Potable Water

Environmental Health in Disaster Events

Introduction

- Injury prevention and safety
- Environmental systems
- Water systems, assessments, and surveys
- Safe water in emergencies
- Water disinfection
- Water sampling

Learning Objectives

By the end of this module participants will

- Increase understanding of water issues faced in disasters
- Increase understanding of the role of environmental health practitioners in addressing water issues
- Be able to identify key response partners
- Increase understanding of the basic components of systems
- Practice and demonstrate basic skills related to water issues
  - Common tests, sampling, treatment, assessment
- Identify key messages for the public and response partners

Why Do Disaster-Related Waterborne Outbreaks Not Occur in the United States?

Environmental Health Functions

- Ensure adequate supply of safe water is available to the public
- Prevent waterborne diseases
- Provide information on water safety and supply
- Conduct interventions needed for food service and other industries
Reasons for Concern

- Aging water and wastewater infrastructure
- Population growth
- Frequency of natural disasters
- Terrorism threats
- Well construction oversight

Impact on Water Supplies

- Source water contamination
- Physical damage
  - Treatment plants
  - Distribution pipes
  - Wells
- Workforce affected

Key Partners

- Emergency management agency
- State and local departments of environmental quality, protection, health
- Public works and water purveyors
- Volunteer and community organizations
- Water haulers
- Emergency Support Functions (ESF)
  - 3, Public Works and Engineering
  - 6, Mass Care
  - 8, Health and Medical
  - 10, Oil and Hazardous Materials
- Industry
- Media

Roles

- Assessment
- Consultation
- Environment monitoring
- Public information
- Preparing
- Leadership
- Planning
- Support activities
- Liaison activities

Priority Activities

- Determine whether water service or quality has been affected
- Ensure adequate lab capacity
- Interpretation of sample results
- Assist water system operators if requested
- Distribute emergency water supplies
- Ensure emergency water supplies are safe
- Provide information on water needs, rationing, storage, disinfection
- Monitor emergency water supplies

Injury Prevention and Safety
Safety Is Job #1

- Personal sanitation
- Electrocution
- Carbon monoxide
- Musculoskeletal hazards
- Thermal stress
- Structural instability
- Hazardous materials
- Confrontations
- Fire
- Drowning, mechanical
- Personal protective equipment – use it!
- Driving, animals, insects, slips/falls
- Stress, fatigue
- Confined spaces – must be trained

Water Systems, Assessments and Surveys

Water Supply Assessment
Important Considerations

Quality (Prevention of waterborne illness)
- Hepatitis A, Norovirus, E. coli, Salmonella, Cryptosporidium, etc.

Quantity (Prevention of water-washed infections)
- Skin and eye infections, louse-borne typhus, Shigellosis

Coverage
- Access to safe water for 100% of users

Continuity
- Safe water 24/7

Cost
- Reasonable

Water System Protections

Water System - Public
Threats to Groundwater

Well Contamination?

Other Drinking Water Contamination Sources

Water Protection: Pressure Loss

• Cross Connection
• Back Flow
• Back Siphonage

Water Protection: Pressure Loss

• Backflow Preventer
• Air gap
• Reduced Pressure Backflow Assembly (RPBA)

• Pressure Vacuum Breaker (PVB)
• Double Check Valve (DCVA)
Private Water Systems

Typical Drilled Well Finished in Bedrock

Well casing must be at least 40 feet below surface grade and at least 10' into bedrock. Full-length grouting is shown here.

Bored/Augured Well Construction

“Buried slab” style of bored well construction using a concrete or bentonite seal. Buried slab should be a minimum of 10' below surface grade. Precast concrete well curbing/tile stacked on top of each other, which act as the well casing.

Dug Wells
Environmental Health Water Surveys: Points to Consider

- Remember: SAFETY FIRST
- Primacy agency or EOC have own priority list
- Priority systems: large community, community, non-transient and transient non-community systems
- Agencies, other utilities, RWAs coexist in field
- Contract operators can be slow to visit systems

Environmental Assessment Procedures

- Rapid field assessment
  - Water sources and supplies
  - Sewage management practices and other sources of contamination
  - Recent and historical water quality data
  - Water samples

EH Water Surveys: Action Steps

- Get maps and data from primacy agency (GPS - extremely helpful)
- Contact the lead operator or owner
- Send inspectors into damaged areas
- Rapid information is critical first step
- Detailed survey information follow-up
- Rapid impact assessment reports
Environmental Health Water Surveys

