

SAFE DRINKING WATER COURSE

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CIPHI's 75th
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National Collaborating Centre
for Environmental Health

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Small Drinking Water Systems

Active Surveillance – PHI's Role with Drinking Water





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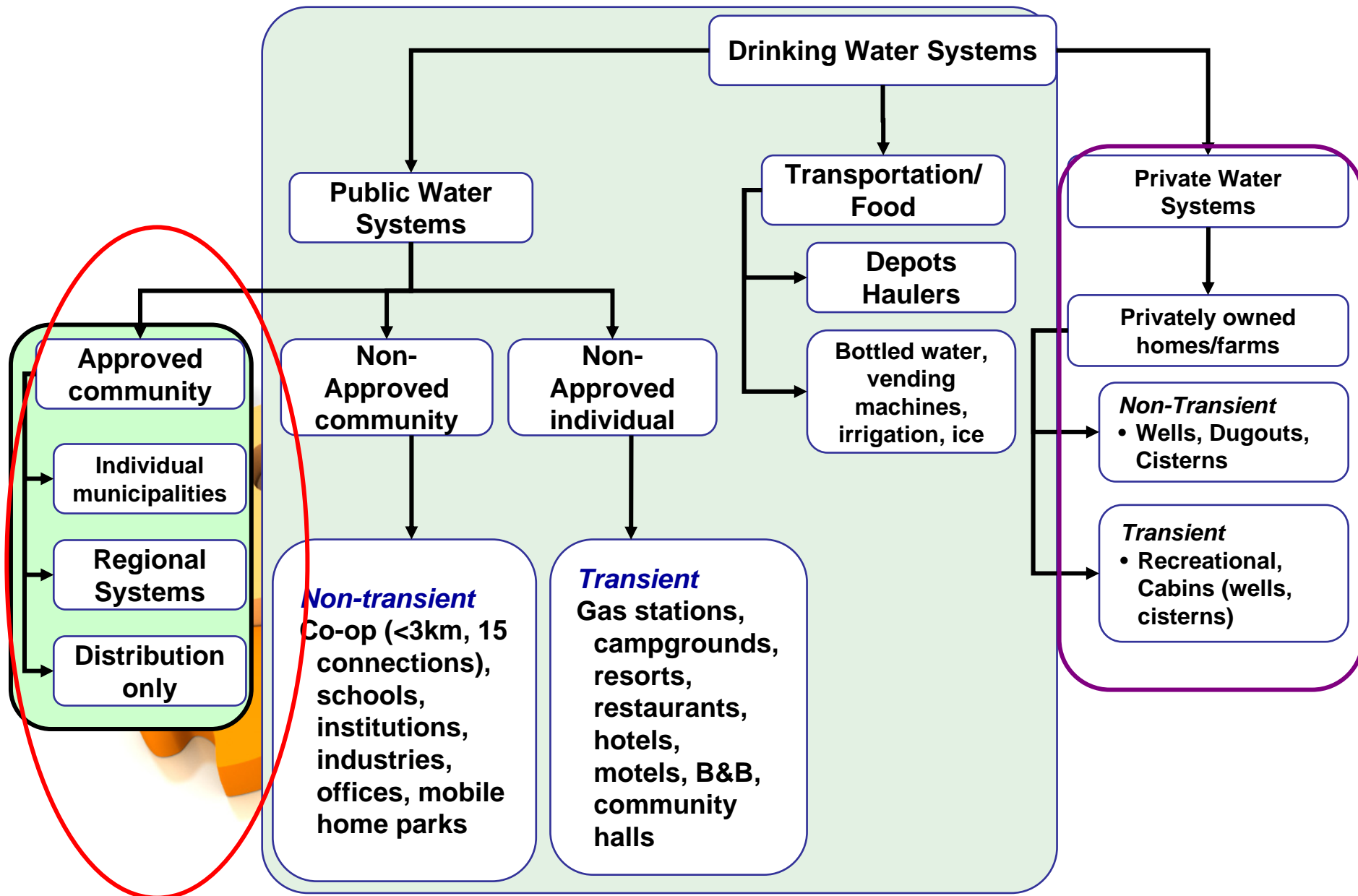
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Role of Public Health in Preventing Waterborne Outbreaks

Drinking Water Systems in Alberta



Waterborne Outbreak Prevention



- **Source-to-Tap**
- **HACCP and Critical Control Points**

Not done !!!

Public Health Protection

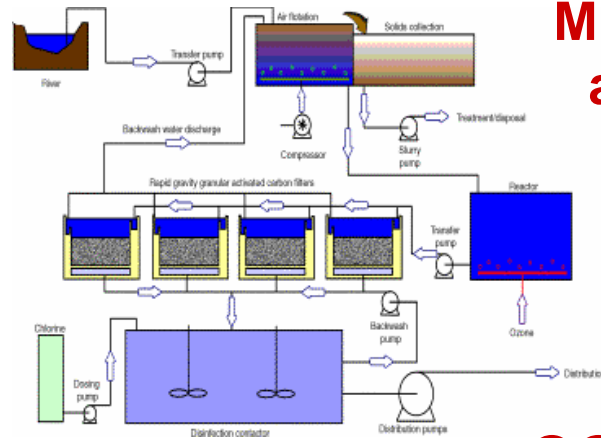
- **Active monitoring and passive surveillance**
- **Effective and timely declaration of Boil Water Advisory (intervention strategy)**



Health Education



- **Promote water safety**
- **Provide information to public**



**Multi-barrier
approach**

CCPs



Prevention

Protection



Waterborne Outbreaks

Symptoms

(in order of occurrence)

