1).

#### **3.3.1 Entrapment or Entanglement Incidents**

Although entrapment or entanglement hazards are present in untreated waters, they have received special attention with respect to pools and spas in recent years. As these hazards are intentionally introduced into the recreational water environment for the purposes of entertainment or filtration, it is of great concern that they have resulted in serious injuries and fatalities.

Drowning or near-drowning due to entrapment from filtration or recirculation equipment is a rare event, and the segment of the population most at risk is small children using spas, although swimming pools may pose a similar hazard (Consumer Product Safety Commission [CPSC], 2005; WHO, 2000b). Suction entrapment can take three primary forms, as shown below with corresponding statistics over various periods in the United States (CPSC, 2005).

- Body or Limb Entrapment: 9 reported incidents, including 7 deaths (1990–1996).
- Hair Entrapment: 30 reported incidents, including 10 deaths (1990–1996).
- Evisceration or Disembowelment: 15 incidents with no fatalities (1980–1996).

The first presumed case in Canada that resulted in death was in 1986, when an 11-year-old male got his limb entrapped in a drain when he removed the drain's protective cover (Moore, 1986). In 1994, 2 other deaths were attributed to entrapment, 1 of which was in BC. Most recently in 2001, the entrapment drowning of a 13-year-old male in Ontario prompted the Chief Coroner for the province to issue a release regarding the need for a minimum of 2 drains along with properly designed drain covers (Government of Ontario, 2001). Based on the data available, there have been relatively few cases in Canada; however, recent data from the United States shows that over the period of 1990 to October 2003, there were 113 cases of entrapment due to pools or spas, resulting in 23 deaths and 2 cases of disembowelment (Elder, 2004).

In a recent survey of 175 community indoor and outdoor pools in the province, 80 per cent were reported as being 15 years or older and requiring at least some form of refurbishment or part replacement (BCRPA, 2004). As many of the innovations and improvements to drainage and engineering occurred in the early 1990s, this could indicate a potential concern with a large proportion of the pools. Furthermore, there are no specific standards or provisions in the current *Health Act* that make retrofit mandatory in this area for existing pools. The decision to issue a permit to pools and spas is assigned to the environmental health officers and/or public health

engineers. Therefore pools that predate legislation on the number of drains may continue to only have one drain (L. Egan, personal communication, March 15, 2005).

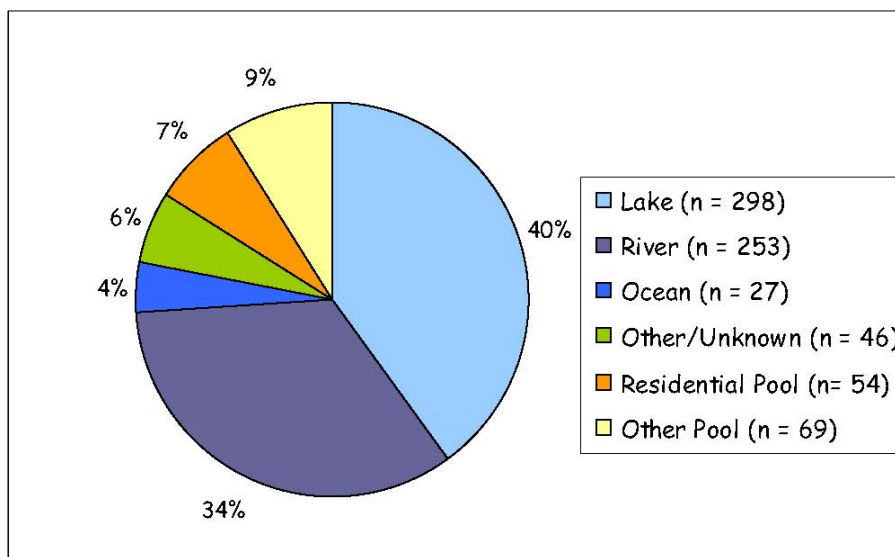
Under proposed draft pool regulations of the *Health Act*, new pools must be an approved design to prevent suction entrapment, and existing pools must be maintained to prevent entrapment.

### 3.3.2 Drowning and Near-drowning Outcomes

Worldwide, the drowning injury burden is very serious. For the year 2000, the WHO (Peden, McGee, & Sharma, 2002) estimates the total number of DALYs lost to drowning at 13,263,000, with 97 per cent of deaths occurring in middle- to low-income countries. This equates to a drowning injury burden for high-income countries between 30,000 and 100,000 DALYs, depending upon gender (Peden et al., 2002).

The Canadian Red Cross Society (2003) reports that although there has been a decline in drowning overall across British Columbia and Canada, the burden still remains high. The report states that over the periods 1991–1995 and 1996–2000, the annual incident rates for deaths in Canada due to drowning from swimming or wading decreased from 0.29 to 0.23 and 0.07 to 0.04 per 100,000 population respectively. The locations of these drowning incidents in Canada are summarized by percentage in Figure 4.

**Figure 4: Recreational Swimming Drowning by Type of Water, Canada, 1991–2000**



**Note:** n=747

**Source:** Canadian Red Cross Society, 2003.

Of all drowning events, over two-thirds occurred during recreational activities (CRCS, 2003). Recreational aquatic drowning, excluding boating, accounted for approximately 25 per cent of drowning deaths from 1991–2000 (CRCD, 2003). This 25 per cent equates to 1,183 deaths, of which 69 per cent (747) are attributed to swimming, 15 per cent (168) to playing or wading, 3 per cent (28) to diving or jumping and 4 per cent (39) to the use of hot tubs. Over the 9-year period, deaths due to all activities decreased except for hot tub deaths, which increased by 245 per cent.

British Columbia's share of the national total of all drowning deaths is significant at nearly 20 per cent. Over the years 1987–2001 there were 798 deaths among BC residents due to accidental drowning.<sup>17</sup> Data available from the BC Vital Statistics Agency illustrates that although the overall numbers are not significant to all causes of death, recreational water use comprises a significant portion of drowning-related deaths. Given that these are purely unintentional, non-occupational, fatal accidents they should be up to 90 per cent preventable (Ministry of Health, 1997).

Information on pool drowning has only been available since the ICD-10 codes became the standard means for reporting and categorizing incidents, as of 2001/2002.<sup>18</sup> There were 2 fatalities reported in 2000, 1 death in 2001, 4 deaths in 2002, and 7 deaths in 2003 due to drowning in swimming pools.<sup>19</sup> In the United States, the Consumer Product Safety Commission reported an excess of 700 drowning deaths directly attributable to pools and spas during the period 1980–1998.

Near-drowning is another type of negative outcome associated with recreational water use. In near-drowning cases, the individual may survive the drowning incident, but subsequent complications due to oxygen deprivation or spinal injuries can have serious long-term effects and costs. A regional comparison for 2000–2001 shows that BC had the highest near-drowning<sup>20</sup> hospitalization rate at 1.67 hospitalizations per 100,000 (unadjusted), whereas the national rate was 0.88 per 100,000 (Canadian Institute for Health Information [CIHI], 2003). One study of near-drowning in California found that 62 per cent of cases were attributed to swimming pool use (Ellis & Trent, 1995).

The age groups with the highest percentage of traumas related to near-drowning were those in the under-20 category; according to CRCS (2003), the average number of hospitalization for near drownings between 1991 and 2000 for the under-20 age group was 420, which is 57 per cent of all hospitalizations in Canada due to near drowning. It is widely recognized that the young are at highest risk for both recreational water drowning and near-drowning, with males representing 70 to 85 per cent of those involved in these types of accidents (WHO, 2000b; CRCS, 2003). An American study by Ellis & Trent (1995) corroborates the Canadian figures and estimates the near-drowning rate as 1.7 times higher for males than females. For this demographic category, the cause of the near-drowning incident had a less than 3 per cent chance of being related to any watercraft. This clearly illustrates that drowning during swimming or active contact with the water is still the major cause of drowning or near-drowning within the under-20 age category.

Furthermore, although the overall number of unintentional injury accidents in BC have decreased since 1997, drowning and near-drowning incidents from 1997–2002 have fluctuated between 39 (1999–2000) and 77 (1998–1999) for hospitalizations, and 13 (2000–2001) and 6 (1997–1998)

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<sup>17</sup> Data extracted from VISTA (Vital Statistics).

<sup>18</sup> As of 2001-2002 data, diagnostic/statistical information for BC was received coded to ICD-10-CA. (CIHI, 2004b).

<sup>19</sup> Data extracted from VISTA (Vital Statistics).

<sup>20</sup> Near-drowning in this figure relates to incidents resulting from the use of watercraft, recreational activities (swimming) and bathing. It does not include diving or jumping injuries.

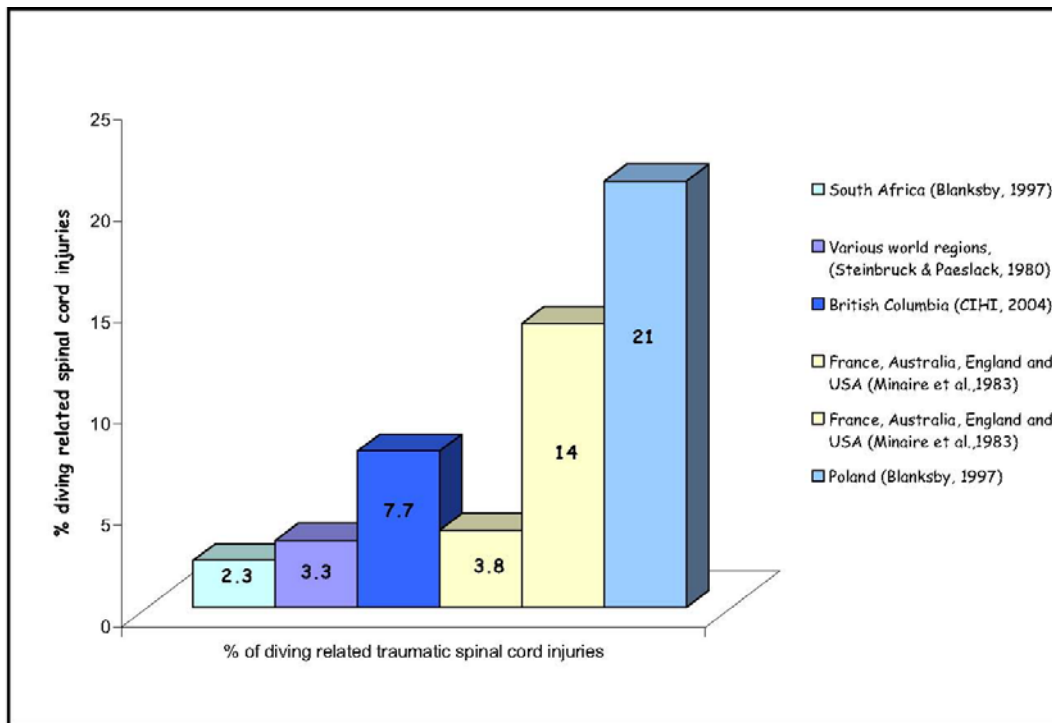


for injury in-hospital deaths (CIHI, 2004a). This example highlights the need for more sustained progress on prevention of recreational water-related incidents.