- General: access, power, staffing
- Wells: electrical, flood damage, flow
- Pumps: power, damage, flow/pressure
- Treatment: chemicals available, injectors, process damage, debris
- Storage: vents, damage, leaks
- Distribution: pressure*, leaks, zones
- Lab: functioning, equipment, hazmats
- Communication

Conducting Rapid and Detailed Damage Assessments

- Compile rapid assessment info
- Categorize into power outage and facility damage
- Determine extent of power outage and prognosis for power recovery
- Dispatch any unused portable generators to critical areas
- Dispatch skilled personnel to facility damage locations

Conducting Rapid and Detailed Damage Assessments

- Complete detailed assessment form
- Develop status monitoring system (status board)
- Prioritize response plan according to critical needs
- Dispatch available in-house resources – Request outside assistance if needed

Emergency Response and Preparedness

Water and Wastewater Agency Response Networks
Safe Water In Emergencies

Water Exercise

• Prepare a draft PSA
  Include:
  - Recommendations for storing water for disaster events
  - Water sources in the home
  - Outdoor water sources
  - Who to contact with questions/concerns
  - Where to look for disinfection guidelines

Preparedness in the Home

• Store one gallon per person per day (two-week supply)
• Store water in thoroughly washed plastic, glass, fiberglass, or enamel-lined metal containers

Preparedness in the Home

• If you have water pressure, fill sanitized bathtub and sinks
• Commercially bottled water can be stored for 2 years without affecting quality and taste
• Home-bottled water should be replaced every 6 months

Hidden Water Sources in Your Home

• Sources: hot water tank, water supply lines, ice cubes, toilet reservoir tank (not toilet bowl), water beds
• Any water from waterbeds should be used only for bathing
• Water from all other sources should be disinfected

Emergency: Outdoor Water Sources

• Rainwater, streams, rivers, and other moving bodies of water
• Ponds and lakes
• Natural springs
• Swimming pools

IMPORTANT!
Disinfect water from these sources before drinking
Avoid water with floating material or bad odors
Distill saltwater
Making Water Safe

- Boiling: best way to make water safe – rolling boil for 1 minute (under 5,000 ft)
- Chlorination, disinfection tablets (chlorine or iodine), hiking/camping filters (1/8 teaspoon or 8 drops per gallon)
  - Cryptosporidium forms oocysts, making disinfection difficult
- Distillation, reverse osmosis, and filtering

Water Disinfection

- Municipal systems
- Hauled or bulk water
- Groundwater well

Drinking Water - Chlorine residual of not more than 2.0 mg/L or less than 0.2 mg/L

Disinfection Principles

- Need three pieces of information

Chlorine Disinfection Targets in Municipal Systems and Hauling Tanks

- Target (depending on holding time)
  - 50 ppm (California Environmental Health Disaster Field Manual)
  - 100–200 ppm (Handbook of Environmental Health)
  - 25–100 ppm (CDC)

Levels of Disinfectant for Community Water Systems

- 4.0 mg/L* is maximum residual disinfectant level
- Minimum trace levels are required at points of distribution throughout the system

*4.0 mg/L is noted as free chlorine levels

Community Water Systems
Chlorine Products for Disinfection

- Chlorine gas: 100%
- Calcium hypochlorite: 65% to 75%
- Sodium hypochlorite: 5.25% to 12.5%

Chloramines

- More stable and longer lasting than free Cl
- Typically used for maintaining disinfectant residual⁴ = longer disinfectant rate
- Lower concentrations of disinfection by-products
- More pleasing aesthetics, i.e., less taste, less odor

⁴ 4.0 mg/L is max residual disinfectant level
www.epa.gov/region9/water/chloramine.html

Water Disinfection Tablets

Hauled Drinking Water

- Large private (business) water systems
  - Source of water (treatment plant vs. hydrants)
  - Manifests showing source, disinfection test results
  - Storage tanks & hauling trucks: food grade?
  - Rechlorinating inside lodging facilities

Unapproved Tankers
Disinfection Exercise

Disinfection Principles
• Bleach, 5.25%:
• 1% solution = \( \frac{1 \text{ g solute}}{100 \text{ mL solvent}} = \frac{52,500 \text{ mg Cl}}{1 \text{ L}} \)

\[ 5.25\% = \frac{5.25 \text{ g Cl}}{100 \text{ mL}} \times \frac{1,000 \text{ mL}}{1 \text{ L}} \times \frac{1,000 \text{ mg}}{1 \text{ g}} = \frac{52,500 \text{ mg Cl}}{1 \text{ L}} \]

