Operation and Maintenance of Water Supplies

Presented to
Clean and Safe Drinking Water Workshop
Gander, Newfoundland

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CH2M HILL MILL Canada Limited

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Ask yourself this Question

- **Is my system at risk?**
  - What could happen that would put my system out of compliance?

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What is meant by compliance?

- **Meeting or exceeding the Guidelines for Canadian Drinking Water Quality**
  - They are not regulations but guidelines and do not have the same force of law
  - Will Newfoundland follow Ontario and US and move to regulations?

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What are the concerns in my water supply?

- **Microbial contamination**
  - Bacteria - E.coli, Samonella
  - Viruses - Hepatitus A, Coxsackie A & B
  - Protozoa - *Giardia, Cryptosporidium*
- **Chemical / Physical contamination**
  - Organics - THM's, Benezene,
  - Inorganic - Mercury, Lead, Arsenic
  - Pesticides/Herbicides/PCB - DDT,
  - Radionuclides - Radium, Cesium

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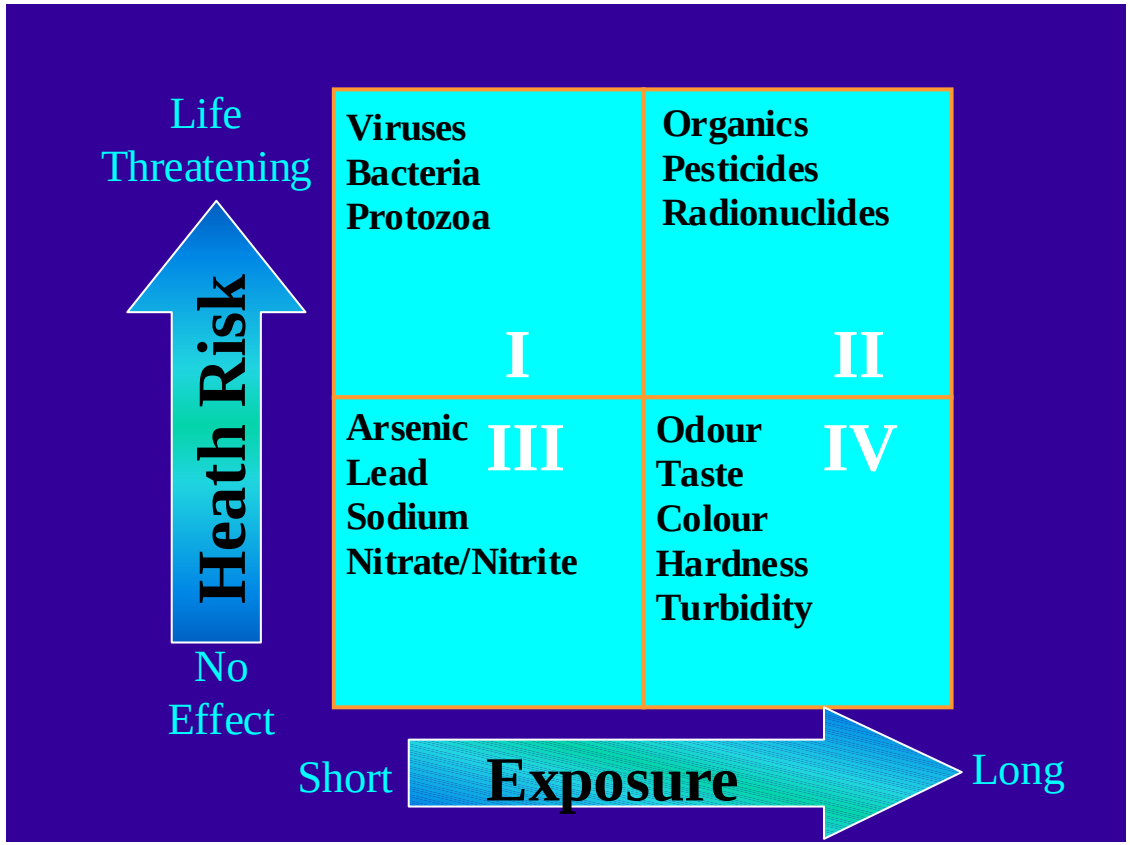
Understanding the Risk



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Probability of contaminants being present above MAC

- **Chemical /Physical contaminants**
  - Lower risk most are isolated single occurrences
  - a total of 654,382 samples taken from1993 to 1997- 99.98% met ODWG
- **Microbiological parameters**
  - Much higher risk 220 AWQR so far in 2000
  - Can happen in any system

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Cases of waterborne disease out breaks in the US 1980-1996

- **Microbial - Every year in the US 7,000,000 cases of mild to moderate water related illness**
- **403,000 from single *cryptosporidium* outbreak in 1993 in Milwaukee 100 people died**
- **Chemical poisoning - 3,097 cases of illness**

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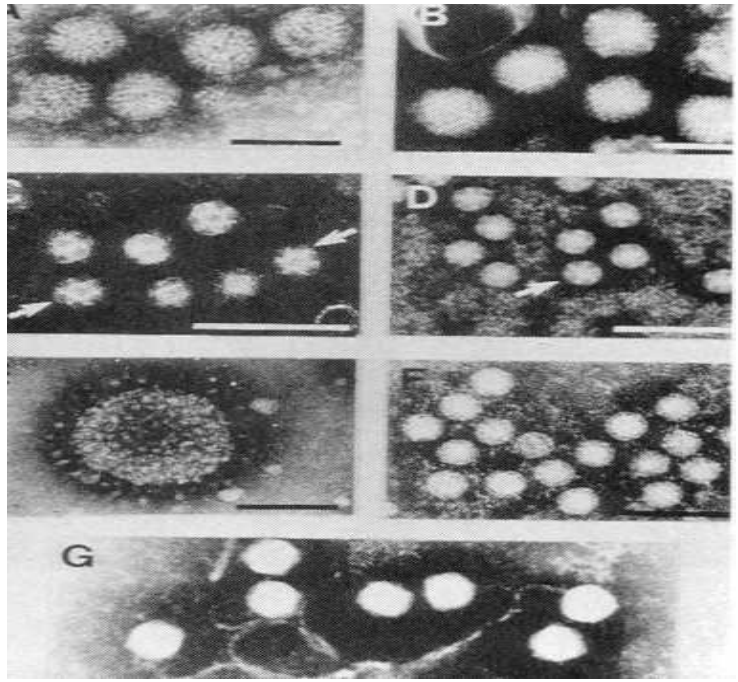
Viruses 0.02 - 0.09 µm

- Norwalk
- Hepatitis A
- Coxsackie A & B
- Echoviruses
- Rotavirus
- Adenovirus



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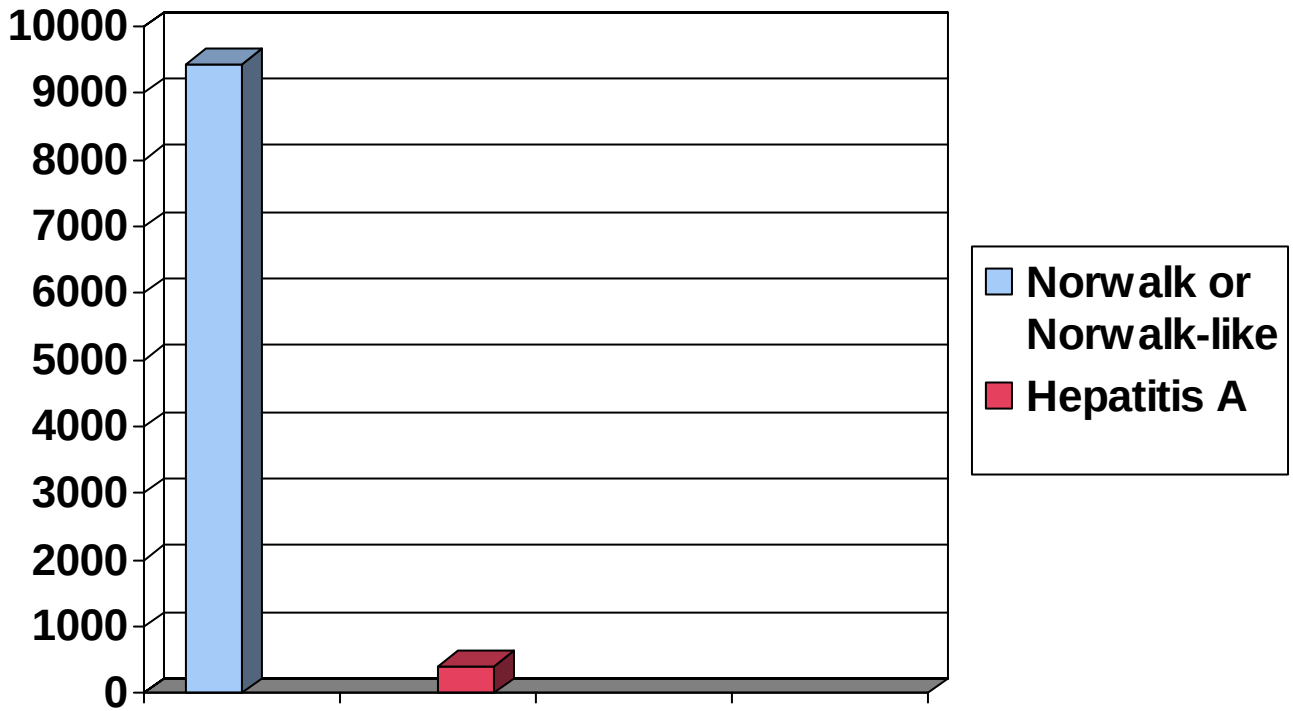
Cases of documented viral waterborne disease in the US 1980-1996



