Agenda

Water in the News

- Shuniah landfill site
- Thunder Bay harbour

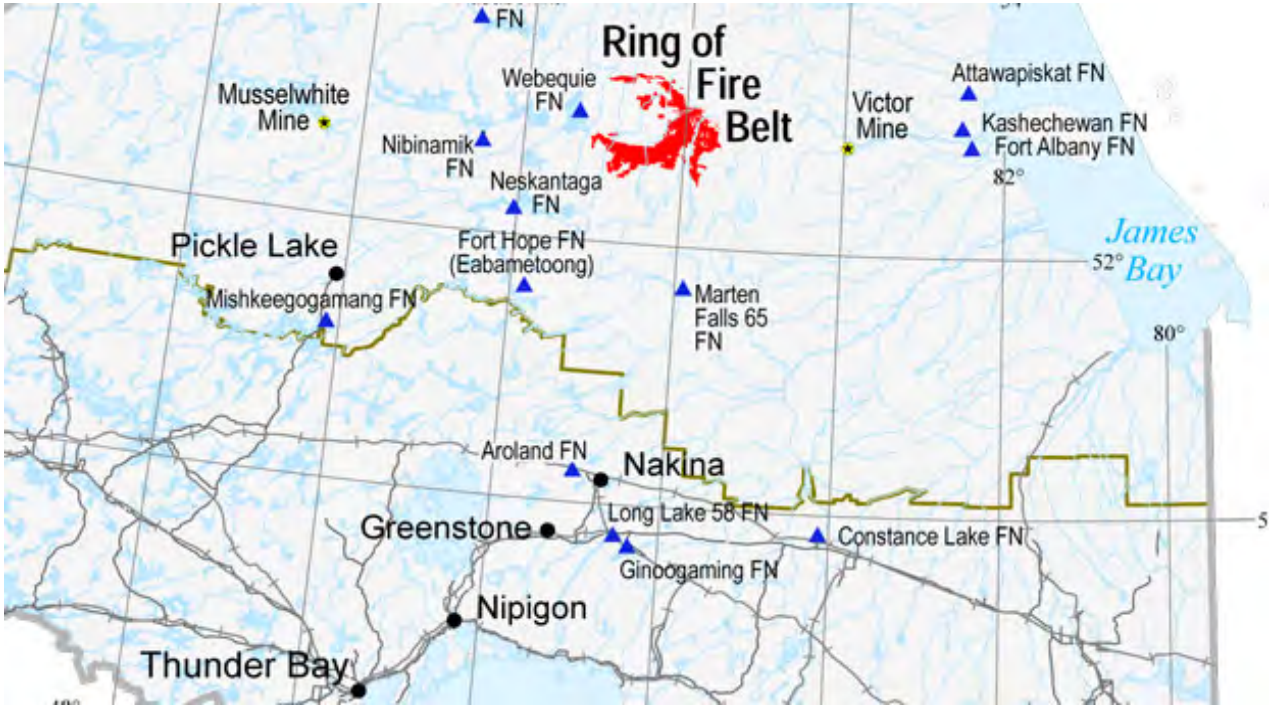
- As of **October 31, 2016**, there were **133 Drinking Water Advisories** in effect in **90 First Nations communities** (Health Canada)

Lecture: WATER SUPPLY AND WATER QUALITY

Water . . . in the news

After completing substantial research, organizations involved in the Thunder Bay harbour cleanup are recommending that "Bird or Animal Deformities or Reproduction Problems" be removed from the list of local concerns. Thunder Bay's harbour was one of over forty environmental "Areas of Concern" around the Great Lakes in 1987.

Water . . . in the news



Neskantaga First Nation has been on a boil water advisory since 1995

WATER SUPPLY AND WATER QUALITY

1. Water Supply Management
2. Water Quality Management
3. Municipal Water Quality
4. Walkerton and related threats
5. Concerns and Threats to Drinking Water

