Total Coliform and Distribution System Rules: Where are we Headed?
Virginia – AWWA Research Committee

Design, Operation and Maintenance of Distribution Systems to Address Public Health Risks

October 22, 2007

Presented by
Gregory J. Kirmeyer, P.E.
National Director, Drinking Water
425.450.6291 G.Kirmeyer@hdrinc.com
Kylee M. Dewis
Water Quality Specialist
425.450.6276 kylee.dewis@hdrinc.com

HDR
ONE COMPANY | *Many Solutions*®
500 108th Avenue NE, Suite 1200 425-450-6200
Bellevue, Washington 98004 www.hdrinc.com

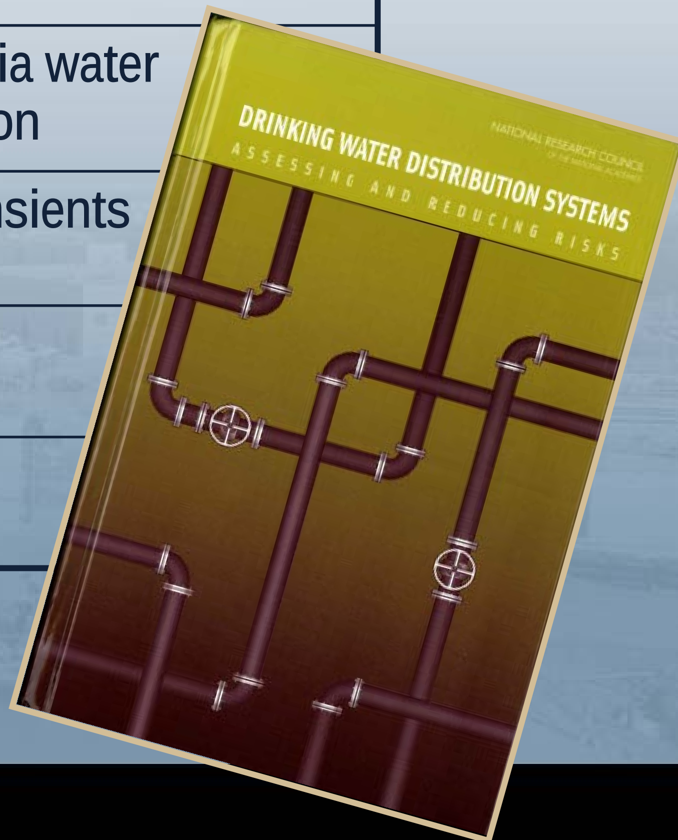
Public Health Protection
Multiple Barrier Approach

Traditional Barrier		Current/Emerging Barriers
1. "Source" Selection (Best)	→	Water Re"Source" Protection
2. Filtration (Microbes)	→	Filtration (Microbes and Chemicals)
3. Disinfection (Chlorination)	→	Disinfection (and Minimize By-Products)
4.	→	Distribution System MOM
5.	→	Staff Training and Certification

Prioritizing Risk

“Public Water Distribution Systems – Assessing and Reducing Risks”*

High Priority	Medium Priority
Cross connection & back flow	Biofilm growth
New and repaired water mains	Loss of residual via water age and nitrification
Finished water storage	Low pressure transients and intrusion
Premise Plumbing	
Operator Training	



*National Research Council, September 2006

Current Risk Minimization Techniques

Strategies to minimize risk

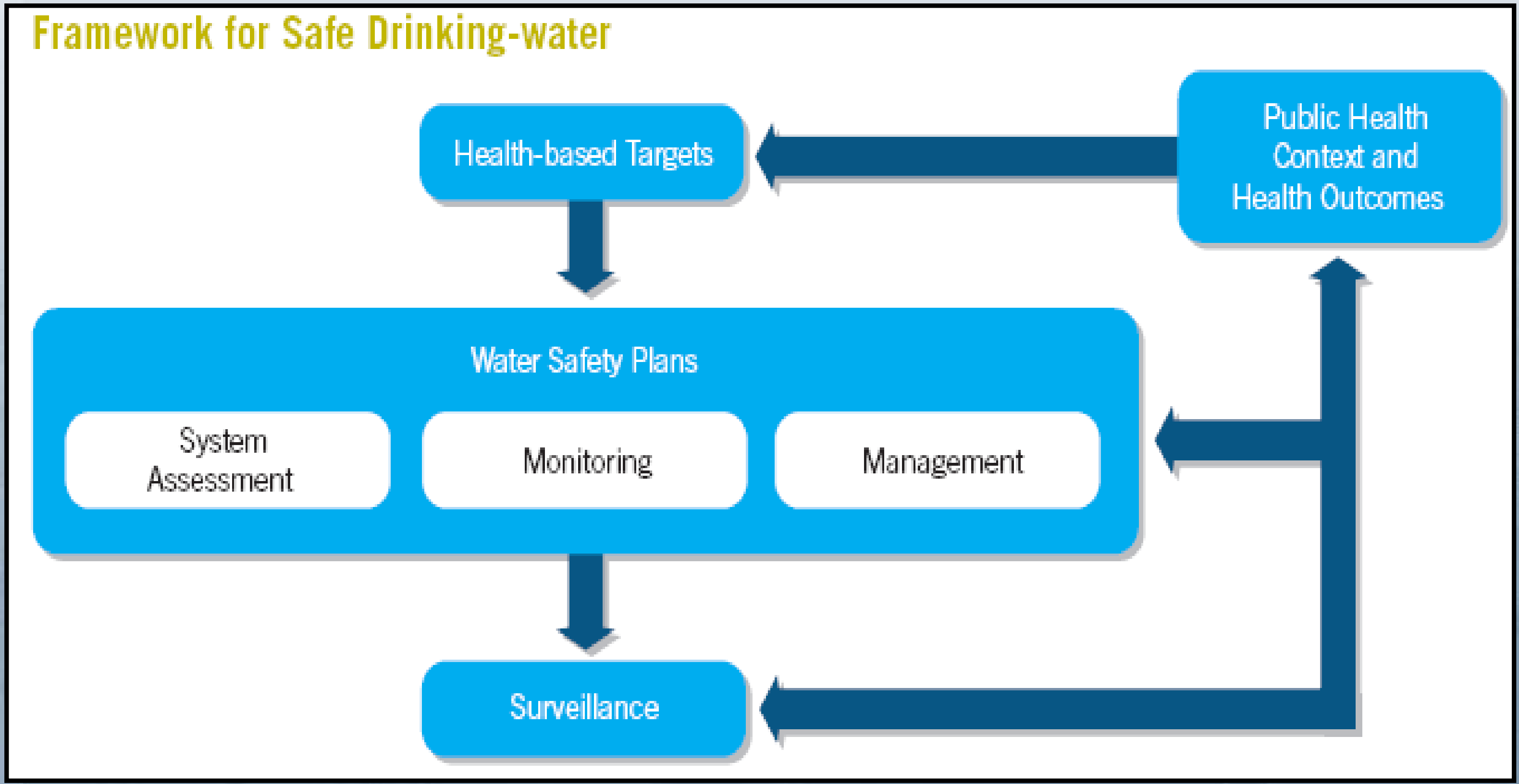
- Water Quality Management Approaches
- Water Treatment-Water Entering System
- Maintaining a Disinfectant Residual
- System Design, Construction and Materials
- System Operations and Maintenance
- Sensors and Monitoring Devices