Disinfection Principles
Scenario:
• 1,000 gal hauling tank
• Target = 50 ppm
• Bleach, 5.25%

Disinfection Principles
• Calculate total Cl needed:
• \( 1,000 \text{ gal} \times 3.78 \text{ L/gal} \times 50 \text{ mg Cl} \)

\[ = \frac{189,000 \text{ mg Cl}}{1 \text{ L}} \]

Disinfection Principles
• Calculate amount of bleach needed:

\[ = \frac{189,000 \text{ mg Cl}}{52,500 \text{ mg Cl}} \times \frac{1 \text{ L}}{1 \text{ L}} \times \frac{1 \text{ gal}}{3.78 \text{ L}} = \frac{0.95 \text{ gal}}{1 \text{ gal}} \approx 1 \text{ gal} \]
Water Volume

For well or pipe capacity
• www.pages.prodigy.net/rich_demartile/files/pipe-vol.xls
For circular and rectangular tank volume
• www.sterilex.com/toolscalc.htm

Well and Pump Inspection

• Flood conditions at the well: flood water can carry large debris that could loosen well hardware, dislodge well construction materials, or distort casing
• Electrical system: do not turn on equipment until the wiring system has been checked by a qualified electrician, well contractor, or pump contractor
• Pump operation: pump (including valves and gears) will need to be cleaned of silt and sand

Well Seal

Drop pipe
Well casing
Screened vent pipe: inch minimum diameter
Conduit box
Top steel plate of well seal
Well casing
Rubber gasket sandwiched between two steel plates

Pumps

Chlorine Dosage

<table>
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<th>Desired Chlorine Concentration in Milligrams per Liter</th>
<th>1</th>
<th>5</th>
<th>25</th>
<th>50</th>
<th>100</th>
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<tr>
<td>1000</td>
<td>2,000</td>
<td>200</td>
<td>20</td>
<td>10</td>
<td>5.25% Household Bleach</td>
<td>3.6 fl oz (3/4 cup)</td>
</tr>
<tr>
<td>2000</td>
<td>5,000</td>
<td>500</td>
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<td>25</td>
<td>5.25% Household Bleach</td>
<td>10.5 fl oz (1-1/2 cups)</td>
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<td>7,500</td>
<td>750</td>
<td>75</td>
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<td>15.8 fl oz (2 cups)</td>
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<td>1000</td>
<td>100</td>
<td>50</td>
<td>5.25% Household Bleach</td>
<td>21.1 fl oz (3 cups)</td>
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<td>5000</td>
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<td>1250</td>
<td>125</td>
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<td>5.25% Household Bleach</td>
<td>26.4 fl oz (4 cups)</td>
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<tr>
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<td>1500</td>
<td>150</td>
<td>75</td>
<td>5.25% Household Bleach</td>
<td>31.7 fl oz (5 cups)</td>
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<td>7000</td>
<td>17,500</td>
<td>1750</td>
<td>175</td>
<td>87.5</td>
<td>5.25% Household Bleach</td>
<td>37.0 fl oz (6 cups)</td>
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<tr>
<td>8000</td>
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<td>2000</td>
<td>200</td>
<td>100</td>
<td>5.25% Household Bleach</td>
<td>42.3 fl oz (7 cups)</td>
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</tbody>
</table>

Video Presentation

Well Disinfection
Well Depth

- Average of well depths in area
  - Determined in advance?
- Measure depth?
  - A rule of
  - “Put a gallon of bleach in the well”???

(Discussion)

Cistern Disinfection Steps

- Thoroughly clean the catchment area (rooftop) and remove all debris
- Drain cistern completely
- Without entering tank, scrub the inside with a stiff brush or broom and solution of 1 cup (8 oz.) 5.25% unscented bleach in 10 gallons of water
- Refill cistern with rainwater or potable water
- Add 4 cups (32 oz.) per 100 gallons in the cistern (~100 ppm)

Cistern Disinfection Steps

- Run water through all home plumbing until you smell chlorine
- Let solution sit undisturbed for 24 hours
- Drain cistern completely
- Refill tank naturally or with potable water
- Flush all plumbing until chlorine odor is gone

Well Abandonment

Drilled wells (*check state guidelines)
- Remove pumps, piping, conduit, wiring, and any other obstructions
- Calculate water volume and disinfect well by adding chlorine at 0.5 oz/100 gal (65% Cl₂) or 7.0 oz/100 gal (5% Cl₂)
- Inject neat cement or bentonite grout into well, filling from the bottom to the top
- If using bentonite, fill the top 10 feet of casing with cement or concrete
- Fill to top of casing to create a concrete/cement plug