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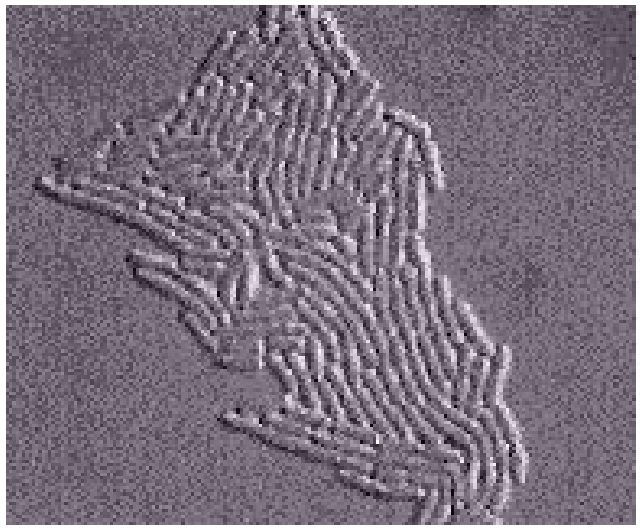
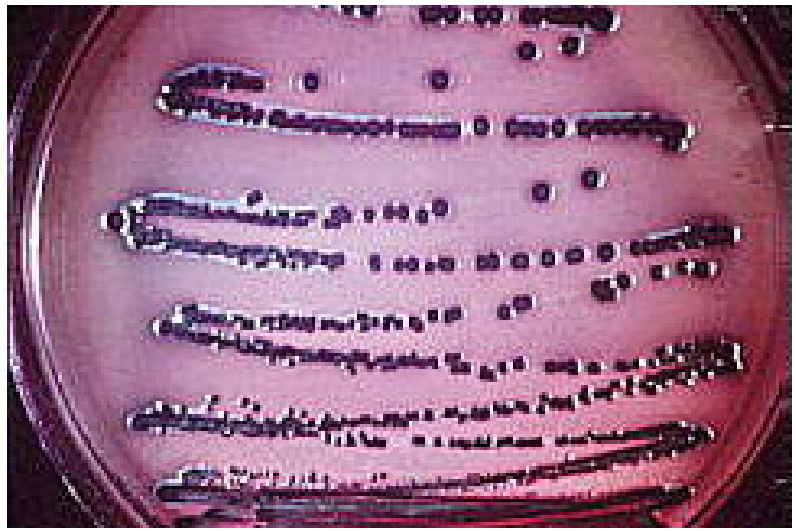
Bacteria 0.2 to 2 µm



Eshericha coli cells



Eshericha coli colonies

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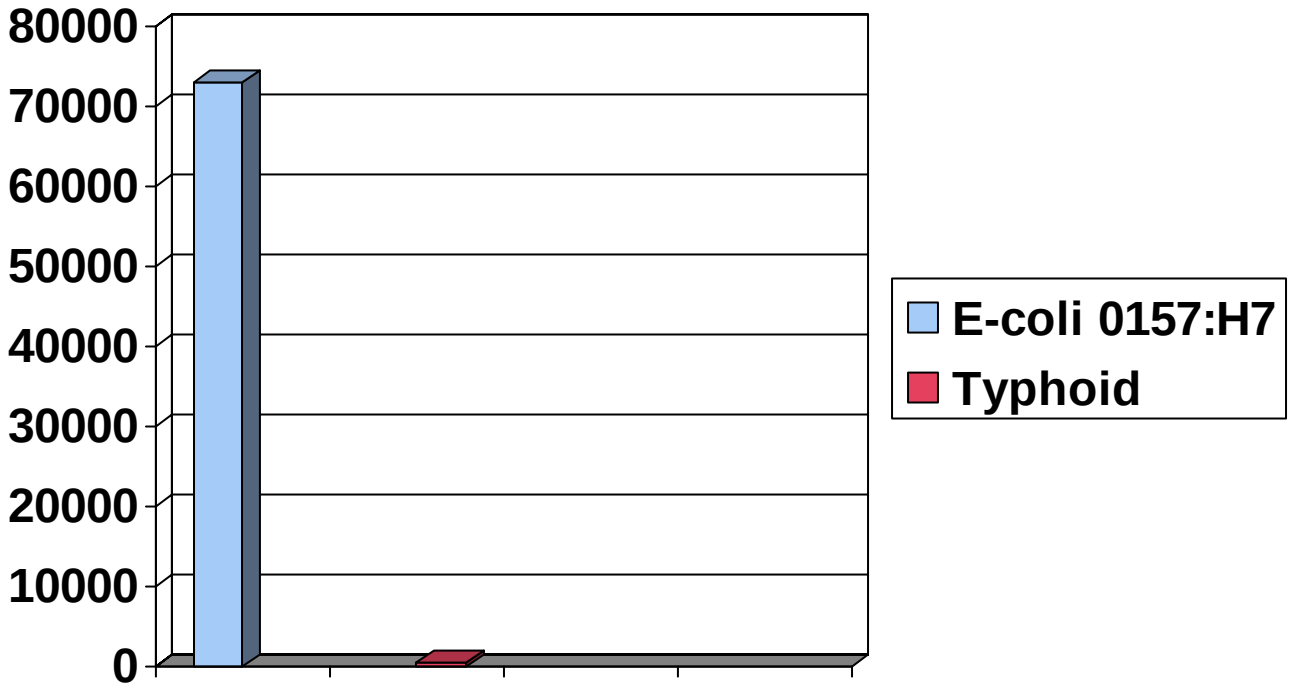
Cases of documented bacterial disease in the US 1998



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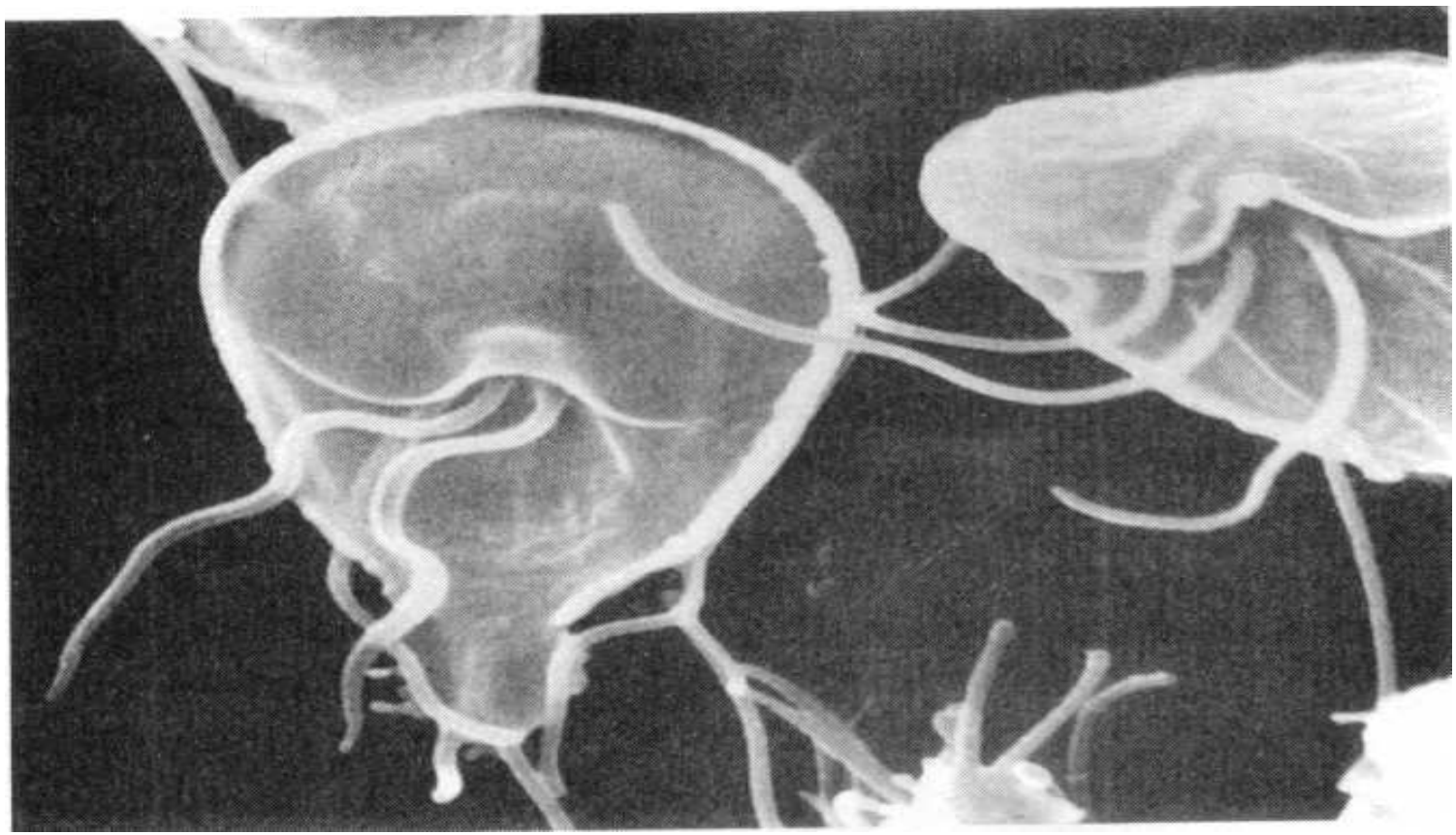
Protozoa - *Giardia lamblia*
8 to 18 µm