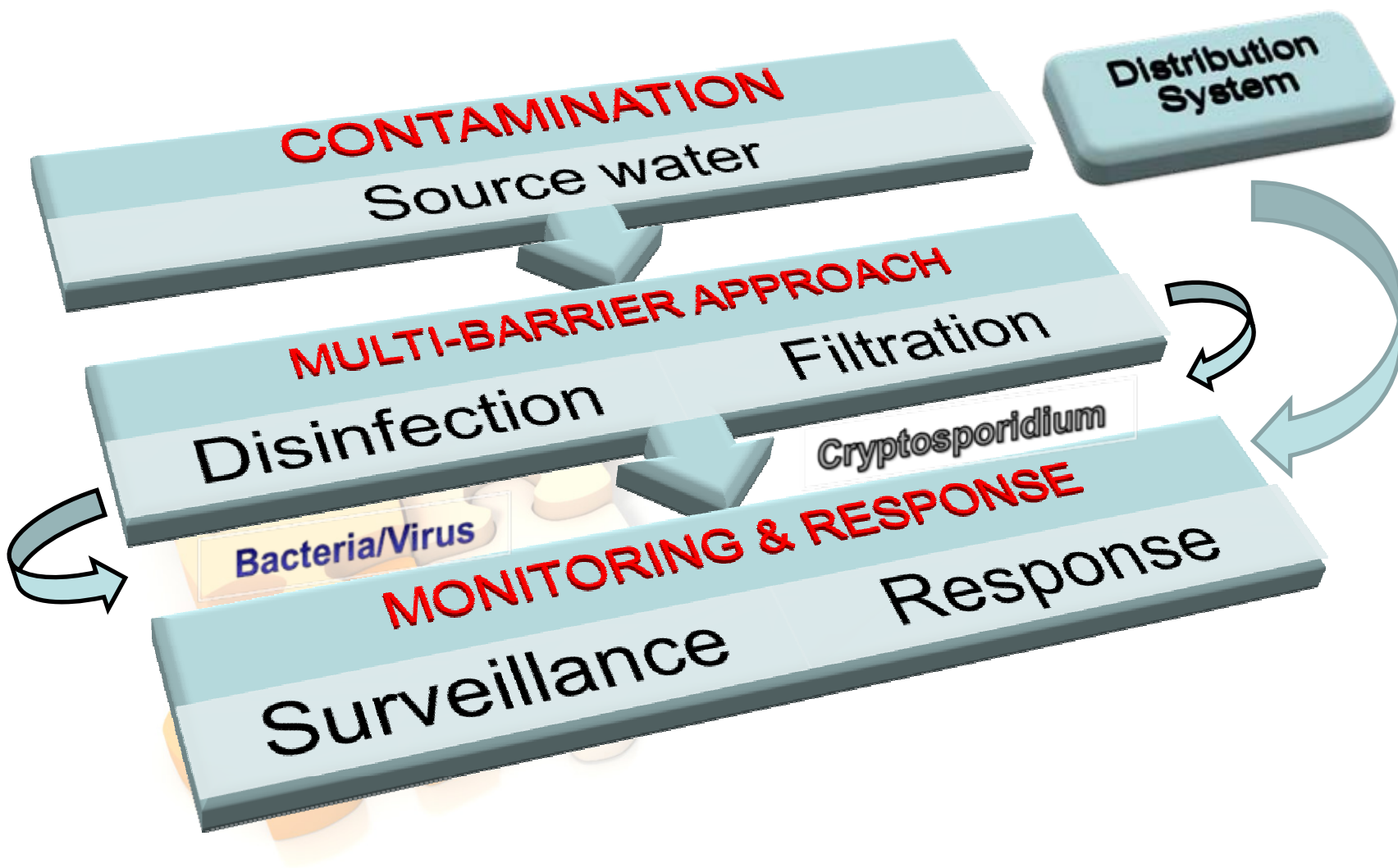
- **Watershed events**
- **Variations in WTP operational parameters**
- **Occurrence of cases (syndromic surveillance) and consumer complaints**
- **Etiologic agents found in water**



Multi-Barrier Approach

Based on the theory that no single barrier can consistently inactivate or remove all waterborne pathogens, and can be breached by some overwhelming pollution events