**3.3.3 Other Injuries (Spinal, Head, Internal, Superficial and Other)**

Every year in Canada, the Canadian Red Cross Society (2001) estimates that there are 60 spinal cord injury hospitalizations due to diving accidents. In 2001–2002 in British Columbia, there were 53 injuries related solely to diving or jumping into water (ICD-10-CA W16). Of these 53 incidents, 7 fell into the more serious categories of spinal cord (4), intracranial injury (1) and internal (2) injuries (CIHI, 2004a). BC’s injury statistics agree with those found elsewhere in the world (see Figure 5), indicating somewhat that these types of injury occur more due to the behaviour of the bather, rather than the presence or absence of the hazard. Sadly, recreational diving or jumping traumas can result in serious injuries and economic impacts: 90 per cent of spinal cord injuries due to diving result in quadriplegia or paraplegia, compared with 50 per cent of spinal cord injuries from other incidents (Samples, 1989).

**Figure 5: Summary of Studies on Diving-related Trauma**



Source: Adapted from WHO, 2000b.

The WHO (2000b) stresses that the numbers in Figure 5 underestimate the real burden of diving-related injuries, as these injuries result in quadriplegia and paraplegia more often than any other type of accidental injury, and usually occur to people under the age of 24.

**3.3.4 Associated Costs of Related Risks**

SMARTRISK (2001) estimated that, in 2004, the cost of unintentional injury in BC due to drowning or suffocation would be in the range of \$65 million (see Appendix 1, Table 11). This figure includes both indirect and direct morbidity and mortality costs for hospitalization and non-

hospitalization, where the patient was at some point admitted to a hospital facility (i.e., it excludes costs of deaths at the site or in transport to a facility).

Ellis and Trent (1995) reported that in California in 1991, near-drownings resulted in 4,545 days in hospital. Their estimates of the hospitalization costs (adjusted to 2005 CAD) were \$11.4 million for 865 cases, with the mean cost being \$13,215, although the median over \$2,198 is more reflective, as several extreme cases skewed the average figures. A comparable figure for BC is available for the years 1998–1999 and 2001–2002. In these years there were 64 and 42 hospitalizations due to drowning events respectively, based on the E codes of the ICD-9 coding system (SMARTRISK, 2001; CIHI, 2004a). The comparable hospitalization cost figure for 1998 was \$251,500, with an approximate mean of \$3,900.

The median length of stay (LOS) for drowning—1.0 days—was also similar between the United States and Canada. The mean LOS for 2001–2002 data was slightly higher at 2.5 days. A point to consider, however, is that of the 1998 injuries, 20 per cent resulted in partial permanent disability and 9 per cent in total permanent disability (SMARTRISK, 2001). The cost estimates (in 2005 CAD) for ongoing disabilities related to near-drowning range in annual cost from \$199,978 (Ellis & Trent, 1995) to \$208,253 (WHO, 2000b), posing a serious economic burden. Although an annual disability cost figure is not available for BC, in the SMARTRISK study (2001), the total lifetime cost of permanent disability due to the 6 drowning- or suffocation-related incidents in 1998 was estimated to be \$4,337,700 (\$2,440,700 of which were indirect morbidity costs). This figure excludes any acute direct or indirect hospital costs directly after the incident. This cost is very high, especially as it represents only 6 of the 64 people injured in this year.

It is important to stress that for these types of incidents, the indirect costs, losses to society through lost productivity and ongoing rehabilitation comprise most of the total costs. Primary and secondary prevention efforts will have the largest impact on reducing the burden as these incidents have serious chronic health effects that are only minimally addressed by acute hospital care and post-injury treatment.

**Table 4: Summary Estimates of Physical Outcomes Incidence and Costs, British Columbia**

Outcomes	Sources	Annual Incidence Ranges	Cost	Cost in 2005
All Drowning Deaths	Suffocation & Drowning	207*	\$49,515,800 <sup>a</sup>	\$57,516,968
	Drowning Deaths	61 <sup>b</sup>	n/a	n/a
	Accidental Fall into water (E9109)	14 <sup>b</sup> (1998)–38 <sup>b</sup> (1994)	n/a	n/a
	Drowning in Swimming Pool (E9108)	5 <sup>b</sup> (1998)–29 <sup>b</sup> (1991)	n/a	n/a
	Average Annual Deaths 1990–98**	87 <sup>b</sup>	n/a	n/a
	Annual Deaths 0–24 yrs***	41 <sup>c</sup>	n/a	n/a
Near Drowning & Physical Hazard Incidents	Yearly	42 <sup>d</sup> –64 <sup>a</sup>	\$254,100 <sup>a</sup>	\$295,160
	Injury Hospital Admissions 1998 (E910)	77 <sup>c</sup>	n/a	n/a
	Drowning and Suffocation non-hospitalization incidents	455 <sup>a</sup>	\$142,900 <sup>a</sup>	\$165,990
	Diving in Water (ICD E Code = W 16)	53 <sup>d</sup> (2001-2002)	n/a	n/a
	Subsequent deaths	6 <sup>b</sup> –104 <sup>d</sup>	n/a	n/a
Spinal/Head injuries	Permanent Partial Disability	13 <sup>a</sup>	n/a	n/a
	Quadriplegic	6 <sup>a</sup>	\$26,026,20035 <sup>**</sup>	\$30,231,726
	General Spinal/Head Injuries (2001-2002)	7 <sup>d</sup>	n/a	n/a

**Notes:** All dollar figures converted to 2005 using CPI calculator available at [http://www.bankofcanada.ca/en/inflation\\_calc.html](http://www.bankofcanada.ca/en/inflation_calc.html).

\* This relatively high number can partly be explained as it includes both hospitalized and non-hospitalized cases, deaths due to water-related drowning, water craft, unintentional suffocation and those deaths for which an ICD-9 code can be mapped to E910, E830-E838 and E913 external cause (ICD 9 E code) (SMARTRISK, 2001).

\*\* Figure represents lifetime maintenance costs for one impaired victim (approx 20-years-old), estimated at \$4 million.

**Sources:**

- a SMARTRISK, 2001.
- b Kashaninia, Macdonald, & Armour, 1999.
- c Ministry of Health, 1997.
- d CIHI, 2004a.
- e CIHI, 2003.

### 3.4 Limitations or Data Deficiencies

Drowning and other accidental water incident research falls under the umbrella of injury research. In comparison to other health research priorities, it has traditionally received far less attention and many of the statistics have been derived from administrative data. Unsurprisingly, the available data can often be limited (SMARTRISK, 1998), appear to lack a common

methodology for calculation, or may be based on varying case definitions. As a result, it is difficult to make a meaningful comparison of incidence and costs between years and countries.

The information used in this paper regarding the incidence and costs of water-related physical outcomes in BC was the 2001 SMARTRISK report. The BC cost estimates for the economic burden of unintentional injury due to water-related events included suffocation events along with drowning or near-drowning. It was therefore not possible to ascertain precisely what portion of the incidence and costs cited in the report were only attributable to drowning or near-drowning in a recreational water environment.

#### **4.0 RECREATIONAL WATER HAZARD SUMMARY AND MITIGATION OPTIONS**

The preceding discussion clearly shows that recreational water poses a variety of health hazards to users and that the risks are difficult to quantify, as the goal-oriented monitoring and reporting programs necessary for a detailed evaluation have traditionally been absent. Also, because recreational water environments encompass a vast number of both predictable and unpredictable circumstances, the ability to clearly state a risk figure is daunting. Not only are factors concerning an individual's behaviour and pre-existing health conditions highly variable in the population, but the environment, and the interactions between people and that environment, will affect the likelihood of a health outcome.

To assist in simplifying the complex and diverse horizon of possibilities, this section provides a list of hazards along with the potential options for mitigation. This section is only a summary, not a clear prescription of how to deal with every environment. Each specific site or situation should be analyzed in context of costs, relative risks and stakeholders. Decisions or actions that are intended to mitigate the hazards, where possible, and will require significant resources, should be evaluated using the WHO recreational water management framework introduced in Section 5.

**Core Public Health Functions for BC: Evidence Review**  
**Water Quality (Recreational Water)**

<b>Microbiological Hazards in Recreational Water</b>			
<b>Untreated Natural Recreational Water – Fresh and Marine Beaches</b>			
<b>Health Outcome</b>	<b>Hazards</b>	<b>Multi-use Interactions or Contributing Factors</b>	<b>Mitigation Options</b>
Swineherd’s disease, Stuttgart disease and Weil’s syndrome, collectively termed leptospirosis.	Leptospirosis (Fresh water)		<ul style="list-style-type: none"> <li>• Bank side management to control rodents, dents, litter collection.</li> <li>• Treating and covering cuts and abrasions prior to exposure.</li> <li>• Seeking medical advice if influenza-like symptoms are noticed a few days after recreation.</li> </ul>
Primary amoebic meningoencephalitis (PAM).	<i>Naegleria fowleri</i>		
Various potential health outcomes from skin and eye irritations to vomiting, diarrhea and flu-like symptoms.	<ul style="list-style-type: none"> <li>• Cyanobacterial toxins (Fresh water)</li> <li>• <i>Anabaena</i>, <i>Aphanizomenon</i>, <i>Nodularia</i>, <i>Oscillatoria</i>, <i>Gloeotrichia</i></li> </ul>		<ul style="list-style-type: none"> <li>• Control of eutrophication.</li> <li>• Monitoring and fresh reporting of cyanobacterial populations.</li> <li>• Public awareness and education.</li> </ul>
Swimmers’ itch.	avian schistosomes		<ul style="list-style-type: none"> <li>• Control weeds and aquatic snails.</li> <li>• Avoid warm, snail-infested ponds.</li> <li>• Public awareness and education.</li> <li>• Information on occurrence of schistosomiasis.</li> </ul>
Inflammation of the cornea (keratitis) Granulo-matous amoebic encephalitis (GAE).	<ul style="list-style-type: none"> <li>• <i>polyphaga</i> and <i>A. castellanii</i>: cause keratitis</li> <li>• <i>A.culbertsoni</i>: causes GAE</li> </ul>		
Acute febrile respiratory illness (AFRI). Eye/ear infections Gastrointestinal illness. Diarrhea, vomiting, dysentery and flu symptoms.	<ul style="list-style-type: none"> <li>• Fecal streptococci: (AFRI)</li> <li>• Water-borne infections caused by various pathogens derived from fecal pollution (<i>E. coli O157:H7</i>, <i>Shigella spp.</i>, <i>Giardia lamblia</i>, <i>Cryptosporidium parvium</i>, Norwalk-like viruses, adenovirus, etc.</li> </ul>	<ul style="list-style-type: none"> <li>• Bather shedding.</li> <li>• Combined sewer outflows.</li> <li>• High and intense rainfall events.</li> <li>• Sanitary system overflows (SSO) (US EPA, 2002).</li> <li>• Marinas and multi-use docks/harbour areas.</li> <li>• Failing septic systems and contributions from other surface and groundwater sources.</li> </ul>	<ul style="list-style-type: none"> <li>• Microbial guidelines.</li> <li>• Licensing, ensuring, control and treatment of discharges of sewage, effluents, storm overflows.</li> <li>• Improvements where indicated by unsatisfactory microbial quality.</li> <li>• Personal awareness of local conditions.</li> <li>• Time-relevant beach sampling and monitoring.</li> </ul>

