Disinfection of Drinking Water

with

Ultraviolet Light

Jackie Leinberger, P.Eng.

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"Millions of people will die each year from dirty water and water-related diseases."

Chairman of the World Commission on Water for the 21st Century

"Water, this most precious commodity, is in peril in virtually all parts of the globe."

Marq De Villiers

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E. coli scare hits Norwich

Canadian Press

NORWICH — A trace of E. coli in a water sample from a well in this southwestern Ontario village set off alarm bells last week, just as the epidemic caused by the bacteria in Walkerton was reaching its height.

THE GLOBE AND MAIL

CANADA'S NATIONAL NEWSPAPER • FOUNDED 1844 • FRIDAY, MAY 26, 2000

This could have been prevented'

Accusations fly that Walkerton's tainted water supply was covered up for five days; death toll continues to climb

Warning issued in Shelburne

SHELBURNE (CP) — Mayor Ed Crewson and other town officials were distrib[ute]ng leaflets last night, warn[ing] residents one of the c[ases] has been close[d] detected in[] Since [] Shelbur[ne] has wanted [] Wh[ile] detec[tion] tion[] the[] h[as]

The system: 'It's not foolproof'

A young g[irl] ing from E. coli infection lies with her teddy bear as she is taken to an evacuation helicopter at a medical [facility]

Camps, parks often ignore water-test requirements

'It's scary out there,' ministry inspector says

SUSAN BOURETTE
The Globe and Mail, Toronto

[] thousands of Ontario families [] favourite

Hospital imports 15,000 litres of bottled water

By Mira Oberman
Free Press Reporter

[] order remains in [] and the contamination is gone.

"There are other types of E. coli that can be serious and all contaminations must be taken seriously," Dr. Sharon Hertwig, acting medical [] Health, said yesterday.

[] everyone drinking fountain. Tests were also run on the neighbouring buildings and in St. Thomas, but those results won't be available until today.

"People are starting to get a little more concerned now that they've found another (contamination)," [] Dave Erskine, the hospital [] don't see you

Beware of rural drinking water, Premier says

RICHARD MACKIE
Queen's Park Bureau, Toronto

many as 10 [] onment [] going to be very sadly disappointed."

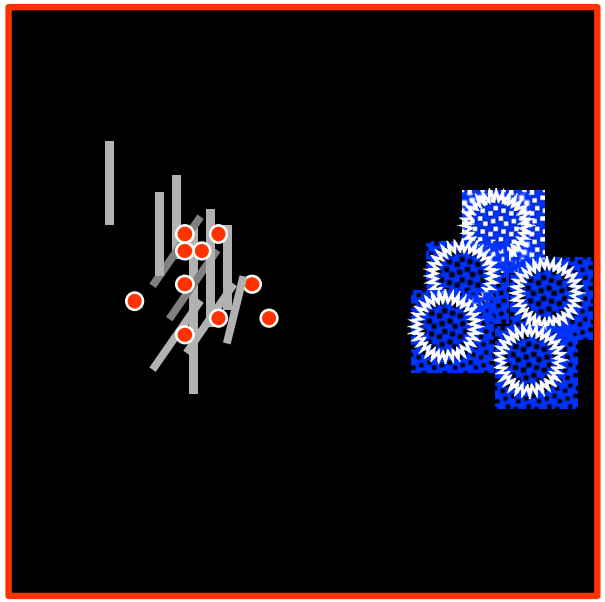
[] aid the [] to di- [] ality in [] Mr. Newman told reporters that operators with Private [] reads the letter written this spring. Mr. McGuinty told the legislat[ure] that the [] Globe and Mail [] ...

Kitchener woman's death possibly E. coli-related

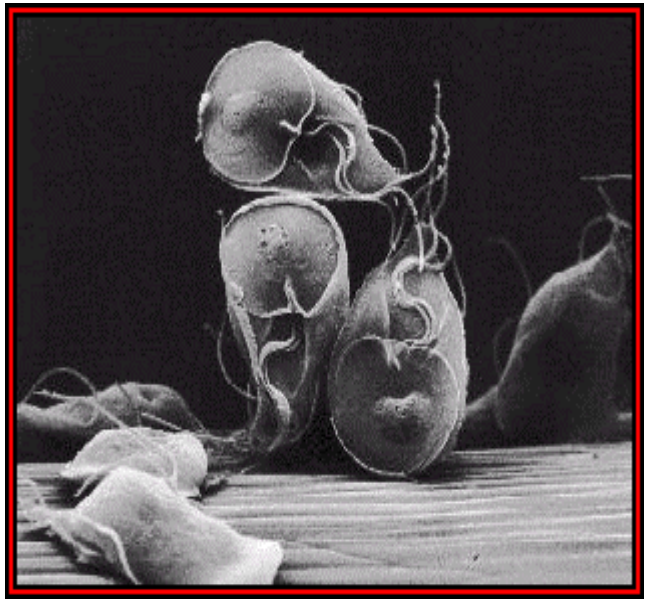
Pathogenic bacteria, viruses and protozoa in un-disinfected water and wastewater represent potential risks to Public Health

Bacteria *(E.coli)*

Viruses *(Hepatitis, Polio)*



Protozoa (*Giardia***)**



Protozoa (*Cryptosporidium*)