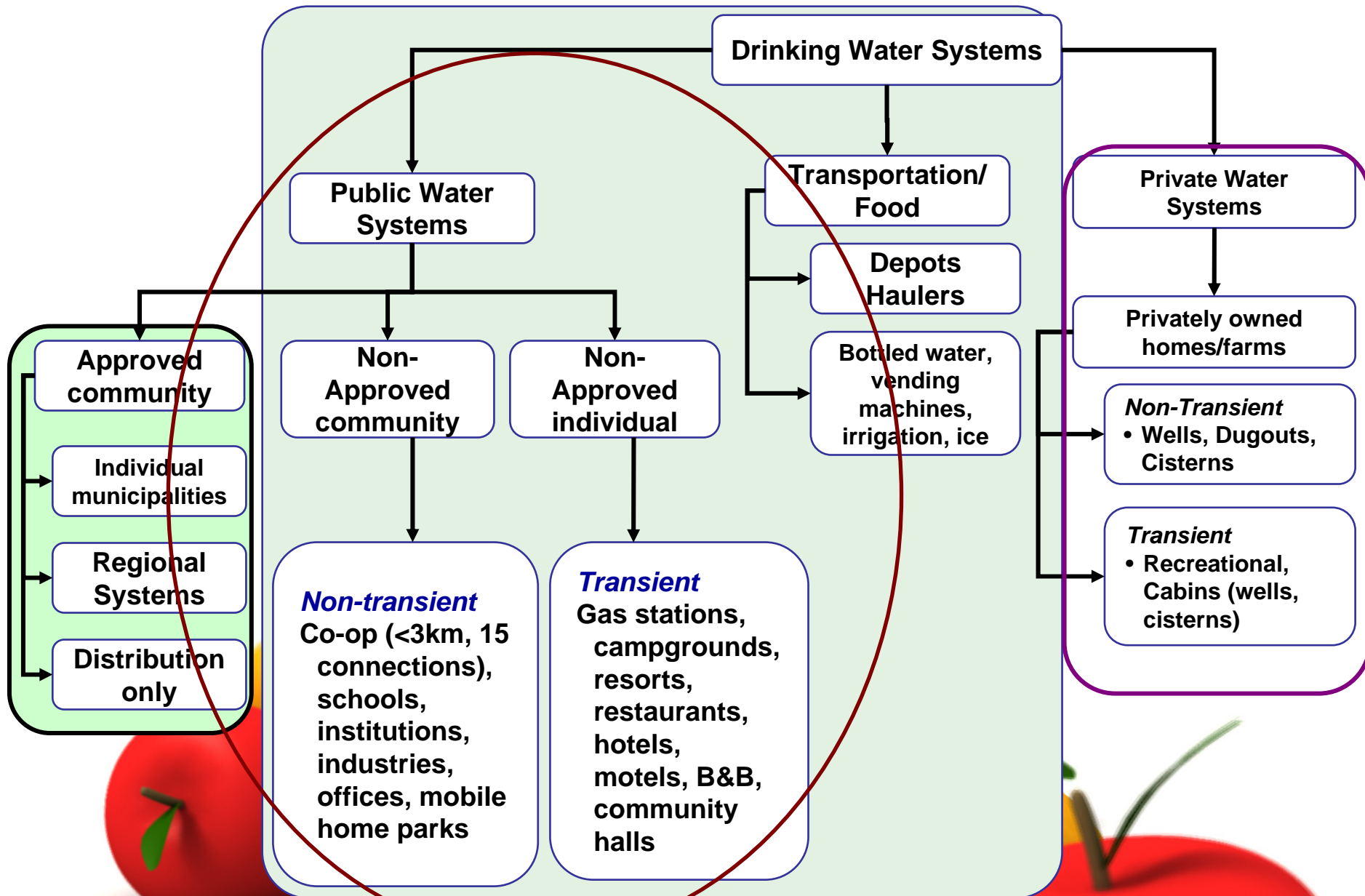


Large and Small Drinking Water Systems



Public Health's Role?

Drinking Water Systems in Alberta



Waterborne Outbreaks - Municipal Systems

- **Prevent waterborne outbreaks from occurring through 'HACCP' or 'source-to-tap' control**
- **Protect the public by minimizing the risk of waterborne outbreaks through surveillance and timely declaration of boil water advisory**
- **Education**



Waterborne Outbreaks - Municipal Systems

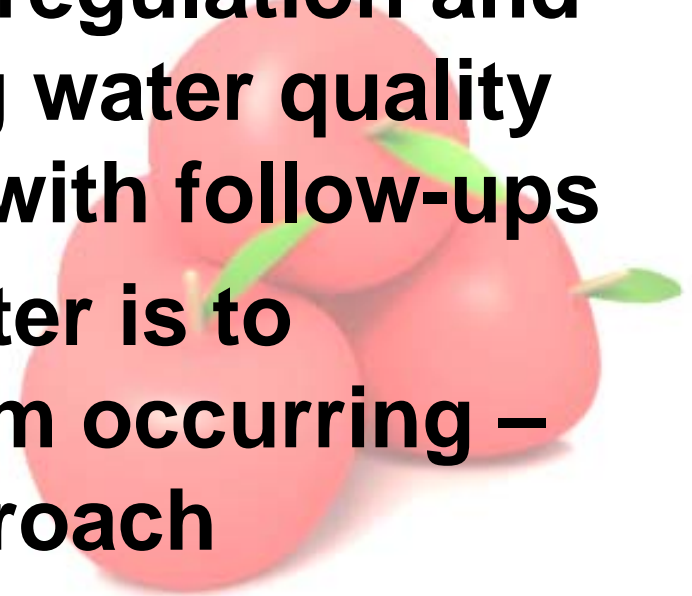
‘Symptoms’ for outbreaks (in order of occurrence)

- **Watershed event**
- **Variation in WTP operational parameters**
- **Occurrence of cases and consumer complaints**
- **Etiologic agents found in water**



Waterborne Outbreaks - Municipal Systems

- Compliance monitoring **ALONE** limits responses to reactive ones
- 2006 survey found 74% of EHOs/PHIs 'enforce' drinking water regulation and standards by monitoring water quality (bacteria and chemical) with follow-ups
- Role in safe drinking water is to **PREVENT** outbreaks from occurring – practical preventive approach

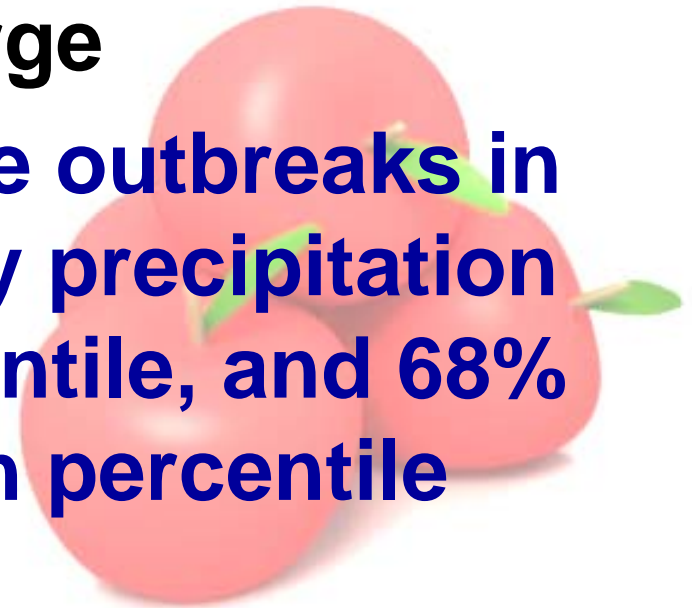


Waterborne Outbreaks - Municipal Systems

Watershed events:

- **Heavy rainfall**
- **Spring run-off**
- **Sewage/lagoons discharge**

51% of waterborne disease outbreaks in the US were preceded by precipitation events above 90th percentile, and 68% by events above the 80th percentile



Waterborne Outbreaks - Small Systems

Watershed Events?

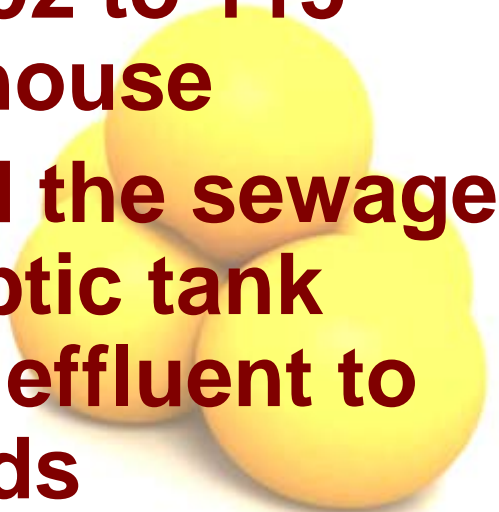
Study in Florida found high levels of precipitation (>6 cm) from July to September result in high water tables and septic tank overflows

Leachate unable to percolate through the soil during wet season resulting in groundwater contamination



Waterborne Outbreaks - Small Systems

Watershed Events?

