CANADIAN WATER NETWORK
RÉSEAU CANADIEN DE L'EAU

Microbial Outbreaks Related to Drinking Water

Water New Zealand Workshop
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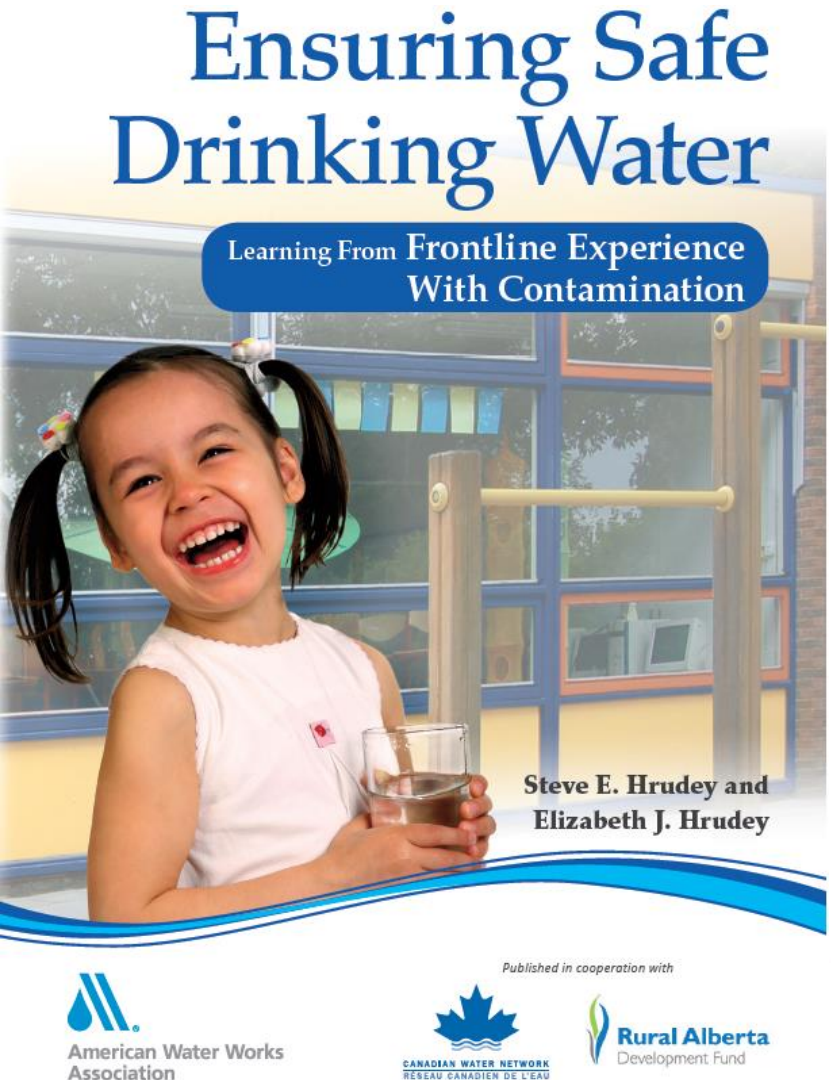
RELEVANT INTERNATIONAL EXPERIENCE

- Our evidence for the Inquiry summarized 38 outbreaks of serious drinking waterborne disease in 13 affluent countries (9 in USA, 7 in Canada, 6 in England, 3 in Finland, 2 each in Denmark, Norway, Sweden, Switzerland and 1 each in Australia, Ireland, Japan, New Zealand and Scotland)
- Caused a total of 77 fatalities in **9 fatal outbreaks** and a total of ~460,000 cases of illness
- These outbreaks clearly illustrate the relevance and application of 6 ADWG Guiding Principles– *to follow*