UV Disinfection Theory

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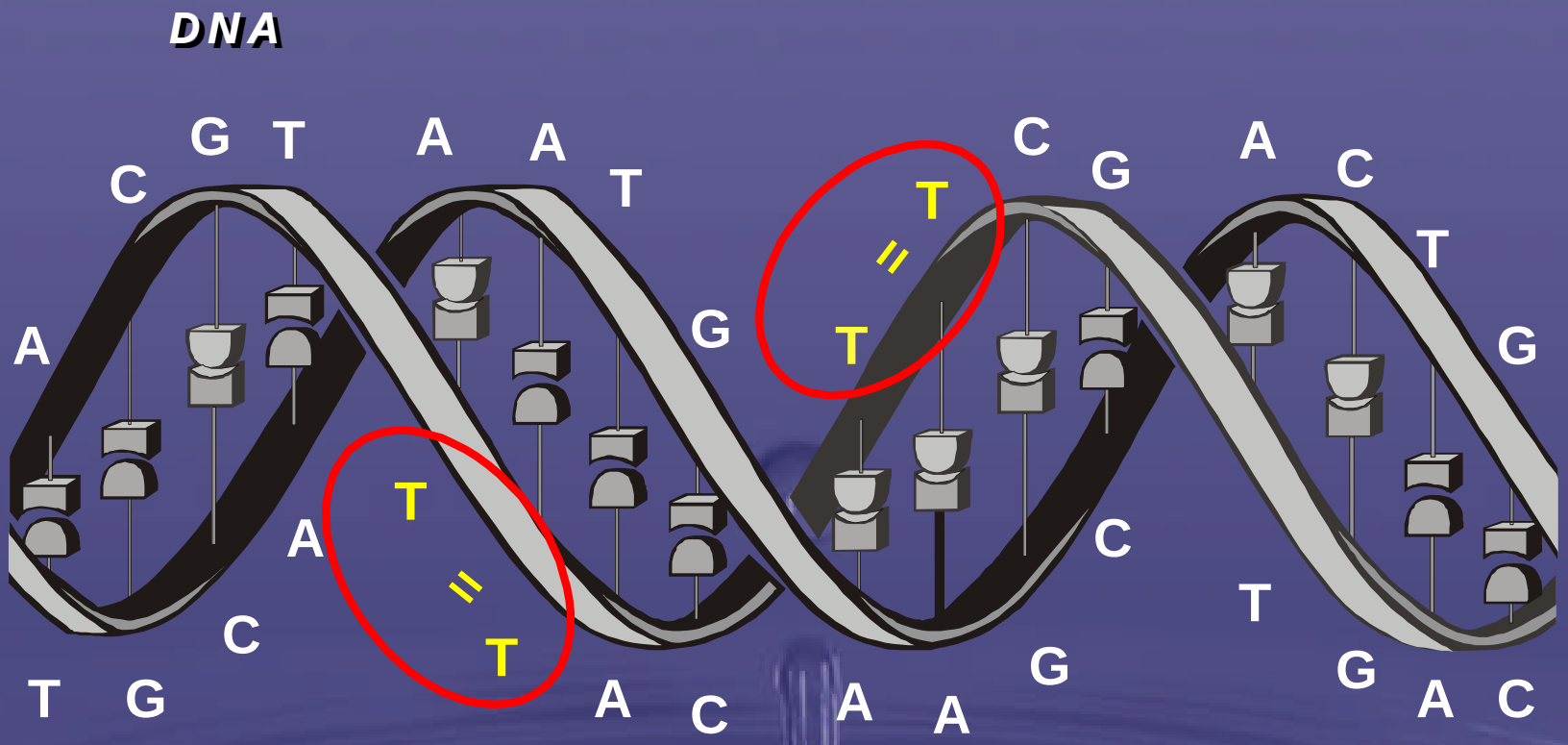
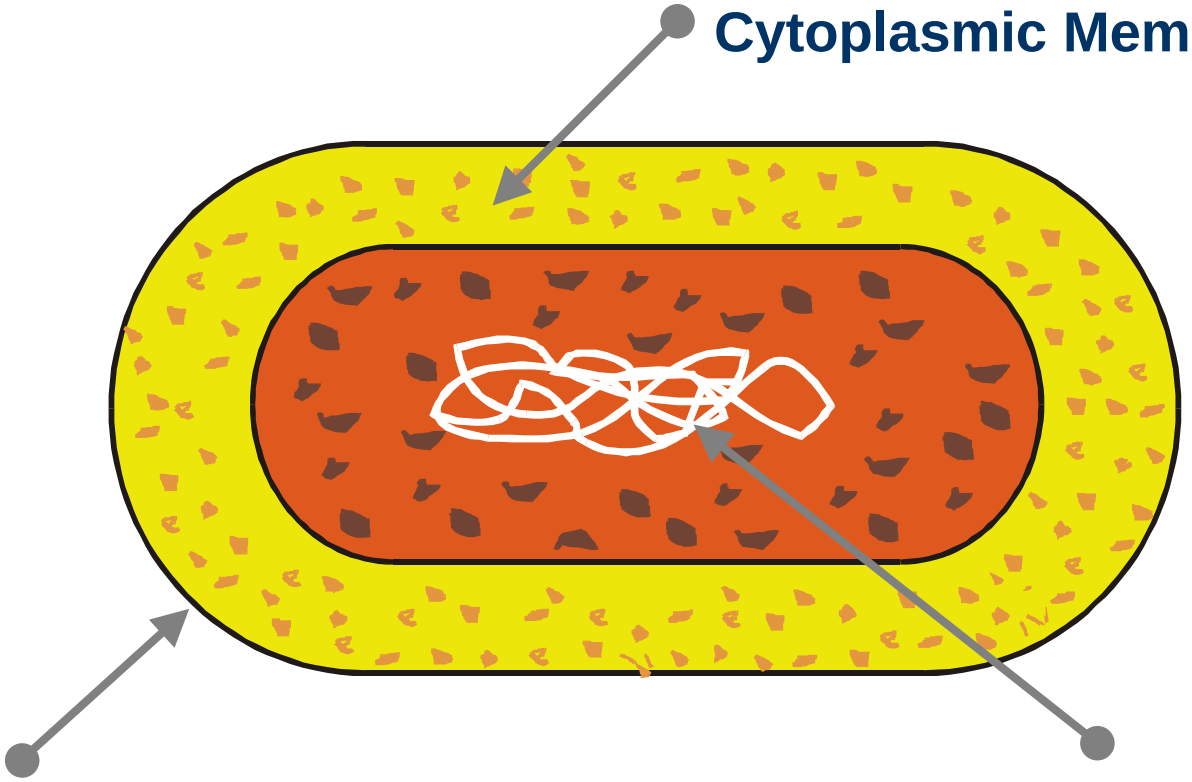
How UV Works