- **2001 Wyoming, snowmobile lodge- 35 cases of norovirus infection**
 - **Three wells located within 92 to 115 feet of a septic tank or outhouse**
 - **Renovations that increased the sewage load without increasing septic tank capacity, resulting in more effluent to pass through the leach fields**
- 
- Three yellow, 3D-rendered spheres are positioned in the lower right area of the slide, partially overlapping the text of the third bullet point. They are arranged in a small cluster, with one sphere slightly behind and to the left of the other two.

Waterborne Outbreaks - Small Systems

Watershed Events?

- **2006 Wyoming, summer youth camp**
- **2 wells 30 to 50 feet deep**
- **120 feet away from septic tank**
- **Tank filled to capacity**
- **Norovirus and *Campylobacter* infection**



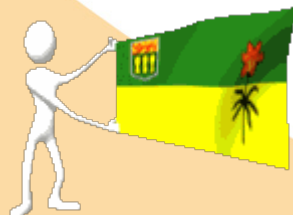
Waterborne Outbreaks - Small Systems

Watershed Events?

Rural Saskatchewan Study:

- **47% of wells with high nitrate had livestock in close proximity, adjacent to, or within area of wells**

Sketchell and Shaheen, 2000 study





Waterborne Outbreaks - Small Systems

Watershed Events?

South Bass Island, Ohio 2007

- **1,450 cases of GI illness
(*Campylobacter*, norovirus, *Giardia* and *Salmonella*)**
- **Septic tanks overflow plus extreme precipitation**
- **Increase in water table level, saturate sub-surface soil in disposal field**



Waterborne Outbreaks - Small Systems

Watershed Events?

South Bass Island, Ohio 2007

- Illegal sewage disposal site on the center of the island that accept untreated sewage from residential homes and businesses – wastewater dumped by sewage truck hauler into sinkhole leading to the groundwater aquifer**



Waterborne Outbreaks - Small Systems

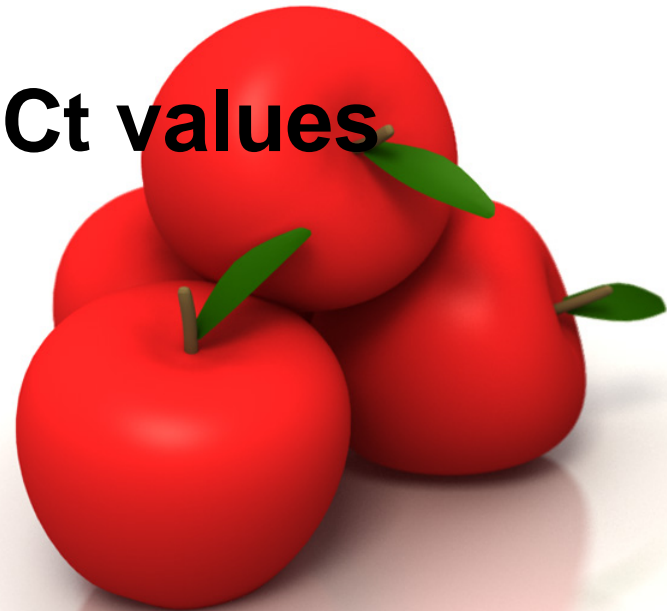
Watershed Events?



Waterborne outbreaks - Municipal Systems

Variation in WTP operational parameters:

- **CCPs**
- **Turbidity spikes**
- **Particle counters**
- **Log removal efficiencies, Ct values**
- **Chlorine residuals**
- **Pressure**



Waterborne Outbreaks - Small Systems

With little or no operational parameters (except chlorine residual) to monitor, how can EHOs/PHIs properly evaluate the potential for a private system to have a waterborne outbreak?

Without such controlling factors, how can waterborne outbreak be prevented?



Waterborne Outbreaks - Small Systems

Canada

Causative factor for waterborne outbreaks:

- **Public: water treatment issues, inadequate regulation**
- **Semi-public: septic tanks, water treatment issues, inadequate regulation**
- **Private: septic tanks**




Waterborne Outbreaks - Small Systems

Prevention?

USEPA 1993 document on Wellhead Protection:

The most common threat to the integrity of a private water well is contamination resulting from the entry of surface water either directly into or down the outside of the well casing because of poor construction or maintenance



Waterborne Outbreaks - Small Systems

EPA (1977) had designated areas with septic tank densities of greater than 40 systems per square miles (1 system per 16 acres) as regions of potential groundwater contamination

Recent studies found densities less than two systems per acre do not result in contamination levels above EPA standards



Waterborne Outbreaks - Small Systems

EPA estimated 10-20% of all on-site wastewater treatment systems in the US are not functioning properly

Densely packed systems may exceed the natural ability of soils to receive and purify the wastewater before it reach groundwater or adjacent surface water



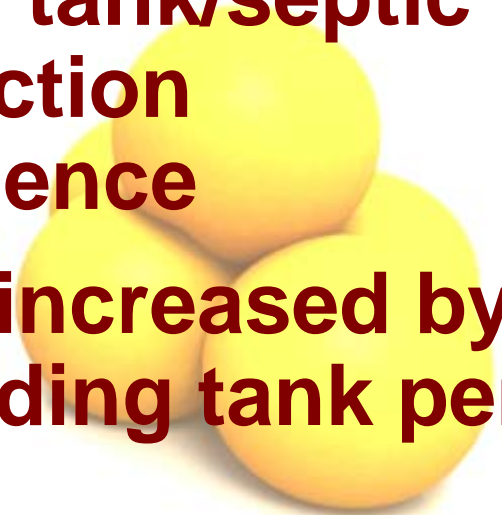
Waterborne Outbreaks - Small Systems

**Study of illness among children in
Wisconsin**

**Viral diarrhea for children was associated
with the number of holding tank/septic
systems in the 640-acre section
surrounding the case residence**

