WATERBORNE DISEASE OUTBREAKS

Case studies at small water systems

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2012 New Mexico Rural Water Conference
Objective of presentation

- To understand and learn from the causes of waterborne disease outbreaks at small water systems to prevent them from reoccuring
Waterborne disease

- A waterborne disease is a disease resulting from ingestion of contaminated water.
- Disease agents can be chemical or microbial.
  - *Chemical contaminants* are generally *chronic* contaminants, which can cause health problems after long-term exposure.
  - *Microbial pathogens* are generally *acute* contaminants, which can cause serious health problems after one exposure.
Pathogen groups

**Bacteria**
- E. Coli 0157:H7
- Salmonella
- Campylobacter jejuni

**Viruses**
- Hepatitis A
- Rotovirus
- Norovirus

**Protozoa**
- Cryptosporidium
- Giardia lamblia

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*Waterborne Disease Outbreaks*
Sources of pathogens

- Poorly operating wastewater treatment plants
- Sewer line leaks
- Combined sewer overflow
- Septic systems
- Stormwater
- Livestock
- Wildlife
Multiple barrier approach

- Source water protection
- Treatment
- Distribution system security
- Monitoring
- Management
Source water protection

Selecting and protecting the best source of supply
Treatment

Selecting appropriate treatment and operating it effectively to remove and inactivate contaminants
Distribution system security

Ensuring the integrity of system components, maintaining adequate pressure, and preserving water quality
Monitoring

Regular sampling to identify problems with water quality
Management

A trained governing body and operator(s), regulatory oversight, and informed consumers
Alamosa - Overview

<table>
<thead>
<tr>
<th>Date:</th>
<th>March 2008</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disease agent:</td>
<td><em>Salmonella</em></td>
</tr>
<tr>
<td>Source:</td>
<td>Unconfirmed, suspected animal contamination in water tank</td>
</tr>
<tr>
<td>Cases:</td>
<td>122 confirmed/442 reported/1,300 suspected ill 1 death</td>
</tr>
<tr>
<td>System:</td>
<td>SW system, no chlorination, 3 storage tanks, 50 miles of distribution, Arsenic treatment under construction (+ chlorination)</td>
</tr>
</tbody>
</table>
Salmonella

- Bacteria often carried by animals
- Most commonly a foodborne illness
- Incubation period: 1 – 7 days
- Previous waterborne outbreaks:
  - Riverside, CA in 1965; 3 deaths; 18,000 suspected sick
  - Gideon, Missouri in 1993; 7 deaths; 650 sick
- Easily inactivated by chlorine
Chronology

- March 8: First infection
- March 14: Six known infections; cases reported to state health dept.
- March 17: Health dept. notifies state drinking water program that Alamosa water system is suspected; samples collected from distribution to test for Total Coliform.
Chronology

- March 18: 43 cases, 18 confirmed Salmonella
- March 19: Bottle water advisory issued; decided to disinfect and flush entire water system; Colorado statewide Water/Wastewater Agency Response Network (CoWARN) activated to assist with disinfection and flushing
WARN

- CoWARN had been launched in September 2007.
- WARN is a mutual aid agreement to share resources in an emergency.
- Need for equipment (tanker trucks, disinfection equipment) and operators with specialized expertise in system-wide disinfection.
- Within 24 hours, experienced crews from around the state (including Denver) began to arrive in Alamosa.
- Within 48 hours, needed equipment was on the ground.
Chronology

- March 21: Disinfection and flushing begins at the Weber Reservoir; AWWA standards for disinfection of water mains and water storage facilities are followed; Governor declares an emergency.
- March 24: 5 samples from water system positive for Salmonella; disinfection of Craft Tower begins.
Chronology

- March 25: Disinfection of water mains begins; public notified door-to-door and by traffic signs.
  - Chlorine at 25 mg/l held in system for 24 hours
  - Disinfection and flushing took 13 days, 24 hours per day.
  - High chlorine levels were a concern for the WWTP.
- April 3: Replaced bottle water advisory with boil water order
- April 11: Boil water order lifted
Causes: Weber Reservoir

- Showed numerous cracks on top and sides
- Animal tracks found around tank and bird feces on top
- Reservoir hadn’t been inspected by state for several years.
Causes: Craft Tower

- Vent was in need of minor repair.
- Bird feces on top
- Not inspected since 1997
Causes: Ross Tower

- Missing bolts
- Gaps in seams between structural panels
- Hatch not water tight
- Bird feces on tank
Other Issues