UV light alters DNA destroying harmful bacteria and viruses

Bacterium Structure



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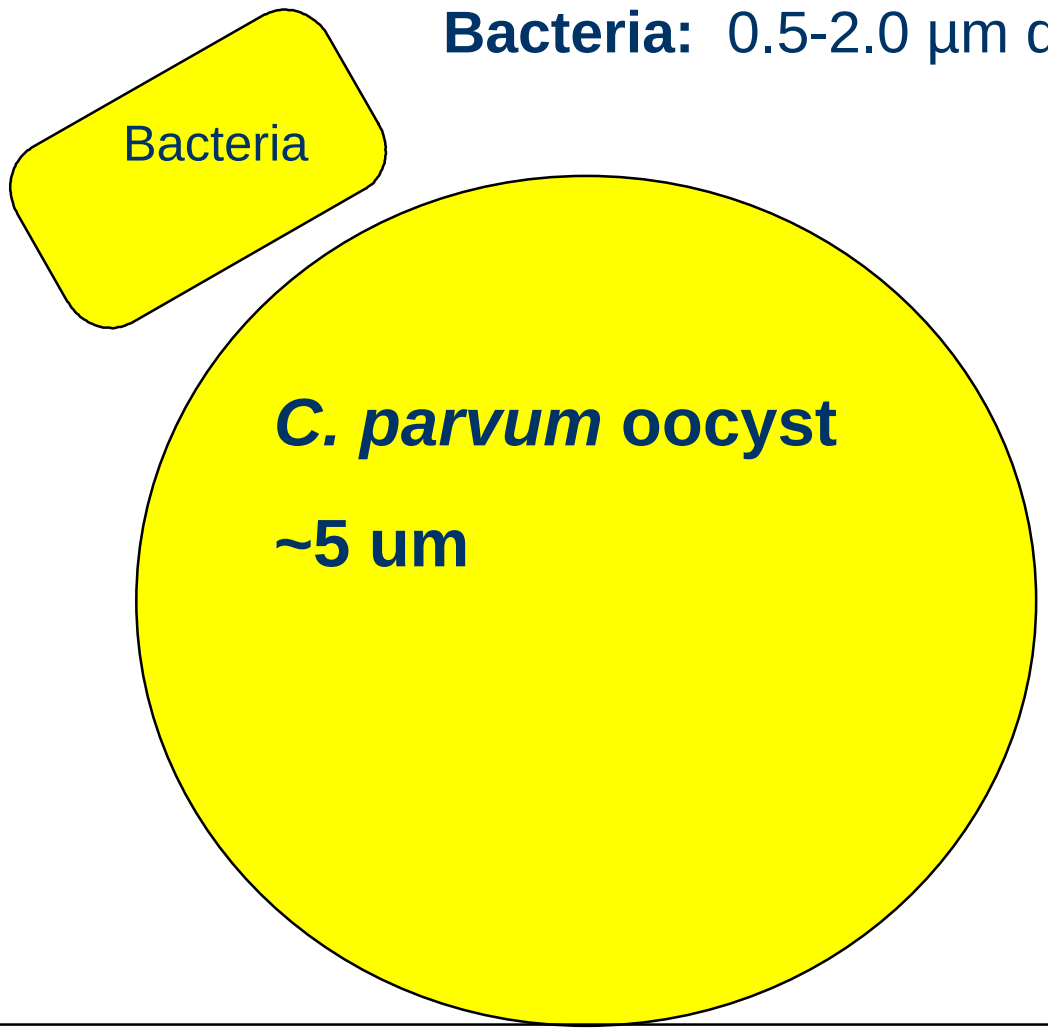
Classes of Microorganisms:

The Microbial World

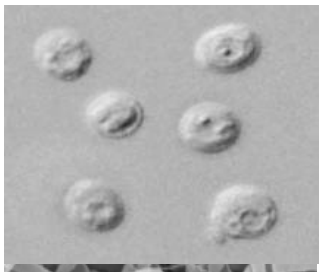
Viruses: smallest (0.02-0.3 µm diameter); Rotavirus

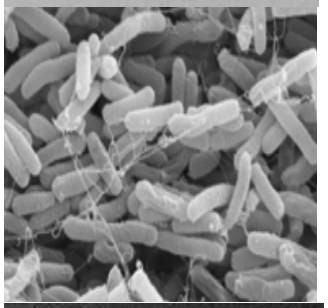
Bacteria: 0.5-2.0 µm diameter; E.coli

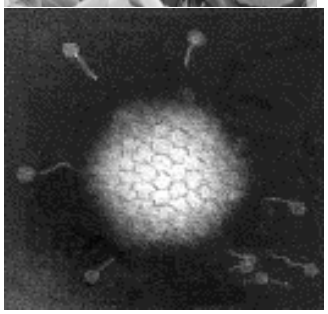
Protozoa: most >2 µm - 2 mm; no cell wall; wide range of sizes and shapes; Giardia, Cryposporidium and microsporidia.