**Risk of viral diarrhea illness increased by
8% for every additional holding tank per
640-acre section**

Borchardt, *EH Perspectives* 2003

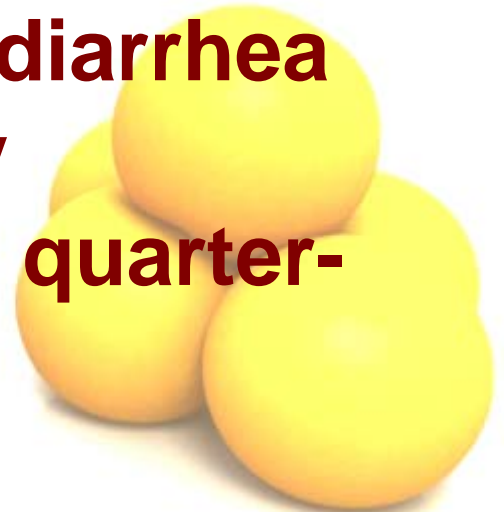


Waterborne Outbreaks - Small Systems

Bacterial diarrhea was associated with the number of holding tanks per 40-acre quarter-quarter section

Risk of developing bacterial diarrhea increased by 22% for every additional holding tank per quarter-quarter section

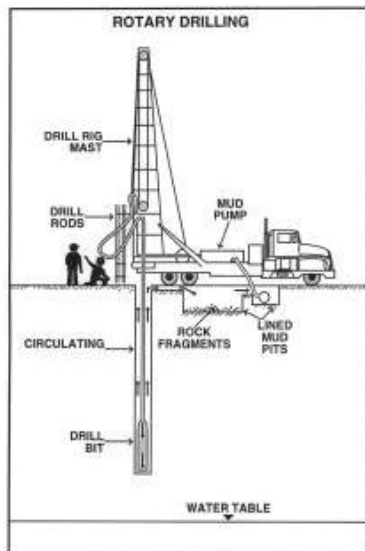
Borchardt, *EH Perspectives* 2003



Waterborne Outbreaks - Small Systems

Water Well Inspection and Surveillance: Study in Colorado

- 71% of wells less than 60m (200 ft) tested positive for total coliform**



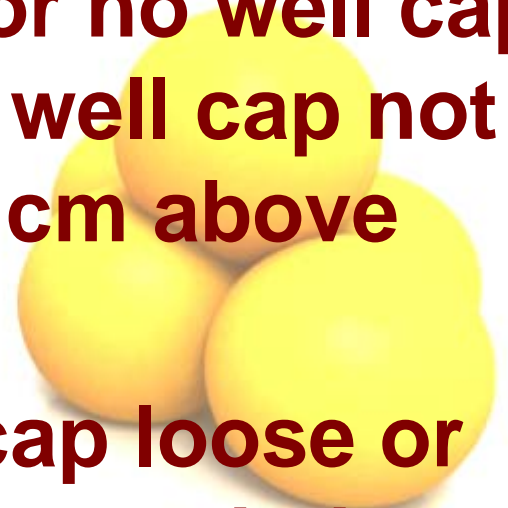
(Gonzales, *J En. Health* Dec 2008)



COLORADO

Waterborne Outbreaks - Small Systems

- **71% of wells with poor and fair wellhead protection tested positive for total coliform**
- **Poor:** non-grouted casing or no well cap or sealed shoe-box lid and well cap not extended a minimum of 30 cm above ground
- **Fair:** grouted casing, well cap loose or not sealed or well cap not extended a minimum of 30 cm above ground



Waterborne Outbreaks - Small Systems

Alberta study:

- **14% of well water sampled have detectable total coliform**
- **Significant proportion of these wells were less than 30 m (100 ft) in depth**
- **Most wells with high nitrate-nitrite levels were less than 30 m (100 ft) in depth**

**Fitzgerald, Canada-Alberta En. Sustainable Agriculture (CAESA)
1997 study**

Waterborne Outbreaks - Small Systems

Rural Saskatchewan Study:

- **63% of wells with high nitrate were < 60 feet, 88% less than 30 m (100 ft)**
- **33% of wells positive for TC were <30m**
- **One well that was positive for TC was 586 feet but connected to abandon well with a collapse water line**



Waterborne Outbreaks - Small Systems

**County Fair, Albany, New York 1999, 127
cases of *E. coli* O157:H7, 45
Campylobacter, 14 HUS**

- 2,800-5,000 ill, 71 hospitalization and 2 dead**
- 7 m shallow well was located 11 m from septic tank seepage field**
- Dye tests showed toilet effluent in well in less than 10 hours**



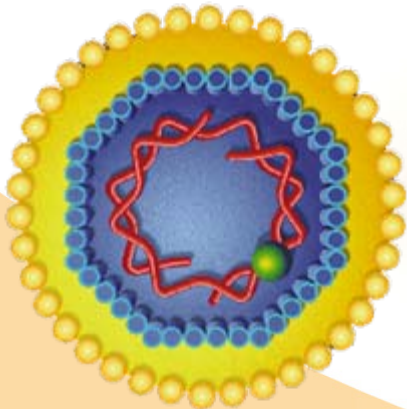
Waterborne Outbreaks - Small Systems

Eight cases of Hepatitis A in a Tennessee county in 2008

Case 0 discharge virus into septic tank, resulting in very high viral load

Septic waste leached into own well and eventually into at least two other wells

TENNESSEE



Waterborne Outbreaks - Small Systems

Proper inspection and surveillance of wells (location in relationship to septic systems and other sources of pollution, wellhead protection) will allow fairly accurate prediction of the likelihood of water well contamination

Inventory of abandon wells



Waterborne Outbreaks - Small Systems

WFL project preliminary findings:

**88.3% with non-qualified/untrained
water operator**

**20% with abandoned or “stand-by”
groundwater wells present**

**15% with visible source of external
contamination at time of
inspection**



Waterborne Outbreaks - Small Systems

WFL project preliminary findings:

20% had well in pit

**29% with well casing not above
ground**

14.3% had no well cap

**72.2% did not shock chlorinate on a
regular basis**

**20.4% had no bacteriological or
infrequent water sample taken**



Waterborne Outbreaks - Small Systems

**On-site WW systems are effective
for most WW pollutants including
BOD, suspended solids, bacterial
indicators, metals, phosphorus
and some viruses**