Bored wells (*check state guidelines)
- Remove plumbing, piping, and obstructions
- Calculate water volume and disinfect well by adding chlorine at 0.5 oz/100 gal (65% Cl₂) or 7.0 oz/100 gal (5% Cl₂)
- *Remove as much casing as possible
- Remove soil and other subsurface material to a depth of 3 feet and at least 1 foot wide around remaining casing
- Fill well to top of casing with cement, concrete, or bentonite grout
- Pour 1-foot-wide cement or concrete plug to ground surface around well casing
Water Sampling

Proper Sample Collection Techniques and Procedures

• Before sampling, have all of your supplies on hand, including:
  – Cooler for shipping and storage of sample
  – Ice for shipping cooler
  – PVC or Neoprene gloves
  – 125 mL sample bottle with sodium thiosulfate for chlorinated systems
  – Lab slips, labels, and markers
• Additional recommended items
  – Paper towels for drying off sample container
  – Plastic storage baggies for ice and sample container

Sample Collection (continued)

• Sampling containers
  • 125 mL sterilized plastic bottles most common
• Avoid using damaged sample containers
• Collecting a clean sample
  • Wash hands
  • Avoid smoking, eating
• Adhere to good sampling collection practices

Proper Sampling Techniques, TCR Coliform and E. coli

1. Sampling site selection
  – Approved sampling location as designated by your approved sampling site plan
  – Proper design of sampling faucets and/or specially installed sampling taps
2. Remove any aerator, strainer, or hose
3. Optional steps
  – Some sampling practices involve spraying the tap with a chlorine solution, or even flaming the tap

Proper Sampling Techniques (continued)

4. Turn on cold water and flush tap for 2–3 minutes
  • Reduce flow (no greater than ¼-inch diameter)
  • While water is running, fill out labels, tags, and laboratory forms
  • Apply labels to the container
  • Test for both chlorine and water pH; enter the results on your lab slip
5. Carefully remove the bottle cap: touch only outside surfaces
  • Position the bottle under the water flow
  • Hold the bottle in one hand and the cap in the other.
  • Fill bottle to about ¼ inch from the top or the 100-mL fill line

Proper Sampling Techniques (continued)

7. Cap sample container tightly
  • Blot sample container dry
  • If iced and shipped, bag separately to avoid contamination of the sample
8. Turn tap off; replace aerator, strainer, or hose
9. Check for correct label information
  • Check the laboratory form and attach it to the bottle with a rubber band; complete all additional laboratory forms
  • Follow lab instructions
Proper Sampling Techniques (continued)

IMPORTANT:
• Analysis must begin within 30 hours of collection.
• Samples should be refrigerated or cooled to below 10° Celsius (50° Fahrenheit).
• Use ice packs; deliver the samples if lab is close by
  – Tape the chest before shipping
  – Bag samples and ice separately
  – Copy forms if possible

Exercise

Water Sampling Equipment

Lab Test

• The most common test (Colilert) uses a reagent that changes color and/or glows, depending on the organisms present
  – Clear for no growth
  – Yellow for total coliforms only
  – Fluorescence for E. coli

Fluorescence

What You See

• Lab results form ——
  – Contain things such as
    • System ID
    • Date and time of sampling
    • Sampling type
    • Reason for sampling
• Bacterial results appear here on this form

How to Interpret the Form

• In the example below
  – Sample 1 tested negative for both organisms
  – Sample 2 had total coliforms present
  – Sample 3 had both total and fecal coliforms present (fecal=acute MCL violation)
How to Interpret the Form

- Sample 1 (well)
  - No further action needed
- Sample 2 and 3 (taps)
  - Both sites are unsatisfactory, can be declared unfit to drink, and will need to be resampled
  - This resampling should be done according to SDWA Total Coliform Rule sampling plan or other emergency guide

Maximum Contaminant Levels

- Each organism has its own MCL*
  - Total coliforms
    - A MCL violation = present in any compliance sample and repeat sample
  - Fecal coliforms
    - A MCL violation = present in any compliance or repeat sample
    - Also, coliforms must be present in repeat sample

* MCL = Maximum Contaminant Level

Coliform Occurrence

- Treatment breakthrough
- Source positive
- Disinfection failure
- Filter malfunction
- Open storage
- Residual maintenance
- Regrowth