Water Quality Management Approaches:

- Water Safety Plans
- ISO 14001
- DSOP (Distribution System Optimization Plans)
- AWWA Standard G200-04

Water Safety Plans (WSPs)

- Comprehensive risk management and risk assessment approach – source to tap – that consists of three main components:



WHO., 2006. Guidelines for drinking-water quality, third edition, incorporating first addendum.
Breach, B. and T. Williams. 2006. The Pivotal Role of Water Safety Plans. Accessed: 01/11/2007
http://www.iwahq.org/templates/ld_templates/layout_633184.aspx?ObjectId=644058

Water Safety Plans (WSPs)

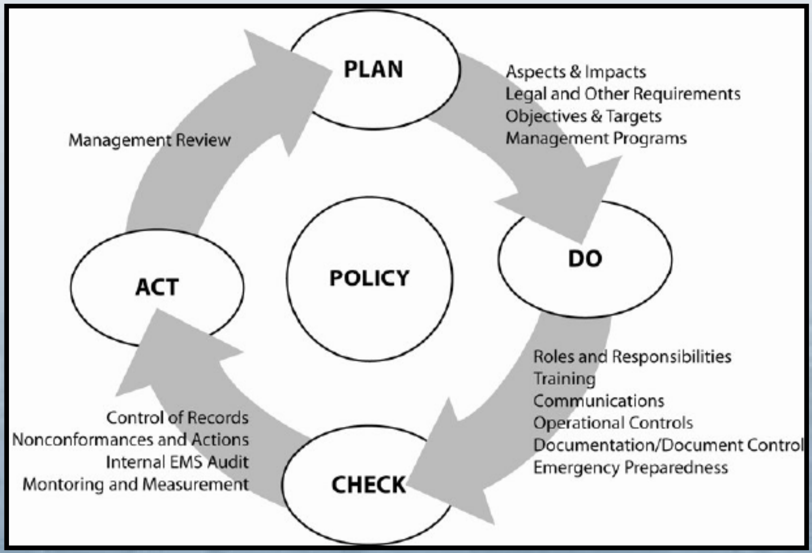
- Uses the Multi-barrier approach and other water quality management tools as the building blocks for the WSP
- Key element of the Bonn Charter for Drinking Water and WHO (World Health Organization) Guidelines for Drinking Water Quality

- National regulators in Portugal, England and Wales are actively promoting WSPs for utilities in their jurisdictions
- New Zealand will require WSPs by 2013 for all drinking water systems serving population >25 persons

WHO., 2006. Guidelines for drinking-water quality, third edition, incorporating first addendum);
Breach, B. and T. Williams. 2006. The Pivotal Role of Water Safety Plans. Accessed: 01/11/2007
http://www.iwahq.org/templates/ld_templates/layout_633184.aspx?ObjectId=644058

ISO 14001- What is it?

- Voluntary environmental management system standard that has been adopted by many organizations across the globe, including in the USA
- Consists of 17 elements that form a PLAN, DO, CHECK, ACT framework.



(AwwaRF, 2006)

AwwaRF, 2006. Environmental Management Systems: A Tool to Help Utilities Manage More Effectively. AwwaRF and USEPA. Denver, CO.

ISO 14001: Case Study – Distribution System

- Charleston, SC implemented ISO 14001 and was certified in 1999.
- Benefits related to the ISO14001 implementation:
  - Identified and addressed gaps in emergency procedures: *"We discovered first-hand how important and beneficial these procedures were during a major transmission main failure, which occurred a few weeks after the emergency plan was approved."*
  - Better targeting of improvement projects including a unidirectional flushing program, corrosion control program and valve and hydrant replacement programs

Oberoi, K. and R. Bickerstaff. ISO 14001 Registration for Water Distribution Operation, Charleston SC Experience. http://www.charlestonwater.com/downloads/iso14001_certification_paper.pdf Accessed: 01/11/2007

Distribution System Water Quality Optimization Plan (DSOP)

- A plan for maintaining water quality throughout the distribution system
- A working document that organizes and integrates all policies and programs affecting water quality in the distribution system
- Identifies a utility's strengths and areas that need improvement, with a focus on water quality
- Develops a road map and short and long term goals for future activity
- Provides documentation of plans and procedures

DSOP: Approach

1. System Review
2. Compare to Industry BMPs
3. Develop Work Plan
4. Carry Out Work Plan (may include field work)
5. Prepare DSOP

DSOP: Case Study - Flushing

- “System # 2” typically conducted flushing for routine maintenance and in response to water quality enquiries
- A planned unidirectional flushing (UDF) program was evaluated and found not to provide additional benefit over existing utility programs on distribution system water quality
- The utility saved money by not investing in programs of little real benefit

Friedman, M., G. Kirmeyer, G. Pierson, S. Harrison, K. Martel, A. Sandvig and A. Hanson. 2005. Development of Distribution System Water Quality Optimization Plans. AwwaRF and AWWA Denver, CO.

AWWA Standard:
G-200.04 –Distribution Systems Operation and Management

- The AWWA Standard G-200.04 goes above and beyond regulations and defines the critical requirements for the operation and management of water distribution systems including:
  - Maintenance of Water Quality
  - System Management Programs
  - Operation and Maintenance of Facilities
  - Improved data management
- The AWWA standard can integrate directly with DSOP