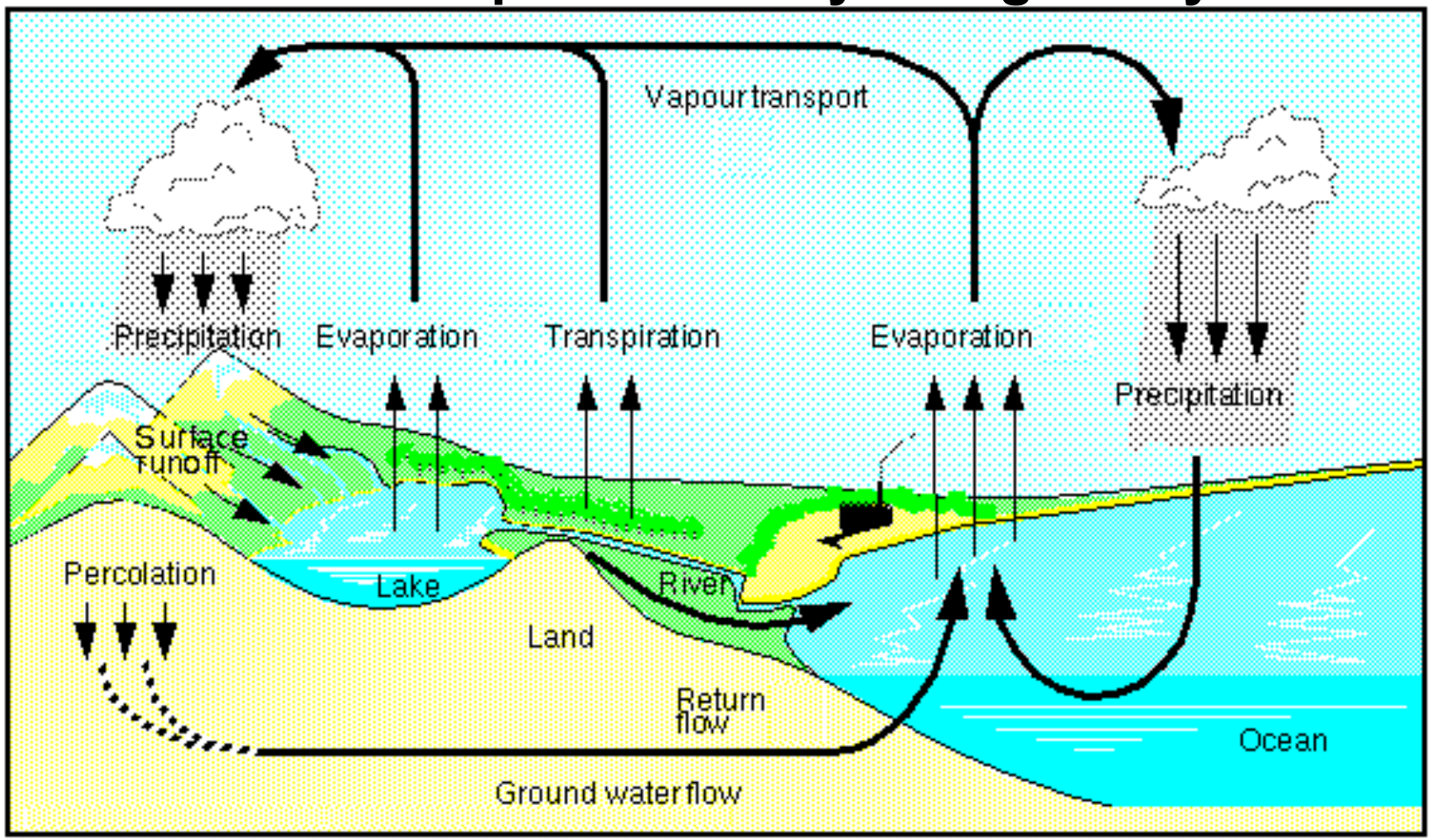
1. WATER SUPPLY MANAGEMENT

Water supply is the provision of water for different types of human use, such as drinking, domestic use, irrigation and urban-industrial supply.

Two basic issues are related to the balance between demand and availability and the quality of water:

- Supply is dependent on the physical principles of the hydrologic cycle
- Demand is related to
  - density of population
  - type of usage.

Basic Principles of the Hydrological Cycle



Courtesy Erich Roeckner, Max Planck Institute for Meteorology

$$\frac{\text{Total amount of runoff}}{\text{population}} = \text{a crude estimate per capita}$$

2. Water Quality Management

What determines water quality?

The water of even the healthiest rivers and lakes is not absolutely pure. All water (even if distilled) contains many naturally occurring substances:

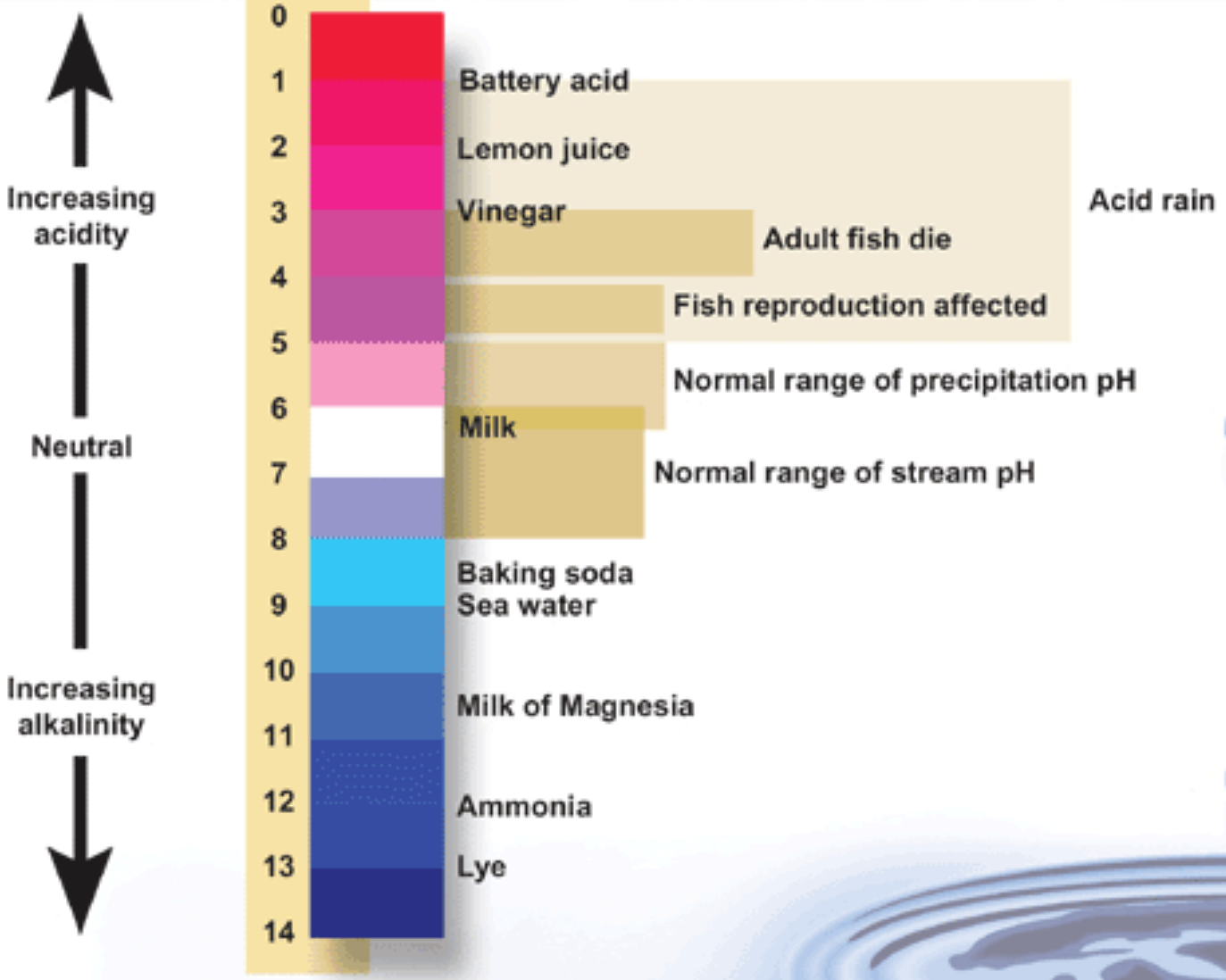
- bicarbonates
- sulphates
- sodium
- chlorides
- calcium
- magnesium
- potassium