**Core Public Health Functions for BC: Evidence Review**  
**Water Quality (Recreational Water)**

<b>Microbiological Hazards in Recreational Water</b>			
<b>Treated Recreational Water – Pools, Spas, Wading Pools</b>			
<b>Health Outcome</b>	<b>Hazards</b>	<b>Multi-use Interactions or Contributing Factors</b>	<b>Mitigation Options</b>
Water-borne infections and G.I. Illnesses Haemorrhagic colitis Haemolytic uramic syndrome	<ul style="list-style-type: none"> <li>Non-chlorine-resistant fecally derived agents:               <ul style="list-style-type: none"> <li>Viruses: adenovirus, hepatitis A, Norwalk virus, echoviruses</li> <li>Bacteria: <i>Shigella</i>, <i>E. coli</i>.</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>Bather shedding in pool and spa waters and on wet surfaces around pools and spas.</li> <li>Pool water contaminated with urine from infected humans and animals.</li> </ul>	<ul style="list-style-type: none"> <li>Proper chlorination and disinfection (free chlorine residual of 0.4 mg/L).</li> <li>Automatic dosing systems.</li> <li>Limits on bather load.</li> <li>Enforcement of showers.</li> <li>Education for parents and children.</li> <li>Education to those suffering from gastrointestinal illness</li> <li>Education for immunocompromised individuals.</li> <li>Constant monitoring of lifeguards and reporting of AFRs.</li> </ul>
Water-borne infections and Gastrointestinal Illnesses	chlorine-resistant fecally derived agents: <i>Cryptosporidium</i> and <i>Giardia</i> cysts.	<ul style="list-style-type: none"> <li>Bather shedding in pool and spa waters and on wet surfaces around pools and spas.</li> <li>Pool water contaminated with urine from infected humans and animals.</li> </ul>	<ul style="list-style-type: none"> <li>Ozone disinfection at 5 mg of ozone per litre or filtration with a porosity of less than 4 µm or use of coagulants and flocculants.</li> <li>Education of pool users about hygiene.</li> <li>Information to immunocompromised individuals.</li> <li>Automatically activated walk-through showers at pool entrance.</li> </ul>
Pontiac fever Legionnaire’s disease.	<i>Legionella spp.</i>	<ul style="list-style-type: none"> <li>Aerosols from spas and HVAC systems.</li> <li>Bather shedding in pool and spa waters and on wet surfaces around pools and spas.</li> <li>Pool water contaminated with urine from infected humans and animals.</li> <li>Poor ventilation.</li> </ul>	<ul style="list-style-type: none"> <li>Free chlorine residuals should be maintained at 1.0 mg/L at all times in spas and hot tubs.</li> <li>Vigilant cleaning and disinfection of spa features and equipment with hypochlorite solution of 5 – 10 mg/L.</li> <li>Vigilant cleaning and disinfection of areas around spas and hot tubs.</li> <li>Ventilation in spa and hot tub rooms.</li> </ul>
Folliculitis Swimmer’s ear	<i>Pseudomonas aeruginosa</i>	<ul style="list-style-type: none"> <li>Bather shedding in pool and spa waters and on wet surfaces around pools and spas.</li> <li>Pool water contaminated with urine from infected humans and animals.</li> <li>Poor ventilation.</li> </ul>	<ul style="list-style-type: none"> <li>Free chlorine residuals should be maintained at 1.0 mg/L at all times in spas and hot tubs.</li> <li>Vigilant cleaning and disinfection of spa features and equipment with hypochlorite solution of 5 – 10 mg/L.</li> <li>Vigilant cleaning and disinfection of areas around spas and hot tubs.</li> <li>Ventilation in spa and hot tub rooms.</li> </ul>
Swimming pool granuloma Hypersensitivity pneumonitis Hot tub lung	<i>Mycobacterium spp.</i> <i>Mycobacterium avium</i>		<ul style="list-style-type: none"> <li>Education on bather hygiene.</li> <li>Information to immunocompromised or high-risk individuals.</li> <li>Appropriate bather load.</li> <li>Shock chlorination treatments.</li> <li>Frequent cleaning and rinsing of equipment and superheating of spa water to 70°C on a daily basis for non-disinfected natural hot springs.</li> <li>Preventing domestic and wild animals access to spas and hot tubs.</li> </ul>
Skin, wound and ear infections	<i>Staphylococcus aureus</i>		
Haemorrhagic jaundice Aseptic meningitis	<i>Leptospira interrogans</i>		

**Core Public Health Functions for BC: Evidence Review**  
**Water Quality (Recreational Water)**

<b>Microbiological Hazards in Recreational Water</b>			
<b>Treated Recreational Water – Pools, Spas, Wading Pools</b>			
<b>Health Outcome</b>	<b>Hazards</b>	<b>Multi-use Interactions or Contributing Factors</b>	<b>Mitigation Options</b>
Molluscum contagiosum Plantar wart Athlete's foot	Viruses and Fungi Molluscipoxvirus Human Papilloma virus <i>Trichophyton spp.</i> <i>Epidermophyton floccosum</i>	<ul style="list-style-type: none"> <li>Bather shedding.</li> <li>Unclean facilities.</li> </ul>	<ul style="list-style-type: none"> <li>Education to limit contact between infected and non-infected individuals.</li> <li>Regular cleansing of pool and spa areas.</li> </ul>
Primary amoebic meningoencephalitis (PAM). Acanthamoeba keratitis Granulomatous amoebic encephalitis (GAE) (immunocompromised only)	Ameobas <i>Naegleria fowleri</i> <i>Acanthamoeba spp.</i>	<ul style="list-style-type: none"> <li>Pools and spa water.</li> <li>Aerosols from HVAC systems.</li> </ul>	<ul style="list-style-type: none"> <li>Vigilant cleaning of HVAC systems.</li> <li>Public awareness on use of contacts in spas.</li> <li>Information on hazard to immunocompromised.</li> </ul>

**Core Public Health Functions for BC: Evidence Review**  
**Water Quality (Recreational Water)**

<b>Chemical Hazards in Recreational Water</b>			
<b>Treated Recreational Water – Pools, Spas, Wading Pools</b>			
<b>Health Outcome</b>	<b>Hazards</b>	<b>Multi-use Interactions or Contributing Factors</b>	<b>Mitigation Options</b>
Potential evidence for elevated risk for bladder cancer Chronic respiratory illness Acute pneumonitis	<ul style="list-style-type: none"> <li>• Chemical Exposures</li> <li>• Primary disinfection agents Chlorine, bromine<sup>21</sup></li> <li>• Disinfection By-products<sup>22</sup></li> <li>• THMs (chloroforms, BDCM and DBCM, NCL<sub>3</sub><sup>23</sup>)</li> </ul>	<ul style="list-style-type: none"> <li>• Dermal, ingestion and inhalation exposures</li> <li>• Duration and frequency of exposure (time).</li> <li>• Disinfection used bather load</li> <li>• Ventilation, ambient temperatures and humidity in pool facility.</li> <li>• pH.</li> <li>• Pool water dilution.</li> </ul>	<ul style="list-style-type: none"> <li>• Minimize the introduction of precursors (organic and inorganic matter brought into the pool by the users).</li> <li>• Educate and enforce thorough showering.</li> <li>• Good ventilation in pool and spa buildings.</li> <li>• Maintain free chlorine well below 5 mg/L.</li> <li>• For bromine-based disinfection, bromine levels constantly maintained at 15-20 mg/L.</li> <li>• Possible evidence that use of chlorine and ozone combination (lower level of free chlorine required) will reduce the disinfection by-products and dermal exposure to chloroform.</li> </ul>

<sup>21</sup> Two case studies of suspected bromine poisoning in hot tubs leading to reactive airways dysfunction system (Burns & Linden, 1997).

<sup>22</sup> Epidemiological studies in this area are relatively recent, and limitations in clearly defining hazards and risks from disinfection by-products are due to difficulties in exposure assessment (Nieuwenhuijsen, 2003; Whitaker et al., 2003). For detailed information on other disinfectants and disinfectant by-products, refer to WHO (2000a, 2000b).

<sup>23</sup> Bernard et al. (2003) have recently studied the possibility that NCL<sub>3</sub> predisposes childhood swimmers to asthma and that swimming in chlorinated pools by this population could be a contributor to the higher levels of childhood asthma present in developed countries.



**Core Public Health Functions for BC: Evidence Review**  
**Water Quality (Recreational Water)**

<b>Physical Hazards in Recreational Water</b>			
<b>Health Outcome</b>	<b>Hazards</b>	<b>Multi-use Interactions or Contributing Factors</b>	<b>Mitigation Options</b>
<b>Untreated Natural Recreational Water – Fresh and Marine Beaches</b>			
Drowning or Near-drowning	<ul style="list-style-type: none"> <li>Sea current (including tides, undertow and rate of flow).</li> <li>Offshore winds (especially with flotation devices).</li> <li>Possibility of underwater entanglement.</li> <li>Bottom surface gradient and stability.</li> <li>Waves (coastal, boat, chop).</li> <li>Water transparency.</li> <li>Impeded visibility (including coastal configuration, structures and overcrowding).</li> <li>Collision with or entrapment by wrecks, piers, weirs, sluices and underwater obstructions.</li> </ul>	<ul style="list-style-type: none"> <li>No lifeguard provision.</li> <li>No provision of rescue services.</li> <li>Poor access to emergency response services (e.g., telephones with emergency numbers).</li> <li>Local hazard warning notices.</li> <li>Overcrowding.</li> <li>Lack of supervision.</li> <li>Alcohol consumption.</li> <li>Falling unexpectedly into water.</li> <li>Not being able to swim.</li> <li>Breath-hold swimming and diving.</li> </ul>	<ul style="list-style-type: none"> <li>Regulations that discourage unsafe behaviors (e.g., alcohol consumption).</li> <li>Local hazard warning notices.</li> <li>Development of rescue and resuscitation skills among general public and user groups.</li> <li>Coordination with user group associations concerning hazard awareness and safe behaviours.</li> <li>Wearing of adequate lifejackets when boating or recreating.</li> </ul>
<b>Treated Recreational Water – Pools, Spas, Wading Pools</b>			
Drowning or Near-drowning	<ul style="list-style-type: none"> <li>Treated water.</li> <li>Pool filtration equipment.</li> <li>Pool features (diving boards etc.).</li> <li>High water temperatures.</li> <li>Inadequate pool and spa covers.</li> </ul>	<ul style="list-style-type: none"> <li>Drain suction excessive, improperly maintained drain covers or outdated equipment.</li> <li>Easy illicit access to pools.</li> <li>Impeded visibility.</li> <li>Overcrowding.</li> <li>Lack of supervision.</li> <li>Alcohol consumption.</li> <li>Not being able to swim.</li> <li>Breath-hold swimming and diving.</li> </ul>	<ul style="list-style-type: none"> <li>Suction outlet cannot be sealed by single person, and at least two suction outlets per pump.</li> <li>Accessible emergency shut-off for pump.</li> <li>Gill/piles on drain gate prevent hair entrapment.</li> <li>Wear bathing caps.</li> <li>Maintain water temperature below 40°C.</li> <li>Isolation fences around outdoor pools and locked doors for indoor pools.</li> </ul>