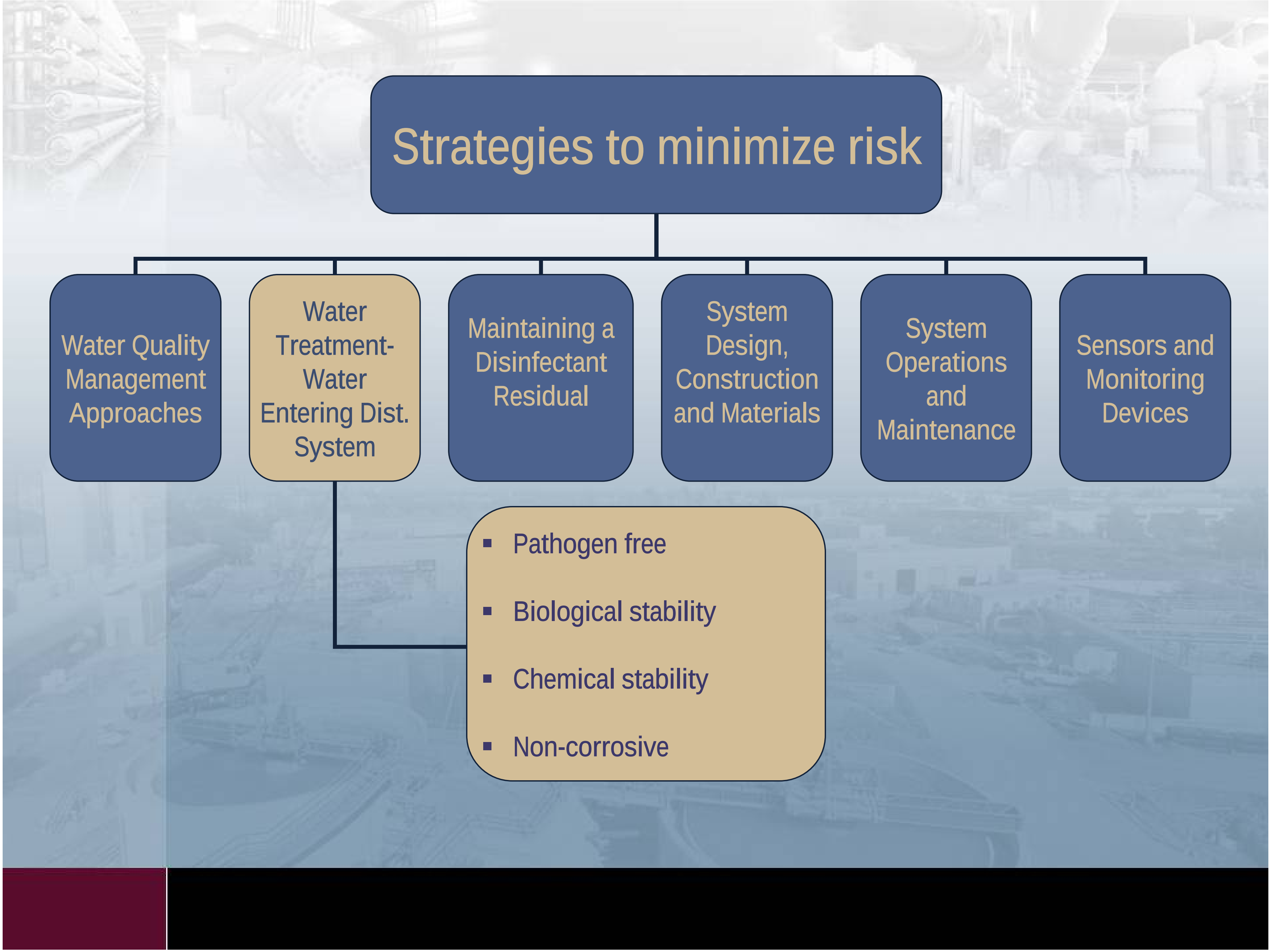
AWWA Standard G-200.04: Case Studies – Distribution Systems

- Pilot studies for evaluating the AWWA Standard were conducted in Abingdon VA and Birmingham AL
- Utilities identified benefits:
  - "Improve utility processes overall"
  - "Could help in an area of a utility that is typically not impacted by lots of regulations"
  - "Provides a continuous improvement framework that could transcend time.."
  - "…capture the vast amount of institutional knowledge that exists in our very experienced staff and use that knowledge to sustain and improve the level of service we provide"

Ginley, Jim. - American Water Works - Personal communication 01/09/2007 - Abingdon Workshop Summary Aug 14-17, 2005.

Water Quality Management Approaches: Summary and Status – Presenter's Opinion

- Many well-run utilities have a defined water quality management plan or are already implementing most of the Good Management Practices
- Some aspects are missing
- For many documentation inadequate or lacking
- Others have a piecemeal approach and could benefit from the structure of a defined water quality management approach – especially for distribution system


Strategies to minimize risk
Water Quality Management Approaches
Water Treatment- Water Entering Dist. System
Maintaining a Disinfectant Residual
System Design, Construction and Materials
System Operations and Maintenance
Sensors and Monitoring Devices
Pathogen free
Biological stability
Chemical stability
Non-corrosive

Desire Pathogen Free

- Water entering the distribution system:
  - Needs to be pathogen-free
  - Primary disinfection should be robust
  - Continuous disinfection – no lapses in treatment
  - Residual disinfectant should be the appropriate type and at an adequate level
- Need to prevent pathogens from seeding the distribution system
- Management Practice – Water Treatment

Desire Biological Stability

- **During treatment** bacterial growth in the distribution system can potentially be reduced by
  - Removal of bacterial nutrients (AOC, BDOC, TOC)
- **In the distribution system** disinfectant decay rates can be reduced by removal of natural organic matter at the water treatment plant

Kirmeyer, G., M. Friedman, K. Martel, D. Howie, M. Lechevallier, M. Abbaszadegan, M. Karim, and J. Funk. 2001. Pathogen Intrusion Into the Distribution System. AwwaRF. Denver, CO.

Desire Chemical Stability

- Iron, manganese, sulfides, and other inorganics oxidized by chlorine (exert chlorine demand) may need to be removed via treatment
- Chemical stability facilitates maintenance and form of residual we want
- Free chlorine contact enhances the stability of chloramines (EBMUD example) in the distribution system

Desire Non-corrosive

- Aim to control or slow down corrosion of iron because:
  - Corrosion process consumes chlorine (i.e. depletes the residual)
  - Source of nutrient for bacterial growth
  - Contributes to particulates in the distribution system
  - Tubercles and corrosion scales can provide media for biological growth
- Risk Reduction - corrosion control treatment

Water treatment- Water Entering the Distribution System: Summary and Status – Presenter's Opinion

- Pathogen free / primary disinfection – advanced
- Biological /Chemical Stability – in process
- Corrosion Control – continuing issue for many - more art than science

Strategies to minimize risk

- Water Quality Management Approaches
- Water Treatment- Water Entering System
- Maintaining a Disinfectant Residual
    - Maintaining a Residual
    - Switching From Free to Combined Chlorine
- System Design, Construction and Materials
- System Operations and Maintenance
- Sensors and Monitoring Devices

Maintaining a Disinfectant Residual

- Free chlorine and chloramines used for residual disinfection to maintain distribution system integrity by:
  - Inactivation of microorganisms
  - Controlling biofilm growth
  - Potentially serving as an indicator of distribution system integrity problems

Entire White Paper on Subject

HDR and Cadmus. 2006. The Effectiveness of Disinfectant Residuals in the Distribution System. Draft December 2006.

Chloramines

- There are dozens of case studies on utilities using chloramines or undergoing a change to chloramines.
  - Advantages
    - Chloramines generally are less reactive and more stable, form less “Regulated DBPs” and can help maintain a residual throughout the distribution system
    - Utilities that have experienced re-growth find chloramines effective at inactivating and slowing microbial growth
  - Disadvantages
    - Potential increase in nitrification due to ammonia
    - Chloramines must be removed before water used for kidney dialysis patients, aquatic life
  - Need to be aware of other less well known changes – redox potential

Strategies to minimize risk

- Water Quality Management Approaches
- Water Treatment- Water Entering System
- Maintaining a Disinfectant Residual
- System Design, Construction and Materials
  - AWWA Standards
  - 10 State Standards
  - State design standards
  - ANSI/NSF Standards
  - Pipeline construction
  - Physical security measures
- System Operations and Maintenance
- Sensors and Monitoring Devices

AWWA Standards

- Widely used voluntary consensus standards
- Adopted and made mandatory by some utilities or regulatory agencies
- 116+ standards developed and/or maintained since 1908
- Cover products (e.g. valves, pipes, meters, chemicals) and procedures (e.g. pipe installation, disinfection, filtration media)
- Many of the standards are oriented towards reducing risk to public health

AWWA. 2006. http://www.awwa.org/Communications/awwastds.cfm). Accessed 01/08/2007.