How do we measure water quality?

Collect samples of the water, of living organisms, and of suspended and bottom sediments.

- pH
- temperature
- dissolved oxygen
- turbidity
- conductivity

The pH scale


Increasing acidity
Neutral
Increasing alkalinity
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Battery acid
Lemon juice
Vinegar
Adult fish die
Fish reproduction affected
Acid rain
Normal range of precipitation pH
Milk
Normal range of stream pH
Baking soda
Sea water
Milk of Magnesia
Ammonia
Lye

A sampling of water quality information

•Canadians with secondary treatment or better has improved from 40% in 1983 to 69% in 2009

•compared with 76% of Americans, 89% of Germans, and 99% of Swedes.·

•In developing nations, 80% of diseases are water-related.

•Of all Canadians, 31% rely on groundwater for domestic use.

•One drop of oil can render up to 25 litres of water unfit for drinking

•One gram of 2,4-D (a common household herbicide) can contaminate ten million litres of drinking water.

•One gram of PCBs can make up to one billion litres of water unsuitable for freshwater aquatic life.

•One gram of lead in 20,000 litres of water makes it unfit for drinking. Older homes often contain plumbing made of lead or soldered in lead, which can then leach into water

•The nitrates in fertilizers promote excessive growth of algae and larger aquatic plants, causing offensive algal blooms and driving out sport fish.

•Methane gas can often be seen bubbling up from the bottom of ponds; it is produced by the decomposition of dead plants and animals in the mud.

3. Municipal Water Quality

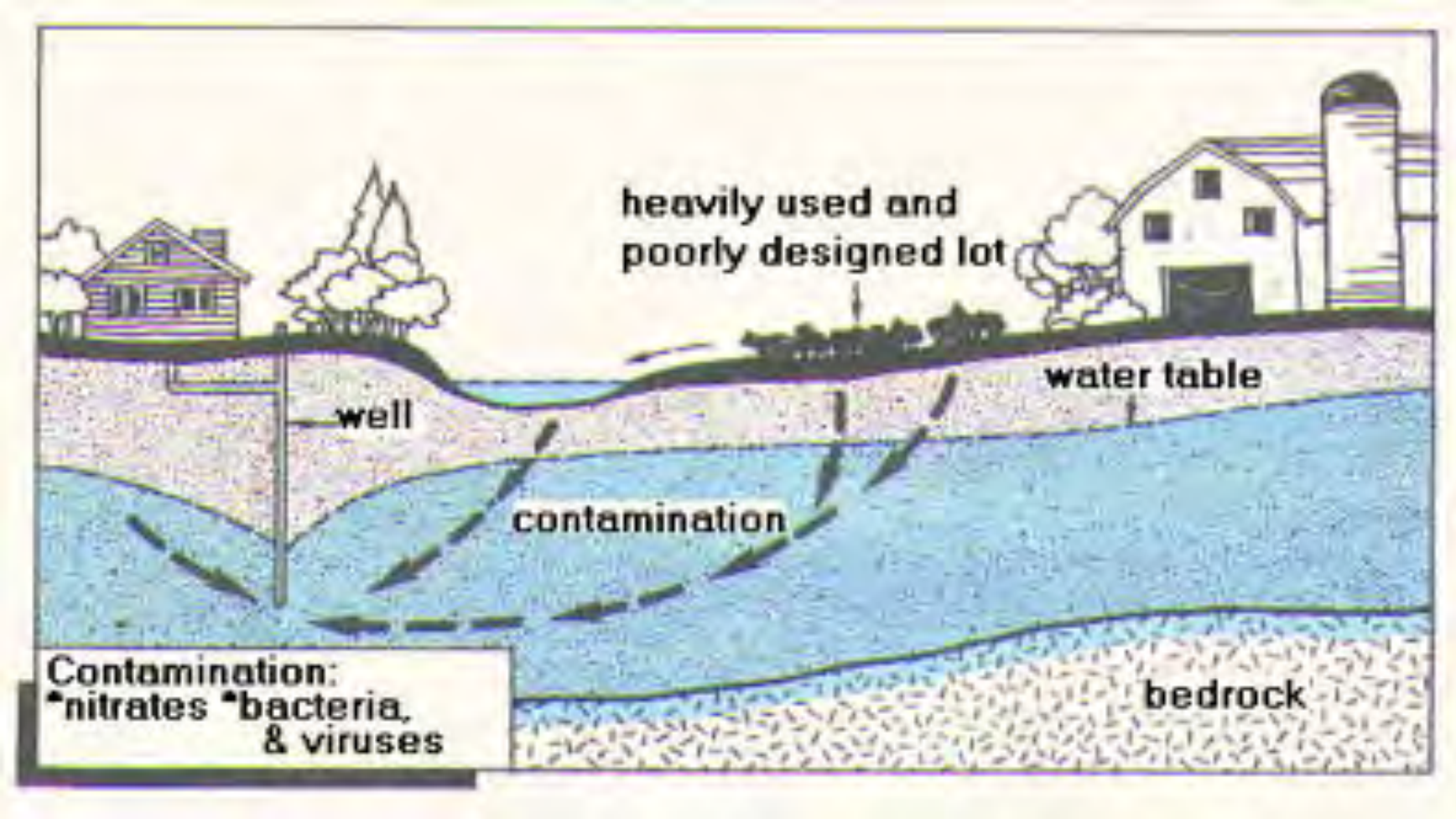
Three major issues of municipal water supply are:

1. drinking water quality
2. wastewater treatment improve quality
3. water demand management

- Improper chlorine treatment
- Equipment being repaired
- Operators had insufficient training
- Private Co. falsified monitoring
- Provincial Monitoring inadequate

- May 2000
- Water supply contamination from E-Coli Bacteria
- 7 died and 2300 became ill
- E-Coli from manure on fields near water supply
- Shallow well and fractured bedrock
- Exacerbated by rainfall
- Farmer followed proper practices

ANIMAL LOTS


heavily used and
poorly designed lot
water table
well
contamination
Contamination:
•nitrates •bacteria,
& viruses
bedrock

Water Quality Programs and the Multi-Barrier Approach

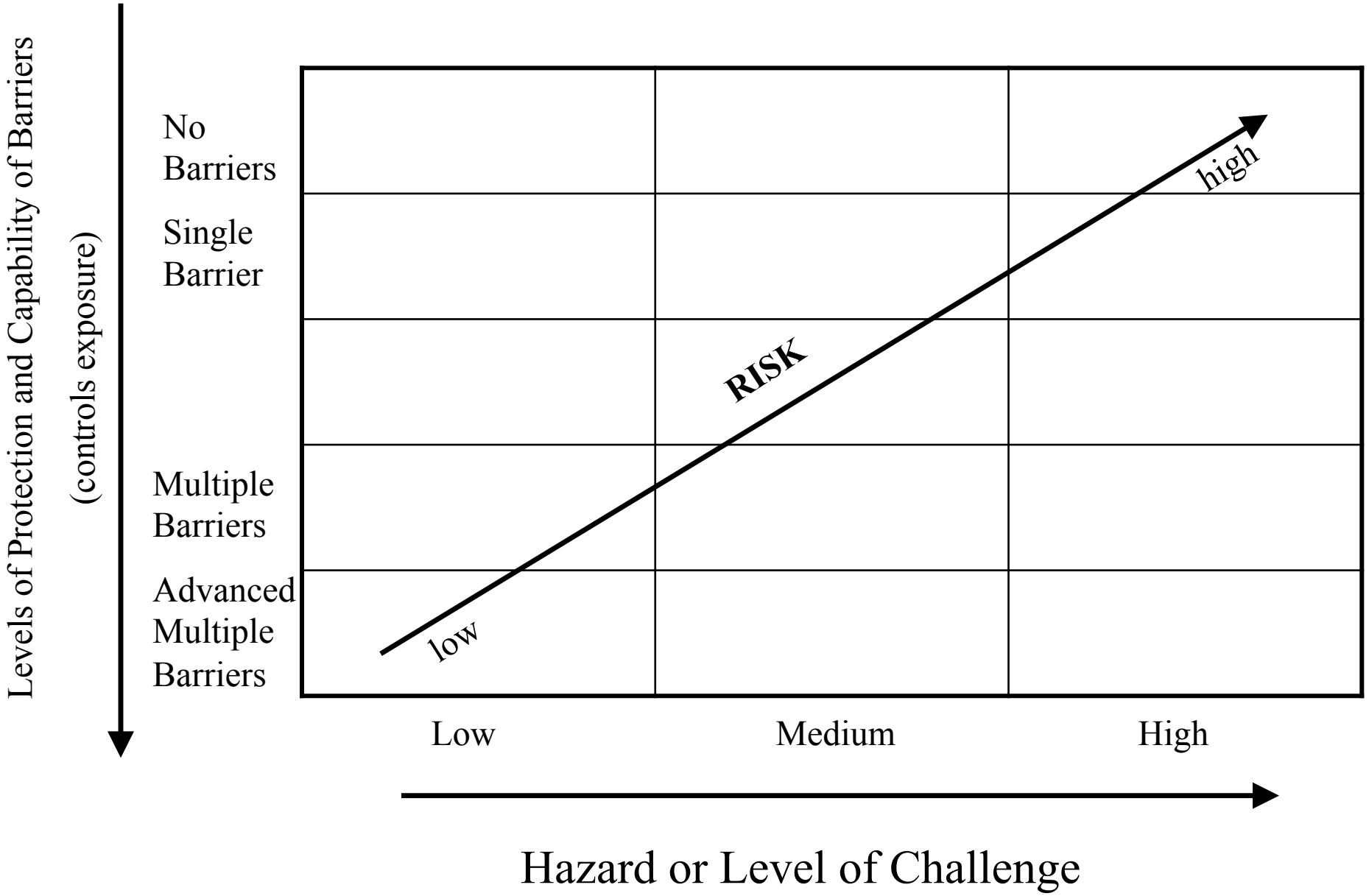
- Provincial governments have the primary responsibility for managing and protecting water quality, including the provision and regulation of drinking water and wastewater services
- The federal government is responsible for ensuring the safety of drinking water within areas of federal jurisdiction, such as national parks and Aboriginal reserves.
- The federal government also protects water quality by regulating toxic substances, conducting water quality research, and promoting pollution prevention.