- Intrusion
- Cross connection
- Backflow
- Main repairs
- Main breaks
- Colonization

Coliform Survival/Growth Variables

- Water temperature
- Disinfection type and residual
- Pipe corrosion and corrosion control
- Debris accumulation
- Nutrients, AOC, BOM
- Hydraulics, residence time

Disaster Boil Water Notices

- Preparation before disaster is critical
- Water systems and public need advice
- Agencies need to coordinate issue/rescind
- Ready for overlapping jurisdictions

Before Boil Water Notice

- Preparation before disaster is critical
- Letters to all public water systems instructing them of regulatory duties and liabilities long before event
- Provide agency emergency contact lists
- Rule requirements take time; are useful
- Public outreach info from PWS and agencies before event
- Media outreach materials, before and after
**Before Boil Water Notice**

- Coordination with food regulators, food service, and processors before event
- Planning for critical medical (hospitals, dialysis)
- EOC/ESF-8 briefings at state and county
- Web post media/public info year round
- Discuss with and train all environmental staff

**What To Expect During A Boil Water Notice**

- Expect power loss in impacted area; therefore communication gaps for days +
- Expect bottled water to be primary source for most people
- Expect deviations from the boil water notice protocols
- Public water systems may not abide by BWN guidelines; mayors, commissioners, administrators, water plant supervisors, owners will take charge to shortcut bureaucracy, usually with safe results

**What To Expect During A Boil Water Notice**

- Limited media info to the public afterward
- Comfort stations, shelters, and other official aide sites may be best information outreach locations
- Not all needed persons will be available due to damage or other reasons (especially weekends)
- Larger utilities are fairly self sufficient – often have mutual aid compacts with other jurisdictions
- This is not true for small systems - contract operators may be overwhelmed or unavailable

**Boil Water Notice: Issue/Rescind**

- BWN can be issued by PWS, health authority, primacy agency, EOC
- Should be lifted by issuing agency only after
  - repairs are completed
  - adequate pressure throughout system
  - safe residual chlorine throughout system
  - low turbidity (esp. for surface water)
  - satisfactory bactis, number based on needs
  - can be lifted in hydraulically discernable areas

**Fuel and Other Chemical Contamination**
Fuel and Chemical Contamination

Fuel/Chemical Sampling

After floods, if fuel or chemical contamination is probable, lab tests are warranted for:

- Total petroleum hydrocarbons (EPA 503.1)
- Benzene, toluene, ethyl benzene, xylene
- Volatile organic compounds (VOCs) (EPA 502.1, 524.1)
- Pesticide scans (EPA 504, 505)
- Metals: lead
- Inorganics: arsenic

Organic Samples

Volatiles will escape if aerated during sampling process

- Remove aerator from spigot
- Run water at least 5 minutes
- Hold bottle at angle to reduce aeration
- Fill bottle completely
- Invert bottle to check for bubbles
- If bubbles are present, pour out and retake sample
- Self deliver or send overnight mail

References

- CDC’s Emergency Preparedness and Response; Natural Disasters & Severe Weather site - www.bt.cdc.gov/disasters
- City of Pensacola; Post-Disaster Recovery and Redevelopment - http://escambia-emergency.com/Local_Mitigation/LMSdraftupdate/E-MitigationPlan/CityofPensacolaPostDisaster/PostDisasterRedevelopment.pdf
- EPA - Private Drinking Water Wells: Drilled Wells - http://www.epa.gov/privatewells/basic_drilled.html
- EPA Region 8: Chloramines - www.epa.gov/region9/water/chloramine.html
- EPA’s Ground Water and Drinking Water; Emergency Disinfection of Drinking Water site – www.epa.gov/safewater/faq/emerg.html
- Florida Department of Health - http://www.doh.state.fl.us/
- For circular and rectangular tank volume www.sterilex.com/toolscalc.htm
- Inspectapedia; Groundwater Pollution Sources of Drinking Water from Household Wells - http://www.inspect-ny.com/water/EPADrink.htm
- Missouri Department of Health and Senior Services; Disinfection of Contaminated Wells and Cisterns - http://www.dhss.mo.gov/Lab/EnvBact/lab-15D.pdf
- National Rural Water Association: http://www.nrwa.org/
- Public Health; Seattle & King County Drinking Water Program: Springs - http://www.metrokc.gov/health/water/springs.htm
- University of South Florida Private Inspectapedia: www.bt.usf.edu
- Volume Calculator for well or pipe capacity - http://pages.prodigy.net/rich_demartile/files/pipe-vol.xls
Questions?