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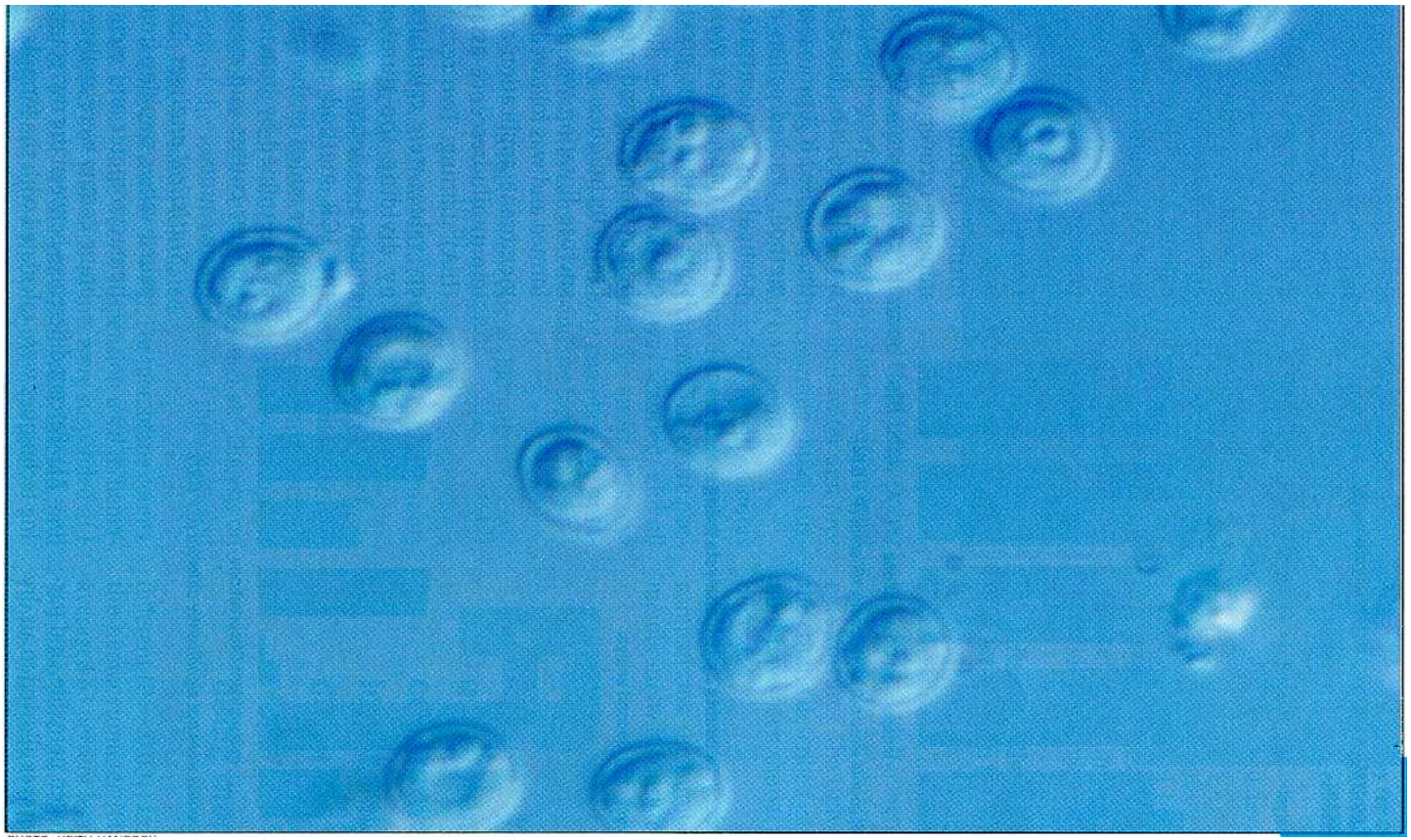
Protozoa - *Cryptosporidium*
4 to 6 µm



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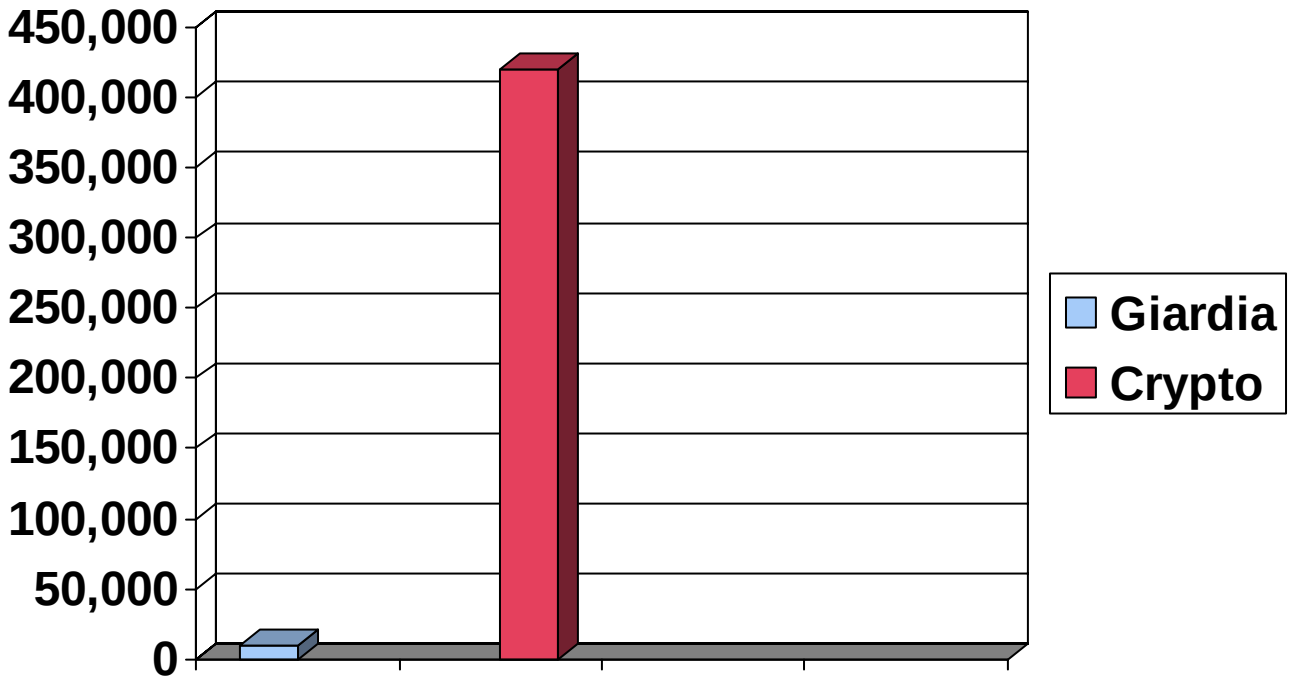
Cases of documented protozoan waterborne disease in the US 1980-1996



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How waterborne diseases are transmitted

- Water contaminated with human or animal feces
- Feces contaminated with pathogens
- Pathogens that survive in water
- Pathogens that enter the water supply
- Water not adequately treated
- Susceptible person drinks water containing pathogens

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Who are the most susceptible?