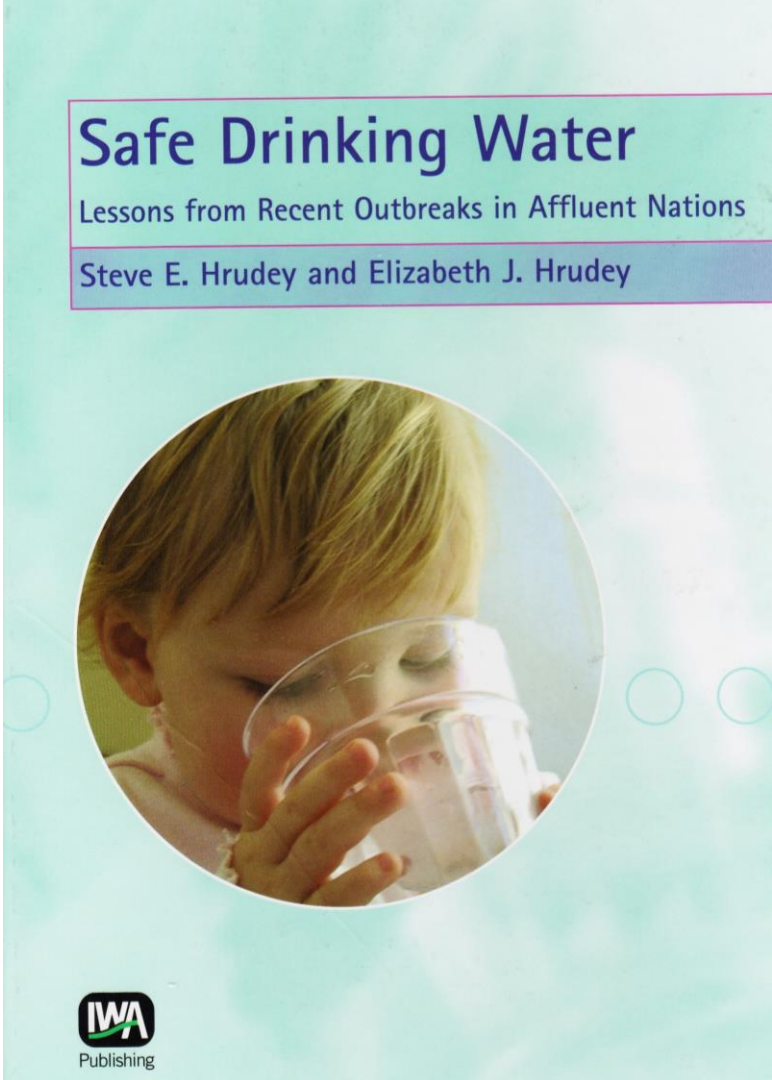
My Personal Experience – Last 20 years

- Starting in 1998, we began risk management revisions to the Australian Drinking Water Guidelines (ADWG) after the 1998 Sydney Water crisis – *a monitoring mistake*
- In May 2000, livestock manure contaminated ground water in Walkerton, Ontario, Canada, leading to over 2,000 cases of illness and 7 deaths from drinking water
- ADWG was a 0.1 m thick binder that we were working to make much even larger with a risk management frame
- **Walkerton water personnel read NO guidance at all**



We wrote a 2004 book inspired by the fatal Walkerton outbreak in May 2000 -

We wrote a sequel for frontline personnel in 2014



Nokia, Finland 2007

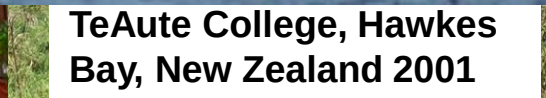
Alamosa, Colorado, USA, 2008

Transtrand, Sweden 2002

Ostersund, Sweden 2010

Klarup, Denmark 1995

LaNeuveville, Switzerland 1998



TeAute College, Hawkes Bay, New Zealand 2001

ADWG "*Read Me First*" GUIDING PRINCIPLES

1. *The greatest risks to consumers of drinking water are pathogenic microorganisms. Protection of water sources and treatment are of paramount importance and must never be compromised*
2. *The drinking water system must have, and continuously maintain, robust **multiple** barriers appropriate to the level of potential contamination facing the raw water supply.*
3. *Any sudden or extreme change in water quality, flow or environmental conditions (e.g. extreme rainfall or flooding) should arouse suspicion that drinking water might become contaminated.*
4. *System operators must be able to respond quickly and effectively to adverse monitoring signals.*

ADWG "*Read Me First*" GUIDING PRINCIPLES

5. *System operators must maintain a personal sense of responsibility and dedication to providing consumers with safe water, and should never ignore a consumer complaint about water quality.*
6. *Ensuring drinking water safety and quality requires the application of a considered risk management approach.*

These Guiding Principles are the distilled wisdom of a group of international drinking water experts including NZ's Dr. M. Taylor

They are certainly as valid now as when they were articulated in Adelaide in 2001.