**Core Public Health Functions for BC: Evidence Review**  
**Water Quality (Recreational Water)**

<b>Physical Hazards in Recreational Water</b>			
<b>Health Outcome</b>	<b>Hazards</b>	<b>Multi-use Interactions or Contributing Factors</b>	<b>Mitigation Options</b>
		Falling unexpectedly into water.	<ul style="list-style-type: none"> <li>• Locked safety covers for spas and hot tubs.</li> <li>• Teaching not to swim beyond skill level.</li> <li>• Parental/caregiver supervision of children.</li> <li>• Diving only under suitable conditions.</li> <li>• Public education regarding hazards and safe behaviours.</li> <li>• Provision of properly trained and equipped lifeguards.</li> <li>• Provision and proper access to rescue services.</li> <li>• Availability of resuscitation skills/facilities.</li> <li>• Restriction of alcohol provision.</li> </ul>
<b>Untreated Natural Recreational Water – Fresh and Marine Beaches</b>			
Spinal cord, brain and head Injury	Collision or impaction with underwater object or floor of water body.	<ul style="list-style-type: none"> <li>• Bottom surface type.</li> <li>• Water depth.</li> <li>• Conflicting uses in one area.</li> <li>• Jumping into water from trees, balconies or other structures.</li> <li>• Underwater visibility.</li> <li>• Local hazard warnings.</li> <li>• General public (user) awareness of hazards and safe behaviours.</li> <li>• Early education in diving hazards and safe behaviours.</li> <li>• Level of separation/segregation.</li> <li>• Lifeguard supervision.</li> <li>• Access to emergency services.</li> </ul>	<ul style="list-style-type: none"> <li>• Local hazard warnings and public education.</li> <li>• General public (user) awareness of hazards and safe behaviours, including use of signs.</li> <li>• Early education in diving hazards and safe behaviours.</li> <li>• Restriction of alcohol provision.</li> <li>• Use separation.</li> <li>• Lifeguard supervision.</li> <li>• Emergency services, access.</li> </ul>
<b>Treated Recreational Water – Pools, Spas, Wading Pools</b>			
Spinal cord, brain and head Injury	Collision or impaction with pool/spa floor or other object.	<ul style="list-style-type: none"> <li>• Diving into shallow water.</li> <li>• Improper diving.</li> <li>• Jumping from tree, balcony or other structure.</li> <li>• Poor underwater visibility.</li> </ul>	<ul style="list-style-type: none"> <li>• Hazard warnings.</li> <li>• General public (user) awareness of depth hazards and safe behaviours.</li> <li>• Early education on diving hazards and safe behaviours.</li> <li>• Lifeguard supervision.</li> <li>• Access to emergency services.</li> <li>• Diving instruction.</li> <li>• Poolside wall markings.</li> </ul>

**Core Public Health Functions for BC: Evidence Review**  
**Water Quality (Recreational Water)**

<b>Physical Hazards in Recreational Water</b>			
<b>Health Outcome</b>	<b>Hazards</b>	<b>Multi-use Interactions or Contributing Factors</b>	<b>Mitigation Options</b>
<b>Untreated Natural Recreational Water – Fresh and Marine Beaches</b>			
Minor injuries Cuts, lesions and punctures	<ul style="list-style-type: none"> <li>• Presence of broken glass, bottles, cans and medical wastes.</li> <li>• Underwater objects (e.g., walls, piers).</li> <li>• Underwater visibility.</li> </ul>	<ul style="list-style-type: none"> <li>• Frequency of beach cleaning.</li> <li>• Solid waste management.</li> <li>• Local availability of first aid.</li> <li>• Adjacent surface type (e.g., water fronts, jetties).</li> <li>• Surface type selection.</li> <li>• Adjacent fencing (e.g., around docks and piers).</li> <li>• Diving or jumping into shallow water.</li> </ul>	<ul style="list-style-type: none"> <li>• Beach cleaning initiatives.</li> <li>• Solid waste management.</li> <li>• Provision of litter bins.</li> <li>• Regulation (and enforcement) prohibiting glass containers.</li> <li>• General public awareness regarding safe behaviours (including use of footwear).</li> <li>• General public awareness regarding litter control.</li> <li>• Local first aid availability.</li> </ul>
<b>Treated Recreational Water – Pools, Spas, Wading Pools</b>			
Minor injuries Cuts, lesions and punctures	<ul style="list-style-type: none"> <li>• Underwater objects.</li> <li>• Swimming aids left poolside.</li> <li>• Slippery decks.</li> <li>• Poor underwater visibility.</li> <li>• Pool filtration equipment.</li> <li>• Pool features.</li> </ul>	<ul style="list-style-type: none"> <li>• Diving or jumping into shallow water.</li> <li>• Overcrowded pool.</li> </ul>	<ul style="list-style-type: none"> <li>• Appropriate surface type selection.</li> <li>• Limits on bather load.</li> <li>• Proper drain and filtration equipment and maintenance.</li> <li>• Lifeguard/parental supervision.</li> </ul>

**Sources:** WHO 2003; WHO 2006; Federal-Provincial Working Group on Recreational Water Quality, 1992.

## **5.0 PROGRAMS AND INTERVENTIONS**

Based upon the analysis of the risks posed by the various hazards listed in Section 4, several intervention options are available, some of which are already being employed. The WHO has identified various interventions in their recent reports on treated and untreated recreational water environments, and each intervention can be very effective in terms of reducing health impacts in a cost-effective manner. The following sections will briefly describe the four major types of interventions that would comprise a comprehensive recreational water management program for the province. These interventions are:

- Regulations, Guidelines and Enforcement.
- Technological and Engineering Controls.
- Education and Public Involvement.
- Public Health Advice and Intervention.

Each section will provide examples, where available, of the success or complications discovered in the implementation of the interventions. For detailed information on these interventions, the reader is directed to the References section of this paper.

### **5.1 Evidence for the Efficacy of Regulations, Guidelines and Enforcement**

At the international and federal level there are no regulations on recreational water management; however, the *WHO Guidelines for Safe Recreational Water Environments* (Volumes 1 and 2) are comprehensive guides for all matters pertaining to recreational water. These volumes provide the template from which governments, health authorities and stakeholders can create a comprehensive management program for recreational water that is specific to local, provincial or national conditions.

Treated recreational water is regulated under the *BC Health Act* for swimming pools, hot tubs, spray pools and wading pools. Currently, there are no legislated requirements specific to untreated recreational waters. At the federal level in Canada, The *Guidelines for Canadian Recreational Water Quality* (Federal-Provincial Working Group on Recreational Water Quality, 1992) provide recommendations pertaining to water quality, which can then be adopted at the provincial or local levels.

Regulatory compliance interventions include regulations and standards at the federal, provincial and local levels. Within the framework of an integrated approach to recreational water management, regulations fit best in the realm where the risk to human health is high and the outcomes are likely severe. Where regulations exist, compliance with these regulations must be verified and enforced. Effective and timely monitoring and surveillance therefore plays a pivotal role in bringing efficacy to any regulations or standards.

Guidelines, monitoring and systematic reporting should ensure that the regulations in place are effective at maintaining a sufficient level of public safety. The act of sustained monitoring supports the WHO's identification of the need for not only regulation, but “regulatory action”.

This term refers to the commitment of local authorities to plan and act in a manner that is congruent with protecting the public's health and to the continuous revision of regulations and guidelines as new information on risks emerge. The regulations and guidelines should not be viewed as static, and may require revision or amendments based on new information. Goal-oriented monitoring plays a key role, in that it feeds the information back to the authorities and ensures that standards are current and relevant. Evidence of the effectiveness and importance of regulations, guidelines, monitoring and enforcement were presented throughout this review, as were areas for improvement.

### 5.1.1 Treated Recreational Water

#### *Regulatory Actions for Mitigating Physical Hazards*

The current regulations for pools have been effective in establishing the structure necessary to facilitate the permitting and inspection of pools. The regulations have not, however, kept up with current information on the various hazards, from new research findings regarding known hazards and emerging hazards. For example, Crandall (1983) strongly recommended that to prevent possible entrapment and subsequent disembowelment or drowning of a spa bather, specific reference to the size of grate covers to recirculation drains should be made in the *BC Health Act*. Since 1983, amendments have been made to the Swimming Pool, Spray Pool and Wading Pool Regulations; however, they currently fall behind the standards recommended by the CDC, WHO and industry.

Another example of an outdated aspect of the current regulations was stressed in a published comment by the President and Chief Executive Officer of SMARTRISK. He stressed that:

There is even more that can be done outside the health system to help reduce injury. For example, pool-fencing bylaws vary across the nation. Many municipalities require that the pool be fenced only on three sides, allowing the house to make up the fourth side. While that may keep strangers out of your pool, it won't keep your own children safe (Conn, 2004).

Legislation and enforced regulation of four-sided fencing and self-latching gates around pools and spas has unquestionably been proven to prevent the health burden caused by accidental drowning and near-drowning (Stevenson et al., 2003; Thompson & Rivara, 2000). The Canadian Red Cross Society (n.d.) states that if all home pools were equipped with self-closing and self-latching gates, nearly all toddler pool drowning and about one-third of all toddler (1–4 years) drowning could be eliminated.

Clearly, as drowning and near-drowning events are highest in the youngest demographic, these outcomes have a significant burden in terms of DALYs and economic costs. Therefore, it should be high on the health protection agenda to enact this component of recreational water management. Even though the last example pertains to residential pools and spas, the outcomes of drowning hazards are severe and should warrant government intervention in a private setting.

*Water Quality Monitoring and Enforcement (Inspections)*

With respect to monitoring or inspection programs for treated recreational water, the current BC legislation does state that the medical health officers or public health inspectors may inspect a pool at anytime to ensure compliance. However, the legislation is vague on the specific frequency of inspection that should take place. For example, the legislation only states that facilities should be tested "frequently" for adequate chlorine residual by operators. As a result, the level of monitoring could be inconsistent and open to interpretation by different pool operators.

The findings noted in Section 3.1.1 by the US EPA (Yoder et al. 2004) appear to support this view. As noted, the US EPA summary and other outbreak investigations (Castor & Beach, 2004, Lenaway et al., 1989, Louie et al, 2004) clearly suggest there is a need for improved training of operators in the routine monitoring and maintenance of facilities, especially for semi-private settings and for wading pools.

In the United States, the CDC recommends that pools and spas be tested for chlorine residual levels a minimum twice per day and hourly during periods of high use. However, similar to Canada, in the United States it is the state or county that legislates the design, construction and operation of pools and spas, and their regulations on monitoring lack specificity. For example, the regulations for California place the responsibility on the pool operators to ensure adequate and continuous disinfection, along with supporting documentation, but do not define a monitoring or testing regime. Although routine water testing and documentation prove invaluable in outbreak investigations, the frequency with which they are currently carried out may not qualify as a preventative action against outbreaks or incidents.

British Columbia may benefit from similar surveillance initiatives to those being carried out by the CDC. Without outbreak investigation and surveillance data, it is tenuous to assume that the need for improvements to monitoring and inspection exists in Canada. The enforcement of stricter monitoring and maintenance would require more visits by public health inspectors, and this effort will need to be justified using BC-relevant data.

In summary, it is speculative to claim that increased inspections of pools and spas and the tightening of monitoring and maintenance of the facilities by the operators would decrease recreational water-related illnesses. Improved surveillance and reporting of recreational water-related illnesses (in both treated and untreated environments) is necessary to create the baseline from which to determine what regulatory or policy actions should be taken (Craun, Calderon, & Craun, 2005; Efstratiou, 2001; Henrickson et al., 2001; WHO, 2003).

The importance of regulatory control and action is perhaps best summarized by the following:

Although the lack of uniform data collection among sites limited the analysis and usability of the data, this report underscores the potential usefulness of uniform collection of these data in a computerized format that can be analyzed routinely and used for full evaluation of inspection programs. CDC and its partners are developing systems-based guidance on pool operation and implementation of uniform methods for data collection and analysis. These data can then be used in

the training of inspectors and operators, planning and resource allocation, and documenting trends related to particular regulatory changes and interventions (CDC, 2003).