UV Disinfection Effectiveness







Cryptosporidium

Giardia

vegetative bacteria

viruses / spores

Least resistant

Most resistant

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UV is effective for Cryptosporidium and Giardia control

UV Dose

UV Dose = UV Intensity x Exposure Time

(Units are measured in mJ/cm^2)

Microbe inactivation is directly related to UV Dose

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UV Inactivation of Pathogens

Pathogen	Average UV Dose (mJ/cm^2) Required to Inactivate			
	1log	2log	3log	4log
Cryptosporidium parvum	**3.0**	**4.9**	**6.4**	**7.9**
Giardia lamblia cysts	**NA**	**<5**	**<10**	**<10**
Giardia muris cysts	1.2	4.7	NA	NA
Vibrio cholerae	0.8	1.4	2.2	2.9
Shigella dysenteriae	0.5	1.2	2.0	3.0
Escherichia coli O157:H7	**1.5**	**2.8**	**4.1**	**5.6**
Salmonella typhi	1.8-2.7	4.1-4.8	5.5-6.4	7.1-8.2
Shigella sonnei	3.2	4.9	6.5	8.2
Salmonella enteritidis	5	7	9	10
Legionella pneumophila	3.1	5	6.9	9.4
Hepatitis A virus	**4.1-5.5**	**8.2-14**	**12-22**	**16-30**
Poliovirus Type 1	4-6	8.7-14	14-23	21-30
Coxsackie B5 virus	6.9	14	22	30
Rotavirus SA11	**7.1-9.1**	**15-19**	**23-26**	**31-36**

NA – Data Not Available

Data summarized from the US EPA Workshop on UV Disinfection of Drinking Water, April 28-29, 1999, Arlington, VA

Advantages of UV Disinfection

- ***Highly effective on broad range of pathogens, including: E. coli, Giardia, Cryptosporidium***
- ***Forms no harmful disinfection by-products (eg. Trihalomethanes)***
- ***Inactivation independent of pH and temperature***
- ***No unpleasant taste or odor***
- ***No transportation, storage or handling of chemicals***

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Advantages of UV Disinfection cont.

- ***Easily installed within existing water treatment facilities***
- ***Low capital and operating costs***
- ***Effective as a stand-alone or part of a multi-barrier treatment strategy***
- ***Simple to operate***
- ***Minimal hazard risk for operators***

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Other Disinfection Methods

- *Chlorine*
  - *Applied as gas or liquid, residual in distribution system*
  - *Dangerous to store, handle, transport*
  - *Forms toxic by-products (Tri-halo-methanes)*
- *Ozone*
  - *Applied as gas, short-term residual in distribution system*
  - *More common in Europe, much more expensive than chlorine or UV*
- *Membrane Filtration*
  - *Physical separation process*
  - *Much more expensive (capital and operating cost)*
  - *No Residual in distribution system*

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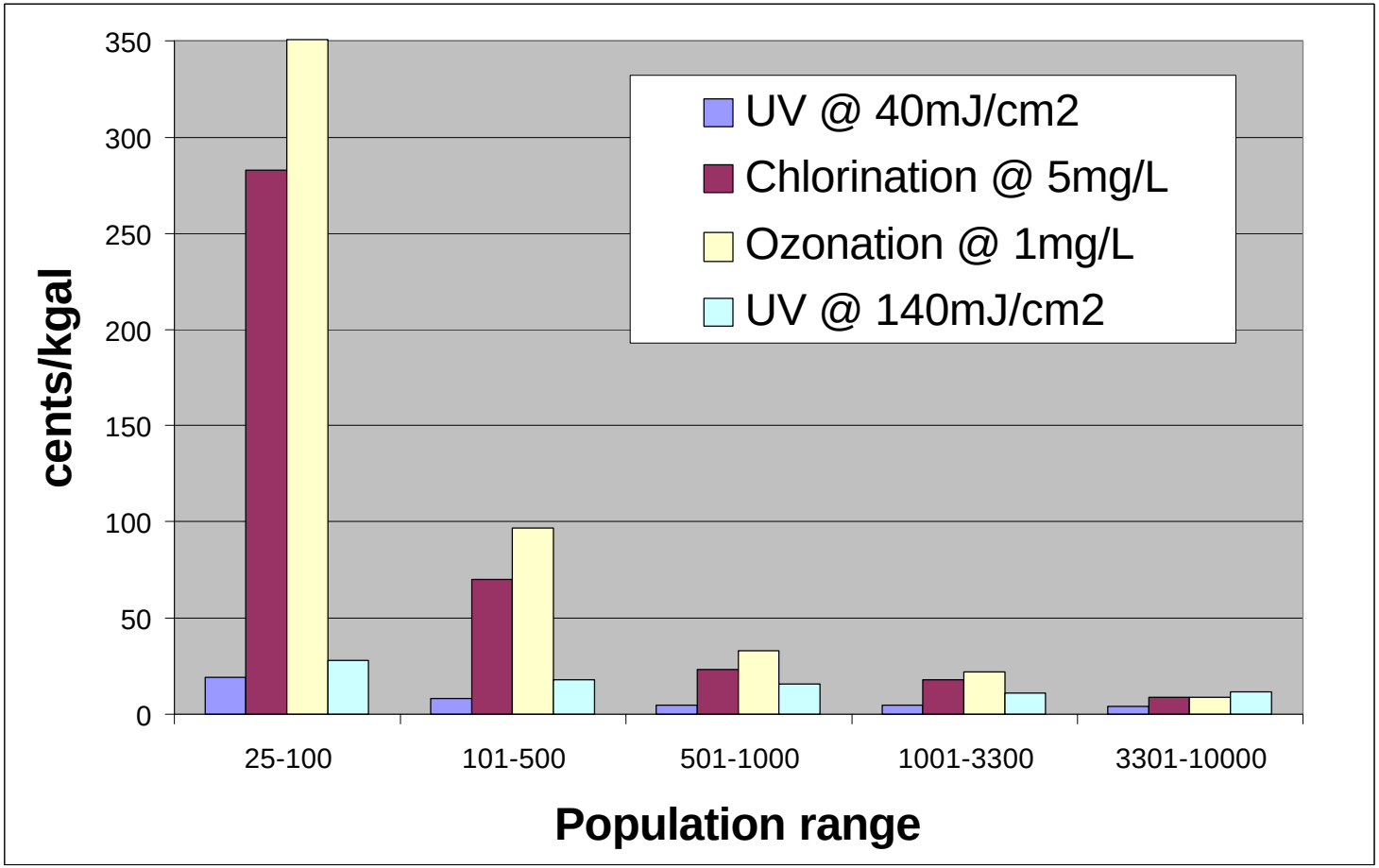
Total Cost of UV vs O_3 and Cl