AWWA Standards

AWWA Standards are minimums and must be supplemented by Tailored Specifications for each Project

10-state standards

- Recommended Standards for Water Works
- Developed by Great Lakes-Upper Mississippi River Board of State Sanitary Engineers
- Guide to design and plan / specifications preparation for public water systems
- Several elements related directly to distribution system
  - Part 2 General Design Considerations
  - Part 7 Finished Water Storage
  - Part 8 Distribution System Piping and Appurtenances

Great Lakes Upper Mississippi River Board of State and Provincial Public Health and Environmental Managers. 2003. Recommended Standards for Waterworks.

10-State Standards: Example

- Interim Standards
  - NITRATE REMOVAL USING SULFATE SELECTIVE ANION EXCHANGE RESIN
  - USE OF CHLORAMINE DISINFECTANT FOR PUBLIC WATER SUPPLIES
- Recommended Standards
  - PART 1 - SUBMISSION OF PLANS
  - PART 2 - GENERAL DESIGN CONSIDE[R
  - PART 3 - SOURCE DEVELOPMENT
  - PART 4 - TREATMENT
  - PART 5 - CHEMICAL APPLICATION
  - PART 6 - PUMPING FACILITIES
  - PART 7 - FINISHED WATER STORAGE
  - PART 8 - DISTRIBUTION SYSTEM PIPIN[
  APPURTENANCES
  - PART 9 - WASTE RESIDUALS

DISTRIBUTION SYSTEM PIPING AND APPURTENANCES

- 8.0 GENERAL
- 8.1 MATERIALS
- 8.2 SYSTEM DESIGN
- 8.3 VALVES
- 8.4 HYDRANTS
- 8.5 AIR RELIEF VALVES
- 8.6 VALVE, METER AND BLOW-OFF CHAMBERS
- 8.7 INSTALLATION OF WATER MAINS
- 8.8 SEPARATION DISTANCES FROM CONTAMINATION SOURCES
- 8.9 SURFACE WATER CROSSINGS
- 8.10 CROSS-CONNECTIONS AND INTERCONNECTIONS
- 8.1
- 8.1
- 8.1

8.8.2 Parallel installation

a. Water mains shall be laid at least 10 feet horizontally from any existing or proposed gravity sewer, septic tank, or subsoil treatment system. The distance shall be measured edge to edge.

b. In cases where it is not practical to maintain a 10 foot separation, the reviewing authority may allow deviation on a case-by-case basis, if supported by data from the design engineer.

Great Lakes Upper Mississippi River Board of State and Provincial Public Health and Environmental Managers. 2003. Recommended Standards for Waterworks.

State Design Standards

- Many elements related to reducing risk to **public health**
- Often incorporate other voluntary standards such as 10-State Standards by reference
- Typically advise conformance with industry standards such as AWWA, ASCE and APWA
- May require conformance with local Uniform Building Code, Uniform Plumbing Code

ANSI / NSF Standards

- Certification standards oriented towards "**public health**"
- Developed by a consortium of stakeholders led by NSF and adopted by ANSI (American National Standards Institute) and known as ANSI/NSF standards
  - ANSI/NSF Standard 60 covers water treatment chemicals
  - ANSI/NSF Standard 61 covers system materials in contact with water (e.g.. coatings, construction materials etc.)
  - Other ANSI/NSF standards for product performance

AWWA. 1995. Principles and Practices of Water Supply Operations. Water Treatment. Denver, CO.

Water Science and Technology Board, National Research Council of the National Academies Press. 2006. Drinking Water Distribution Systems: Assessing and Reducing Risks. Washington DC, 2006.

ANSI / NSF Standards

- Manufacturers of components designed to be in contact with water must be submitted to NSF International or qualified laboratory for approval plus subject to periodic testing and process inspections.
- Provide assurance that products meet defined standards e.g. leaching

AWWA. 1995. Principles and Practices of Water Supply Operations. Water Treatment. Denver, CO.

Water Science and Technology Board, National Research Council of the National Academies Press. 2006. Drinking Water Distribution Systems: Assessing and Reducing Risks. Washington DC, 2006.

ANSI / NSF Standards: Case Study – Seattle Public Schools

Table 1. Estimated range of lead contributions from end-use plumbing components.

Component or Fitting	Exposed Volume (mL)	Laboratory Measured Pb (µg/L)[a,b]		Calculated Mass of Pb (µg)		Estimated Pb Concentration in 250-mL Sample (µg/L)[c]	
		Worst Case	Typical	Worst Case	Typical	Worst Case	Typical
Brass bubbler head w/ stainless steel nipple (Type A)	10	60	10	0.6	0.1	2.4	0.4
Stainless steel bubbler head (Type B)	1.3	33	10	0.04	0.01	0.17	0.05
Flex connector w/ brass ferrule ends, 18" long	33	250	15	8.25	0.5	33	1.98
Brass elbow connector	3	1400	200	4.2	0.6	16.8	2.4
Brass shut-off valve	2	500	100	1.0	0.2	4.0	0.8

Notes: a) Sample concentrations are based on measured values in the exposed volume from laboratory testing.
b) Analytical detection limit was 5 µg/L.
c) Assumes that the resulting Pb concentration in a 250 mL sample is from that particular component only, where the concentration in a 250-mL sample = (exposed volume) × (measured Pb concentration in exposed volume) / (250).

Boyd, G., G. Pierson, M.Britton, R. English. 2006. Pb-Release From end-use Plumbing Components. Proc. AWWA WQTC Nov. 5-9, 2006. Denver, CO.

Pipeline Construction

- Construction/repair activities are often not well-controlled with respect to good sanitary practices.
- 40% of managers identified unsanitary construction practices as a primary cause of microbial contamination

Haas, C.N., R.B. Chitluru, M. Gupta, W.O. Pipes, and G.A. Burlingame. 1998. Development of Disinfection Guidelines for the installation and replacement of water mains. Denver, CO. AwwaRF.

