Water Management Plan Implementation: Environmental Assessments, Testing and Mitigation

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Kentucky Public Health
Prevent. Promote. Protect.

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TEAM KENTUCKY
CABINET FOR HEALTH AND FAMILY SERVICES

Kentucky Department for Public Health

About Us

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The Kentucky Department for Public Health (KDPH) is dedicated to improving the health and safety of Kentuckians through *prevention*, *promotion*, and *protection*.

As a major part of the Cabinet for Health and Family Services, KDPH provides guidance and support for health departments in all 120 counties.

Serving as Kentucky's dedicated public health resource, KDPH is responsible for identifying and allocating resources to communities and public health institutions to prevent and protect against diseases, outbreaks, and hazards statewide.

Kentucky Department for Public Health

Organizational Chart

Learning Objectives

- By the end of this presentation, the learner will be to demonstrate strong rationale for effective and sustained implementation of an effective water management program.
- By the end of this presentation, the learner will be able to summarize and discuss the ecology and control of waterborne pathogens with colleagues and leadership.
- By the end of this presentation, the learner will be able to develop appropriate specifications for environmental assessments, including water sampling and laboratory analysis.
- By the end of this presentation, the learner will be able to evaluate mitigation strategies and determine reasonable options in accordance with their facility's Water Management Plan.

The economics of premise plumbing quality

- Healthcare concern due to
  - » Aging facilities and aging community water infrastructure
  - » Inferior or improperly maintained water systems for
    - – Showers and faucets,
    - – Ice machines, decorative fountains, cooling towers and more.
- Flint co-incidental legionellosis outbreak at McLaren Hospital Flint
  - » 12 deaths, 78 survived
  - » 20/78 died in the months and years subsequent
  - » 115 additional community pneumonia deaths over that time period
    - – 43% increase
- Lawsuits and public relations
- JCHAO and CMS/OIG

Water in Healthcare Facilities: The Public Health and Economic Nexus | Uniform Codes

Table 5. Total direct healthcare cost of ED visits and hospitalizations from domestically acquired waterborne transmission of selected infectious diseases, United States, 2014*

	Value (95% CrI)						
	Treat-and-release ED visits†			Hospitalization			Direct healthcare cost, millions
Disease or syndrome	Cost per visit	Total no. visits	Total cost, millions	Cost per stay	Total no. hospital stays	Total cost, millions	
Campylobacteriosis	1,710 (137–5,810)	319 (31–966)	0.545 (0.0177–2.61)	13,600 (3,850–35,800)	2,150 (192–6,900)	30.0 (1.71–121)	30.5 (2.10–121)
Cryptosporidiosis	1,960 (238–6,270)	492 (167–957)	0.963 (0.0802–3.44)	16,100 (4,360–55,400)	1,120 (102–3,550)	17.9 (1.10–79.5)	18.9 (1.82–80.4)
Giardiasis	1,620 (196–7,510)	567 (185–1,120)	0.917 (0.0861–3.78)	21,800 (6,160–99,200)	1,100 (364–2,180)	23.9 (3.53–104)	24.8 (4.21–105)
Legionnaires' disease	691 (288–1,390)	667 (289–1,200)	0.460 (0.127–1.13)	37,100 (7,950–149,000)	10,800 (7,280–13,100)	401 (79.0–1,690)	402 (79.5–1,690)
NTM infection	1,610 (129–6,430)	5,080 (2,560–7,750)	8.17 (0.584–34.0)	29,600 (6,350–120,000)	51,400 (26,800–74,100)	1,520 (266–6,370)	1,530 (272–6,380)
Norovirus‡	1,140	26,300	30.1	6,080	4,780	29	59.1
Otitis externa	494 (120–1,430)	567,000 (337,000–823,000)	280 (60.2–846)	12,200 (3,320–42,400)	23,200 (13,900–33,600)	285 (67.8–1,040)	564 (187–1,570)
Pseudomonas pneumonia	856 (89–4,190)	291 (75–552)	0.249 (0.0162–1.27)	29,300 (5,910–114,000)	15,500 (4,130–28,100)	452 (49.8–1,950)	453 (49.9– 1,950)
Pseudomonas septicemia	923 (95–3,190)	36 (2–106)	0.0334 (0.000716–0.186)	38,200 (6,340–172,000)	5,590 (722–14,000)	214 (11.4–1,030)	214 (11.4–1,030)
Salmonellosis, nontyphoidal	1,230 (161–4,500)	194 (15–671)	0.240 (0.00734–1.24)	14,900 (4,300–46,900)	1,520 (100–5,660)	22.6 (0.870–110)	22.8 (1.08–110)
STEC infection, serotype O157	1,070 (109–2,350)	12 (2–35)	0.0130 (0.00734–0.051)	19,000 (3,790–85,000)	138 (14–503)	2.67 (0.129–14.5)	2.68 (0.141–14.5)
STEC infection, serotype non-O157	1,070 (109–2,350)	4 (0–16)	0.00440 (0–0.0223)	24,200 (4,780–138,000)	74 (0–308)	1.76 (0–11.0)	1.76 (0.00186–11.0)
Shigellosis	952 (115–3,980)	64 (5–311)	0.0609 (0.00171–0.349)	14,200 (4,130–48,000)	245 (13–1,140)	3.41 (0.106–18.9)	3.47 (0.140–19.0)
Vibrio spp. infection	1,030 (293–3,330)	76 (14–166)	0.0777 (0.00765–0.276)	16,000 (3,780–39,900)	251 (153–362)	4.02 (0.811–10.7)	4.10 (0.891–10.8)
Total cost			322 (100–889)			3,010 (1,120–8,410)	3,330 (1,370–8,770)