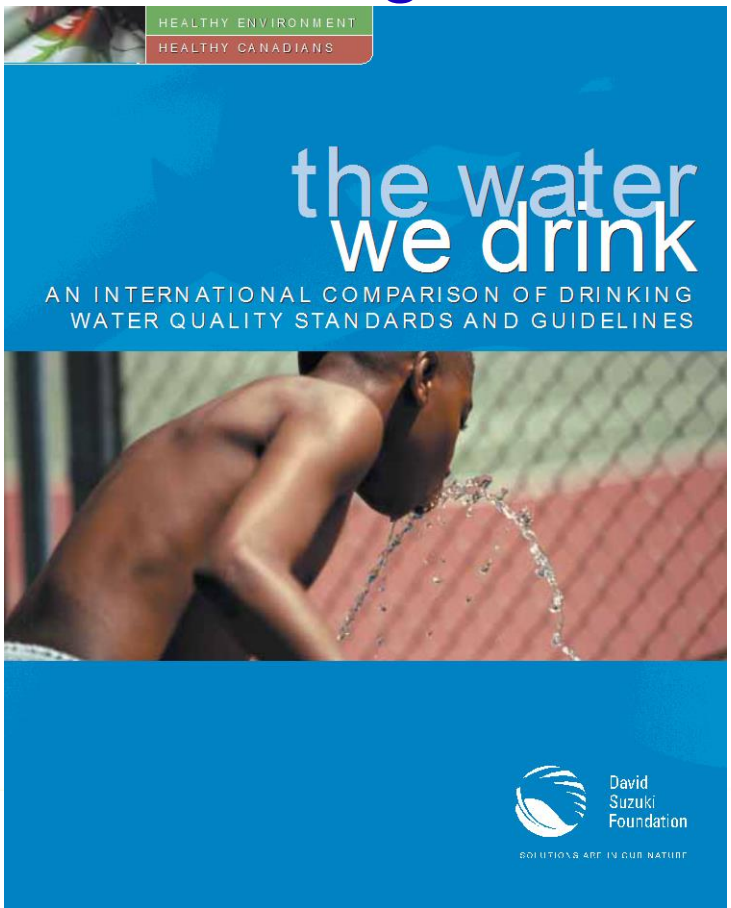
1. *The greatest risks to consumers of drinking water are pathogenic microorganisms*

- Drinking water quality criteria were and continue to be dominated by long lists of chemicals – "*simplistic*"
- Development of the **Water Safety Plan** / ***public health risk management plan*** approach was grounded in an accurate understanding that tables of numbers alone do **not** ensure safe drinking water
- Knowing your own system (**WSP**) and operating it with knowledgeable, continuous responsibility and vigilance is necessary to ensure safe drinking water

1. *The greatest risks to consumers of drinking water are pathogenic microorganisms*

- Evidence for chemical illness via drinking water:
  - exists for very few chemicals (arsenic, **++**fluoride, lead)
  - is inherently site-specific for those few chemicals
  - is uncertain for others with an inadequate dose to harm
- Evidence for pathogen illness via drinking water is:
  - **overwhelming** since the 1850s (Dr. John Snow, cholera & Dr. William Budd, typhoid) and is **absolutely certain**
  - is **pervasive** – occurs wherever humans, pets, livestock or wildlife reside – i.e. **everywhere**

Misguided Efforts at Safe Drinking Water



First Session, Forty-second Parliament,
64-65 Elizabeth II, 2015-2016

HOUSE OF COMMONS OF CANADA

BILL C-326

An Act to amend the Department of Health Act (drinking water guidelines)