A water system must be robust and resilient to change.

Multi-barrier Approach

1. Source: the best possible raw water quality should be maintained and protected
2. Treatment: effective treatment should be designed, operated and maintained
3. Distribution: secure storage and distribution of treated water should be provided
4. Monitoring: appropriate and effective monitoring should be performed
5. Response: appropriate and effective response to adverse monitoring or adverse circumstances are needed

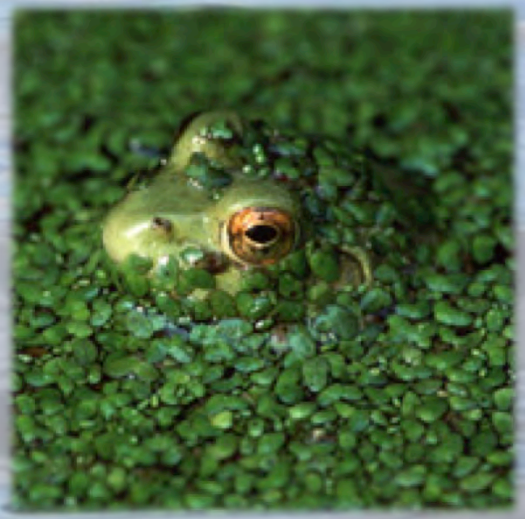
Relationship of drinking water risk to water contamination challenge and treatments system resilience



5. Concerns and Threats to Drinking Water

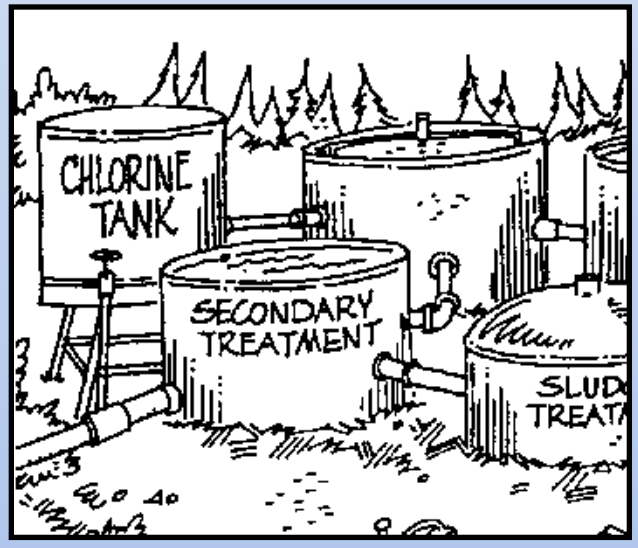
Outline

- Introduction
- Pharmaceuticals and Personal Care Products
- Chlorine Byproducts (THMs)
- Waterborne Diseases
- Water Terrorism
- What Can We Do? / Future Outlook

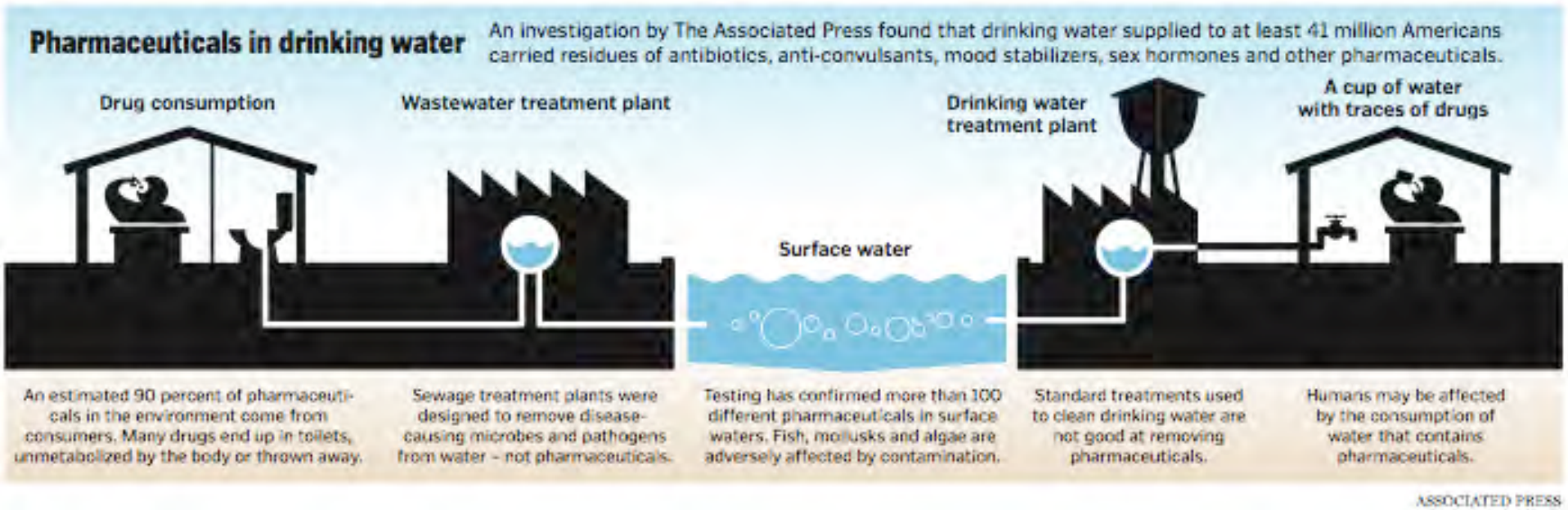


Introduction

- Although Canadian water treatment and infrastructure is of the highest standards of the developed nations, they are not the only reliable safeguard to water quality.
- Many problems exist *within* and *beyond* the existing water management systems from a local, national and international scale.
- "Business As Usual" is not an option.
- Threats are still poorly addressed because of our common failure to understand the scope of the problem.