UV Light Disinfection Technology in Drinking Water Application - An Overview, EPA 811-R-96-002



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Upcoming Regulations

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Status of Regulations

- *US EPA Draft Disinfection Guidance Manual was issued October 2001*
- *Technical review and comments are being collected*
- *Manual is to support two upcoming regulations:*
    1. *DBPR*
    2. *LTSESWTR*
- *Both rules are considering UV disinfection for Crypto and Giardia removal credits*
- *Plants have successfully obtained approval to use UV disinfection as an Add-on to existing disinfection technologies thus providing a multi-barrier strategy*

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UV Disinfection Applications

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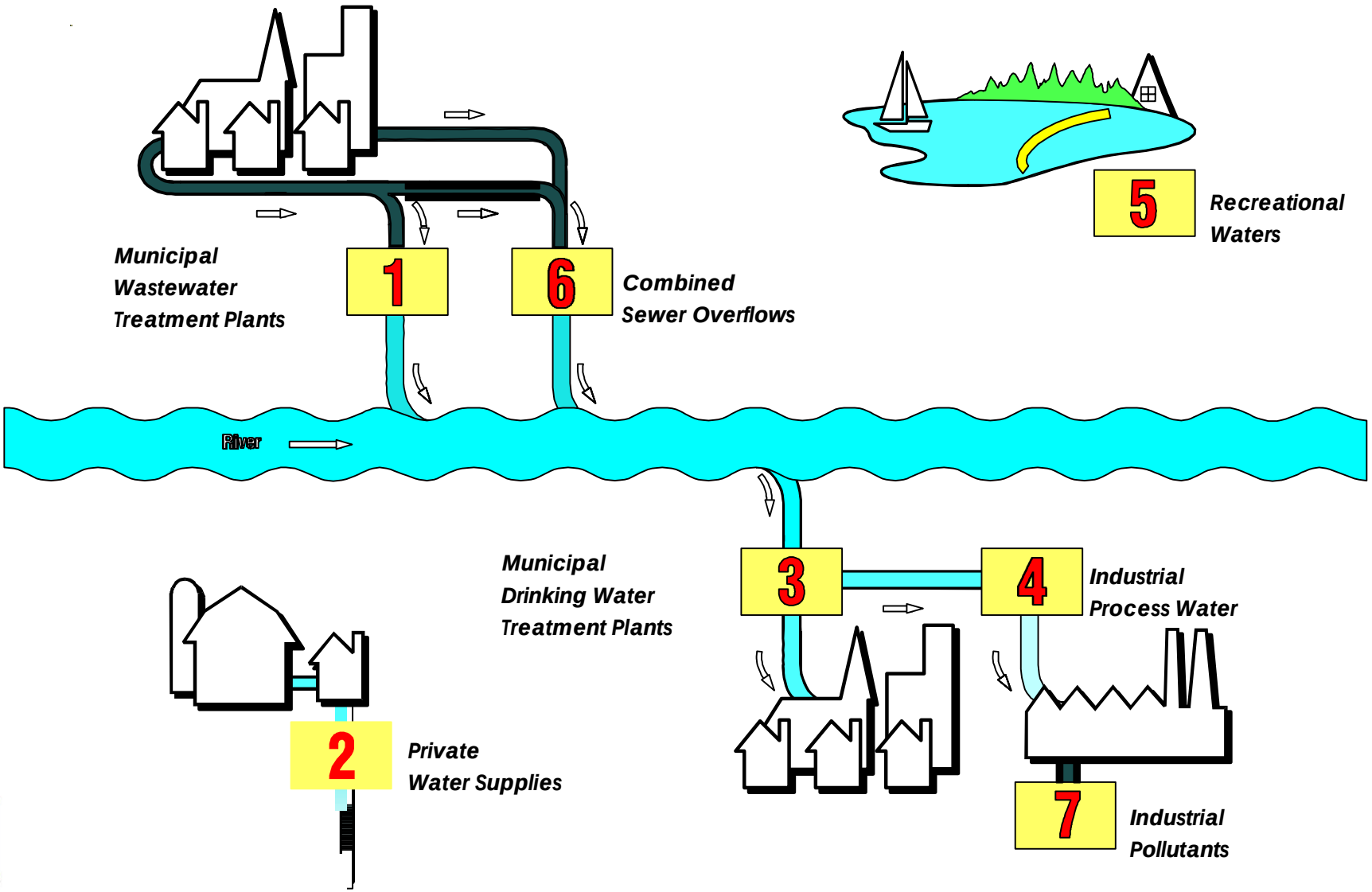
UV Treatment Applications



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Trojan's UV Disinfection Technologies