Estimate of Burden and Direct Healthcare Cost of Infectious Waterborne Disease in the United States - Volume 27, Number 1—January 2021 - Emerging Infectious Diseases journal - CDC

The root cause(s) of outbreaks

"About three quarters (72%) of LD cases and 81% of the fatalities in our sample originated at facilities without a WMP. This report highlights the importance of WMPs in preventing and mitigating outbreaks of LD. Building water system process management is a primary obstacle toward limiting the root causes of LD outbreaks."

Figure 2. Prevalence of environmental deficiencies and water management program deficiencies, all sites.

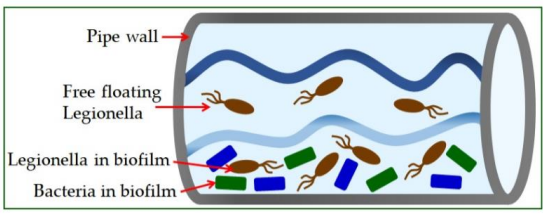
Microorganisms | Free Full-Text | A Methodology for Classifying Root Causes of Outbreaks of Legionnaires' Disease: Deficiencies in Environmental Control and Water Management (mdpi.com)

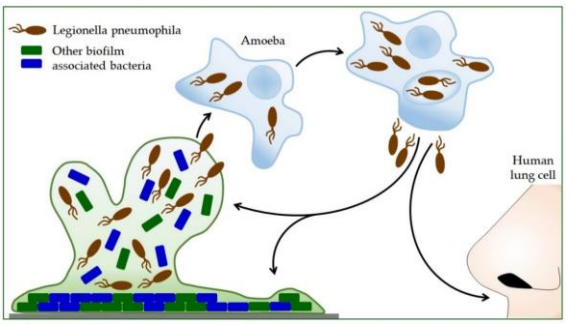
Ecology of *L. pneumophila*

- Legionella is an environmental bacterium which naturally exists in lakes and underground water sources.
- Public water filtration technology cannot remove all microorganisms from water.
- Legionella, in particular, protects itself from chlorination by hiding within amoeba and the slime layer that forms inside plumbing pipes.
- It thrives in water that doesn't regularly flow (little used fixtures, whirlpools, deadlegs) and at temperatures between 70F and 120F.
- Previously, hot water tanks set at greater than 140F were effective in killing the bacteria, but recent anti-scald temperature restrictions have caused many to lower water heater temperature. (Easier than installing mixing valves throughout the plumbing).

Slime layer – Amoeba - aerosolization

Pseudomonas aeruginosa
Nontuberculous mycobacteria (NTM)





Talapko J, et al. (2022). Legionella pneumophila—Virulence Factors and the Possibility of Infection in Dental Practice. Microorganisms. 10. 255. 10.3390/microorganisms10020255.

Not just *Legionella*. . .