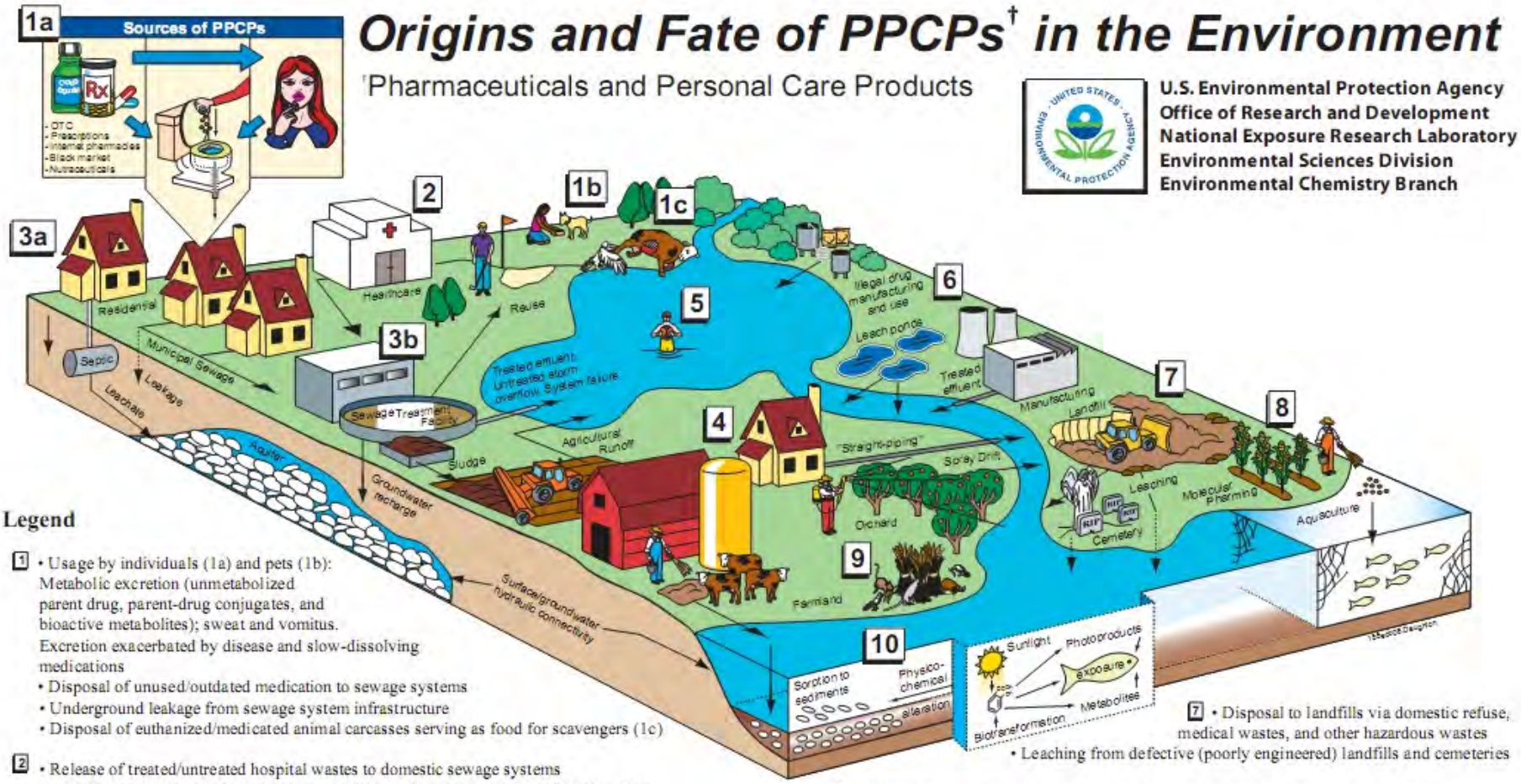
Pharmaceuticals and Personal Care Products in the Water



Origins and Fate of PPCPs† in the Environment

†Pharmaceuticals and Personal Care Products

U.S. Environmental Protection Agency
Office of Research and Development
National Exposure Research Laboratory
Environmental Sciences Division
Environmental Chemistry Branch



Legend

1 • Usage by individuals (1a) and pets (1b): Metabolic excretion (unmetabolized parent drug, parent-drug conjugates, and bioactive metabolites); sweat and vomitus. Excretion exacerbated by disease and slow-dissolving medications
• Disposal of unused/outdated medication to sewage systems
• Underground leakage from sewage system infrastructure
• Disposal of euthanized/medicated animal carcasses serving as food for scavengers (1c)

2 • Release of treated/untreated hospital wastes to domestic sewage systems (weighted toward acutely toxic drugs and diagnostic agents, as opposed to long-term medications); also disposal by pharmacies, physicians, humanitarian drug surplus

3 • Release to private septic/leach fields (3a)
• Treated effluent from domestic sewage treatment plants discharged to surface waters, re-injected into aquifers (recharge), recycled/reused (irrigation or domestic uses) (3b)
• Overflow of untreated sewage from storm events and system failures directly to surface waters (3b)

4 • Transfer of sewage solids ("biosolids") to land (e.g., soil amendment/fertilization)
• "Straight-piping" from homes (untreated sewage discharged directly to surface waters)
• Release from agriculture: spray drift from tree crops (e.g., antibiotics)
• Dung from medicated domestic animals (e.g., feed) - CAFOs (confined animal feeding operations)