FIRST READING, DECEMBER 5, 2016

SUMMARY

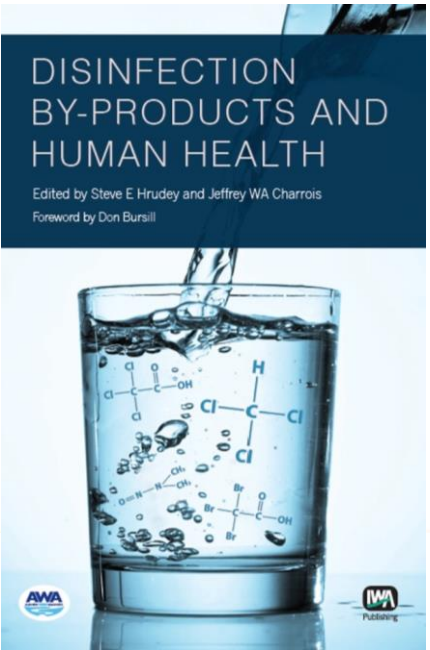
This enactment amends the *Department of Health Act* to require the Minister of Health to conduct a review of drinking water standards in member countries of the Organisation for Economic Co-operation and Development and, if appropriate, to make recommendations for amendments to national guidelines respecting drinking water.

1. *The greatest risks to consumers of drinking water are pathogenic microorganisms*

- North Havelock **was caused** by *Campylobacter* from sheep manure (after a 1998 *Campylobacter* outbreak)
- District Council had a clear and demonstrated aversion to chlorination – **why?**
  - Aesthetic aversion could be understandable – but then must choose disinfection alternatives and accept the added cost
  - Aversion based on fear of chlorination by-products is seriously misguided and is repeatedly shown to be reckless and dangerous
  - Aversion to chlorination was certainly a factor in some and likely a factor in 18 outbreaks with inadequate or without disinfection

1. *The greatest risks to consumers of drinking water are pathogenic microorganisms*

- Fear of chlorination of drinking water is common, but that fear is **NOT** based on credible, compelling evidence



EVALUATING EVIDENCE FOR ASSOCIATION OF HUMAN BLADDER CANCER WITH DRINKING-WATER CHLORINATION DISINFECTION BY-PRODUCTS

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[5]Tufts University, Medford, Massachusetts, USA
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[7]University of North Carolina, Chapel Hill, North Carolina, USA
[8]Hazen and Sawyer, Raleigh, North Carolina, USA

Exposure to chlorination disinfection by-products (CxDBPs) is prevalent in populations using chlorination-based methods to disinfect public water supplies. Multifaceted research has been directed for decades to identify, characterize, and understand the toxicology of these compounds, control and minimize their formation, and conduct epidemiologic studies related to exposure. Urinary bladder cancer has been the health risk most consistently associated with CxDBPs in epidemiologic studies. An international workshop was held to (1) discuss the qualitative strengths and limitations that inform the association between bladder cancer and CxDBPs in the context of possible causation, (2) identify knowledge gaps for this topic in relation to chlorine/chloramine-based disinfection practice(s) in the United States, and (3) assess the evidence for informing risk management. Epidemiological evidence linking exposures to CxDBPs in drinking water to human bladder cancer risk provides insight into causality. However, because of imprecise, inaccurate, or incomplete estimation of CxDBPs levels in epidemiologic studies, translation from hazard identification directly to risk management and regulatory policy for CxDBPs can be challenging. Quantitative risk estimates derived from toxicological risk assessment for CxDBPs currently cannot be reconciled with those from epidemiologic studies, notwithstanding the complexities involved, making regulatory interpretation difficult. Evidence presented here has both strengths and limitations that require additional studies to resolve and improve the understanding of exposure response relationships. Replication of epidemiologic findings in independent populations with further elaboration of exposure assessment is needed to strengthen the knowledge base needed to better inform effective regulatory approaches.