Municipal Wastewater Disinfection

- ***Used in primary, secondary or tertiary treatment***

- ***2,600 systems installed worldwide, serving over 20 million people***
  - ***11% in Canada***
  - ***75% in USA***
  - ***14% rest of world***

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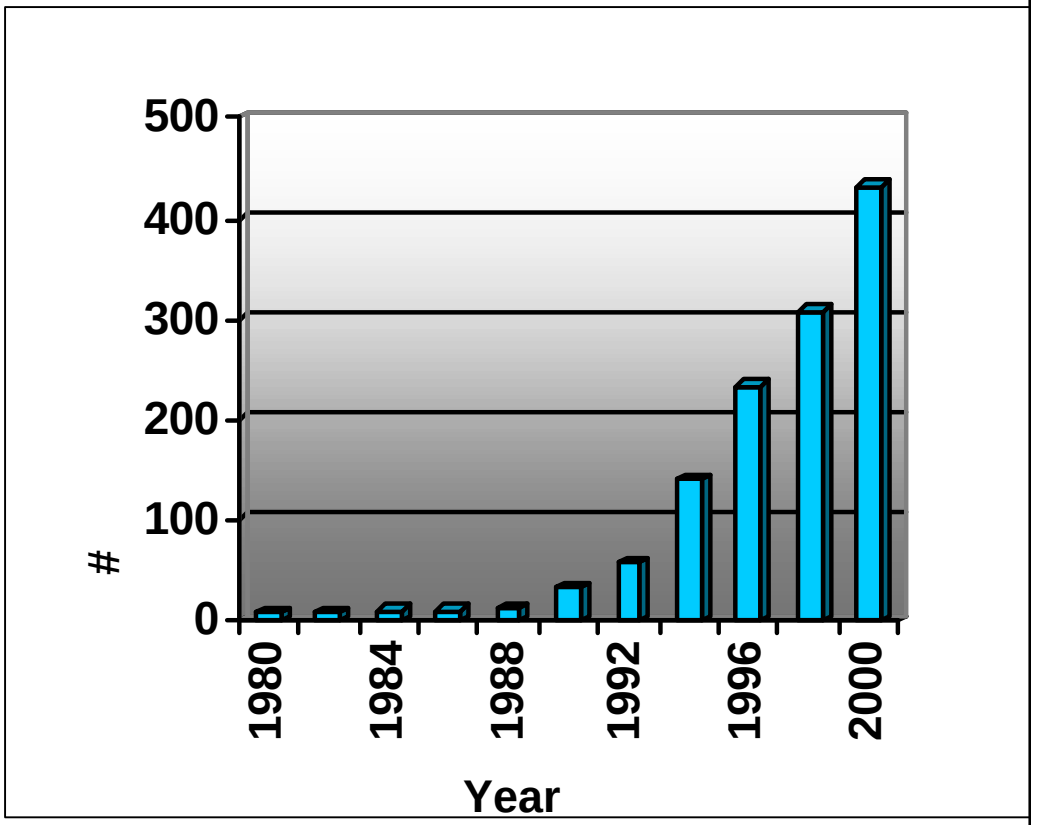
Global Disinfection Strategies for Drinking Water

UV Disinfection in Europe

- **UV is "proven" technology in European drinking water treatment**
- **Widely used since 1980**
- **Approx. 200 Trojan municipal drinking water installations in Europe** (Milan Italy, Toulouse France, Antwerp Belgium, Middelburg The Netherlands, Motala Sweden, Hatfield UK)



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Global Disinfection Strategies for Drinking Water

Under the U.S. Safe Drinking Water Act, the US EPA is developing regulations for improved disinfection while reducing disinfection by-products

1. *Protection against chlorine-resistant bacteria (Cryptosporidium, Giardia etc.)*
2. *Reduction in cancer-causing disinfection by-products created from chemical disinfection*
3. *Development of multi-barrier disinfection strategy for public drinking water supplies*

Adding UV to existing infrastructure responds ideally to all three objectives

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Trojan's full range of products to treat private and public water supplies

TROJANUVMAX™

Residential & Commercial Applications

TROJANUVLOGIC™

Small Communities and Industrial Applications

TROJANUVSWIFT™

Medium & Large Municipal Applications

Residential & Commercial UV Systems

- *Over 130,000 systems sold – used in rural homes & cottages, farms, camps, labs, restaurants, nursing homes*
- *New product launched in March, 2000*
- *Reliable, low cost solution for private water supplies*

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TROJANUVMAX™

Small Municipal Drinking Water UV Systems

- *For communities with 300 to 8,000 people*
- *Ideal as stand-alone system or part of a multi-barrier treatment strategy*
- *Easily installed in existing water treatment facilities*
- *Available with fully-automated self-cleaning system*
- *Remote monitoring via modem interface*
- *Very low capital and operating costs*

TROJANUVLOGIC™

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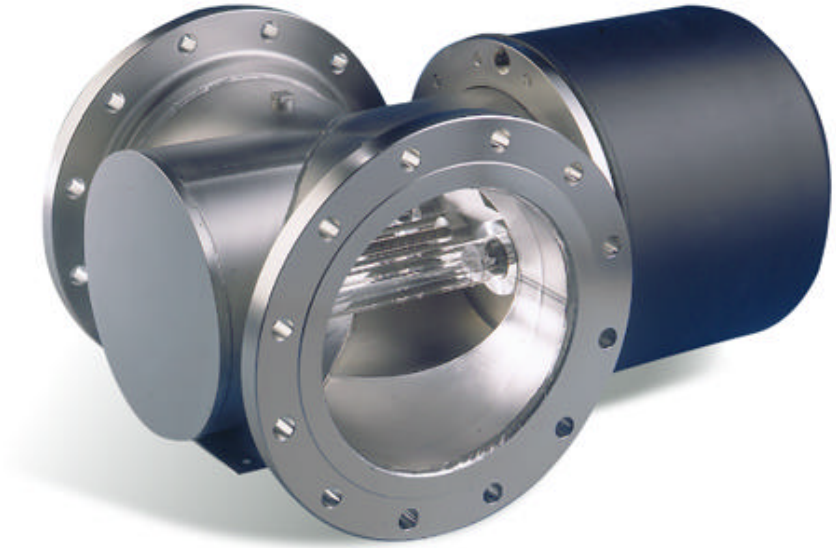
Larger Municipal Drinking Water UV Systems