Case Study – Philadelphia Water

- Survey of 46 Philadelphia, PA construction inspectors found sanitary problems were common before and during installation

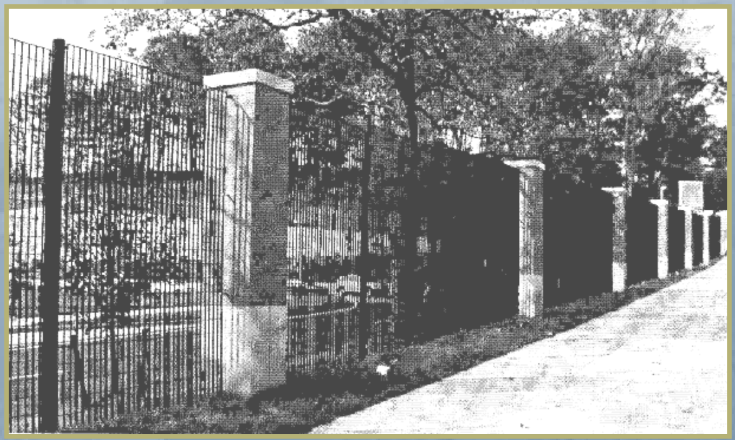
	Percent of Responses (%)			
	Common	Sometimes	Rare	Never
Environmental dirt gains entry into pipe:	53	43	4	0
Street runoff gains entry into pipe:	30	61	9	0
Trash gains entry into pipe:	24	56	15	3
Vandalism:	1	35	41	9
Pipe is delivered contaminated:	4	33	59	4
Animals gain entry into open pipe:	0	11	63	26
Dead animal found in open pipe:	0	4	52	44

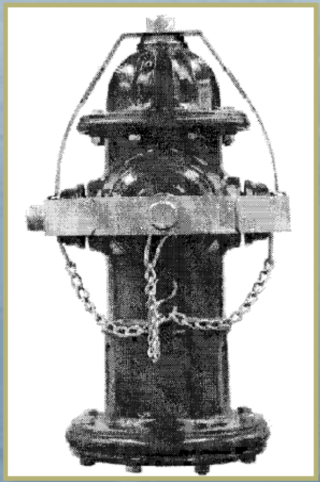
Pierson, G., K. Martel, A. Hill, G. Burlingame, A. Godfree. Practices to Prevent Microbiological Contamination of Water Mains. AwwaRF. Denver, CO.

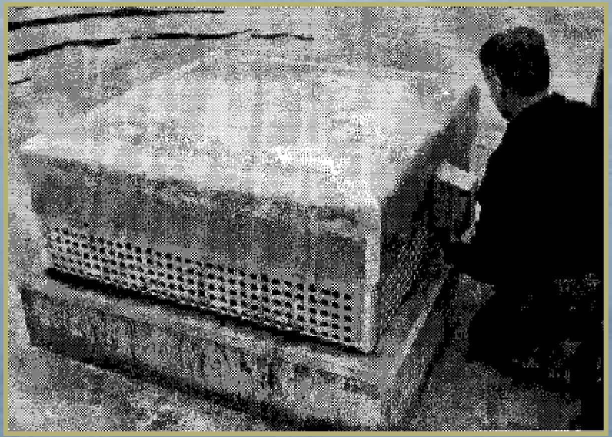

Poor Practices
risk reduction
Best Management Practices

Physical Security Measures in the Distribution System

- Physical security more prominent issue after September 11, 2001
- Public Health Security and Bioterrorism Preparedness and Response Act (June 2002) required vulnerability assessment and emergency plans for utilities with pop. >3,300





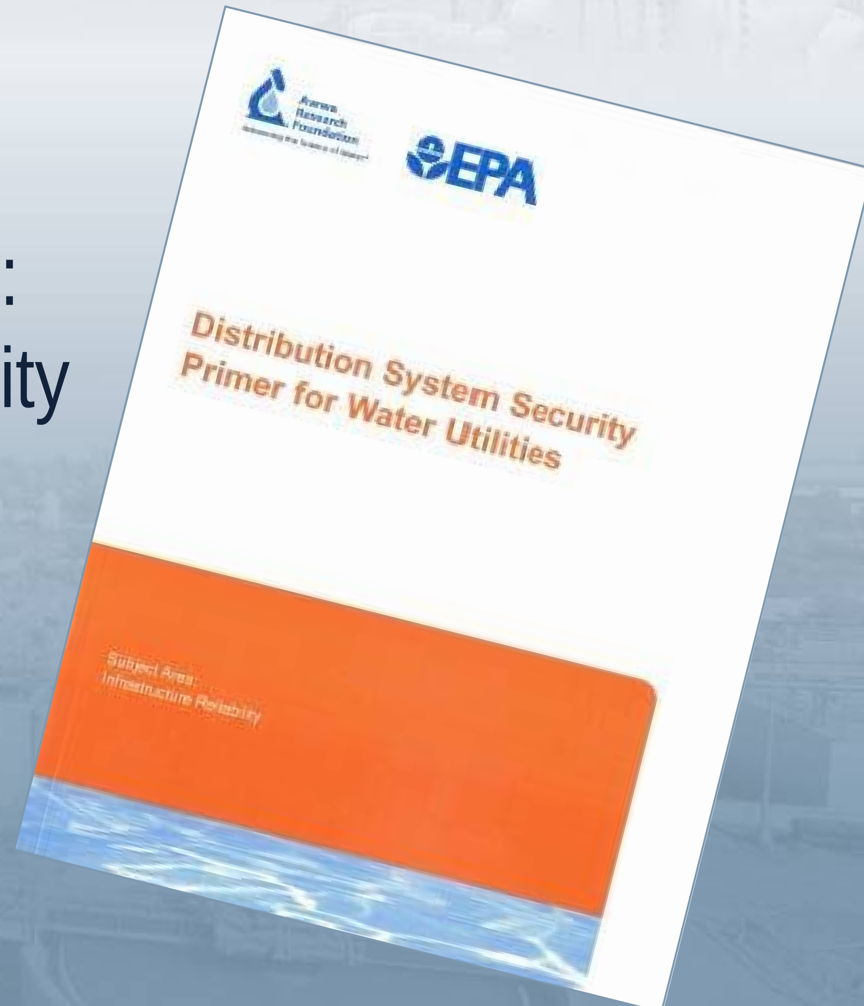


Murphy, B. L. Radder, G. Kirmeyer. 2005. Distribution System Security Primer for Water Utilities. AwwaRF report #91066F. Denver, CO.

Water Science and Technology Board, National Research Council of the National Academies Press. 2006. Drinking Water Distribution Systems: Assessing and Reducing Risks. Washington DC, 2006.

Physical Security Measures in the Distribution System

AwwaRF Report #91066F: Distribution System Security Primer for Water Utilities is a good starting point.



Steve Allgeier, EPA will address Security in more detail

System Design, Construction and Materials: Summary and Status – Presenter's Opinion

- Standards for design, construction and materials for utilities are well developed.
- Start to finish barriers needed for new pipeline construction activities-not just flushing, disinfection, and sampling.
- Need review of ANSI/NSF standard for end-use plumbing components (consider reducing lead content)
- Plumbing codes content and enforcement capability need review and strengthening esp. jurisdictional issues.

