Waterborne Disease

Meeting the Drinking Water Challenge

Cindy Christian
Field Operations and Implementation Manager
ADEC Drinking Water Program

A Few Waterborne Disease Facts

- Worldwide, 1.2 billion people do not have access to safe drinking water
- Every year, 5 million people die from waterborne disease
- Most waterborne diseases occur worldwide – Alaska is not immune
- From 1991 – 2000, there were 155 outbreaks and 431,846 cases of illness in the US
- Cryptosporidium was the most common cause of waterborne illness

Drinking Water Pathogens

- Bacteria
  - Single-Celled Organisms
  - Cholera, *E.coli* 0157:H7
- Viruses
  - Protein-Packaged DNA or RNA
  - Norwalk, Rotavirus
- Protozoa
  - Single-Celled Organisms
  - *Giardia, Cryptosporidium*

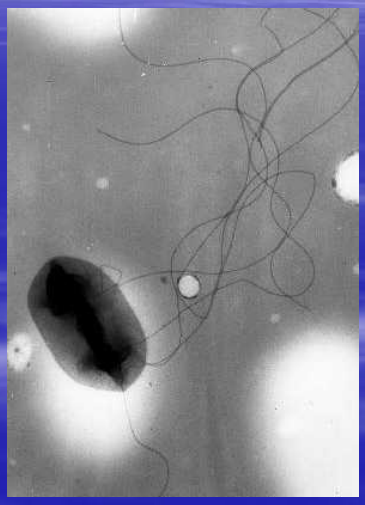
Acute Health Effects

- A Single Exposure May Result in Illness
  - Gastroenteritis
  - Diarrhea
- Rapid Onset of Health Effects
  - Hours or Days After Exposure

Bacteria

- Microorganisms composed of single cells, rods or spheres
- Contaminate both surface water and groundwater
- Prior to widespread chlorination outbreaks of cholera and typhoid were common in the US
- As recently as 2000, an outbreak of *E.coli* 0517 in Walkerton, Ontario made 2300 people sick
- The outbreak was due to improper chlorination of groundwater

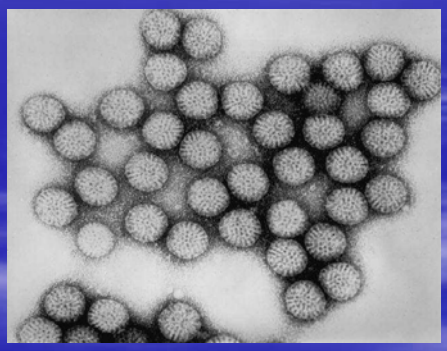
  – Photo: CDC. *E. coli* 0157:H7



Viruses

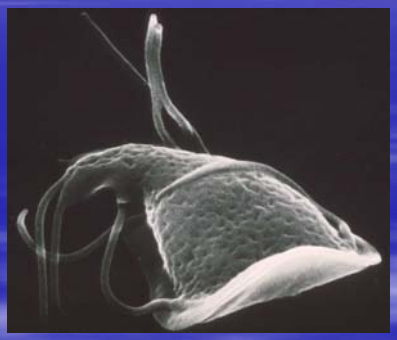
- Viruses are infectious agents that can reproduce only within living host cells
- Contaminate both surface water and groundwater
- Viruses are so small they can pass through filters that retain bacteria
- Enteric viruses infect the gastrointestinal or respiratory tracts
- Major symptoms are diarrhea, fever, vomiting
- Viruses are species specific

  – Photo: Rotavirus, ASM Digital Image Collection



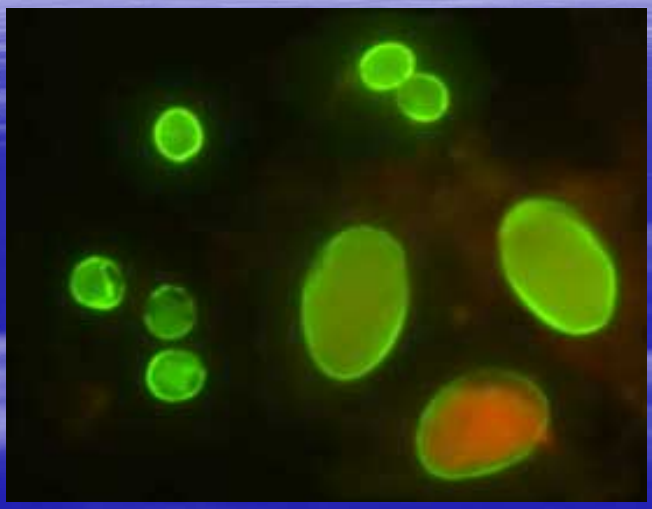
Parasitic Protozoa

- Protozoa are single-celled organisms that feed on bacteria in multicellular organisms
- Most common waterborne protozoa are *Giardia* and *Cryptosporidium*
- Introduced into water by animal or human fecal contamination
- Most commonly found in surface waters
- Worldwide distribution, including Alaska
- Exist as dormant cysts or oocysts in water sources
- Resistant to chlorination
- Photo: *Giardia* Trophozoite, S. Erlandsen