- State granted disinfection waiver for years, but hadn’t regularly inspected water tanks.
Broken barriers – Alamosa

No chlorination

Sanitary deficiencies in tanks existed and allowed to persist

Sanitary surveys didn’t include tanks despite disinfection waivers.
# Walkerton, Ontario - Overview

<table>
<thead>
<tr>
<th>Date:</th>
<th>May 2000</th>
</tr>
</thead>
</table>
| Disease agent: | *E. Coli* O157:H7  
*Campylobacter jejuni* |
| Source:     | Pathogens in cattle manure  
contaminated shallow groundwater supply |
| Cases:      | 2,300 cases of gastrointestinal illness  
65 hospitalized  
27 hemolytic uremic syndrome  
7 deaths |

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*Waterborne Disease Outbreaks*
E. Coli O157:H7

- Pathogenic strain of large family of E. Coli bacteria
- Better known as a foodborne disease
- Originates primarily in cattle
- Can cause mild to severe diarrhea, cramping, nausea, and vomiting. About 2-7% of cases develop hemolytic uremic syndrome, which can lead to loss of kidney function
- Easily inactivated by chlorine
Campylobacter jejuni

- Commonly found in birds (particularly in poultry)
- Can cause diarrhea, abdominal pain, and fever. Most people recover without treatment.
- One of the most common causes of gastrointestinal illness
- Easily inactivated by chlorine
Vulnerable source

• Shallow well in porous (karst) aquifer with thin soil overburden
• After outbreak, investigation confirmed source was groundwater under direct influence of surface water.
Manure fertilizer applied near well
Heavy rainfall

![Graph showing the relationship between rainfall and waterborne disease outbreaks in May. The graph indicates a peak in disease cases around May 16, corresponding to a rise in rainfall.](https://example.com/graphics/graph.png)
Operator failure

- Failed to use appropriate doses of chlorine
- Failed to monitor chlorine residual daily
- Made false entries about chlorine residual in operating records
- Misstated the locations where microbial samples were taken
Operators lacked training

- Operators were grandfathered in when operator certification was instituted in Ontario.
- Operators did not meet continuing education training requirements.
“It is simply wrong to say, as the government has argued in this Inquiry, that Stan Koebel or the Walkerton Public Utilities Company were solely responsible for the outbreak or that they are the only ones who could have prevented it.”

- Justice O’Connor, Walkerton Inquiry
Regulator failure

- Failed to identify that Well 5 source was GWUDI and to require installation of continuous chlorine residual and turbidity monitors
- Failed to detect and require correction of improper chlorination and monitoring practices
- Failed to enforce operator training requirement
Board failure

- Considered responsibilities to be limited to attending meetings and looking after finances
- Relied on General Manager to inform them of major concerns
- Did not ask General Manager to explain negative 1998 Ministry of Environment report, or ensure that he had corrected deficiencies
Broken barriers – Walkerton, Ontario

GWUDI source that was susceptible to runoff from agricultural fields

Insufficient chlorination

Fictitious chlorine residuals and sample locations; no continuous chlorine residual and turbidity monitor

Waterborne Disease Outbreaks
Broken barriers – Walkerton, Ontario

Operator wrong-doing; board and regulator complacency
North Battleford, Saskatchewan

NMED Drinking Water Bureau

Waterborne Disease Outbreaks
## North Battleford - Overview

<table>
<thead>
<tr>
<th><strong>Date:</strong></th>
<th>March 2001</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Disease agent:</strong></td>
<td><em>Cryptosporidium parvum</em></td>
</tr>
<tr>
<td><strong>Source:</strong></td>
<td>North Saskatchewan River, possibly wastewater discharge upstream</td>
</tr>
<tr>
<td><strong>Cases:</strong></td>
<td>275 confirmed/1,907 reported ill</td>
</tr>
<tr>
<td></td>
<td>~7,000 suspected</td>
</tr>
<tr>
<td></td>
<td>0 deaths</td>
</tr>
<tr>
<td><strong>System:</strong></td>
<td>SW system, conventional treatment, pre-chlorination, .82 MGD on average, population served ~14,000</td>
</tr>
</tbody>
</table>
Cryptosporidium parvum

- Protozoa, carried by animals and humans, most often found in surface water
- Dormant stage called on oocyst, very resistant to chlorine
- Incubation period: 2 – 7 days
- Previous waterborne outbreaks:
  - Milwaukie, WI in 1993; 104 deaths; >400,000 sick
WW outfall near DW intake