#### 5.1.2 Untreated Recreational Water

Because of the many government levels and stakeholders involved, legislation of water bodies in the specific use of recreation, in isolation of other multi-use objectives, would be superficial. The WHO (2003) therefore recommends that untreated recreational water management be considered within the umbrella of coastal or freshwater zone management. The main principal of this approach is to take a holistic view that attempts to integrate the needs of all water users (both anthropogenic and non-anthropogenic).

Within this approach, the objectives for safe recreational water sites can be achieved via the coordination of national or provincial environmental legislation, provincial sanitation and sewer regulations, local building and urban design policies and even regulations regarding fines for littering at public beaches. All of these separate entities ideally should work together to ultimately protect the public's health and the environment.

The key health policy challenges specific to microbial water quality in untreated recreational waters have been identified as follows:

- Management actions are retrospective and can only be deployed after human exposure to the hazard.
- The risk to health is primarily from human excreta, the traditional indicators of which may also come from other sources.
- There is poor inter-laboratory and international comparability of microbiological analytical data.
- While beaches are classified as safe or unsafe, there is a gradient of increasing severity, variety and frequency of health effects with increasing sewage pollution, and it is desirable to promote incremental improvements, prioritizing the worst failures (WHO/US EPA, 1999).

The above points are a result of the complex nature of managing natural waters and the number of uncertainties that exist. As noted, there is still debate over what the best indicators and sampling methods are for detecting various pathogens. Even with agreement on certain indicator species, it is still difficult to determine the level of risk, as the source of the indicator (human or non-human)—the primary determinate of the presence of a health risk—is often unknown. Furthermore, sampling results only provide a snapshot at the time the sample was collected and are often deficient in providing timely information. In cases of uncertainty, continuous monitoring and reporting is perhaps the most important long-term strategy available. As an intervention, this can help to establish the baseline and build a foundation on which to base sound decisions and improve the current methods for sampling and/or determination of the severity of a health risk.

Monitoring and reporting has already become a component of health protection under the mandate of the health authorities. There is, however, overlap with the Ministry of Environment,

as this agency monitors for levels of chemical and toxic algae in many multi-use water sites. Good coordination and integration of this information is vital to ensure that environmental and public health objectives are both met. Aside from the active participation of the various stakeholders and authorities, for this level of cohesion to be achieved, several key components need to be in place:

- Goal-oriented sampling and monitoring.
- Sound and standardized data collection, access and management.
- Reporting and review and clear management outcomes.

Routine monitoring and reporting can prevent health risks if the information is accurate and effectively communicated to the public. For public health issues, these activities in BC are the responsibility of the individual health authority and the medical health officers or public health inspectors.

An example of this system in action would be shown in a public new release reporting unsafe conditions (e.g., the Health Advisory issued for Mt. Douglas Park in 2003 regarding a raw sewage spill (Vancouver Island Health Authority, 2003)). Monitoring programs have also been successful in detecting sewage leaks from faulty valves in the Vancouver public sewage system that would have otherwise gone unnoticed in a beach area (Anderson, 2003) potentially putting boaters and beach-goers at risk. These examples demonstrate how regulatory action can be very effective in mitigating recreational water hazards. As a result of sampling, problems are identified based on pre-established guidelines or standards, an investigation ensues, appropriate actions are taken to rectify the immediate situation and future potential problems can be anticipated—instigating the adaptation of regulations and/or standards if necessary.

Perhaps the best example of the importance of regulatory action and compliance can be taken from the United States. A large portion of the evidence used in this paper was derived using the information gathered through the CDC. As the standardization and volume of data gradually improves, we get a clearer picture of which recreational water issues should be prioritized. For example, through aggressive monitoring and reporting at the state and local levels, and in coordination with the CDC, the US EPA's BEACH Program (established in 1997) has:

- Identified new priorities for sampling methods – How do spatial and temporal factors affect the sampling results.
- Begun development of predictive models based on data collected for this purpose.
- Improved risk communication – Real-time reporting to the public by using models and better coordination with laboratories and improved testing.
- Worked towards further enhancing reporting to attempt to capture not only data on outbreaks, but also on endemic water-borne illness (US EPA, 2002; Yoder et al., 2004).

The work being done in this area by the United States, United Kingdom, and WHO will undoubtedly apply in many respects to the Canadian and BC situation. Although water sampling does occur in BC, especially at suspect sites or in response to a spill, a similar level of sustained commitment and goal-oriented monitoring is not apparent in BC. For example, recent email



## ***Core Public Health Functions for BC: Evidence Review***

### **Water Quality (Recreational Water)**

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communications from the Interior Health Authority Program Leader to local inspectors asked the following questions regarding lake sampling:

- What is the frequency of sampling and when do you start?
- What beaches do you sample (e.g., provincial parks, municipal beaches, anywhere people gather to swim, etc.)?
- Are you using anything other than fecal coliforms as indicators?
- Are you relying on sanitary survey information too (current studies, sources of contamination, safety issues, etc.)?
- Do you have a particular method of sampling? How deep? etc.
- Do you sample the same site at the same time each day, or do you vary the routine/schedule?

Six inspectors were surveyed for this information and nearly 92 per cent of the responses were either a negative response or indicated that no standardized system is in place.

There is clear evidence that improvements can be made. Certainly, sampling and monitoring involve financial costs and it is important to weigh these against the burden of disease that is mitigated as a result. As demonstrated in Section 3, this assessment can be difficult to make and, at this time, will depend largely on the agenda of the local health authorities. One option to assist in reducing the expenses, given that the public health risk appears to be relatively low for most beaches in BC, is to foster the involvement of local community members and organizations (Refer to Section 5.3).

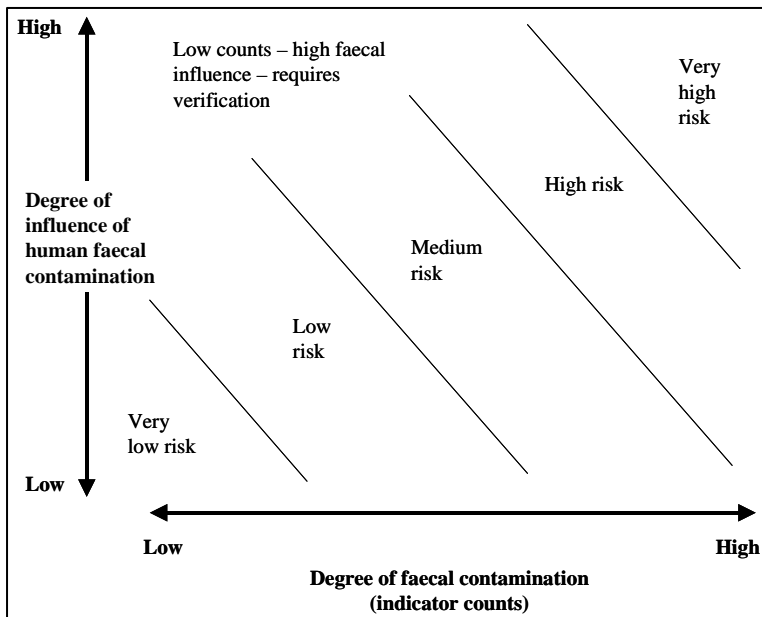
The move towards beach classification systems is viewed as a novel improvement over previous schemes for managing the health risks associated with recreational waters (WHO, 2003; WHO/USEPA, 1999; Micallef & Williams, 2002; Henrickson et al. 2001). Various classification schemes have been in existence for several years in the United Kingdom, United States<sup>24</sup> and Australia, among other countries (Williams & Morgan, 1995; Van Maele, Pond, Williams, & Dubsky, 2000), but they have failed to gain serious attention as a tool in public health protection until recently. The joint effort by the WHO and the US EPA on the Annapolis Protocol specifically promotes beach classification as a critical first step in effective management of public health risks from microbial sources. Health risk posed by recreational water quality is classified based on two primary criteria: 1) high counts of indicator species; and 2) a visual inspection to determine the most likely sources of the bacteria or other indicator species.

In performing this type of classification, the burden on recreational water managers can actually be reduced if the primary source of indicator species is found to be non-anthropogenic. Figure 6 below shows the relationship between the level of health risk and the presence of indicator species.

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<sup>24</sup> The Blue Wave Campaign is run as a non-profit, non-governmental certification program in the United States. More information on the program can be found at <http://www.cleanbeaches.org/bluewave/bluewave.cfm>.

**Figure 6: Schematic Representation of Classes of Health Risk**



Source: WHO/US EPA, 1999.

The document *Monitoring Bathing Waters: A Practical Guide to the Design and Implementation of Assessments and Monitoring Programmes* (Bartram & Rees, 2000), provides technical details on sampling and data handling to facilitate the characterization of recreational water sites. Appendix 3 of this document contains excerpts from the Annapolis Protocol, showing the process for characterization and re-evaluation of recreational waters. (See Appendix 3, Figures 8 and 9).

Although it is likely that experienced recreational water managers have informal methods of classifying beaches and the level of health risk they could potentially pose, the protocol formalizes this process and provides a means to standardize recreational water management across the globe. The ease of implementation and effectiveness of the recommendations set forth by the Annapolis Protocol have yet to be determined.

## **5.2 Evidence for the Efficacy of Technology and Engineering Controls**

Technology and engineering options have the potential to both prevent hazards (i.e., through secondary and tertiary wastewater treatment and upgrades from combined sewer outflows) and also to control those that are already present (such as filtration and disinfection of pools). Forms of this component of recreational water management can be a simple, one-time physical structure, such as fencing to prevent access of beach areas to wildfowl, or involve ongoing interventions, such as having lifeguards at beaches and pools to prevent drowning.

It is important to recognize that each component of a recreational water management plan must be integrated, and will be most effective if designed or implemented in harmony with the other components. Many technological options, especially those requiring significant expenditure of public funds, may require permitting, and fall under some form of regulation, identified under Section 5.1. An example of this could be amendments to the existing regulations to mandate

engineering controls to prevent the increased risk of entrapment and entanglement in pools with new water features (such as slides, wave makers, etc.). Subsequently, any equipment for this purpose would need to be approved in this use, and should be monitored on an ongoing basis to ensure that it continues to accomplish the intended objectives.

Non-coastal areas in the province, where recreational waters are an important part of the social and economic vitality of the community, may need to rely even more heavily on this element of recreational water management, as the volume of their receiving waters is significantly smaller. Kelowna, for example, is one of the fastest-growing communities in the province and this growth rate places increased pressure on wastewater-handling systems. However, this growth was planned for, and protecting the quality of the water in the Okanagan Lake provides immeasurable benefits to this area that justify the costs of such a system. It has therefore been a priority of the local government to treat sewage sludge to the highest possible level, and the city currently operates a world-class treatment system that ensures the protection of public, environmental and economic health.

### 5.2.1 Health Impact Assessment

Health impact assessment (HIA)<sup>25</sup> is identified by the WHO (2003) as a useful planning tool for managing the health hazards of proposed recreational water sites or the impacts of a new development on existing sites. Prior to 1998, HIA was institutionalized in British Columbia as an initiative under the Office of Health Promotion, Ministry of Health. A substantial amount of resources were directed towards this initiative; however, in 1998, a review of the use of HIA concluded that there was a lack of credible evidence that HIA had been used elsewhere successfully in health policy matters (Banken, 2001).