Strategies to minimize risk

- Water Quality Management Approaches
- Water Treatment-Water Entering System
- Maintaining a Disinfectant Residual
- System Design, Construction and Materials
- System Operations and Maintenance
- Sensors and Monitoring Devices

System Operations and Maintenance

- Pressure maintenance and monitoring *
- Cross connection control
- Hydraulic modeling
- Repairs to pipes, disinfection and release
- Water main flushing
- Storage facility inspection, operation and maintenance
- Security Operations*

* only covered briefly here - addressed by other presenters

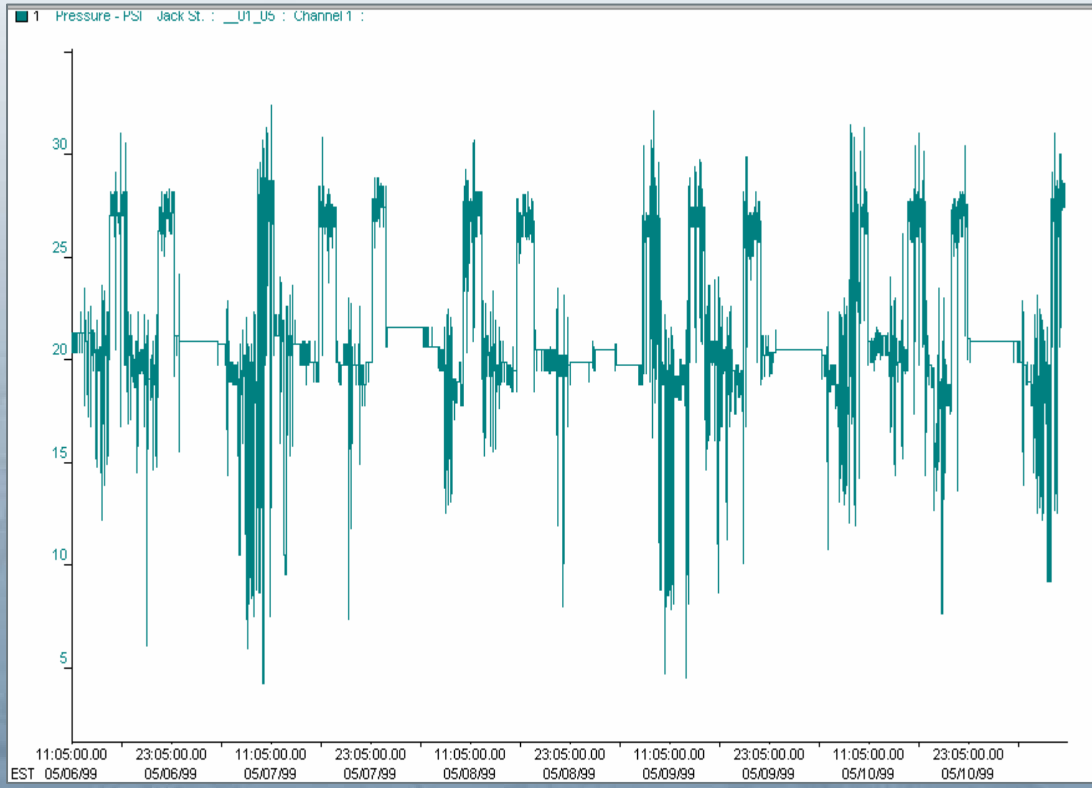
Pressure Maintenance and Monitoring

- Adequate pressure continuously is one of the most important risk minimization methods
- Backflow events cause 78% of documented distribution system illness outbreaks and most cases of illness
- Pressure transients can be short-lived and difficult to monitor

USEPA. 2001. TCR Issue Paper: Potential Contamination due to Cross-Connections and Backflow and the Associated Risks. Office of Ground Water and Drinking Water. Washington, DC.

Pressure Maintenance and Monitoring

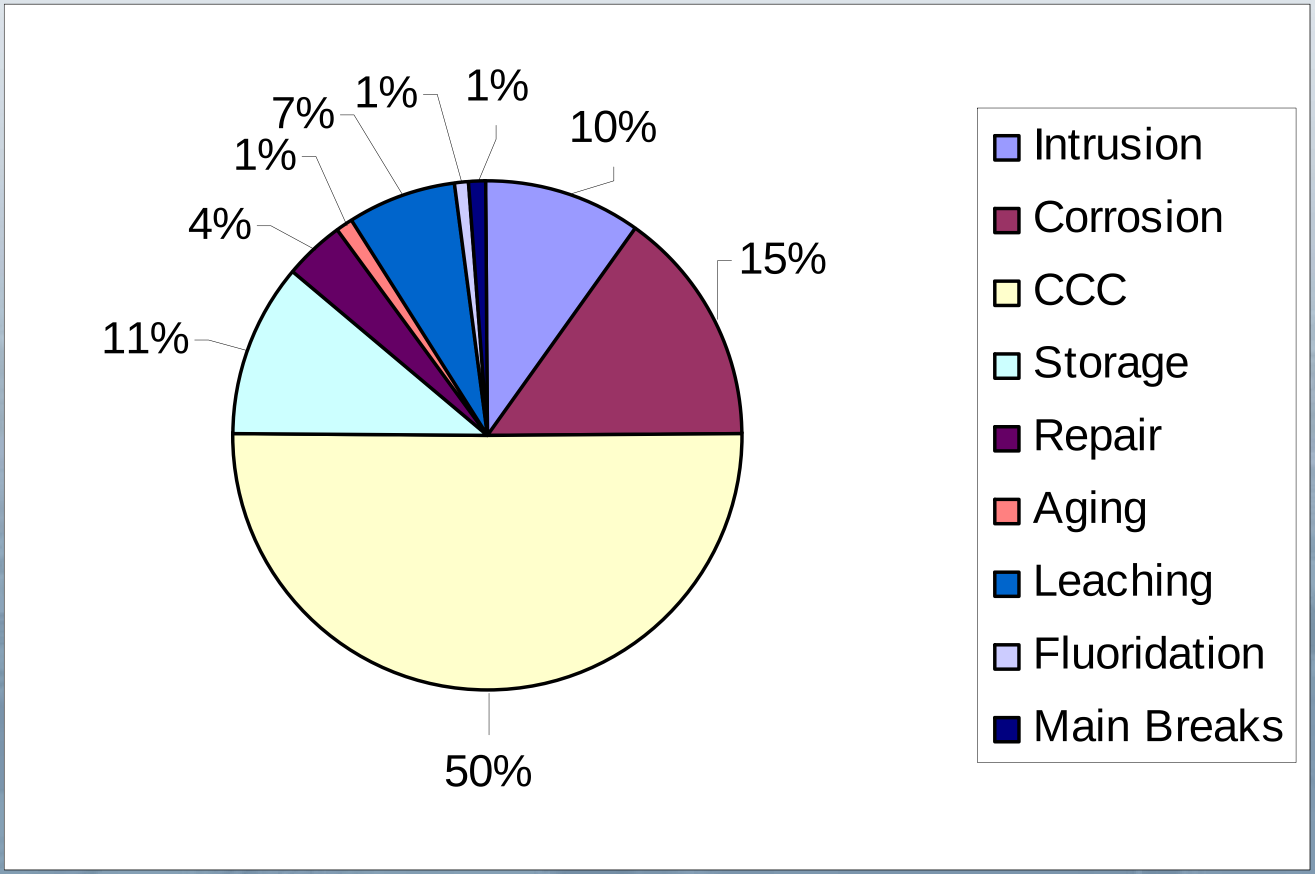
This section was covered by Kala Fleming, American Water



Pressure transients measured at a hose bib outside a residence

Why Likely EPA Focus on Cross-Connections in Next Round of Rule Making?