- *For communities with > 8,000 people*
- *Ideal as part of a multi-barrier treatment strategy*
- *Easily installed in existing water treatment facilities*
- *Available with fully-automated self-cleaning system*
- *Very low capital and operating costs*



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TROJANUVSWIFT™

Trojan Municipal Drinking Water Systems

- *Currently 627 municipal drinking water systems operate in Ontario serving 82% of the population*

  (Source: Drinking Water in Ontario - MOE, 2000)

- *Many will upgrade to include a multi-barrier disinfection strategy over next 2 years*

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Application to Newfoundland Communities

- ***Use as additional treatment step in existing water treatment systems***
  - ***Add UV at stage water enters distribution***
- ***Use as stand-alone treatment at well-head***
  - ***Insert into pipeline where no treatment currently being provided***
- ***Use at point-of-use on private wells***
  - ***Small scale units available for use in private homes***
- ***Install at schools, day-care centres, retirement centres and community centers to protect most vulnerable members of society***

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Typical Smaller Community UV Systems Costs

Community Size	UV System*	With Remote Monitoring	Estimated Installation Cost
25	$800	-	$300
50	$1,000	-	$300
75	$1,200	-	$500
300	$8,500	$13,000	$2,000
1,000	$12,500	$17,000	$3,000
2,000	$20,500	$25,000	$4,500
5,000	$37,500	$42,000	$8,000
8,000	$48,000	$52,500	$10,000

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* Complete with fully automated self-cleaning system

UV Disinfection Equipment

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Project:	*Fern Resort*
System:	*UV04AS20*
Flow Rate:	*110 US GPM*
Service:	*Disinfection*

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Project: *South Berwick, Maine*

System: *UV8012L with Chemical Cleaning System*

Flow Rate: *160 GPM*

Service: *Disinfect Ground Water in a Pumphouse*

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Project: *Huybergen, Netherlands*
System: *UV02M25*
Flow Rate: *815 GPM*
Service: *Disinfect Filtered Ground Water*

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Project: *Regional Municipality of Waterloo, Ontario*

System: *UV01M20*

Flow Rate: *225 GPM*

Service: *Disinfect Ground Water*

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Project: *Indianapolis, Indiana*
System: *UV02M30*
Flow Rate: *750 GPM*
Service: *Disinfection of Ground Water*

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Project: *Ontario, NY*

System: *UVSWIFT-12*

Flow Rate: *3 MGD*

Service: *Primary disinfection (treating surface water from Lake Ontario)*

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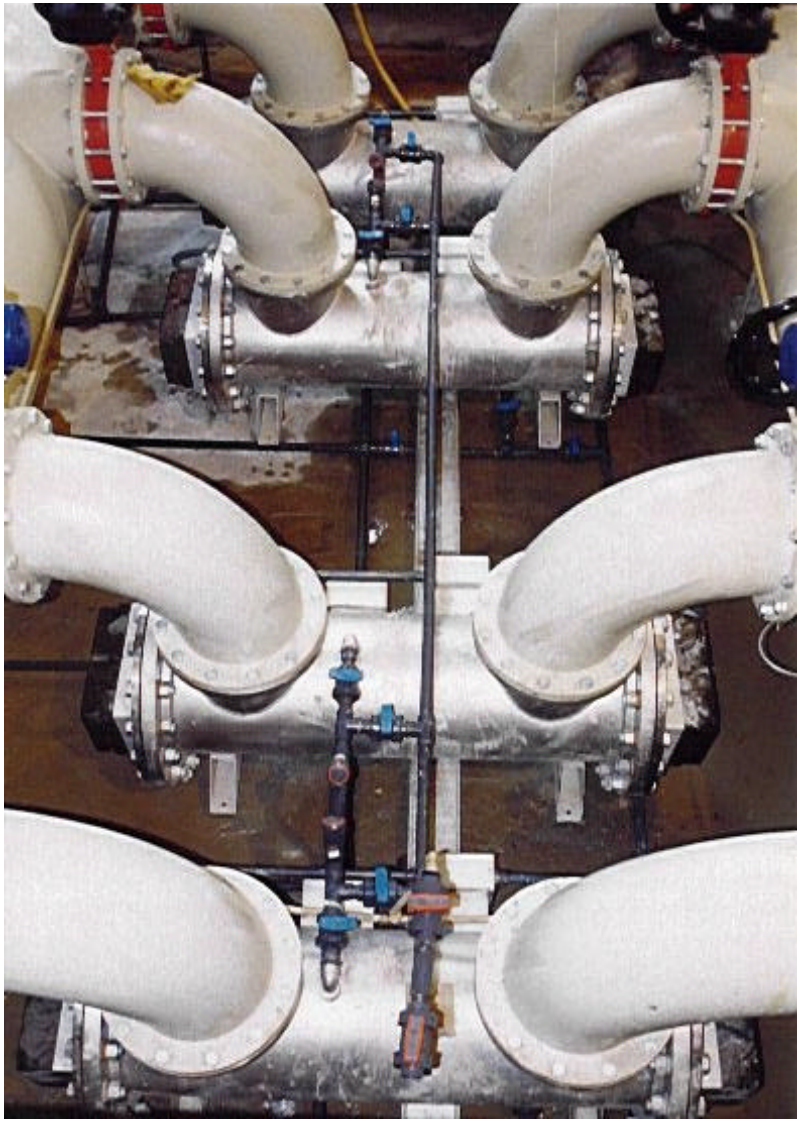
Tivoli Fountains, Italy –