Although it is no longer institutionalized, and may have lost favour politically, an example of where a HIA could be applied in BC is in the development of the False Creek area in the Greater Vancouver Regional District. This particular area is being used increasingly as a recreational site (Anderson, 2004). At the same time, pressures on the water environment from urban development and a rising population need to be managed to ensure water quality in this area is in compliance with public and environmental health protection. Perhaps this development could benefit by employing the HIA process to ensure that the most effective and cost-efficient technical and engineering controls are part of the infrastructure at the earliest possible stage. If the HIA process is applied successfully, the monitoring, recording and documentation of this achievement could provide the evidence base that HIA can be an effective planning tool.

## 5.3 Evidence for the Efficacy of Education and Public Involvement

Many of the hazards encountered in recreational waters are either introduced into the environment by the public, or only result in a negative outcome as a consequence of bathers'

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<sup>25</sup> More information on the application of HIA can be found in the *Canadian Handbook on Health Impact Assessment*, by Health Canada, available at: [http://www.hc-sc.gc.ca/ewh-semt/pubs/eval/index\\_e.html](http://www.hc-sc.gc.ca/ewh-semt/pubs/eval/index_e.html), and *Health Impact Assessment as a Tool for Population Health Promotion and Public Policy*, by the Public Health Agency of Canada, available at: <http://www.phac-aspc.gc.ca/ph-sp/phdd/impact/>.

behaviours. While this fact can pose a challenge to public health protection, it can also be an opportunity to mitigate the risks in a relatively low-cost manner.

For example, both microbial hazards and chemical hazards in treated water environments are exacerbated by bather shedding. Thorough showering would substantially decrease the pathogens and/or disinfection by-products that swimmers are exposed to (WHO, 2003; Castor & Beach, 2004). However, there appears to be insufficient data on bathers' behaviour with respect to pre-swim showering practices and the level of enforcement of showering by lifeguards. Common sense would indicate that better information and enforcement would result in more conscientious showering, thereby also reducing the burden on pool operators or attendants. The cost of implementing such an awareness campaign would be negligible, even taking into consideration that the burden of disease for immunocompetent individuals appears to be quite low.

Bathers with compromised immune systems are sensitive to a variety of environmental hazards, and there is an information network already in place to notify them of potential health risks of various behaviours. However, not all persons may be completely aware of their ability to ward off potentially life-threatening illness. Thus, it should be a public health priority to provide information to the general public on the hazards of pool use. The CDC conducted focus groups comprised of parents with young children and found that most parents were not aware of chlorine-resistant pathogens and believed that pool water was "sterile". When the parents were informed of the risks, they responded in a manner suggesting that they would change their behaviours at swimming venues (Castor & Beach, 2004). This is a very important finding, since children are both a significant source of pathogens and are especially vulnerable to the illness caused by them.

Perhaps where public involvement and education becomes more crucial is when outcomes in question are extremely serious, as in the case of swimming-related drowning and injury. Since 1997, the BC Injury Free Plan (BCIFP) has focused on educating and raising awareness regarding all injury accidents. One goal of the plan was to reduce drowning and diving-related injuries by 10 per cent for the 0–24 years age group by 2001. The baseline number the BCIFP used to assess the reduction in drowning incidents was the average annual number of incidents over the period 1990–1994 (41 deaths). Over the comparative periods of 1991–1995 to 1996–2001, there was a 29 per cent reduction in deaths due to drowning (CRCS, 2003).

Similarly, the baseline of 37 hospitalizations due to diving/jumping into a swimming pool occurred each year for 1990–1991 and 1994–1995 (Ministry of Health, 1997). The corresponding statistic for 2000–2001 under the ICD10–CA codes was 24 injuries (CIHI, 2004a) for persons under 24 years of age. Based on this figure, the BCIFP exceeded their goal of 10 per cent.

In an attempt to prevent these types of injuries, education of the 0–24 age group has been the focus. Programs in Canada such as ThinkFirst and SportSmart have been involved in creating videos for distribution to schools. A study looking at schools in Toronto, Ontario (Bhide, Edmonds, & Tator, 2000) examined the process of distributing the educational videos and the willingness of teachers to voluntarily introduce them into the curriculum. Other studies have

assessed the accessibility of the videos and the general response of youth and teachers to the video content. Studies have not as yet determined the actual potential of the videos to impact the behaviour of youth and mitigate injuries. Greene et al. (2002) examined the American THINK FIRST for KIDS Injury Prevention Program with respect to a variety of injuries and found that, in a study of 870 children (Grades 1 to 3), knowledge regarding the prevention of spinal injuries significantly improved. They hypothesized that this awareness could have a positive impact on reducing the number of injuries in this age group.

Although assessments of preventive educational programs are difficult and rare (Doll, Bartenfeld, & Binder, 2003), continued efforts to monitor and track their progress is vital to ensure the desired effect is taking place. For example, many professional health organizations in the past have questioned whether endorsing swimming lessons would prevent drowning deaths in younger children, as research indicated that increased comfort levels with water environments may increase the risk or increase complacency of guardians (Asher, Rivara, Felix, Vance, & Dunne, 1995). Bhide et al. (2000) found that the success of educational interventions was improved if it was delivered in conjunction with other programs in a comprehensive manner, rather than in isolation.

In addition to the direct benefits of outbreak and incident reduction, public involvement and education has several indirect benefits. Once the public becomes aware of issues and is equipped with the knowledge to make appropriate decisions regarding them, they can begin to serve as another arm of the public health authority by providing the "eyes and ears" in the community, as a health inspector cannot always be present (WHO, 2003).

More frequently, public and private interest groups are becoming active in taking responsibility for protecting and enhancing a particular environment (e.g., the BC Lake Stewardship Society<sup>26</sup> and the Living by Water Project<sup>27</sup>). The WHO (2003) suggests that there is potential for environmental and health protection authorities to work with these types of organizations to improve the management of recreational water. These groups often have specialized knowledge that can make a significant contribution. Furthermore, Bartram and Rees (2000) suggest that the responsibility of regular sampling, monitoring and data reporting (via the Internet) could even be taken on by capable volunteers within these organizations. They suggest that this level of involvement would not only alleviate some of the high costs associated with this activity, but also improve the frequency and standardization as well. Figure 7 displays a list of the various organizations, clubs and institutions that could be targets of outreach and public engagement programs. These same groups could also continue to be involved in delivering awareness material.

The Clean Beaches Council<sup>28</sup> and the National Healthy Beaches Campaign<sup>29</sup> are two competing groups in the United States that have recently had success by certifying beaches and publishing the information through various media channels. Both groups are comprised of government representatives, academics, environmental organizations, tourism organizations and various other

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<sup>26</sup> More information on the BC Lake Stewardship Society can be found at: <http://www.bclss.org>.

<sup>27</sup> More information on the Living by Water Project can be found at: <http://www.livingbywater.ca/>.

<sup>28</sup> More information on the Clean Beaches Council can be found at: <http://www.cleanbeaches.org/bluewave/faq.cfm>.

<sup>29</sup> More information on the National Healthy Beaches Campaign can be found at: <http://www.ihrc.fiu.edu/nhbc/>.

interest groups. The certification is voluntary and is usually initiated by some member of the community that has an interest in promoting the use of a particular beach. Collectively, the organizations have certified 133 beaches in the United States as "healthy" or "clean" beaches. Recently, the Clean Beaches Council initiated an annual conference on "Sustainable Beaches", which draws experts in the field from all over the United States.

The potential for success of such a scheme in BC may be limited due to seasonal differences; however, it does highlight one example of the potential impact that public and private interest groups can have in the management of recreational water environments.

**Figure 7: Public Awareness Information: Organizational Levels and Responsibilities**

<b>Participant</b>	<b>Expert advice</b>	<b>Regulator</b>
<p><b>National sports organizations</b> Issue codes of practice and newsletters for membership, regulator competitive sport, promote training. International liaison.</p>	<p><b>Public health body</b> Provide public health information. Liaise with user groups and media to disseminate appropriate health messages.</p>	<p><b>Central government</b> Legislate standards, publish results of national monitoring, conduct national health surveillance, involved in finance of capital improvements.</p>
<p><b>Affiliated clubs</b> Informing members of codes of practice, setting rules of conduct for members, supervising organized events, promoting high standards of performance, providing training.</p>	<p><b>Professional institutions, experts</b> Current awareness of health and safety issues, legislation, research. Liaison with , and expert representation on, government committees and national sports organizations.</p>	<p><b>Local authorities and government agencies</b> Monitoring, reporting results to central government, displaying results to public. Giving information on health. Enforcing public health measures, closing facilities if conditions are hazardous to health.</p>
<p><b>Club members</b> Responsible to club for conduct and act on club's advice, in addition to making their own value judgements.</p>	<p><b>National and international lifesaving federations</b> Lobby group. Dissemination of safety information.</p>	<p><b>Providers of facilities</b> May be local authorities (public facilities) owners or service providers, including clubs with their own facilities. Adopting and implementing local codes of operational practice, providing safety facilities, preparing a recreational water safety plan, carrying out improvements. Publicizing facilities and results of monitoring.</p>
<p><b>General public</b> Make own value judgements from personal awareness and knowledge.</p>		

Source: WHO, 2003.

## **5.4 Evidence for the Efficacy of Public Health Advice and Intervention**

WHO (2003) defines the component of public health advice and intervention in relation to recreational water as the response of the health protection authorities to short-term incidences and non-compliance with health standards. Ultimately, it is the goal and responsibility of the health authority to ensure that the regulations and guidelines are followed, and to protect the health of the public in the event of a breach of these measures. Furthermore, it is the responsibility of the health authority to be actively engaged in this role and ensure that the other three interventions detailed in previous sections are achieving an adequate level of health

protection. Where a gap is identified, there should be a mechanism in place for health authorities to present this evidence, thus facilitating adaptive management and continuous improvement of the recreational water management program or strategy.

In some cases, public awareness and education is not sufficient, or there are delays in changing patterned behaviours (e.g., not showering before entering a pool). There are many examples of the effectiveness of promoting this component of recreational water management. Unfortunately, there are often high costs associated with maintaining the required health officers/inspectors and applicable staff, and insufficient resources often make public health intervention programs appear ineffective. Often, it is the lack of sustained commitment on the part of local, provincial and federal governments to fund these public health advice and intervention initiatives that are a barrier to implementing this component successfully. SMARTRISK (1998) even goes so far to postulate that funding lapses or shortages anywhere in the cycle of monitoring, intervention and regulatory action could actually increase the number of outbreaks or injury incidents. They point out that if the data gathered through surveillance and monitoring practices is incongruent, it will be difficult, if not impossible, to ascertain the appropriate response to address the issue.

It appears that, at this time, the United States has made this commitment to improving all recreational water management in the country. The coordinated surveillance and monitoring efforts by the public health departments have revealed a gap in public health with respect to the maintenance of disinfection levels in public and semi-private pools. In the short-term, pools that were identified as an immediate risk to public health were closed until the issue was rectified. This act alone clearly prevented potential negative health outcomes from occurring. However, the involvement of the health officers did not cease at this point. They remained involved in the pooling and coordinating of information with a federal public health body (the CDC), allowing a broader perspective of the problem to emerge. The awareness gained through this process should facilitate the selection of the most appropriate interventions and re-evaluation of the status quo. Theoretically, if this current initiative is sustained, and the appropriate measures taken, the rates of gastrointestinal illness contracted in treated recreational water should drop substantially. The CDC has suggested that one alternative may be to design and administer more targeted education and training on pool maintenance, which again demonstrates the integrated nature of the recreational water management core components.