North Saskatchewan River

sewage outfall

drinking water intake
Causes: Upflow clarifier

- North Battleford’s SW treatment plant used an upflow clarifier:
Causes: Upflow clarifier

- On March 20, the operators decided to repair a crack in the clarifier.
- They completely drained unit and cleaned out the sludge blanket.
- After the repair, it was put back online with no sludge blanket after effluent fell below 5 NTU.
- Raw water turbidity was low so sludge blanket would take a long time to develop.
Causes: Upflow clarifier

Percent settling of floc collected from the inner area of the upflow area of clarifier:

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Waterborne Disease Outbreaks
Causes: Upflow clarifier

- The reduced settling caused an increase in turbidity of finished water with spikes exceeding 1 NTU and averages well over 0.3 NTU.
- Operators believed that chlorine would take care of any problems due to increased turbidity.
- None of this was reported to the provincial regulators.
Health impact

Number of people within the Battleford’s Health Service Area with illness:

- Confirmed cases (n=110)
- Epidemiologically linked cases (n=829)
- Non-outbreak related diarrheal illnesses (n=119)

Maintenance of Surface Water Treatment Plant (March 20, 2001)
Health impact

Number of people outside the Battleford’s Health Service Area with illness:

-confirmed cases (n=165)
-epidemiologically linked cases (n=703)
-non-outbreak related diarrhea illnesses (n=21)

Boil Water Order issued (April 26, 2001)

Maintenance of Surface Water Treatment Plant (March 20, 2001)
Causes: Other factors

- Lack of operator training
- Supervisor position unfilled since December
- Sewage treatment plant outdated and inadequate; insufficient funding
- No individual filter monitoring, only CFE using chart recorders
- No filter-to-waste after backwashing filters
- Drinking water regulators not notified of situation until April 24
- Raw water had low turbidity making it harder to build floc, operators failed to do jar testing
Broken barriers – North Battleford

Upstream WWTP completely inadequate

Clarifier not functioning properly for extended period; no filter-to-waste

No individual filter monitoring

Source Water Protection

Treatment

Monitoring

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Waterborne Disease Outbreaks
Broken barriers – North Battleford

Operator missteps; insufficient operator training; failure to fill supervisory position; failure to allocate enough funds for maintenance; failure to notify regulators
## Washington County Fair - Overview

<table>
<thead>
<tr>
<th>Date:</th>
<th>August 1999</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disease agent:</td>
<td><em>E. Coli</em> 0157:H7, <em>Campylobacter jejuni</em></td>
</tr>
<tr>
<td>Source:</td>
<td>Undetermined: Septic system or infiltration of shallow groundwater by runoff carrying cattle manure</td>
</tr>
<tr>
<td>Cases:</td>
<td>781 confirmed/2,800-5,000 cases of suspected gastrointestinal illness, 71 hospitalized, 14 hemolytic uremic syndrome, 2 died</td>
</tr>
</tbody>
</table>

*NMED Drinking Water Bureau  Waterborne Disease Outbreaks*
The water system

- 6 shallow, ~25 foot-deep wells in gravelly sand
- 3 out of 6 wells chlorinated
- Not classified as a “public water system” because Fair only open 1 week out of the year, and therefore not subject to drinking water regulations
NY Dept of Health recommendations

- With no regulations to enforce, New York Department of Health provided technical assistance, and advised the Fair to:
  - Locate and map potential contamination sources within 150 feet of wells
  - Require back flow prevention for food vendors
  - Perform quarterly sampling
  - Retain services of an engineer
Broken barriers – Washington County Fair

Shallow well in porous soils with hydraulic connection to septic tank. Nearby manure storage area with no containment.

No chlorination

Quarterly sampling of well subject to rapid contamination did not capture problems with water quality.
Broken barriers – Washington County Fair

Fair management and consulting engineer did not take appropriate steps to ensure safe drinking water; no regulatory oversight.
Take-home lessons

1. Understand the potential threats to your water system
2. Evaluate your water system in terms of the multi-barrier approach
3. Take the deficiencies identified in your Sanitary Survey seriously
4. Outbreaks are often preceded by change (e.g. extreme weather, unusual operating conditions).
5. Operators, board members, and regulators all play a critical role in ensuring safe drinking water.
For more information...

- *Source Water Protection* presentation (up next...)
- Drinking Water Bureau Source Water Booth
- *How to Stay in Compliance* presentation (Tuesday, 10:30 am)
- *Sanitary Survey* presentation (Tuesday, 3:30 pm)