12 MGD UV8000 System



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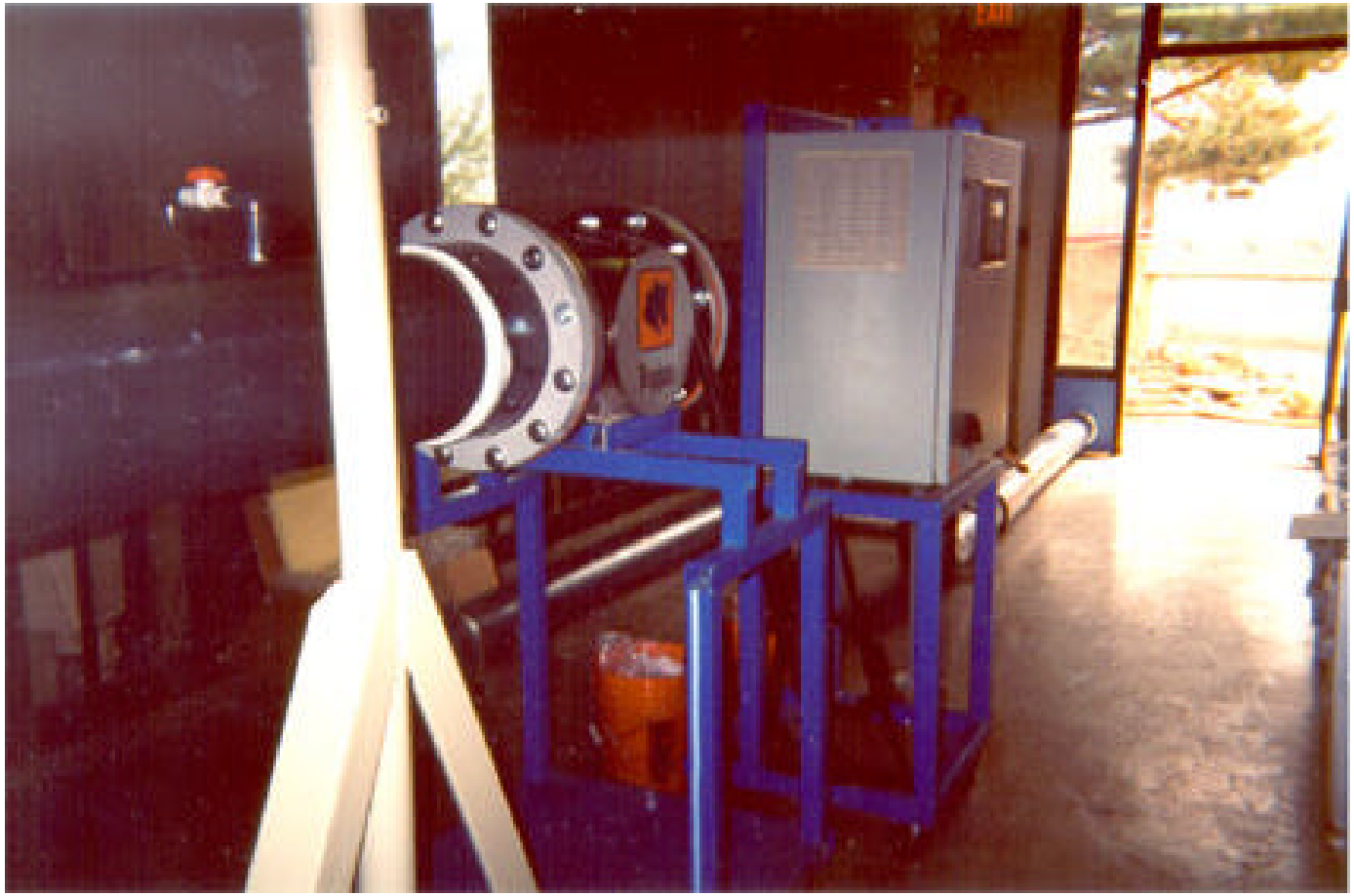
AWWARF 2593: Inactivation of Pathogens by Innovative UV Technologies, Salt Lake City, UT



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Trojan Technologies Inc.

- *Founded in 1977, in London,Ontario*
- *The design, manufacture and sale of UV based disinfection technologies for residential & commercial drinking water, municipal drinking water, industrial process water and wastewater markets globally.*
- *Singular focus on environmentally responsible disinfection technologies*
- *300 dedicated professionals on staff*
- *Offices in Canada, USA, the UK, the Netherlands, Norway, Spain, Germany*

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Expertise:

- *$6 million invested in R&D in 2001*
- *Invested over $30 million in R&D since inception*
- *Trojan is largest private funder of UV disinfection research in the world.*
- *R&D and engineering expertise: 110 university & college graduates*
- *16 PhD's; 10 Masters'; 50 electrical & mechanical engineers*
- *Over 500 person-years of UV disinfection experience*

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Trojan Research & Partnerships

R&D in Drinking Water Treatment

- *Cryptosporidium & Giardia research at McGill, Duke, UNC.*

  (Recent outbreaks in North Battleford,, Collingwood, Waterloo)

- *Continuous improvement in Reactor design,UV efficiency, lamp technology*

Technical advisory role to regulators

Trojan currently serves on US EPA advisory committee on municipal drinking water disinfection strategies

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Questions

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