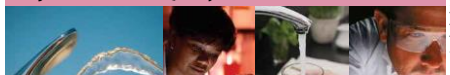
Water Research Foundation
advancing the science of water

American Water Works Association

Evidence for Association of Human Bladder Cancer With Chlorination Disinfection By-Products

Web Report #4530

Subject Area: Water Quality



40 years on: what do we know about drinking water disinfection by-products (DBPs) and human health?

Steve E. Hrudey and John Fawell

ABSTRACT

2014 marks the 40th anniversary of the seminal discovery by Johannes Rook, in 1974, that trihalomethanes (THMs) were formed by the chlorination of natural organic matter (NOM) in drinking water. Since this discovery, which revolutionized how we viewed drinking water safety and quality, hundreds of other classes of disinfection by-products (DBPs) have been discovered. The finding in 1976 by the US National Cancer Institute that chloroform, the dominant THM, was a rodent carcinogen spurred a large number of epidemiology and toxicology studies into chlorinated drinking water. In 1985, this cancer finding was shown to be wrong. We should now be asking: What do we know about the human health impacts of DBPs in drinking water? Bladder cancer has been the most consistent finding from epidemiologic studies in North America and Europe and the possibility that chlorinated drinking water contributes an increased risk of bladder cancer remains a viable hypothesis. Despite some recent improvements in exposure assessments to focus on inhalation and dermal exposures rather than ingestion, no causal agent with sufficient carcinogenic potency has been identified, nor has a mechanistic model been validated. Consequently, a sensible precautionary approach to managing DBPs remains the only viable option based on four decades of evidence.

Key words | causation, chloroform, precaution, rationale, risk trade-off, trihalomethanes, uncertainty

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LIST OF ABBREVIATIONS

BDCM	bromodichloromethane
CH	choral hydrate
CxDBP	chlorination disinfection by-product
DBAN	dibromoacetonitrile
DBCM	dibromochloromethane
DBP	disinfection by-product
DCAA	dichloroacetic acid
DCAN	dichloroacetonitrile
HAA5	sum of five haloacetic acids, MCAA, DCAA, TCAA, monobromoacetic acid (MBAA) and dibromoacetic acid (DBAA)
MCAA	monochloroacetic acid
NDMA	*N*-nitrosodimethylamine
NOM	natural organic matter
TBM	tribromomethane, bromoform
TCAA	trichloroacetic acid
TCP	trichlorophenol
THM	trihalomethane
THM4	sum of chloroform, BDCM, DBCM and TBM

doi: 10.2166/ws.2015.056

INTRODUCTION

The year 2014 provided a major anniversary in the history of drinking water quality and safety assessment. In 1974, the Dutch water chemist, Rook (1974) published his seminal discovery that trihalogenated methanes (THMs) are formed by the reaction of chlorine used to disinfect drinking water (inactivate pathogenic microorganisms) and natural organic matter (NOM). This discovery was soon followed by the publication of Bellar *et al.* (1974) who independently made the same discovery in the USA. This single discovery forever changed how we look at drinking water quality and has led to the subsequent discovery of hundreds of other unintended

1. *The greatest risks to consumers of drinking water are pathogenic microorganisms*

- Important risk features of pathogen contamination
  - Loading able to cause an outbreak will usually be intermittent
  - Pathogens will be heterogenously distributed in water because of their faecal origin
  - Consumer exposure to an infective dose of pathogens will usually be non-uniform because of potential for clumping
  - Pathogens differ in disinfection susceptibility but all pathogens are fine particles
  - Pathogen challenges in drinking water are usually event-driven
  - Multiple failures are usually required making multiple barriers and validation of barrier performance critical

2. *The drinking water system must have, and continuously maintain, robust multiple barriers*

- "*Multiple*" barriers means **more than one** barrier – an obvious statement that needs to be made given what was allowed to happen in North Havelock
- Reliance on an unverified, demonstrably questionable and possibly unverifiable classification as "*secure*" groundwater as the only barrier for ensuring safe drinking water should be recognized as seriously inadequate
- With benefit of hindsight, in N.H., it was reckless.