- Infants
- Aged
- Women in pregnancy
- Immunocompromized

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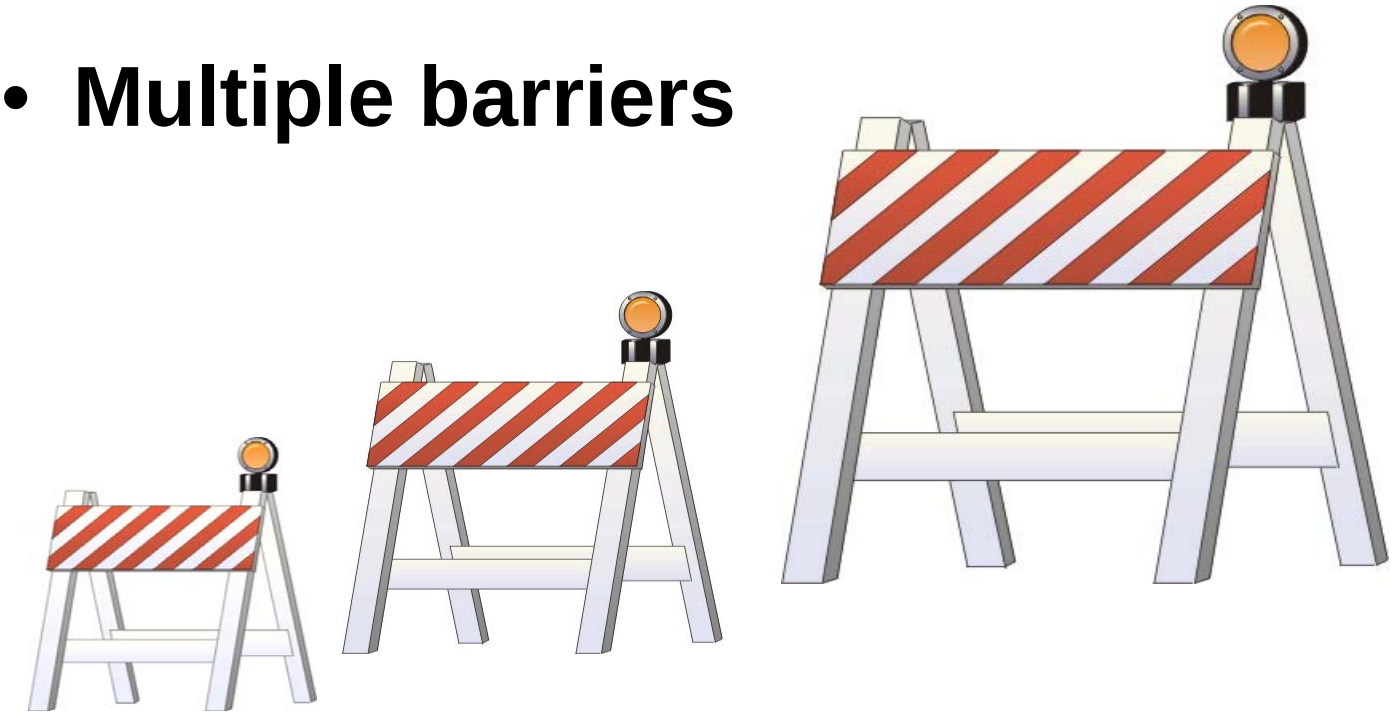
How to reduce the risks

- **Multiple barriers**



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Multiple barrier approach

- **The use of both water quality protection and water treatment to reduce the risk of waterborne diseases in our drinking water**

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Implementing a multiple barrier approach

- Identify available barriers
- Assess vulnerability of each barrier to the passage of pathogens
- Recognize and anticipate conditions under which pathogen risk increases

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Implementing a multiple barrier approach (cont'd)

- Implement proven measures to control pathogens
- Monitor to maintain barriers at high level of effectiveness
- Maintain vigilance in protecting your system
- Knowledgeable, trained operators

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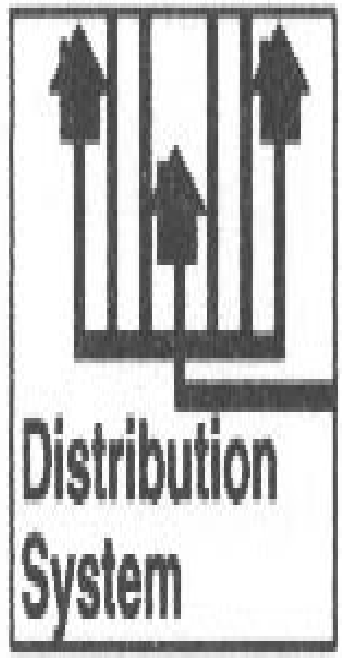
Multiple barrier components



None 100% effective in inactivating pathogens

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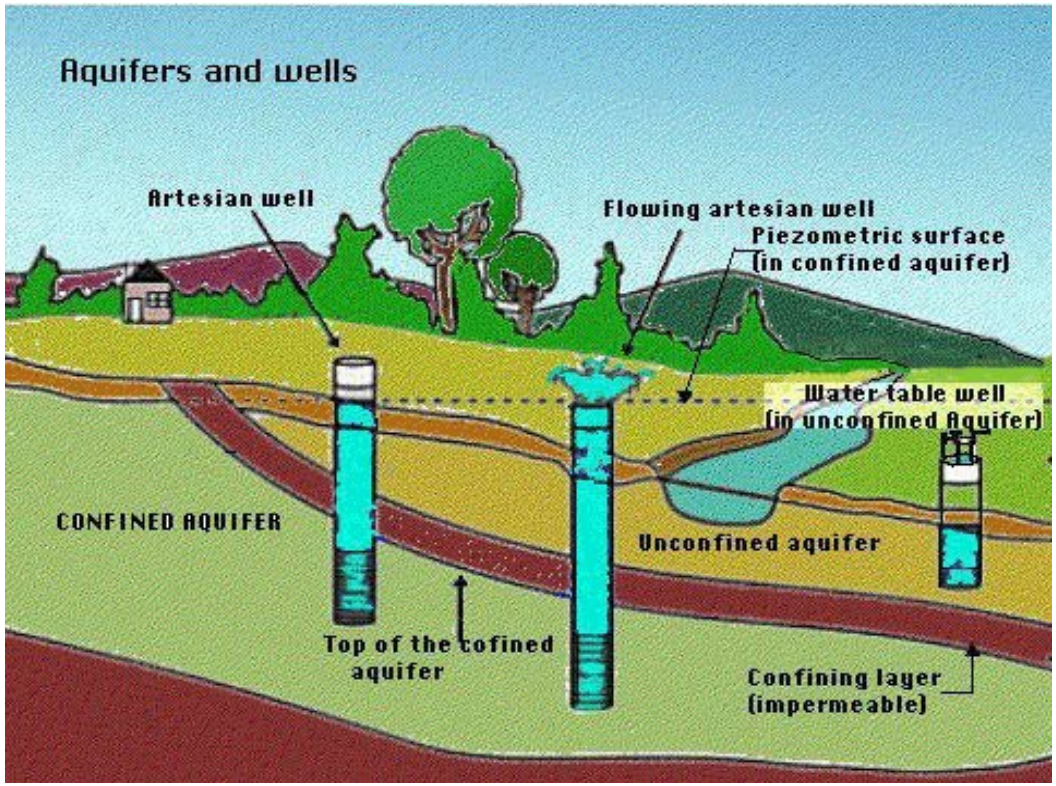
Groundwater protection



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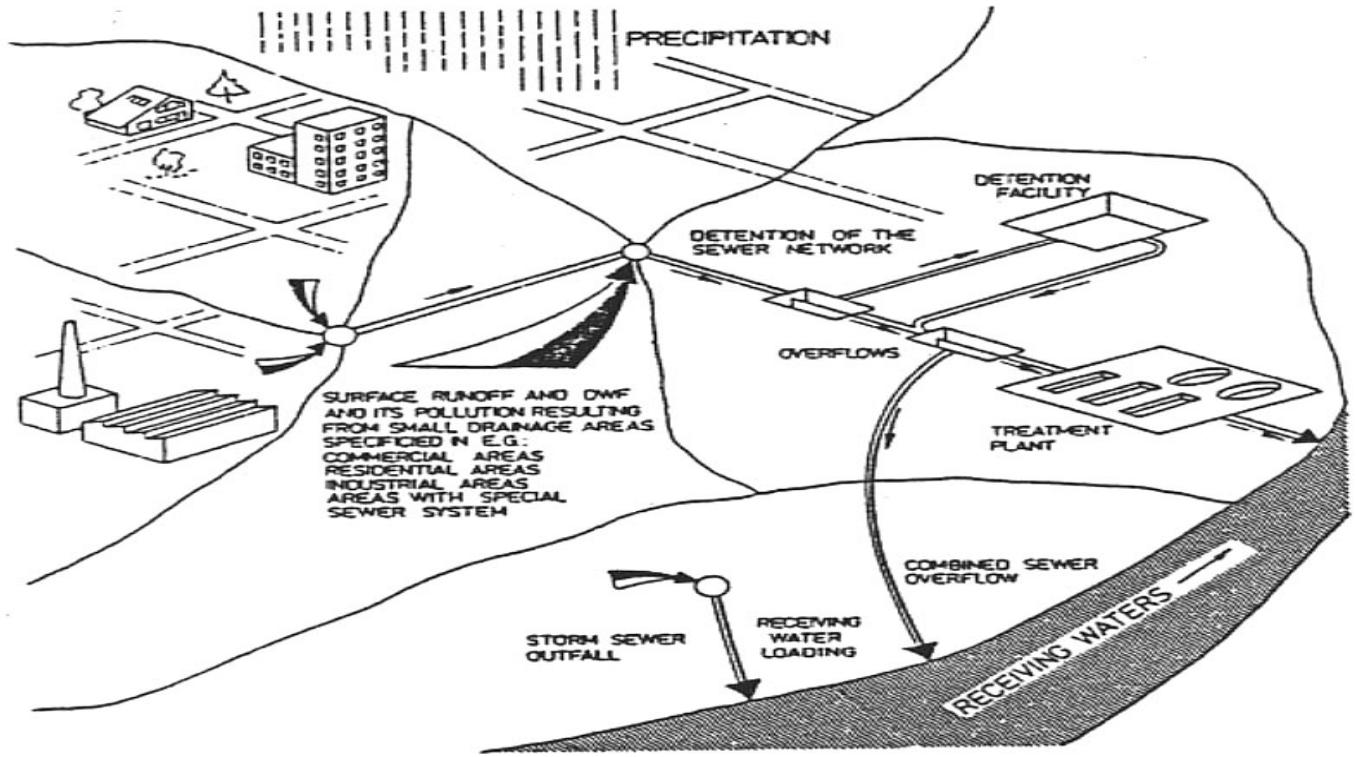
Surface water source protection