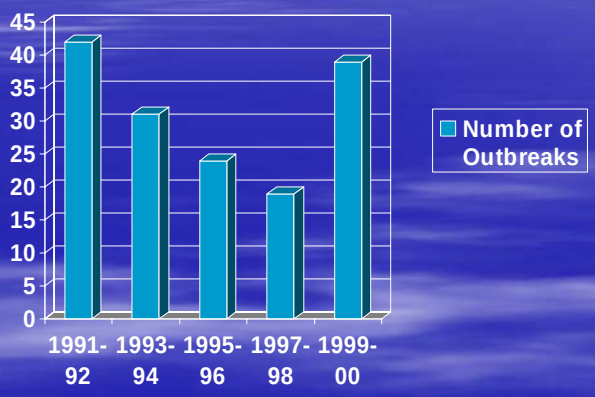


Protozoa

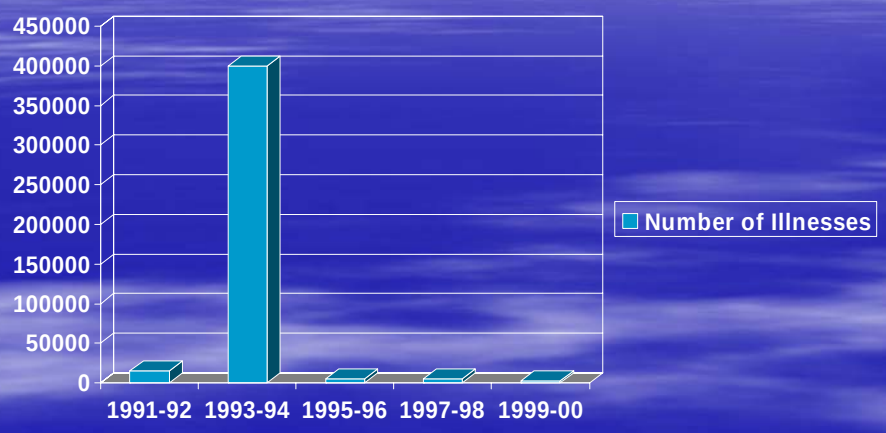
Protozoa



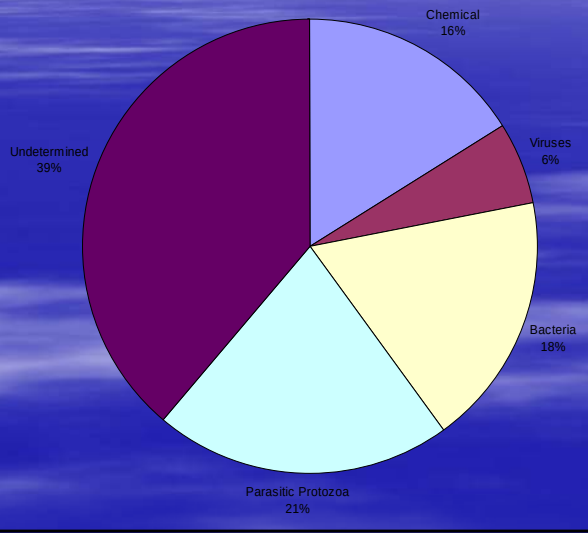
Number of Drinking Water Outbreaks 1991-2000



Number of Cases of Illness Due to Drinking Water Outbreaks, 1991-2000



Causes of Waterborne Disease Outbreaks in the US, 1991-2000



Causes of Waterborne Outbreaks

- Community Water Systems

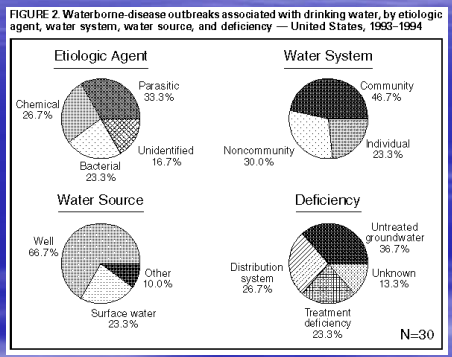
Giardia	11	2073
Cryptosporidium	7	407,642
Campylobacter	1	172
Salmonella	2	749
E.coli	3	208
E. coli 0157	0	0
Shigella	1	83
Plesiomonas	0	0
V. Chloerae	1	11
Hepatitis A	0	0
Norovirus	1	594
Other virus	1	148
Chemical	18	522
Undetermined	11	10,162