Causes of Distribution System Outbreaks, 1981 - 2002



Hydraulic Modeling

- Computer simulation can be used to identify areas of:
  - Low pressures
  - High water age
  - Low chlorine residual
- Modeling can also be used to locate or track contaminant source

Water Science and Technology Board, National Research Council of the National Academies Press. 2006. Drinking Water Distribution Systems: Assessing and Reducing Risks. Washington DC, 2006.

Hydraulic Modeling Case Study

- Cincinnati, OH conducted modeling for IDSE and gained valuable operations knowledge:
  - " More appropriate placement of Stage 2 (disinfection byproduct) monitoring sites"
  - "Better understanding of system"
  - "Oldest water not necessarily most distant"
  - "More data sources = better decision"

Swertfeger, J., D. Hartman, P. Herlinger, B. Fromme. 2006. Using Hydraulic Modeling to Perform the IDSE: A case study. Presented at Safe Drinking Water Act Seminar, Nov. 2006. http://www.ohiowater.org/oawwa/ . Accessed: 01/10/2007.

Repairs to Pipes, Disinfection and Release

- External conditions during pipe repair provides potential for direct contamination of distribution system.
- Construction, rehabilitation, repair of water mains are extremely common activities
- Over 237,600 breaks per year in US

Kirmeyer, G., W. Richards, and C.D. Smith. 1994. An Assessment of Water Distribution Systems and Associated Research Needs. Denver, CO: AWWARF.

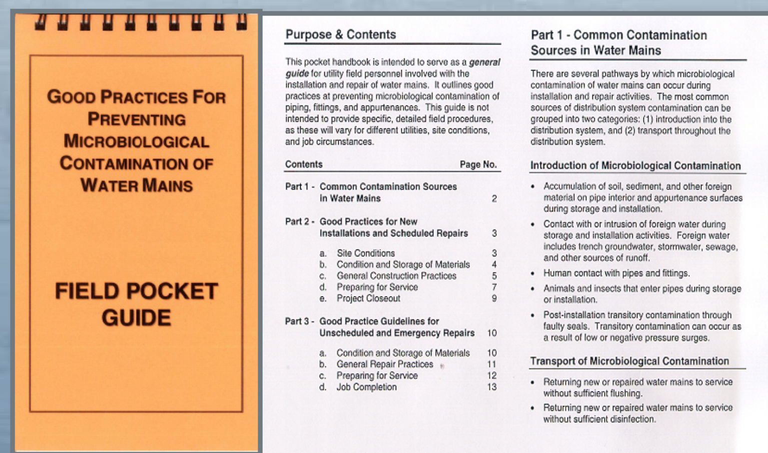
Philadelphia Case Study - during installation

	Percent of Responses (%)			
	Common	Sometimes	Rare	Never
Broken service line fills trench with water:	46	39	13	3
Rainwater runoff gets into the trench:	20	60	20	0
Dirt from trench gains entry into pipe:	24	37	35	4
Spill from street contaminates trench:	4	42	50	4
Sewage contaminates trench:	0	6	56	38

Pierson, G., K. Martel, A. Hill, G. Burlingame, A. Godfree. Practices to Prevent Microbiological Contamination of Water Mains. AwwaRF. Denver, CO.

Repairs to Pipes, Disinfection and Release Preventive Strategies

- Follow AWWA Standards:
  - C600 – Pipe storage and handling during construction
  - C651 – Construction & Disinfection Practices
- Establish Release to Service Criteria- Case Study Cincinnati, OH
- Document Release to Service – 80% of utilities surveyed don't maintain a water quality database for new main construction and breaks - (Haas *et al*., 1998)
- Ensure field staff training covers these strategies


GOOD PRACTICES FOR PREVENTING MICROBIOLOGICAL CONTAMINATION OF WATER MAINS

FIELD POCKET GUIDE

Purpose & Contents

This pocket handbook is intended to serve as a ***general guide*** for utility field personnel involved with the installation and repair of water mains. It outlines good practices at preventing microbiological contamination of piping, fittings, and appurtenances. This guide is not intended to provide specific, detailed field procedures, as these will vary for different utilities, site conditions, and job circumstances.

Contents	Page No.
Part 1 - Common Contamination Sources in Water Mains	2
Part 2 - Good Practices for New Installations and Scheduled Repairs	3
a. Site Conditions	3
b. Condition and Storage of Materials	4
c. General Construction Practices	5
d. Preparing for Service	7
e. Project Closeout	9
Part 3 - Good Practice Guidelines for Unscheduled and Emergency Repairs	10
a. Condition and Storage of Materials	10
b. General Repair Practices	11
c. Preparing for Service	12
d. Job Completion	13

Part 1 - Common Contamination Sources in Water Mains

There are several pathways by which microbiological contamination of water mains can occur during installation and repair activities. The most common sources of distribution system contamination can be grouped into two categories: (1) introduction into the distribution system, and (2) transport throughout the distribution system.

Introduction of Microbiological Contamination

- Accumulation of soil, sediment, and other foreign material on pipe interior and appurtenance surfaces during storage and installation.
- Contact with or intrusion of foreign water during storage and installation activities. Foreign water includes trench groundwater, stormwater, sewage, and other sources of runoff.
- Human contact with pipes and fittings.
- Animals and insects that enter pipes during storage or installation.
- Post-installation transitory contamination through faulty seals. Transitory contamination can occur as a result of low or negative pressure surges.

Transport of Microbiological Contamination

- Returning new or repaired water mains to service without sufficient flushing.
- Returning new or repaired water mains to service without sufficient disinfection.

AWWA and EES. New or Repaired Water Mains: Total Coliform Rule Revisions Distribution System White Paper. http://www.epa.gov/safewater/disinfection/tcr/pdfs/whitepaper_tcr_watermains.pdf . Accessed 01/10/2007.

Pierson, G., K. Martel, A. Hill, G. Burlingame, A. Godfree. Practices to Prevent Microbiological Contamination of Water Mains. AwwaRF. Denver, CO.

Water Main Flushing: Prevention and Response

- Good Management Practice helps prevent water quality deterioration in the distribution system
  - Removal of accumulated silt, sediment, biofilm, contaminated water, older-water (with low chlorine residual)
  - Reduces potential nitrification and chlorine demand in the distribution system
- Flushing is also a tool for emergency response

Kirmeyer, G., M. Friedman, J. Clement, A. Sandvig, P. Noran, K. Martel, D. Smith, M. LeChevallier, C. Volk, E. Antoun, D. Hiltebrand, J. Dyksen and R. Cushing. 2000. AwwaRF Project #90798. Guidance Manual for Maintaining Distribution System Water Quality. Denver, CO.