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Source protection

- Pathogens can come from animals and humans
- Pathogens can be present in both surface and ground water

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Source protection

- **Watershed planning that involves**
  - Hydrogeologicial studies
    - *Specific understanding of the aquifer and surface waters in the watershed*
  - Water resource strategy
    - *Land-use planning to protect the watershed from pollution*
  - Regulations
    - *That ensure protection of the watershed*

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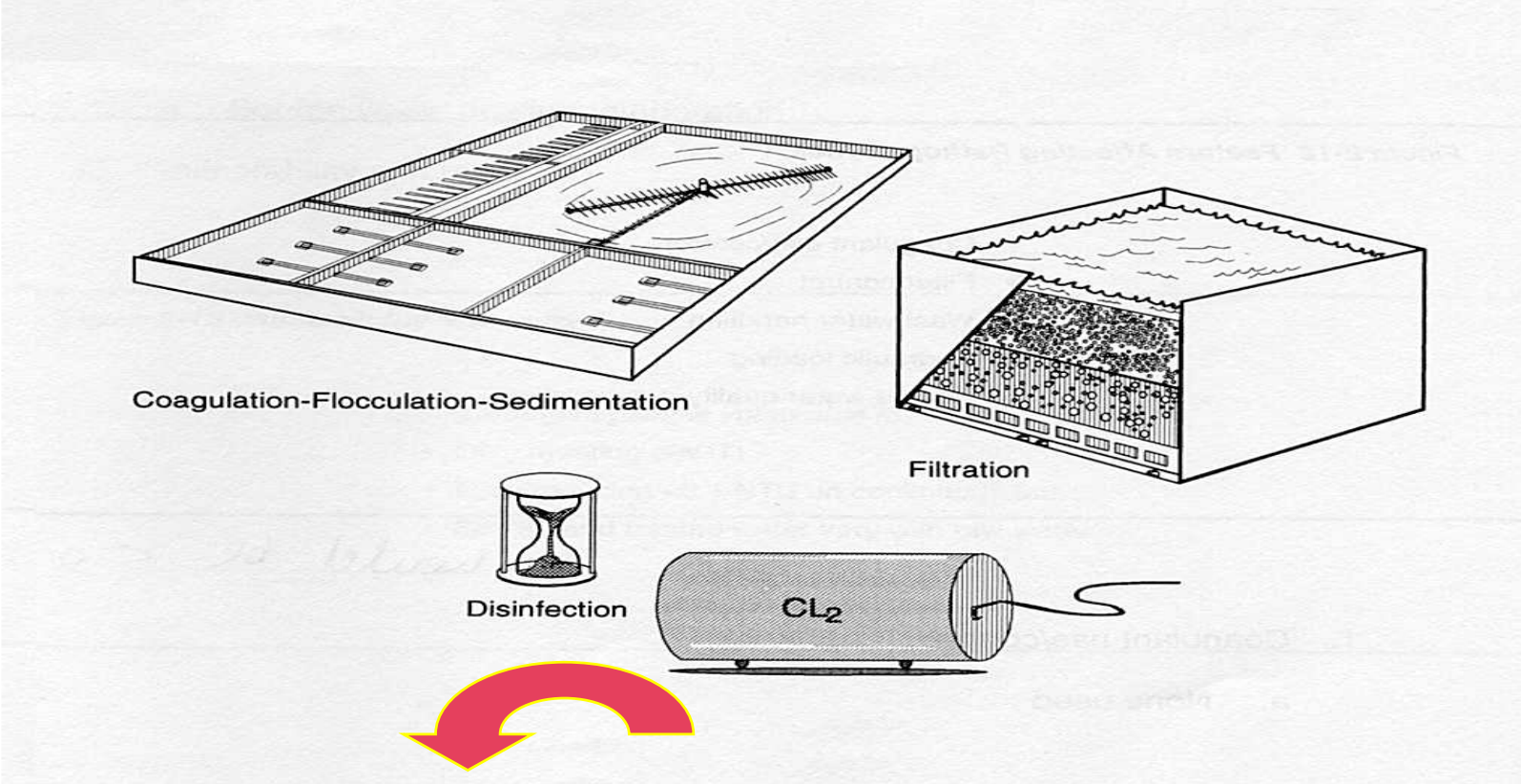
Treatment increases the effectiveness of pathogen reduction



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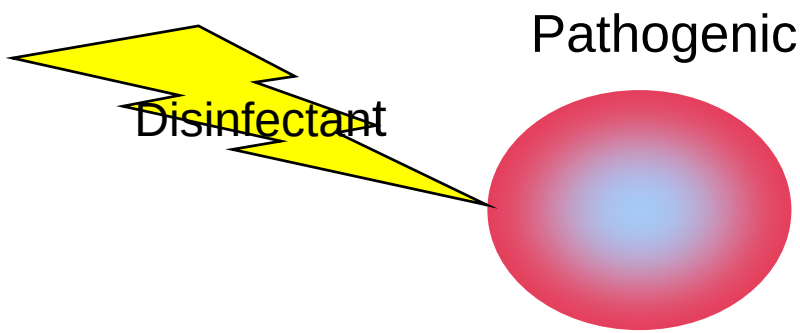
Disinfection

- **Primary purpose to reduce pathogenic organisms**



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Groundwater requirements

- **Minimum chlorine residual, measured as free or combined, after 15 minutes contact time at maximum flow before the first customer of 0.2 mg/L**

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Groundwater requirements (cont'd)

- **Where under the influence of surface water greater than 3 - log reduction of *Giardia and* 4-log reduction of viruses**
- **May be achieved by disinfection only to avoid filtration**