- Noncommunity Water Systems

Giardia	5	167
Cryptosporidium	2	578
Campylobacter	3	66
Salmonella	0	0
E.coli	3	39
E. coli 0157	1	781
Shigella	5	484
Plesiomonas	1	60
V. Chloerae	0	0
Hepatitis A	1	46
Norovirus	4	1806
Other virus	1	70
Chemical	0	0
Undetermined	38	4837

Surface Water vs. Groundwater

- During the 1993-1994 reporting period, 23.3% of waterborne disease outbreaks were associated with a surface water source
- 33.3% of outbreaks were due to parasitic protozoa
- 23.3% were associated with a treatment deficiency
- 46.7% of the outbreaks were from Community Water Systems

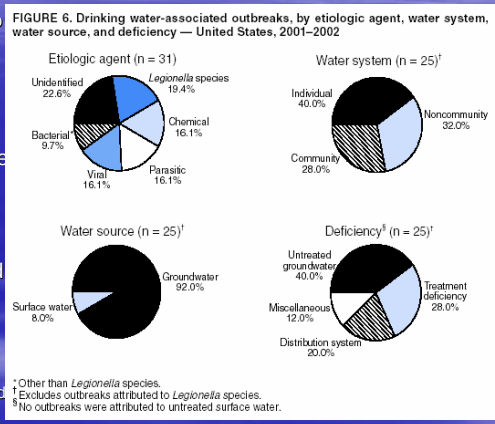


Source: CDC Surveillance for Waterborne Disease Outbreaks – United States, 1993-1994

Surface Water vs. Groundwater

- In the 2001-2002 reporting period, 8% waterborne disease outbreaks were associated with surface water
- Parasitic protozoa were the cause of 16.1% of the outbreaks
- Treatment deficiencies were the cause of 28% of the outbreaks
- 28% of outbreaks occurred in Community Water Systems
- The decrease in outbreaks associated with inadequate treatment of SW sources is likely due to increasingly stringent regulations

Source: CDC Surveillance for Waterborne Disease Outbreaks Associated with Drinking Water – United States, 2001-2002



Alaska Statistics

	2000	2001	2002	2003	2004	2005*
Cryptosporidium	0	1	1	1	0	0
Giardia	115	121	115	89	101	38
E. coli 0157	32	4	8	5	2	6
Hepatitis A	13	16	12	10	4	3

- Statistics for 2005 represent numbers reported during January – June 2005. Annual Report is not yet available.
- Numbers from the State of Alaska Epidemiology Section.

Hepatitis A

1973	1974	1975
249	283	257

There has been a dramatic decrease in the numbers of Hepatitis A cases in the last 30 years. This is mostly due to improved sanitation conditions and the construction of water treatment plants in rural Alaska communities.

An Alaska Case Study

- In 1995, Northern Testing Laboratories, Inc. conducted a study of ten surface water sources on the North Slope.
- Results of the study were published in the proceeding of the Eighth International Conference on Cold Regions Engineering.
- "Occurrence and Significance of *Cryptosporidium parvum and Giardia lamblia* in Surface Waters on Alaska's North Slope", by Michael R. Pollen, Cindy Christian, Craig Nordgren and Jonathan Pollen

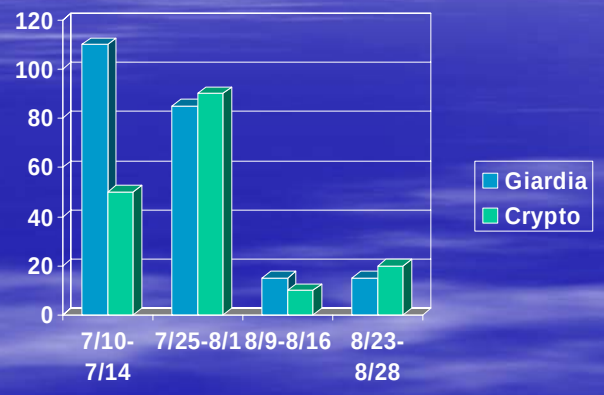
An Alaska Case Study

- Nine surface water sources for North Slope Borough villages of Atqasuk, Kaktovik, Nuiqsut, Point Hope, Point Lay and Wainwright were sampled by NTL and NSB Department of Municipal Services staff.
- A total of four sampling events took place.
- Samples for Giardia and Cryptosporidium analysis were analyzed using the *ICR Protozoan Method for Detecting Giardia Cysts and Cryptosporidium Oocysts in Water.*