5 • Direct release to open waters via washing/bathing/swimming

6 • Discharge of regulated/controlled industrial manufacturing waste streams
• Disposal/release from clandestine drug labs and illicit drug usage

7 • Disposal to landfills via domestic refuse, medical wastes, and other hazardous wastes
• Leaching from defective (poorly engineered) landfills and cemeteries

8 • Release to open waters from aquaculture (medicated feed and resulting excreta)
• Future potential for release from molecular pharming (production of therapeutics in crops)

9 • Release of drugs that serve double duty as pest control agents:
examples: 4-aminopyridine, experimental multiple sclerosis drug → used as avicide; warfarin, anticoagulant → rat poison; azacholesterol, antilipidemics → avian/rodent reproductive inhibitors; certain antibiotics → used for orchard pathogens; acetaminophen, analgesic → brown tree snake control; caffeine, stimulant → *coqui* frog control

10 Ultimate environmental transport/fate:
• most PPCPs eventually transported from terrestrial domain to aqueous domain
• phototransformation (both direct and indirect reactions via UV light)
• physicochemical alteration, degradation, and ultimate mineralization
• volatilization (mainly certain anesthetics, fragrances)
• some uptake by plants
• respirable particulates containing sorbed drugs (e.g., medicated-feed dusts)

Christian G. Daughton, U.S. EPA-Las Vegas

March 2006
(original February 2001)

http://epa.gov/nerlesd1/chemistry/pharma/images/drawing.pdf
from: http://epa.gov/nerlesd1/chemistry/pharma/

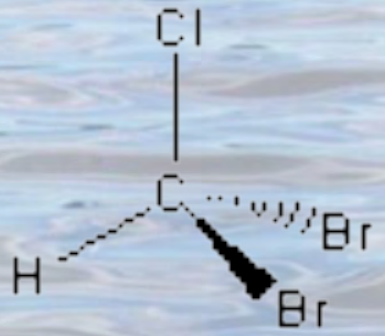
17α-Estradiol

Estra-1,3,5(10)-triene-3,17β-diol

Thousands of different active molecules belonging to various therapeutic classes, with different physiochemical properties, chemical structures, environmental behavior and persistence have lead to the complex issue involving environmental pollution from PPCPs.

Chlorination Disinfectant Byproducts

TRIHALOMETHANES (THMs)



- Chlorine is a disinfectant added to drinking water
- Reduces and eliminates microorganisms such as viruses and bacteria
- CDBPs are chemical compounds that form when water, containing natural organic matter, reacts with chlorine
- THMs are a major subgroup of chlorination by-products

PROBLEM?

Evidence of close relationships between bladder cancer and exposure to THMs

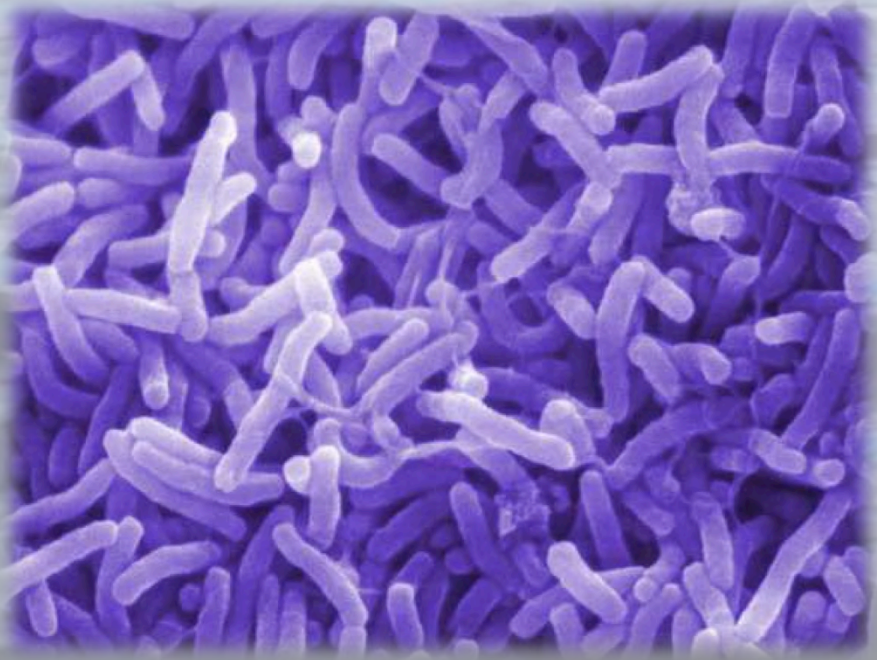
Case Studies

- One study in Ontario, Canada examined the relationship between bladder cancer and exposure to chlorination byproducts in public water supplies (King and Marrett, 1996).
- Thunder Bay has also done studies on the rate of bladder cancer in Loch Lomond water supply

Solutions:

- A carbon filter can remove chlorine and its byproducts
- Alternatives to chlorine disinfectants
  - Ozonation
  - Chloramines
  - Chlorine dioxide
- Better knowledge and application of more precise methods
- Ontario drinking water quality standard (ODWQS)

Waterborne Diseases



Waterborne Diseases

- Types of diseases linked to water
  - Water-based diseases
  - Water-washed diseases
  - Water-related diseases
  - Water-borne diseases
    - typhoid
    - cholera

Solutions

- Vaccinations
- Oral Rehydration Therapy
- Need to be Proactive!
  - Education
  - Water Treatment Facilities (urban)
  - Safe Water System (rural)
  - Wells vs Surface Water