- Multiple Gram negative bacteria, including *Pseudomonas* (16)
- Non-fecal coliforms (5)
- Nontuberculous mycobacteria (NTM or Environmental Mycobacteria) (17)
- Other bacteria/actinomyces (4)
- Fungi (4)
- Protozoa (3)

Considerations for Reducing Risk: Water in Healthcare Facilities | HAIs | CDC

Important starting pointers

- Complete a comprehensive WICRA and a comprehensive LEAF
  - Water Infection Control Risk Assessment (WICRA) for Healthcare Settings (cdc.gov)
  - Legionella Environmental Assessment Form (LEAF) (cdc.gov)
- Obtain water management resource and reference documents
  - ASHRAE – iWrapper free online access to ASHRAE 188-2021
  - Environmental Assessment and Sampling Resources | LD Investigations | CDC
- Develop a functional water management plan
- A company hired to take samples should have adequate training
- The analyzing laboratory should have appropriate certifications and clearly and correctly explains analytic results.

LEAF – Legionella Environmental Assessment Form

- Use this fillable form to document a facility's water systems, help determine whether to conduct Legionella environmental sampling, and, if so, develop a sampling plan.
- Thoroughness of completion is correlated with usefulness
  - Ideal situation
    - » Administration
    - » Facilities Engineers
    - » IP
    - » TJC/CMS compliance
    - » Consultant

Legionella consultant: ASSE 12080 Certification

- The ASSE 12080 Legionella Water Safety and Management Specialist Certification
  - Complete a 24-hour training course encompassing all aspects of ASSE Standard 12080, and
  - Successfully pass a 100-question written exam demonstrating core competencies in
    - environmental testing,
    - risk assessment,
    - water safety and management programs,
    - mitigation and remediation methods, construction and renovation, and
    - case investigation.
- Basic certification for a Legionella consultant or contractor

ASSE/IAPMO/ANSI 12080 for Legionella Water Safety and Management Personnel Is Now Available - ASPE Pipeline

Water samples

- Outlet conditions, or Pre-flush
  - Water samples that represent the outlet conditions are collected as a first draw sample, where water is collected immediately after the tap or fitting is opened and flow has been established.
  - A first draw sample represents water held within the tap or fitting and the adjacent connected piping. Ideally, the sample should be taken when the tap has not been recently used.
  - A first draw sample will typically have little or no residual disinfectant, may include water that has been open to the environment, and may have significantly higher Legionella concentrations than water at other locations in the building water system.
- System conditions, or Post-flush
  - Water samples taken after a period of water flow or flushing of the outlet prior to collecting a water sample.
  - The time required to flush an outlet depends on the length of the pipe run from the main header, riser, or circulating loop.
  - A flush sample is representative of water conditions in the riser, header, or circulating loop.
  - Consulting with a building engineer to confirm length and size of pipe runs to a given outlet to determine the volume and time required to flush the outlet is suggested.

ASHRAE Guideline 12-2023

AIHA Recommended sample procedure

- Pre-flush
  - To catch what is in the line and outlet
- Post-flush
  - Broader picture of system contamination
- Swab
  - Taken after the pre-flush sample
  - Need to remove aerators
- Temperature, free/total chlorine, pH for each sample
  - Chlorine test kit sensitive enough to detect chlorine level below 2 ppm and up to 10 ppm (may need two kits).
  - Free chlorine may be measured when it is known that chlorine is the method of disinfection (as opposed to monochloramine, bromine, or another disinfectant). Otherwise, measure total chlorine.
- NOT RANDOM – follow the plumbing from supply through to end of the line

CDC Sample Plan suggestions

POTABLE WATER

Site	Approximate number of samples	Type of samples	Sample processing[†]
Incoming water main (where water enters the facility/campus/building from the municipality)	1	1L bulk water	Concentrate
Every well and water tower that supplies water to the facility/campus/building	1 per well or water tower	1L bulk water	Concentrate
Every holding tank or cistern	1 per holding tank/cistern	1L bulk water	Concentrate
Centralized water heater	1	1L bulk water (a biofilm swab if drained)	Direct
Expansion tank for hot water (absorbs excess water pressure caused by thermal expansion within the hot water heater)	1	1L bulk water	Concentrate
Hot and cold water returns	1 each for hot and cold	1L bulk water	Concentrate
For buildings with water softeners, special filters, and disinfection systems, sample water before and/or after these processes		1L bulk water	Concentrate
Shower	2 per shower[‡]	1 biofilm swab and 1L bulk water	Concentrate
Faucet	2 or 3 per faucet[‡]	1 biofilm swab inside the faucet, (1 biofilm swab of the inside of the aerator if visual inspection indicates that it's overgrown with biofilm), 1L bulk water	Concentrate
Whirlpool baths[‡] (i.e., Jacuzzis)	1	1 biofilm swab inside the jets	Concentrate