As the role of the person carrying out the public health advice or intervention often involves the inspection or monitoring of a recreational water site, this component works in conjunction with monitoring and compliance. At the point when a gap is discovered, and the public is informed—either through risk communication or site closure—the importance that a sound means for the education and dissemination of this information exists. In BC, many of the health authorities have begun to post beach quality ratings on the internet for example, along with many fact sheets on the potential hazards of recreational water. In the event that NGOs or private interest groups begin to take on more of a sustained role in sampling and monitoring recreational waters, a system will have to be established to ensure that information is still passed through to the health authorities and to the broader public when required.

The main obstacle to assess the cost-benefit of health protection initiatives with respect to recreational water is a lack of data. Although estimates of the dollars saved per dollar invested in

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interventions exist for many diseases and injury accidents, similar data is not available for recreational water. In large part this is because this area has only recently become a public health priority and the required surveillance, epidemiological and biological evidence is still evolving. In the face of uncertainty however, those responsible for protection of public health do have tools available, such as the WHO reports, that can assist in creating a comprehensive recreational water management program that can be adaptable, affordable and ensure a high level of public health protection.



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## APPENDIX 1: BASE DATA AND STATISTICS

**Table 5: Recreational Facilities Usage, 2003**

Type of User	Ice Arena	Indoor Pools	Outdoor Pools	Curling Facilities	Total
Programs	1,245,332	3,439,010	238,144	504,919	5,427,405
Spectators	4,769,773	3,164,780	131,500	132,318	8,198,371
Rentals	6,420,905	1,758,056	127,167	208,688	8,514,816
Drop-in/ Members	1,552,982	10,714,586	561,103	82,953	12,911,624
Other	272,672	462,232	338,180	17,421	1,090,505
Total	14,261,664	19,538,664	1,396,094	946,299	36,142,721
People engaged in activity in pools (less spectators)	9,491,891	16,373,884	1,264,594	813,981	27,944,350

Source: Adapted from BCRPA, 2004.

**Table 6: Approximate Number of Treated Recreational Water Facilities, British Columbia**

	Indoor Pools	Outdoor Pools	Semi-Private Indoor/Outdoor Pools	Hot Tubs	Semi-Private Hot Tubs	Kiddy Pools
Interior Health	n/a	n/a	n/a	n/a	n/a	n/a
Fraser Health	52	34	179/163	27	285	11
Vancouver Island	n/a	n/a	n/a	n/a	n/a	n/a
Vancouver Coastal						
North Shore	7	44	64	6	34	1
Vancouver	20	5	270	n/a	183	21
Northern Health						
East	11		2		13	2
West	10			25		5
Interior	n/a	n/a	n/a	n/a	n/a	n/a
<b>Total</b>	<b>100</b>	<b>83</b>	<b>515/163</b>	<b>58</b>	<b>515</b>	<b>40</b>

**Notes:**

- Based on estimates provided from health authorities on those facilities that require inspection by medical health Officers and have received permits by a public health engineer.
- n/a = incomplete or data not provided by health authorities.

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**Table 7: Drowning Outcome Statistics, British Columbia, 1996–2003**

Year	Drowning and Submersion while in Pool (W67)		Drowning and Submersion while in Natural Water (W69)		Drowning and Submersion due to fall into Natural Water (W70 now W16)		Unspecified Drowning and Submersion (W74)	
	M	F	M	F	M	F	M	F
2003	5	2	9	1	6	1	9	3
Deaths BC Total	29	7					14,773	14,333
2002	-	-	10	1	5	0	14	1
Deaths BC Total	29	2					14,612	14,074
2001	-	-	6	1	7	1	12	1
Deaths BC Total	25	3					14,661	13,503
2000	-	-	16	0	3	3	9	2
Deaths BC Total	28	5					14,076	13,197
1999*	n/a	n/a	n/a	n/a	n/a	n/a	27	9
Deaths BC Total	27	9					14,695	13,099
1998	n/a	n/a	n/a	n/a	n/a	n/a	27	6
Deaths BC Total	27	6					14,496	13,294
1997	n/a	n/a	n/a	n/a	n/a	n/a	41	6
Deaths BC Total	41	6					14,458	12,782
1996	n/a	n/a	n/a	n/a	n/a	n/a	34	10
Deaths BC Total	34	10					14,649	12,712

**Notes:** Table Excludes accidents to watercraft causing drowning and submersion V90, accidental drowning (including water V90, V92 excluding W65-W74 as these codes relate to bathtubs or transport).

\* Prior to 1999, ICD-9 external injury classification is E910 (accidental drowning and submersion).

**Source:** British Columbia Vital Statistics Agency, 2003 (Appendix 2).

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**Table 8: Drowning and Near-drowning Incidence. Hospitalizations and Fatalities in Pools and Natural Waters, 2001–2002**

Specific Health Outcome	Geographic Area	Year/Period	Number of Deaths (Incidence per 100,000)
Non-fatal drowning in hospital (natural water)	US	2001-2002	909 (0.32)
Near-drowning trauma hospitalization*	BC	2000-2001	(1.14)
	Canada	2000-2001	(0.60)
Fatal drowning in hospital (all)	US	2001-2002	3,372 (1.18)
Fatal drowning in-hospital deaths (in pool)	US	2001-2002	596 (0.21)
Fatal drowning in-hospital deaths (natural water)	US	2001-2002	1,497 (0.51)
Non-fatal drowning in hospital (all)	US	2001-2002	4,174 (1.46)
Non-fatal drowning in hospital (in pool)	US	2001-2002	2,751 (0.96)

**Note:** All US figures are in recreational water environments and activities, including boating.

\* The original statistic provided by the Canadian Red Cross Society (2003) for drowning is 1.67 per 100,000 and includes water-related near-drowning hospitalizations due to watercraft overturning, fall from watercraft, drowning during recreational water activities and bathing. Greater than two-thirds of drowning were during recreational activity, with 34 per cent of recreational drowning in Canada between 1991 and 2000 attributable to aquatic activities (swimming). The figure for comparison purposes with the United States is 1.14 as shown ( $1.67 * 2/3$ ). However, the approximate incidence rate specific to swimming, would be approximately [ $1.67 * .68 = 1.14 * 0.34 = 0.39$ ] 0.39 near-drowning hospitalization incidents per 100,000 in BC for 2000–2001.

**Source:** CDC, 2004a.

**Table 9: Population Data Total**

Year	Canada	United States	United Kingdom
1995	31,278,097	266,557,091 (12%)	58,426,014 (54%)
2000	29,619,002	282,338,631 (10%)	59,522,468 (50%)
2005	32,805,041	295,734,134 (11%)	60,441,457 (54%)
Canadian X % Comparative Population		11%	52%
BC X% Comparative Population (Based on 13% of Canadian Population)		1.43%	6.76%

**Source:** <http://www.census.gov>.

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Table 10: Estimated Usage Rates, Number of Visits to British Columbia Pools, 2004

Data from BC Recreation and Parks Association Survey		Indoor	Outdoor	Total
Municipality owned and/or operated*		103	72	175
Privately owned servicing community*		29	4	33
Total for pools		132	76	208
Usage rate estimate				
Number of reporting pools for usage rates**	A	95	58	153
Percentage of pools reporting usage rates*	B	72%	76%	74%
Reported annual usage*	C	16,373,884	1,264,594	17,638,478
Average annual usage per facility (C/A)*	D	172,357	21,803	194,160
Average daily usage per facility (365 day for indoor, 120 for outdoor)	E	472	182	
Estimated usage for semi-public (10% of E for indoor; 40% for outdoor)	F	50	72	
Estimate of pool usage in BC by facility type				
Municipality owned and/or operated***	G	103	83	183
Privately owned servicing community***	H	515	163	678
Total (E+F)	I	616	246	861
Total annual visits to BC pools (G*E*365) + (H*F*120)		27,143,590	3,217,969	30,361,559
BC Population*		3,895,948		
Annual visits to pools by BC residents*		6	2	6.3

**Sources:**

\* Figures based on BC Recreation and Parks Association survey only. Visit numbers exclude spectators.

\*\* T. Clark, personal communication, March 9, 2005.

\*\*\* Estimated numbers; provided by the individual health authorities only for the purposes of this review.

Table 11: Estimated Cost of Unintentional Injury in British Columbia

Year	BC Population	Percentage Change	Estimated Percentage Increase in Unintentional Injury Costs Based on Population Increase	Estimated Cost (1,000) Based on 2004 Population and Inflation
1998 <sup>1</sup>	3,998,325	0% (Baseline)	0% (Baseline)	55,343
2010 <sup>1</sup>	4,411,729	10.3%	8.6%	Unknown
2004	4,177,000*	4.5%	3.7%	65,213

**Source:**

Population Section, BC STATS, Ministry of Finance and Corporate Relations, Government of BC. Information on 2004 BC population taken from <http://www.britishcolumbia.com/information/details.asp?id=43>.

## APPENDIX 2: COST ESTIMATES AND OTHER CALCULATIONS

**Table 12: Estimated Burden of Disease (Number of Cases) for a Selection of Recreational Water-related Gastrointestinal Illnesses, United States and British Columbia**

Recreational Water-related Gastrointestinal illness examples of disease-causing bacteria		<i>E.coli O157:H7</i>	<i>Shigella spp.</i>	<i>Cryptosporidium parvum</i>	<i>Giardia lamblia</i>	Norwalk-like virus 9	Gastro-intestinal Illness (no cause identified)	Total
US Annual Number of Cases (Estimated)*	A	73,480	448,240	300,000	2,000,000	23,000,000		
US Cases Due to Recreational Water (1985–1998) ** (Average Annual Cases)	B	234 (18)	1,780 (137)	429 (33)	65 (5)	89 (133)	1,984 (153)	
US Untreated Recreational Water Cases (1997–2002)*** (Average Annual Cases)	C	134 (22.3)	48 (8)	213 (35.5)	2 (0.33)	311 (51.8)	1,046 (174.3)	1,754 (292.3)
US Treated Recreational Water Cases (1997–2002)*** (Average Annual Cases)	D	42 (7)	93 (15.5)	2,846 (474.3)		69 (11.5)	91 (15.2)	3,141 (523.5)
Scenario E Equivalent Cases for BC Based on Percentage of US Population (B * 1.43%)****	E	0.25	1.95	0.47	0.07	1.90	2.20	6.84
Scenario F Equivalent Cases for BC Based on Percentage of US Population (C * 1.43%)****	F	0.30	0.10	0.50	0.00	0.70	2.50	4.20
Scenario G Equivalent Cases for BC Based on Percentage of US Population (D * 1.43%)****	G	0.10	0.20	6.80	0.00	0.20	0.20	7.50
Scenario H*****				220				

**Notes:**

- \* Source for gastrointestinal illness estimates from Mead et al. (1999) are based on average annual number of cases varying between the years 1983 to 1997, depending on the pathogen. Refer to article for specific details.
- \*\* Based on reported figures to Centers for Disease Control and Prevention, and published in Morbidity and Mortality Weekly Report (WHO, 2003).
- \*\*\* Source is CDC *Morbidity and Mortality Weekly Reports*, Water-borne Surveillance Reports 1997-2002.
- \*\*\*\* Refer to Table 9.
- \*\*\*\*\* Based on estimates from Horman et al. (2004).  $4,177,000/100,000 \cdot 41.77 \cdot 3,340 = 139,511$  cases crypto cases per year \* % attributable to recreational water  $(2,846/300,000) = 0.0016 = 220$  cases due to treated recreational water use.