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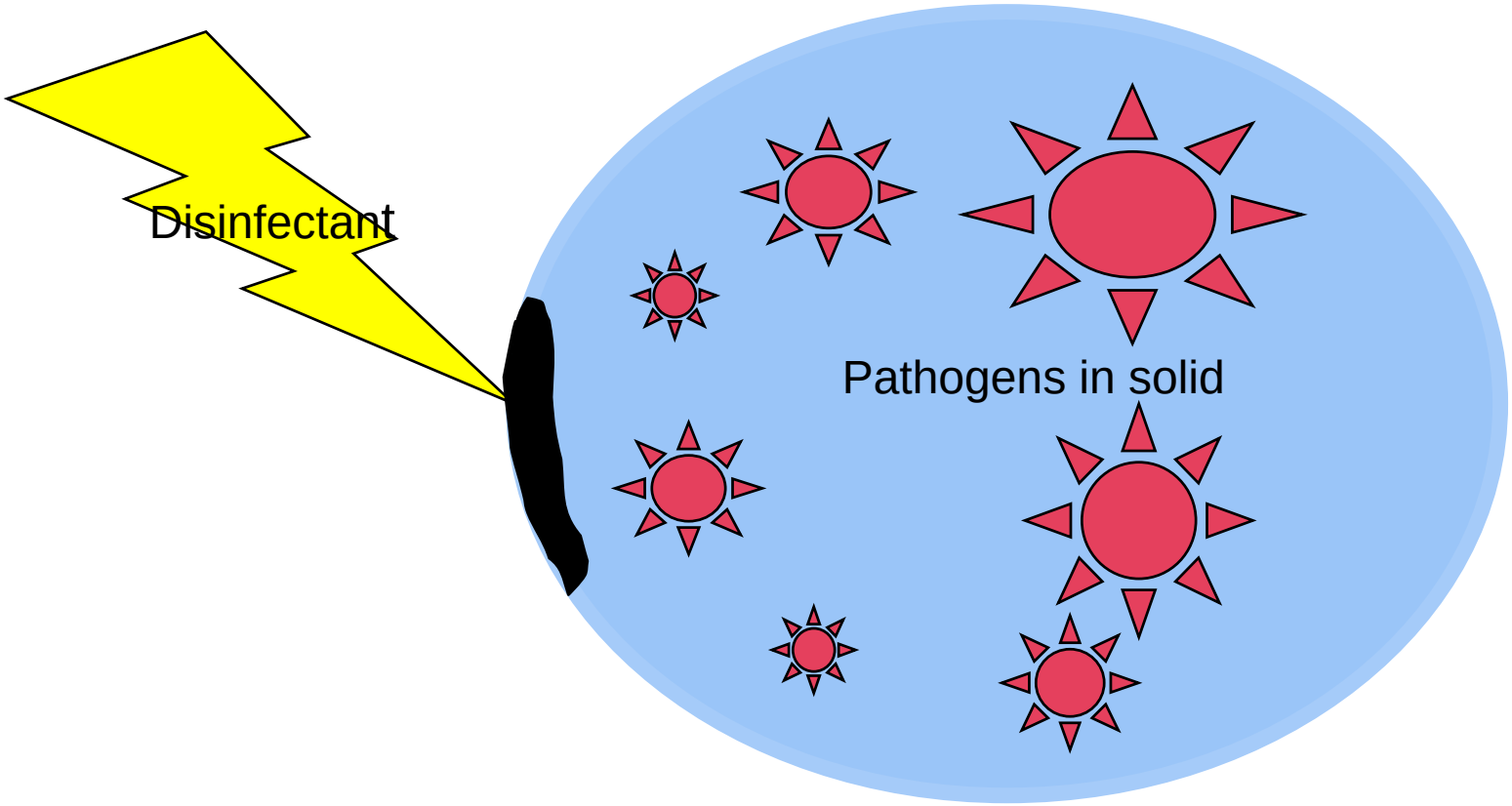
Clumping of solids shields pathogens



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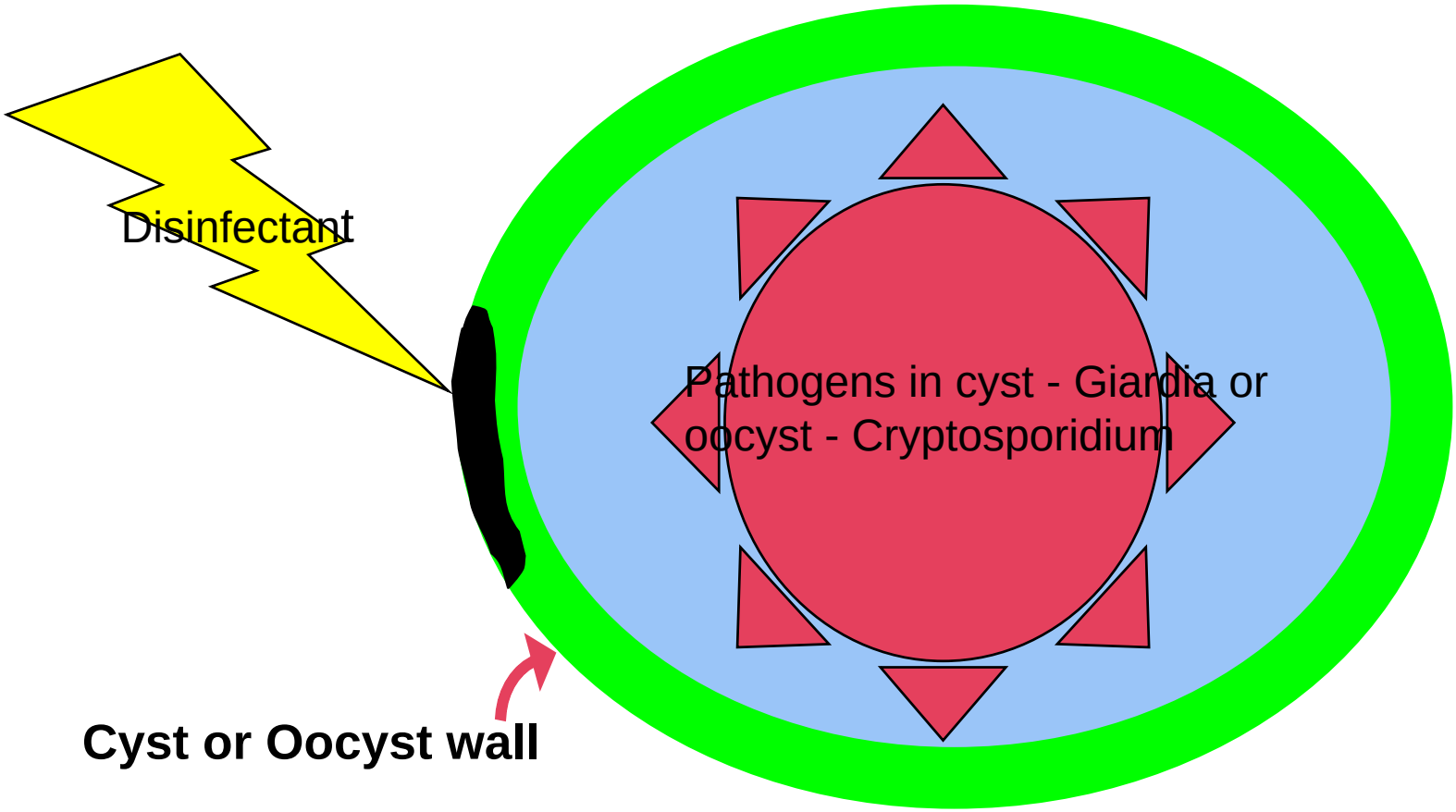
Dormant stage of some species shields pathogens



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Pretreatment

Coagulation-Flocculation-Sedimentation

Coagulation and Flocculation

- Increases the tendency for small particles to attach to one another so they settle or can be filtered out
- Promotes adsorption or precipitation of some soluble materials

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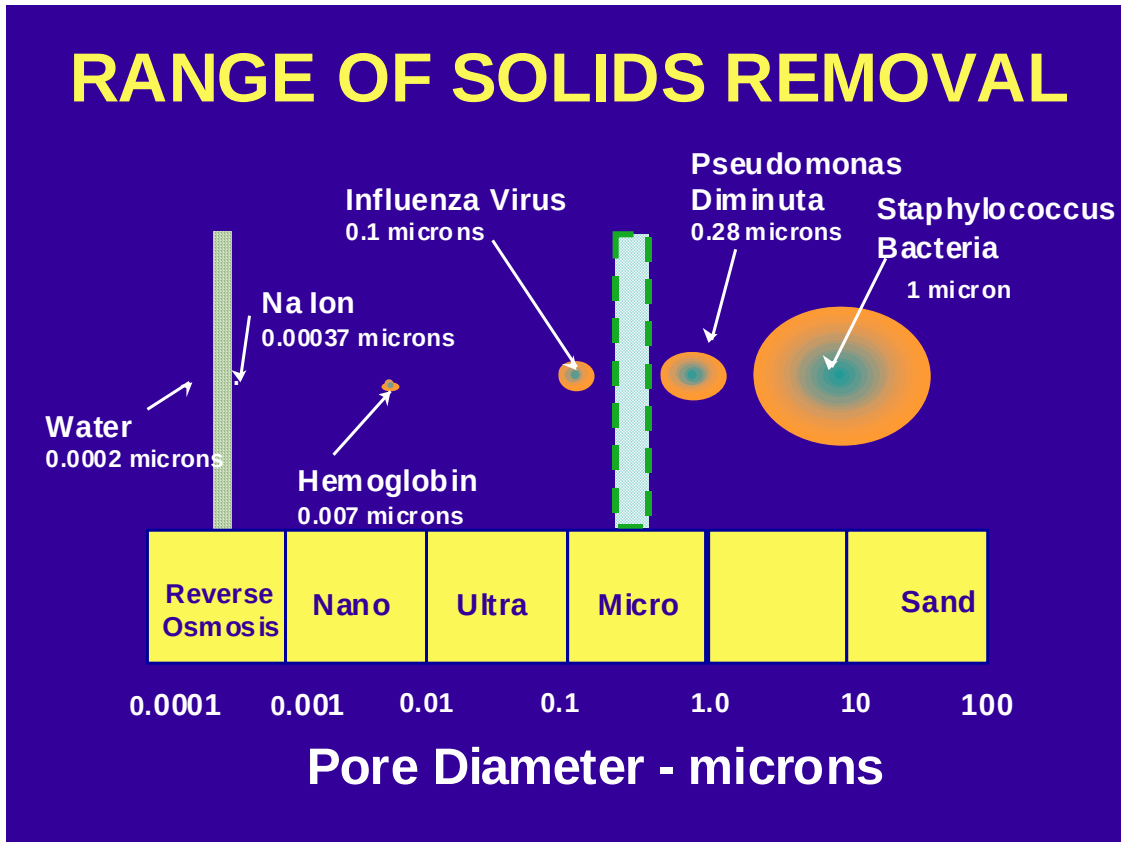
What can filtration achieve?