Water Terrorism

- Biological, chemical, cyber and physical threats
- Risks to infrastructure, human health, economy
- Biological
  - potential to do the most harm
  - Anthrax, salmonella, Q fever, pneumonic plague, human waste
  - Contaminate reservoirs, bottling plants
- Chemical
  - Pesticides, chlorine, prussic acid (large quantities)
  - Some available in stores, others on the black market

Water Terrorism

- Cyber Threats
  - The use of computer network tools to shut down critical national infrastructure
  - Energy, transportation, dams
  - The most likely form of water terrorism (Lewis 2002)
- Physical Threats
  - Destruction of infrastructure from explosives

Water Terrorism

- Examples:
  - Romania 1944 German military polluted a Romanian towns drinking water with human waste (biological)
  - 1985- A cult in the Ozark mountains were planning to poison the water supply of New York, Chicago, Washington D.C., with potassium cyanide (chemical)
  - 2000 Australian man gained control over the waste water system, releasing sewage into parks, rivers, and private properties. Did this using a laptop and radio transmitter (Cyber)
  - U.S. security heightened post 9/11

Strategies to Increase Public Education and Awareness

- Educate citizens to engage and inspire to permanently change behaviour
  - Websites
  - Newsletters
  - Annual water quality report and fact sheets
- Information should help public understand guidelines, conservation issues, costs of providing services, improvements, further research needs, pollution mitigation

Lakehead Region Conservation Authority
Conserve Today...For A Better Tomorrow

Education

- Educating land owners on regular water testing and well maintenance
- Land owners should be aware of best management practices
  - Stream banks
  - Buffer strips
  - Tree planting
  - Fencing

Research & Science

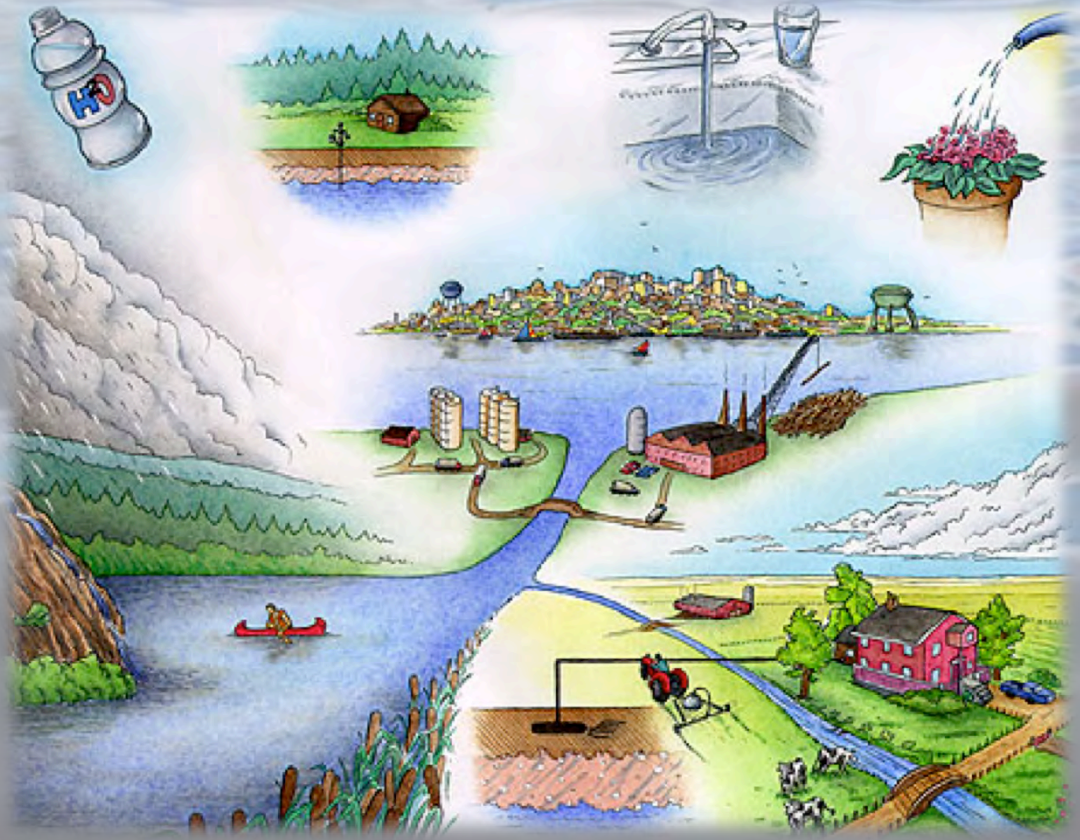
- Science-based decisions should be made - rather than on policies and assumptions which could result in measures that are overly or under-protective of human and ecological health.
- Research and development must be supported – it is not a cost, it is an investment in the future.
- Science is usually only 10-20% of the solution. The remaining management requires partnerships across jurisdictions, industry, commerce and the community.

Responsibility and Management

- Political Issues – Up/Downloading of responsibility
- Stewardship of landowners
- Preventive Risk Management Approach
  - Understanding water supply from beginning to end
  - Know the ways it can be contaminated and the required treatments
- Example: The Multi-Barrier Approach
  - Identifies all known and potential hazards
  - Ensures barriers are in place to reduce or eliminate risk of contamination

Closing Remarks

- Better knowledge of who is responsible
- Recognizing tomorrow's threats and finding the solutions today, rather than looking to solve today's problems tomorrow



MINISTRY OF THE ENVIRONMENT
DRINKING WATER ONTARIO

What do you think is the best way to manage threats?

What other threats may exist to our drinking water supply?

Four main global surface temperature measurement datasets

- HadCRUT4 86 per cent coverage
- NCDC 90
- GISTEMP 99
- JMA 85
- Satellite: University of Alabama

- Kriging: **Can we really extrapolate temperatures?**