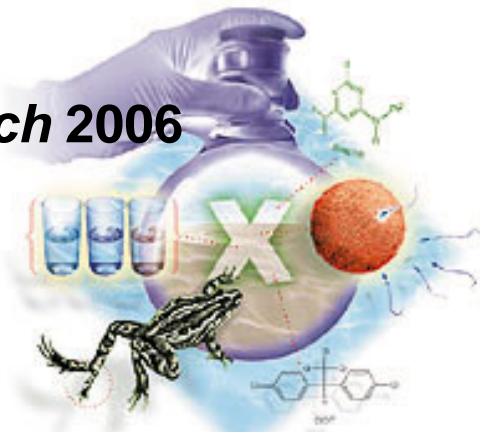
**Not designed for many other
organic pollutants**



Waterborne Outbreaks - Small Systems

- **Monitoring of endocrine disruptor chemicals in septic system and in down-gradient groundwater**
- **High level of organic wastewater contaminants as far as 6 m down-gradient**

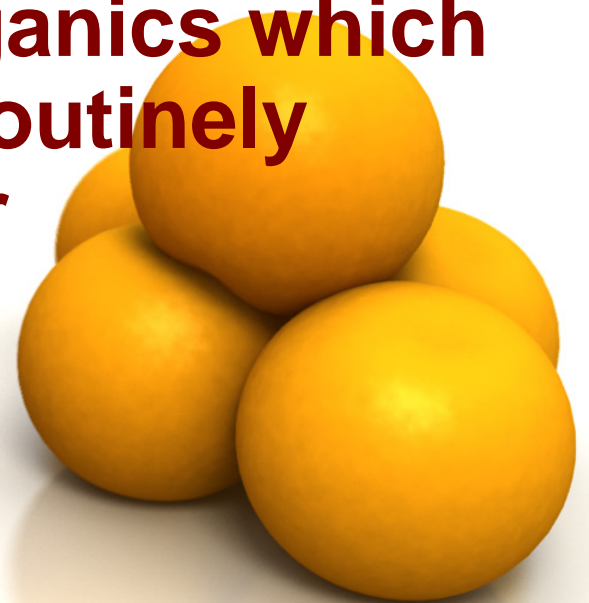
Swartz *En. Science & Tech* 2006



Waterborne Outbreaks - Small Systems

- **Concentration of many organics (EDC and PPCP) were within a factor of 2 of near-source concentrations - suggest that there is the potential for the migration of these organics which are unregulated and not routinely monitored in groundwater**

Swartz *En. Science & Tech* 2006

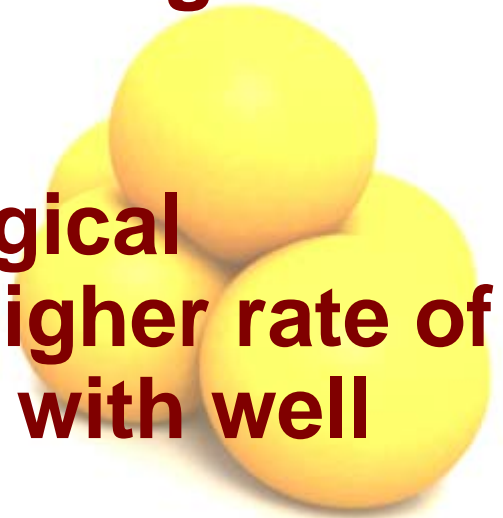


Waterborne Outbreaks - Small Systems

- **PPCP carbamazepine, sulfamethoxazole and nicotine in underlying sand and gravel aquifer after effluent percolation through a 2 m thick sand vadose zone**

Godfrey, Ground Water, 2007

- **April 2009 American Urological Association Conference- higher rate of bladder cancer associated with well water consumption**



Waterborne outbreaks - Municipal Systems

Occurrence of cases (syndromic surveillance) and consumer complaints

- **Active surveillance (day care, institutions, OTC medication)**
- **Passive surveillance (Notifiable Disease Report)**



Waterborne Outbreaks - Small Systems

Occurrence of cases

- **Oct 2008 *E. coli* lettuce outbreak in the US**
- **Jail nurse reported a suspected foodborne illness**
- **Same bacteria was identified as the cause of illnesses at Michigan State University and other Michigan counties**



Waterborne Outbreaks - Small Systems

Occurrence of cases

- **May 2008 Texas, 36 cases of *Salmonella* traced to homemade ice cream served at a religious event**
- **Pharmacist noted customers coming in for medication to treat the same symptoms**



Waterborne Outbreaks - Small Systems

Occurrence of cases


- **Smaller communities are more suited for active (syndromic) surveillance because of smaller defined population and limited contact points (physicians or pharmacists)**

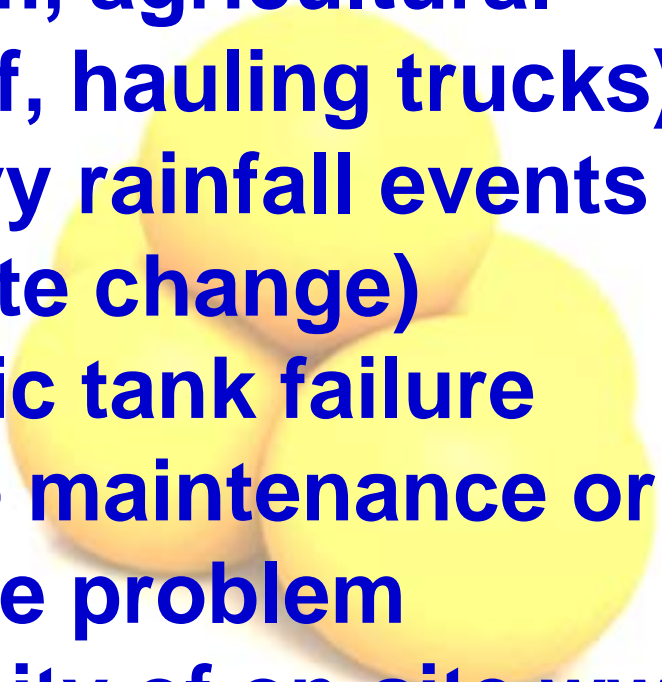


Contributing Factors to Waterborne Outbreaks for Large and Small Water Treatment Systems



Watershed event

- 
- **Flooding**
 - **Sewage discharge**
 - **Spring run-off**

- 
- **Flooding (septic system, agricultural run-off, hauling trucks)**
 - **Heavy rainfall events (climate change)**
 - **Septic tank failure due to maintenance or volume problem**
 - **Density of on-site ww systems and land use pattern**