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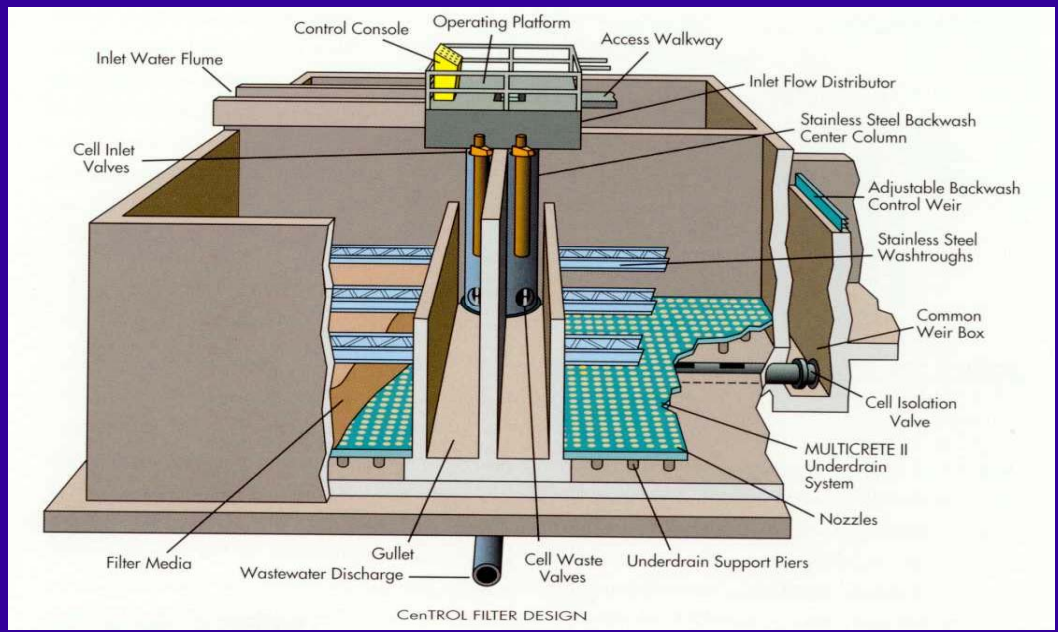
Filtration

Rapid Filtration - Custom Design



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Advanced Filtration Technology

Membranes

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Advanced Filtration Technology

Reverse Osmoses

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“CT” Disinfection Concept

- Uses combination of disinfection residual concentrations (mg/L) and the effective contact time in minutes to measure pathogen reduction in the treatment process
- CT values calculated for each unit process and summed

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“CT” Disinfection Concept

- CT values dependent upon temperature, pH and free chlorine residual
- Based on actual CT value Log inactivations are then calculated
- Procedure B13-3 of the ODWPR based on EPA method

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Log reduction

Log Removal	% Removal
0	0
1	90
2	99
3	99.9
4	99.99

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Credits associated with physical and chemical treatment

Treatment	Giardia Cysts	Viruses
Conventional filtration	2.5 log	2.0 log
Direct filtration	2.0 log	1.0 log
Slow sand filtration	2.0 log	2.0 log

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Treatment plant barriers

- **Plant operations**
  - Knowledgeable
  - Licensed
  - Dedicated to high quality plant performance
  - Empowered to react to problem areas

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In your distribution system

- **Maintain free chlorine residual of not less than 0.2 mg/L and if appropriate 1.0 mg/L combined residual in the distribution system at any location**
- **Re-chlorinate if detention times too long**

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In your distribution system

- **Maintenance programs**
  - Flushing
  - Cleaning mains and reservoirs
  - Renewal or rehabilitation of mains
  - Leakage detection
- **Operations**
  - Guard against low pressure problems
  - Guard against corrosion

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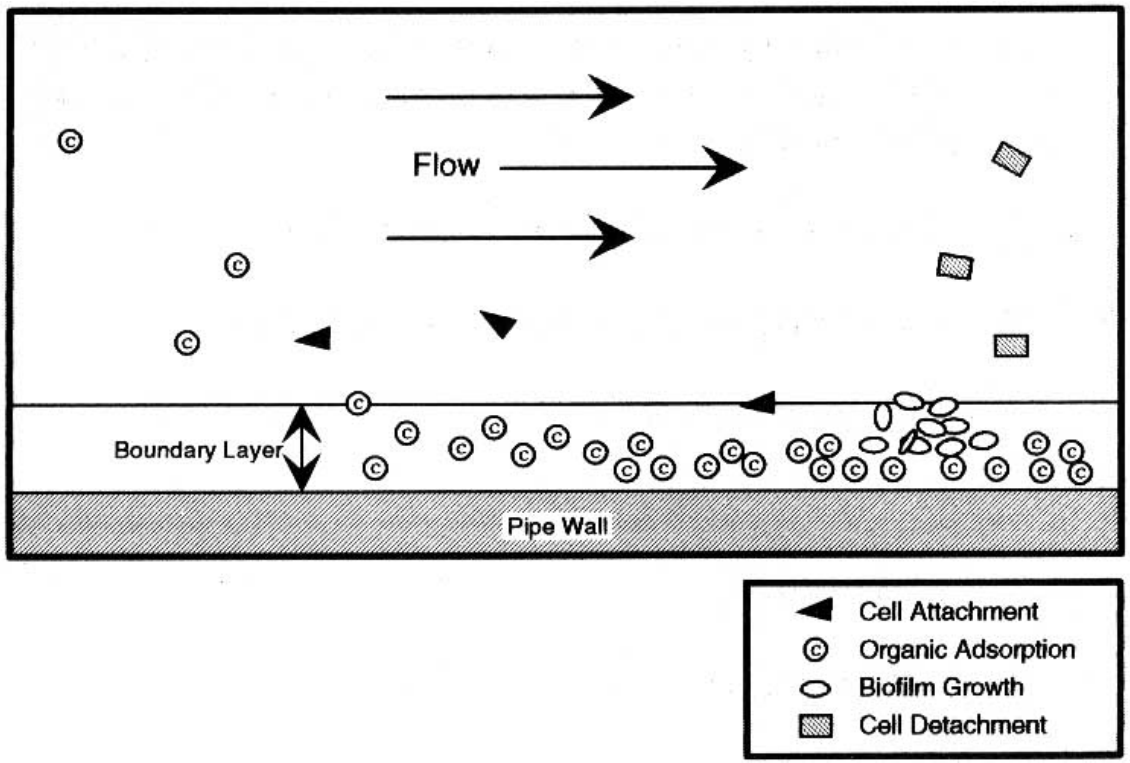
Biofilm formation



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In your distribution system

- **Keep good records**
  - System performance
    - *Water quality parameters ODWS*
    - *Taste and odour*
    - *Breakages*
    - *Emergency response*
  - Asset inventory
  - Asset condition