2. *The drinking water system must have, and continuously maintain, robust multiple barriers*

- Source water protection is vital to ensuring safe drinking water and it surely does count as an important barrier among multiple barriers
- Additional barriers are necessary because source water protection alone cannot provide the level of assurance that public drinking water demands
- Misguided faith in source water protection alone is often based on a misguided belief that "*natural* " is inherently safe, **but** pathogens are certainly "***natural*** "

2. *The drinking water system must have, and continuously maintain, robust multiple barriers*

- Full Principle 2 includes: "*appropriate to the level of potential contamination facing the raw water supply*"
- Be wary of this being misrepresented to justify a single barrier (source water protection) as in so-called "*secure groundwater*" – **multiple does mean >1**
- The purpose of this phrase was to deal adequately with source waters known to be at substantial risk of pathogen contamination – those need many barriers
- **Burden of proof** must be on "no treatment" advocates

3. *Any sudden or extreme change should arouse suspicion about contamination of drinking water.*

- To recognize and judge a change, you must know what is normal!
- There is an imperative to know your own system to know what is normal – i.e. a true **Water Safety Plan**
- Normal operations for most water providers are uneventful, perhaps even boring
- This creates a recipe for complacency on all sides
- Challenge is to deal with the rare unusual events

3. *Any sudden or extreme change should arouse suspicion about contamination of drinking water.*

- What can be done to address this complacency?
- At a minimum, look to other public safety situations that require high reliability – e.g., airlines
- Except for takeoffs and landings, most of the time flying commercial aircraft is boring
- Even takeoffs and landings are now generally routine
- Train pilots by simulation and case studies of failure
- Why not do this universally in the water industry?

3. *Any sudden or extreme change should arouse suspicion about contamination of drinking water.*

- This is a call for those running a system to be **curious** about changes in conditions because:
  - All disasters are preceded by change, even though very few signals of change will mean impending disaster
  - False alarms will greatly exceed true alarms
- Multiple factors must usually coincide before disaster
- Walkerton was highly vulnerable to contamination for 22 years before the May 2000 disaster
- Slow or subtle changes must also be detected but...

4. *System operators must be able to respond quickly and effectively to adverse signals.*

- "Operator" needs to be interpreted broadly to include all those with responsibility for safe water
  - Supervisors
  - Managers
  - Politicians
  - Regulators
- Regulators need to be as, **or more**, aware and should not be able to shrug responsibility for systemic failure because they are physically remote

5. System operators must be responsible and dedicated to providing safe drinking water

- Operators with their hands on the controls are the critical first line of defense and their importance needs to be recognized and fairly compensated
- All with responsibility need to be equipped with knowledge to discharge that responsibility
- Knowledge of the consequences of failure is vital
- **North Havelock water safety plans characterized the consequences of contamination as "*moderate*" (2008) and "*minor*" (2015)!!!!**

6. Ensuring drinking water safety requires considered risk management approach

- Water Safety Plan approach (PHRMP) intended to be pragmatic and effective risk management
- Beware, because risk management language can be used to justify a multitude of sins
- District Council submitted to the Inquiry that its decision to not fix sub-surface bore heads was a risk management decision, despite 1998 outbreak and numerous unexplained *E.coli* incidents
- Nokia, had a WSP- failed to detect cross connection

6. Ensuring drinking water safety requires considered risk management approach

- For the Walkerton Inquiry Part 2 Report, we described the essential characteristics of risk management as:
  - Being preventive rather than reactive
  - Distinguishing greater risks from lesser ones and dealing first with the former (e.g., disinfection)
  - Taking time to learn from experience
  - Investing resources in risk management that are proportional to the danger posed

Constructive Suggestions Towards Prevention

- Invest in training with a sound foundation of understanding the health and other serious consequences of failure
- Inquiry Stage 1 Report – Appendix 7 listed 44 NZ drinking water outbreaks causing > 7300 cases
- This experience should be “**mined**” to develop training case studies
- Develop training based on anonymized cases of close calls

The Bottom Line

You can have cheap water

Or you can have safe water

But you cannot have cheap, SAFE water!

Questions???

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