Variation in Operational Parameters

- **CCP**
- **Turbidity spikes**
- **Particle counters**
- **Ct values and log removal**
- **Chlorine residual**

Well maintenance and risk assessment

- **Wellhead protection**
- **Well and septic system surveillance and inspection**
- **Maintenance record**
- **Chlorine residual**
- **Education**

Cases in the community

- **Active surveillance**
- **NDR passive surveillance**



Cases in the community

- **Establish relationship with local clinicians and pharmacists**
- **Educate operators on symptoms of outbreaks**
- **Complaints**



**Etiologic agent
found in water:**

- Limited by volume
- Clustering of bacteria
- Results at least 24 hours

**Etiologic agent
found in water:**

- Limited and infrequent sampling (weekly or monthly)
- Education

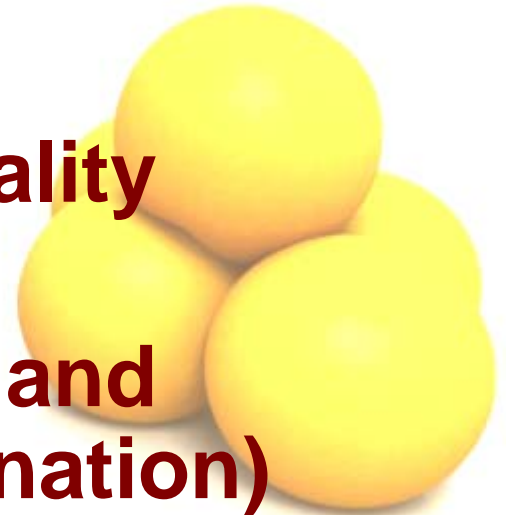
Waterborne Outbreaks - Small Systems

- **Proper risk evaluation and surveillance should be an important part of preventing outbreak from occurring for small systems**
- **Active surveillance and effective communication can be effective to protect the public from contaminated water**



Waterborne Outbreaks - Small Systems

- **Educate: watershed events, well head protection and maintenance**
- **Educate: Operator/owner be aware of symptoms of outbreak and contact information**
- **Educate: monitor water quality (physical and chemical)**
- **Educate: regular sampling and maintenance (shock chlorination)**

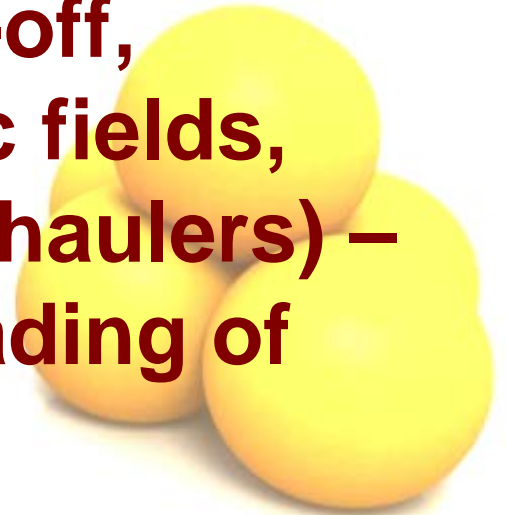


Waterborne Outbreaks - Small Systems

System Assessment – site survey

(land use surveillance with system as a whole and not as individuals):

- **Livestock, agricultural run-off, wastewater sources (septic fields, holding tanks, wastewater haulers) – location and density, spreading of biosolids, abandon wells**

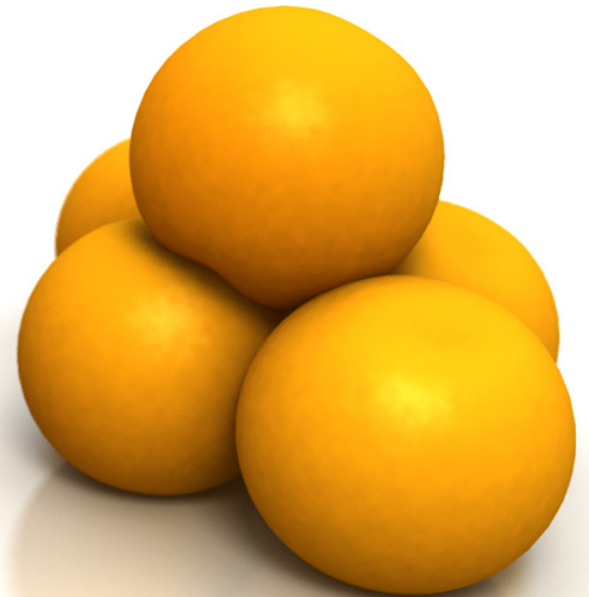


Waterborne Outbreaks - Small Systems

System Assessment – soil survey

(land use surveillance with system as a whole and not as individuals):

- **Groundwater depth**
- **Groundwater vulnerability**



Waterborne Outbreaks - Small Systems

Operational and Monitoring – Supply Survey

- **Wellhead protection, casing integrity, cross-connection control, system design and operation**
- **Changes to operation/facility in relation to waste disposal**
- **Conduct regular dye tests**