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**Table 13: Estimates of Average Costs of Recreational Water-related Gastrointestinal Illness for British Columbia Based on Gastrointestinal Cost Studies**

	Mild Case*	Moderate Case*	Severe (immunocompromised)*	Average*	IID GP Visit**	IID No GP Visit**	Gastroenteritis ***
Average Cost of Case gastrointestinal Illness	\$186	\$760	\$12,491	\$382	\$665	\$90	\$140
Annual Cost: Scenario E****	\$1,272	\$5,198	\$85,438	\$2,613	\$4,549	\$616	\$958
Annual Cost: Scenario F	\$781	\$3,192	\$52,462	\$1,604	\$2,793	\$378	\$588
Annual Cost: Scenario G	\$1,395	\$5,700	\$93,682	\$2,865	\$4,988	\$675	\$1,050
Annual Cost: Scenario H	\$40,920	\$167,200	\$2,748,020	\$84,040	\$146,300	\$19,800	\$30,800

**Notes:**

- \* (Corso et al., 2003). Study examined the 1993 Milwaukee, Wisconsin outbreak of *Cryptosporidium*. Includes direct medical and productivity lost.
- \*\* (Roberts et al., 2003). United Kingdom (£1994/1995) converted to CDN (2005). IID-Infectious Intestinal Disease. Study examined *salmonella*, *campylobacters* and *C.jejuni*; enterovirulent *E.coli* and enteroaggregative *E.coli*; *rotavirus* and *rotavirus* group A, *Clostridium difficile* and small round structured virus (SRSV). Included all direct medical and indirect costs.
- \*\*\* (van den Brandhof et al., 2004). Netherlands (€1999) converted to CDN (2005). Study examined *campylobacter*, *salmonella* and *norovirus*. Included direct and indirect non-medical costs and direct medical costs.
- \*\*\*\* Refer to Table 12.

**Table 14: Cost Estimates for Various Physical Hazard Outcomes Associated with Recreational Water\***

	Low Range	Source	High Range	Source
Average Cost for Drowning Death				
Average Hospitalization Charge for Near-drowning**	\$3,666	Ellis & Trent (1995)	\$22,151 per incident	Ellis & Trent (1995)
Average Cost for Drowning Injury (Near-drowning)	\$111,155***	Rice & Mackenzie (1989)	<sup>4</sup>	
Average Cost for Drowning Permanent Disability in the Year Incurred	\$133,319 initial cost \$111,155 \$244,474	Ellis & Trent (1995) Rice & Mackenzie (1989)	\$249,973 initial cost \$111,155 \$361,128	Ellis & Trent (1995) Rice & Mackenzie (1989)
Average Ongoing Annual Costs for Permanent Disability	\$199,978 per year	Ellis & Trent (1995)	\$208,253 care facility	Wintemute, Kraus, Teret, & Wright (1987)
Estimated Lifetime Costs for Permanently Disabled Person at 20 Years of Age			\$4,000,000	

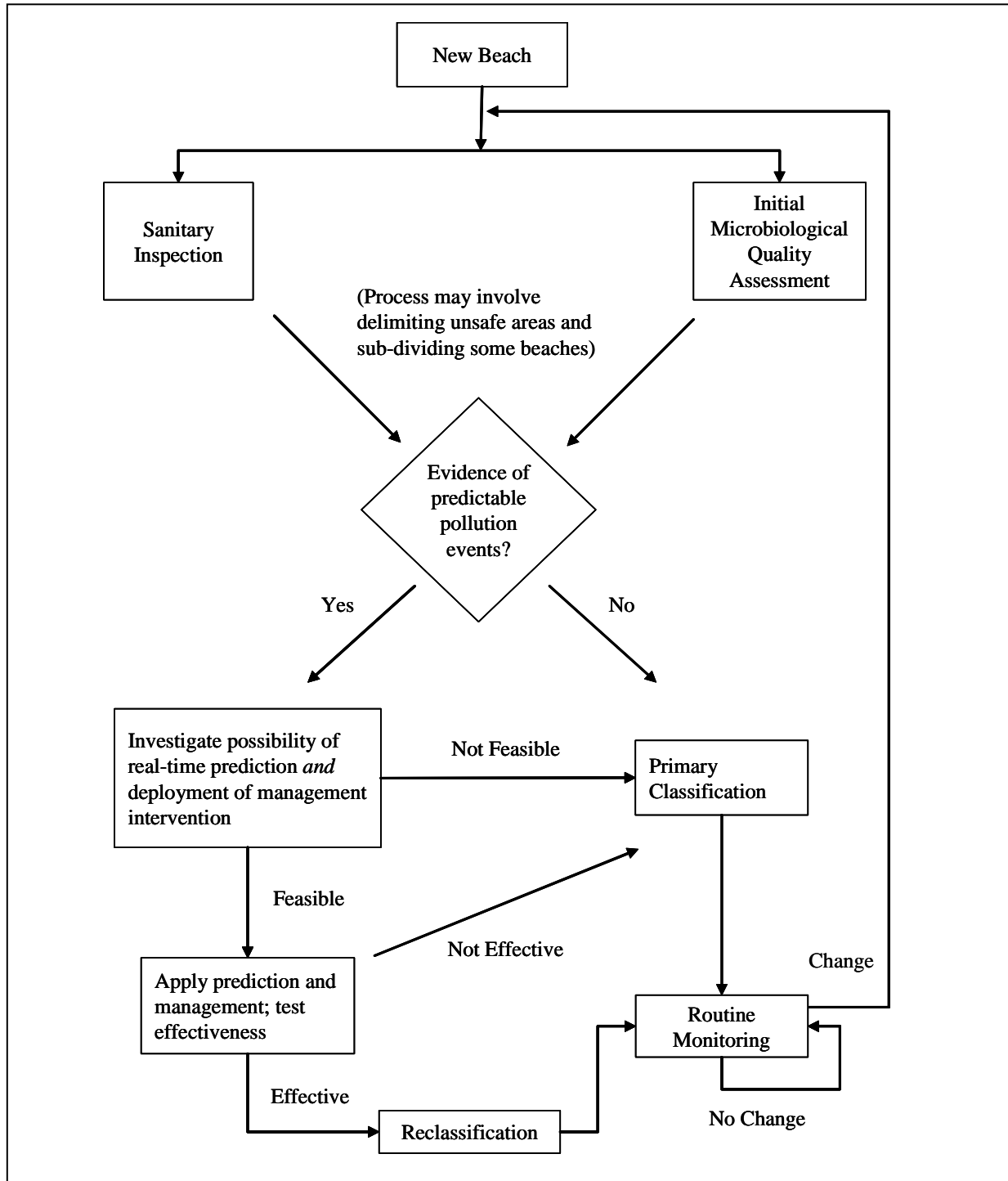
**Note:**

- \* Table uses 2005 Canadian Dollars.
- \*\* Does not include physician fees, long-term care in other institutions or indirect costs.
- \*\*\* Estimated lifetime productivity losses per person due to death or permanent impairment.



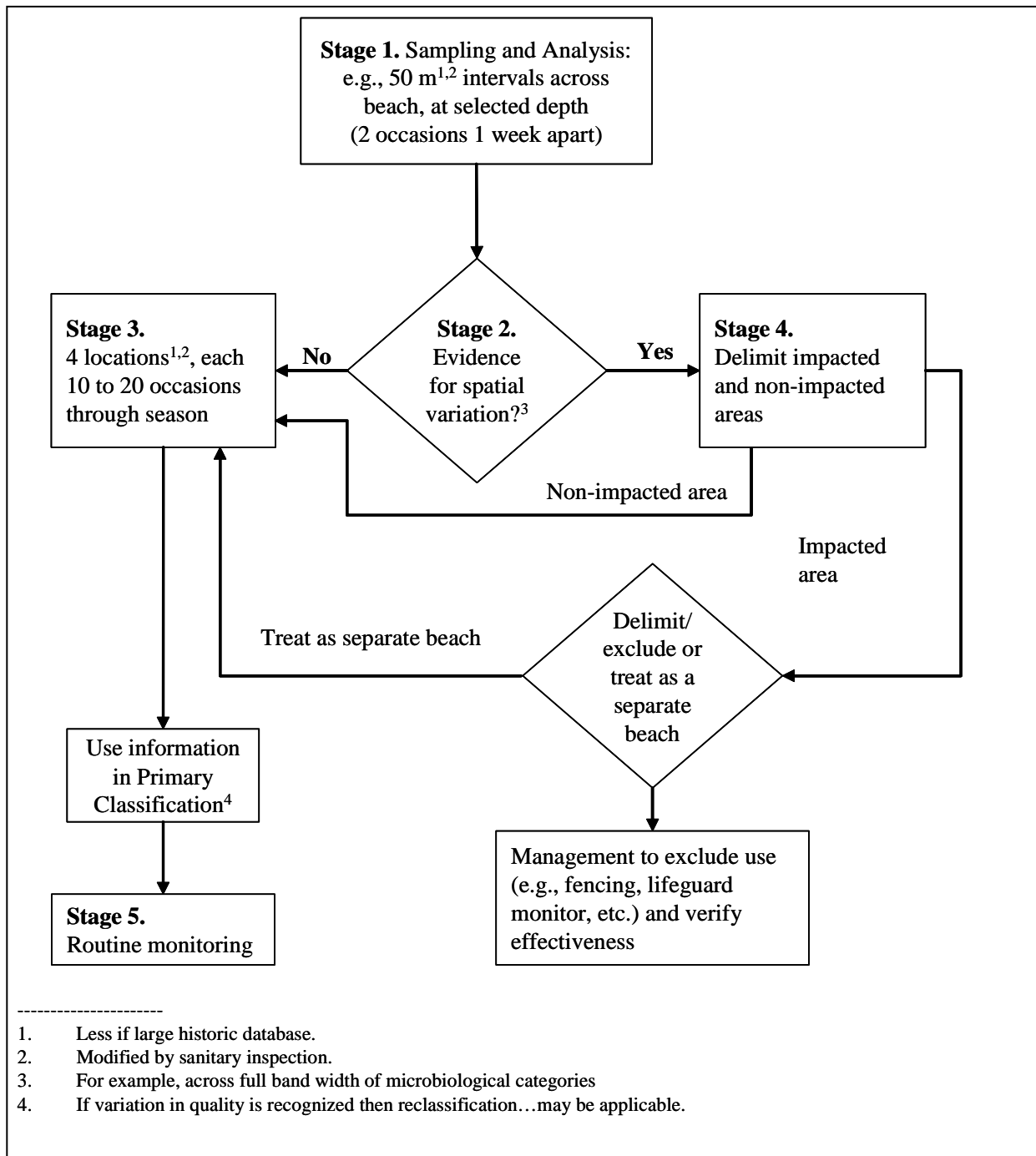
### APPENDIX 3: BEACH CLASSIFICATION AND MANAGEMENT PROTOCOL

Figure 8: Process Followed for a New Beach or Location on Entering the Classification Scheme



Source: Adapted from WHO/US EPA, 1999.

**Figure 9: Example Sampling Protocol for Primary Microbiological Categorization**



**Source:** Adapted from WHO/US EPA, 1999.