Storage Facility Inspection, Operation and Maintenance

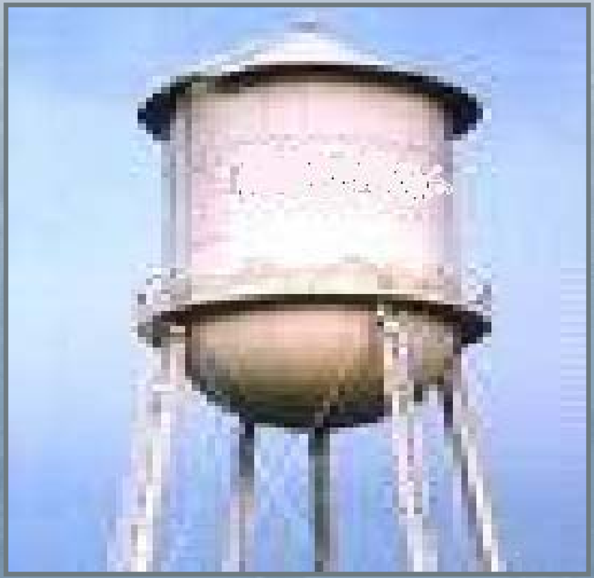
- Distribution system water quality issues often traced to storage tanks
  - Contamination ingress
  - Water age / mixing and loss of disinfectant residual
  - Materials corrosion and leaching
- Identify and address problems through regular water quality monitoring, adjusting O&M practices and tank inspection

Kirmeyer, G. L.Kirby, B. Murphy, P. Noran, K. Martel, T. Lund, J. Anderson and R. Medhurst. 1999. Maintaining Water Quality in Finished Water Storage Facilities. AwwaRF Project #254. Denver, CO.

AwwaRF. 2000. AwwaRF Project #90798. Guidance Manual for Maintaining Distribution System Water Quality. Denver, CO.

Storage Facility Case Study

- The town of Gideon, MO experienced a *Salmonella* outbreak in December 1993 leading to 500 illnesses and 5 deaths
- The outbreak was caused in part by bird droppings in an elevated storage tank



Missouri Department of Natural Resources. 2006. Fact Sheet: Microbial Contamination of Water Storage Tanks. PUB000172.

Storage Facility Case Study
What went wrong?

- Tank inspections had been infrequent
- Inspection standards had not covered sanitary integrity of tanks
- Old tanks had sanitary defects in hatch, vent, overflow and in joints between the roof overhang and tank
- State regulatory agency documented that tank painting contractors had drilled holes to hang their internal rigging and then left them open or covered them in duct tape

Missouri Department of Natural Resources. 2006. Fact Sheet: Microbial Contamination of Water Storage Tanks. PUB000172.

Storage Case Study Gideon MO Changes Implemented

- After the outbreak in Gideon, MO, the MO Department of Natural Resources recommendations for water storage tanks across Missouri included
  - Documented inspection at least every 5 years
  - Use reliable tank inspector or firm
  - Sample tank twice each year for total coliforms and fecal coliforms
  - Follow inspection criteria in AWWA Steel Water-Storage Tanks manual of practices
  - Ensure hatches vents etc. are adequately constructed and sealed etc.

Missouri Department of Natural Resources. 2006. Fact Sheet: Microbial Contamination of Water Storage Tanks. PUB000172.

Security Operations

- Change in culture to emphasize importance of security
- EPA defines 14 features of effective and active security. Those pertinent to operations and maintenance include:
  - Up-to-date vulnerability assessment (VA)
  - Security resources and implementation priorities
  - Contamination detection
  - Threat-level-based protocols
  - Tested and up-to-date emergency response plan
  - Utility specific measures and self-assessment
  - Intrusion detection and access control
  - Information protection and continuity

Covered By Others

EPA. 2006. 14 Features of an Active and Effective Water Security Program: The National Drinking Water Advisory Council's Recommendations. Office of Water publication EPA 817-F-06-002.

System Operations and Maintenance: Summary and Status – Presenter's Opinion

- Pressure is the most important risk minimization tool
- Modeling tools
  - Hydraulic modeling –steady state- well established, extended period simulation – less so
  - Water Quality - general trends
- Pipe repairs – operator training is key
- Flushing – well established benefits
- Cross-connection control – big benefits- need to consider pressure drop across devices 10 to 20 psi
- Storage facility – methods available, need to implement
- Security – distribution system needs to 'catch-up'

Strategies to minimize risk

- Water Quality Management Approaches
- Water Treatment-Water Entering System
- Maintaining a Disinfectant Residual
- System Design, Construction and Materials
- System Operations and Maintenance
- Sensors and Monitoring Devices
  - Chlorine residual
  - Pressure and flow
  - Corrosion monitoring

Sensors/Monitoring Devices: Overview

- Feedback provided improves ability to:
  - Maintain water quality in the distribution system
  - Control treatment e.g. rechlorination stations
  - Establish a water quality record
  - Detect changes that may affect safety and quality and/or trigger an alarm system
- Online devices commonly used for pH, chlorine residual, temperature and turbidity
- Handheld data loggers also used at sampling points or hydrants

AwwaRF. 2005. Project #91048F. Data Integration for Water Quality Management. Denver, CO.

AwwaRF, CRS PROAQUA. 2002. Project #90829. Online Monitoring for Drinking Water Utilities.

Online Chlorine Residual Monitoring

- Helps ensure adequate disinfection throughout distribution system
- Can provide information about: water age, nitrification, ingress and contamination, mixing and flushing
- Provides timely information about the system to enable adjustments to be made
- Used as a trigger for action

Chlorine residual: Case Studies

- **Cincinnati, OH** measures chlorine residual with online analyzers in storage tanks and on influent and effluent lines
  - Provides useful information for better operation of distribution system, tanks and re-chlorination feed system
- **Bellevue, WA** purchases all water treated from Seattle, so use online chlorine analyzers in the distribution system to optimize distribution operations
  - Provides information so that the utility can reduce water age, increase turnover in storage tanks to improve both quality and consistency of water received by customers

Kirmeyer, G., N. Bazzurro, W. Grayman. Ch 12. Case Studies of Online Monitoring Systems. AwwaRF, CRS PROAQUA. 2002. Project #90829. Online Monitoring for Drinking Water Utilities.

Kirmeyer, G., M. Friedman, J. Clement, A. Sandvig, P. Noran, K. Martel, D. Smith, M. LeChevallier, C. Volk, E. Antoun, D. Hiltebrand, J. Dyksen and R. Cushing. 2000. AwwaRF Project #90798. Guidance Manual for Maintaining Distribution System Water Quality. Denver, CO.

Pressure / Flow Monitoring

- Enables detection of occurrence and location of pressure transients
- Technologies for pressure monitoring across the system are one of the greatest risk reduction technologies we have and are well developed
- Future application for high-speed measurement for localized or unusual problems

Pressure- covered in more detail by other presenters at this workshop

Kirmeyer, G., N. Bazzurro, W. Grayman. Ch 12. Case Studies of Online Monitoring Systems. AwwaRF, CRS PROAQUA. 2002. Project #90829. Online Monitoring for Drinking Water Utilities.

Corrosion Monitoring

- Internal corrosion can create favorable environment for microbial growth such as tubercles, corrosion products
- Numerous monitoring methods including
  - Metal uptake - by water
  - Metals loss by pipe – by weight loss
  - Pit depth measurement
  - Electrochemical / online techniques
- None of electrochemical methods work very well on ferrous metals

Sensors and Monitoring Devices: Summary and Status – Presenter's Opinion

- Chlorine – well established techniques – use is expanding
- Pressure and Flow –Standard instrumentation- well established
- Corrosion (Iron) – difficult – no good online device

Current Risk Minimization Techniques: Review