NSB Village Water Sources Sampled During 1995

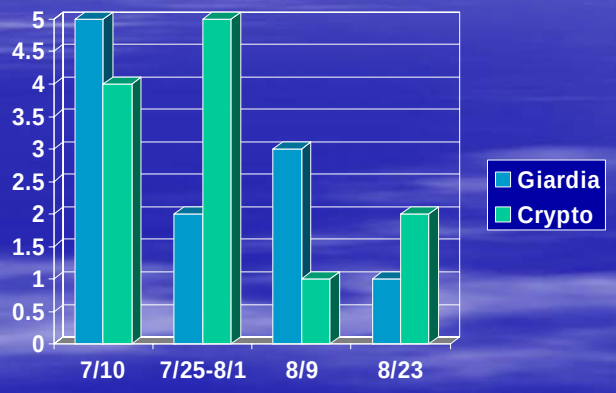
Village	***Source***	***Notes***
Atqasuk	Meade River	Sampled from Shore
Atqasuk	Ikmakrak Lake	Sampled Inside WTP
Kaktovik	Water Supply Lake	Sampled Inside WTP
Nuiqsut	Water Supply Lake	Sampled from Shore
Point Hope	7 Mile Lake	Transmission Line
Point Hope	Alternate Lake	Near 7 Mile Lake
Point Lay	Water Supply Lake	Sampled in Lake
Wainwright	North Lake	Sampled from Shore
Wainwright	South Lake	Transmission Line

Giardia and Cryptosporidium Occurrences in Nine Village Water Sources (Combined) (# of Protozoans/100 mL)



Giardia and Cryptosporidium Results for Nine North Slope Village Surface Water Supplies

Number of Sources with Positive Results



Case Study Conclusions

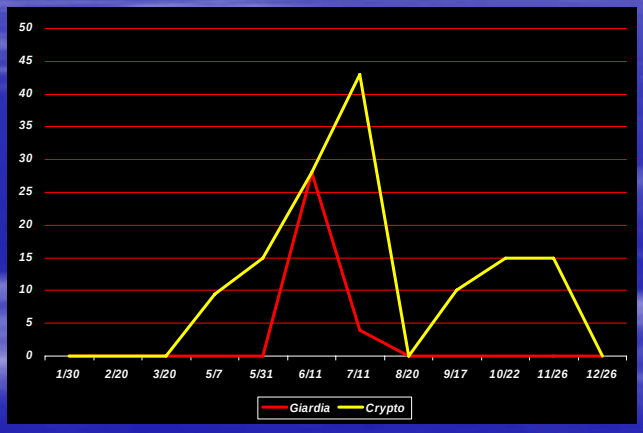
- At least one or both of these organisms were detected in each of these surface water sources during one or more rounds of sampling.
- Eight of the sources had *Giardia* and eight of the sources had *Cryptosporidium.*
- The highest occurrence of *Giardia* and *Cryptosporidium* was immediately after Spring thaw.
- Wind events were correlated with higher turbidity and particle counts.
- There was no direct correlation between higher turbidity and higher *Giardia* and *Cryptosporidium* counts.

BUECI Monthly Raw Water Sampling Program

January – December 1995

- The second project was with the Barrow Utilities and Electric Co-op (BUECI)
- Raw water samples were collected from the Isatkoak Reservoir
- Samples were collected monthly between January and December 1995
- Samples were analyzed for *Giardia lamblia and Cryptosporidium parvum*
- The only occurrence of *Giardia* was associated with the Spring thaw
- *Cryptosporidium* appeared at two periods: Spring thaw and shortly after the return of ice cover in the Fall

Sample Results for BUECI



Conclusions

- The majority of the surface waters tested in Alaska tested have shown the presence of *Giardia* or *Cryptosporidium*
- This corresponds with larger studies conducted in the Lower 48 which found *Giardia* in 85% and *Cryptosporidium* in 87% of surface water sources*
- For treatment purposes, assume that pathogenic protozoa are in your surface water source.

* LeChevallier et al. 1991

Questions?