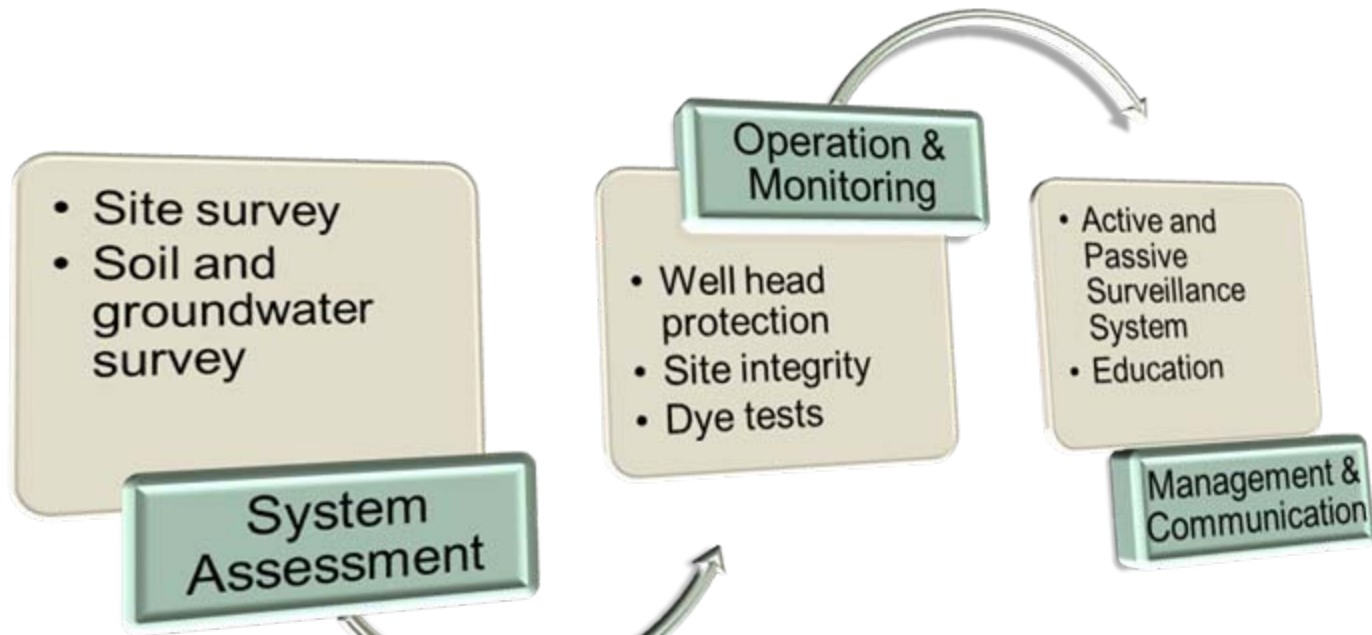
Waterborne Outbreaks - Small Systems

Management and Communication

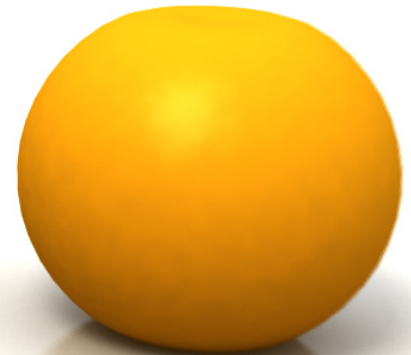
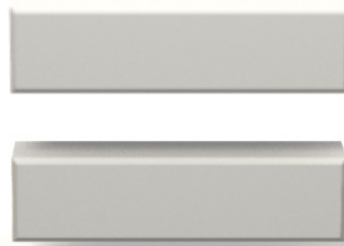
- **Set up active surveillance system within small communities (pharmacies, clinics)**
- **Effective NDR reporting and investigation system**
- **Note consumer complaints**
- **Educate**

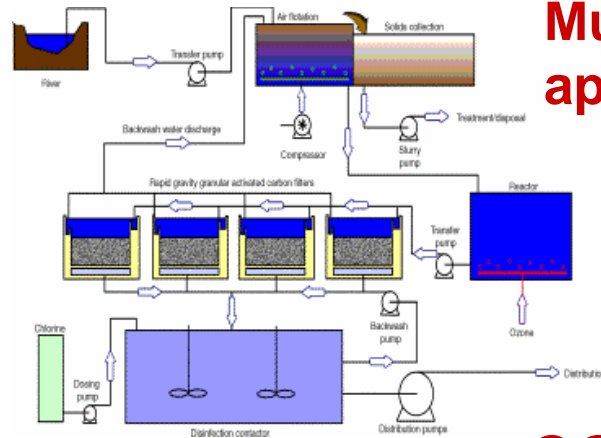


PHYSICAL AND ADMINISTRATIVE BARRIERS THROUGH SURVEILLANCE



Contributing Factors to Waterborne Outbreaks for Large and Small Water Treatment Systems





Multi-barrier approach

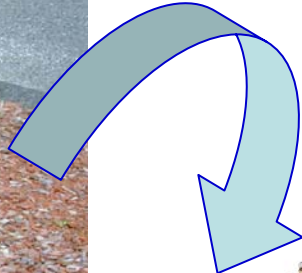
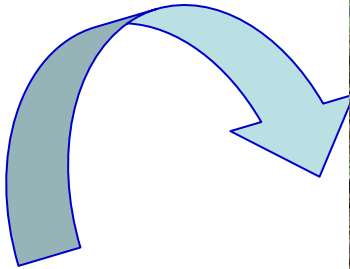
CCPs



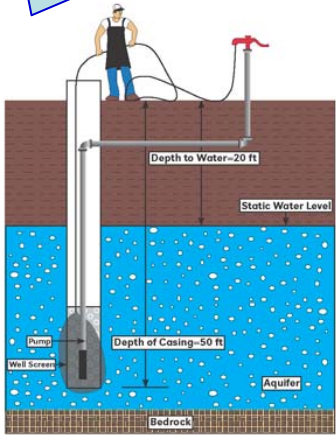
Prevention

Protection

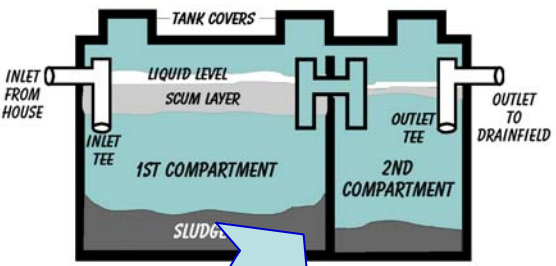




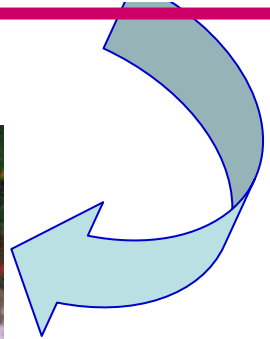
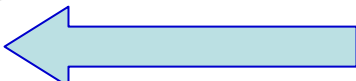
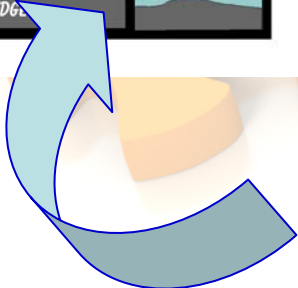
Multi-barrier approach



Prevention



Protection



Waterborne Outbreaks - Small Systems

New risk evaluation tools to be developed for assessing risk of water contamination of small systems based on land-use, density, aquifer, soil type, well head protection, well head maintenance



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