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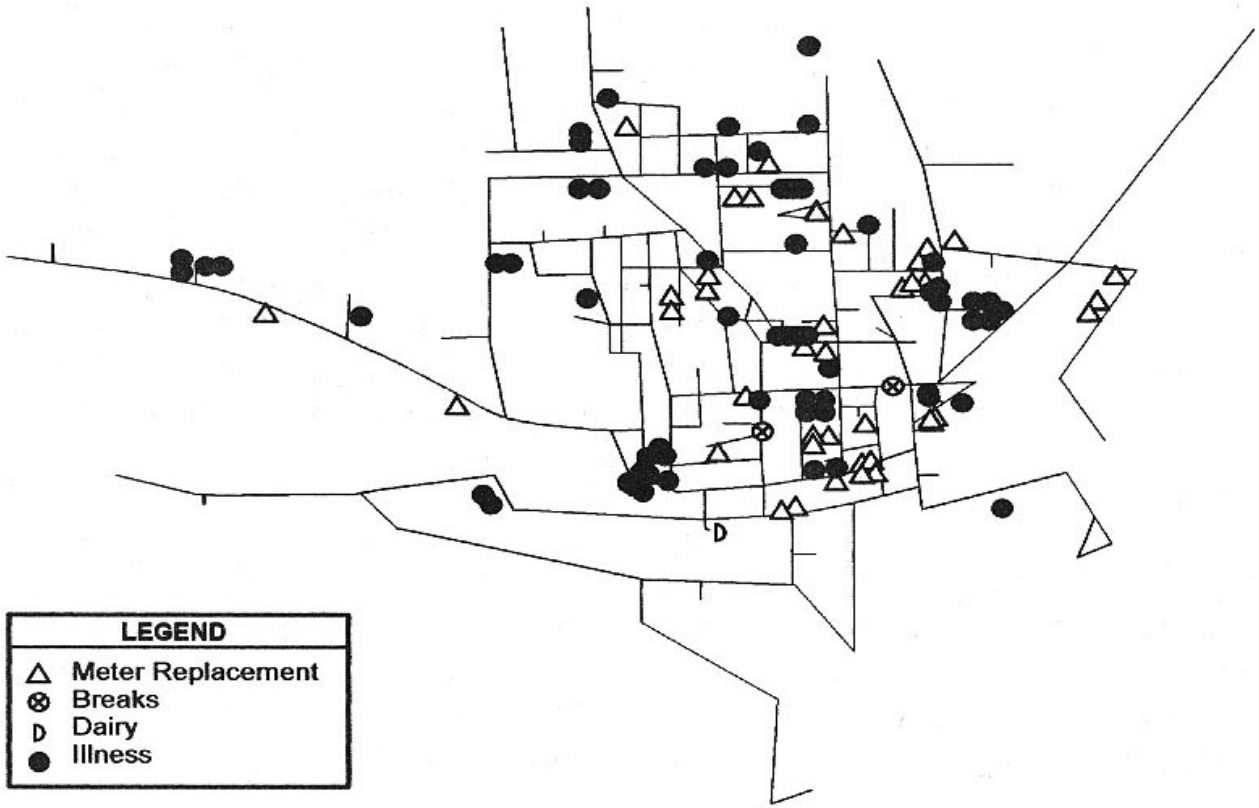
Distribution system contamination



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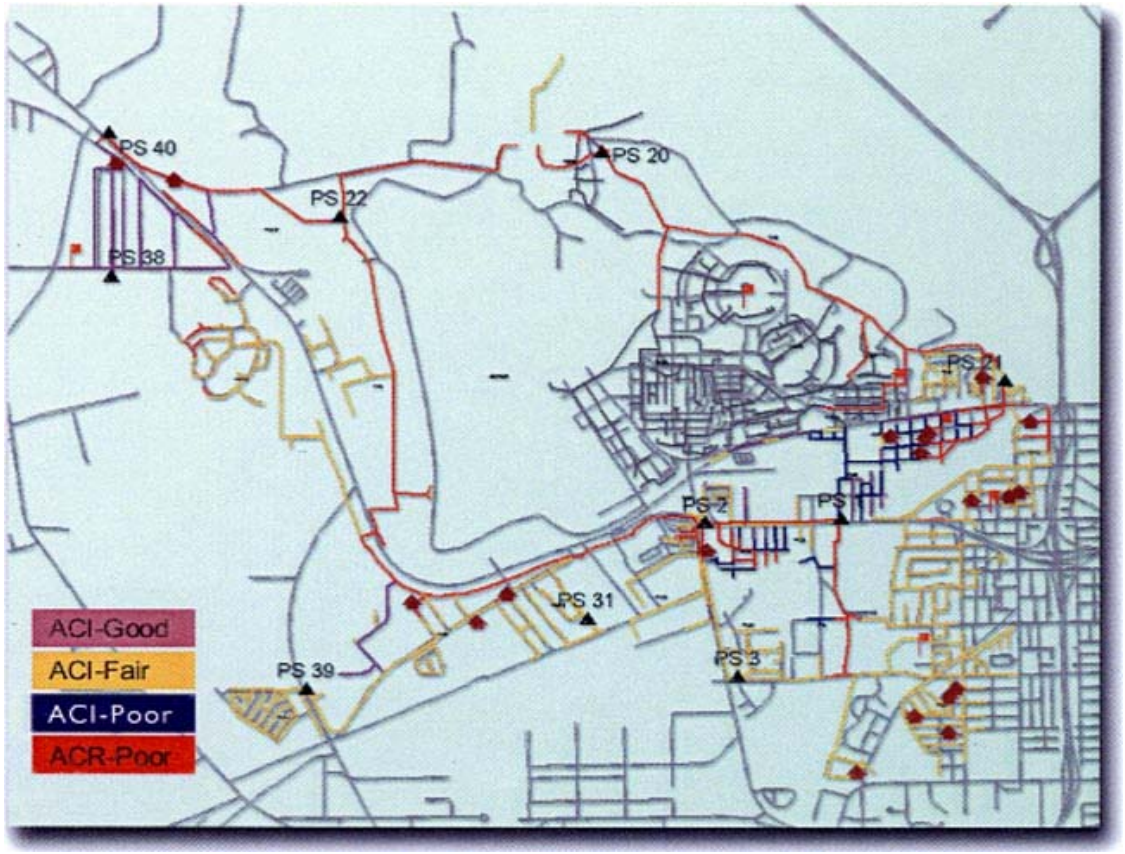
Asset assessment



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Know your system

- No guarantee that water is pathogen free
- Raw water quality will vary — be prepared
- Vigilant monitoring of turbidity throughout treatment process is required

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Develop and implement source protection in your watershed

- **Watershed management plan**
  - Involving land-use planning
  - Well head protection
  - Groundwater and surface water modeling
  - Vigilant monitoring and sampling
- **Regulation**
  - Province must get more involved

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In your Treatment Facilities

- **Strive for low treated water turbidity (less than 0.1NTU)**
- **Provide appropriate disinfection to inactivate virus, bacteria and other pathogens prior to pumping into the distribution system**
- **Strive for a well operated, maintained and properly funded facility**

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In your distribution system

- **Continually monitor for**
  - Cross-connections
  - Back siphoning
  - Main breakage
  - Corrosion
  - Construction activities
    - *relining*
    - *meter installation/replacement*

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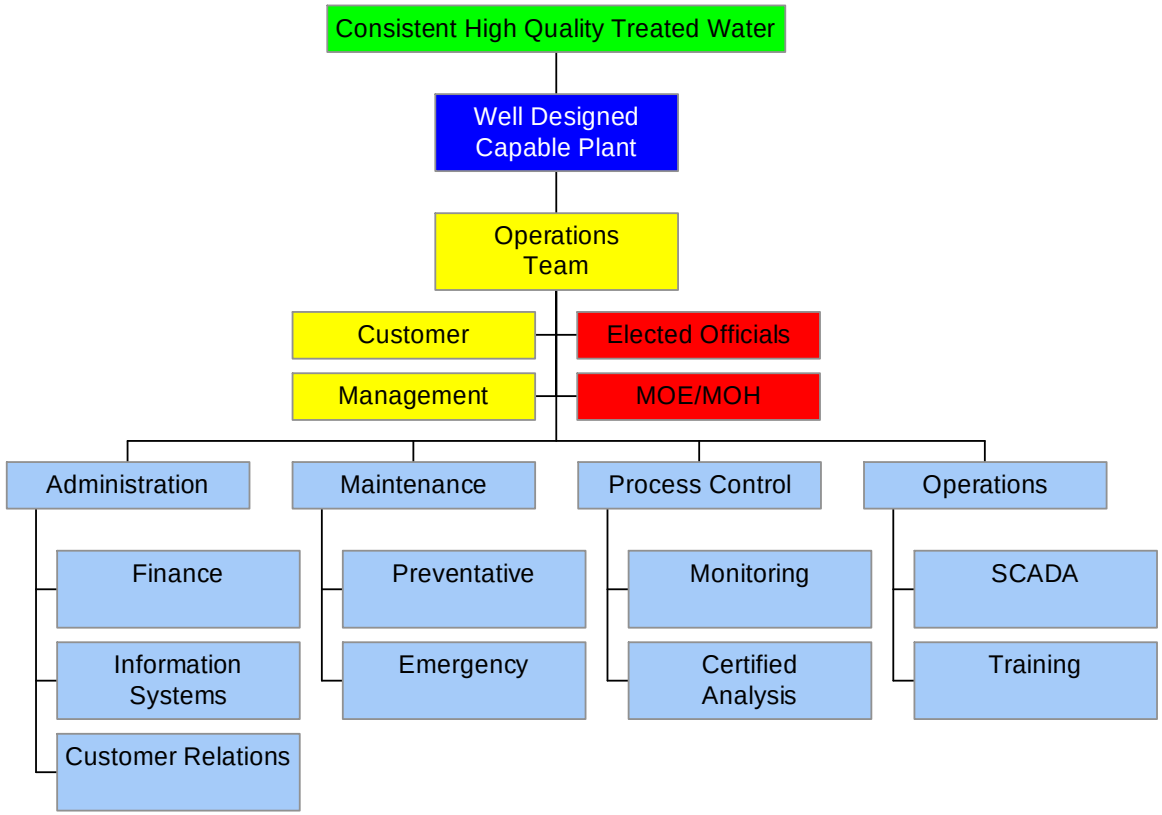
High quality water needs a dedicated trained TEAM



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