COOLING TOWERS[‡]

Site	Approximate number of samples	Type of samples	Sample processing[†]
Make-up water (water added to replace water loss because of evaporation, drift, or leakage)	1	1L bulk water	Direct
Collection basin (an area below the tower where cooled water is collected and directed to the sump)	2	1L bulk water and a biofilm swab at the water line	Direct
Sump (a depressed chamber contiguous to the basin, where water flows to facilitate pump suction; may also be used as collection point for silt and sludge)	2	1L bulk water and a biofilm swab at the water line	Direct
Storage tank or reservoir in the system	1	1L bulk water	Direct
Drift eliminators or other surfaces that remain moist	1	1 biofilm swab	Direct
Heat sources (e.g., chillers)	1	1L bulk water	Direct

Legionella Sampling Procedure and Potential Sampling Sites (cdc.gov)

Laboratory Selection

- If a choice is made to test for Legionella, it is recommended that tests be conducted by a laboratory that is accredited by a regional, national, or international accrediting body according to a nationally or internationally recognized standard that, at a minimum, requires the use of revision controlled standard operating procedures for testing, documentation of the performance characteristics of tests, periodic proficiency testing, and periodic independent audits verifying compliance.
  - An example of such a recognized standard is ISO/IEC 17025 34.
  - The routine method of testing for Legionella in building water system samples used should be included in the laboratory's scope of accreditation.
  - It is recommended that the laboratory have the capability of retaining isolates of Legionella-positive samples.

Laboratory Certification

- ELITE is managed by the WI State Hygiene Laboratory
  - Legionella & Environmental | WSLH Proficiency Testing (wslhpt.org)
- ISO/IEC 17025 34
- AIHA PAT
  - Microbiology laboratories specializing in analysis for microorganisms commonly detected in air, fluids and bulk samples collected from schools, offices, hospitals, and industrial, agricultural and other work environments.
  - The EMPAT Culture Program is for laboratories that specialize in culturing and identifying bacteria and fungi found in these environments
- Laboratory or consultant should adequately explain results and use CDC/ASHRAE recommended explanations

Common testing methods

- Legionella culture method: 7-14 days for growth time
  - Follows ISO 11731:2017 and/or the U.S. CDC (2005)
  - Gold standard
    - » Quantitation of viable and culturable
    - » Quantitation of any species from the Legionella genus
    - » Environmental isolates may be useful for matching patient isolates.
- PCR: Quick but may be limited; confirmatory to culture
  - Follows ISO/TS 12869 2014 Water Quality-Detection & Quantification of Legionella spp.
- Legiolert: Quick but requires culture to speciate and confirm
  - Color change, known false positives

Recognition, Evaluation and Control of Legionella in Building Water Systems, 2nd Edition (2022) American Industrial Hygiene Association

Figure 1. Routine *Legionella* testing: A multifactorial approach to performance indicator interpretation

Concentration indicates that *Legionella* growth appears:

Uncontrolled	Poorly Controlled	Well Controlled			
≥10 CFU/mL[†] in potable water **OR** ≥100 CFU/mL in non-potable water	1.0–9.9 CFU/mL in potable water **OR** 10–99 CFU/mL in non-potable water	Detectable to 0.9 CFU/mL in potable water **OR** Detectable to 9 CFU/mL in non-potable water	No *Legionella* detected in a single round of testing	No *Legionella* detected in multiple rounds of testing	No *Legionella* detected in multiple rounds of testing with methods that detect viable and non-viable bacteria of any *Legionella* species

Change in concentration over time indicates that *Legionella* growth appears:

Uncontrolled	Poorly Controlled	Well Controlled			
100-fold or greater increase in concentration (e.g., 0.05 to 5 CFU/mL)	10-fold increase in concentration (e.g., 0.05 to 0.5 CFU/mL)	*Legionella* concentration steady (e.g., 0.5 CFU/mL for two consecutive sampling rounds)	No *Legionella* detected in a single round of testing	No *Legionella* detected in multiple rounds of testing	No *Legionella* detected in multiple rounds of testing with methods that detect viable and non-viable bacteria of any *Legionella* species

Extent indicates that *Legionella* growth appears:

Uncontrolled	Poorly Controlled	Well Controlled			
Detection in multiple locations AND a common source location[‡] **OR** Detection across many locations within a water system	Detection in a common source location that serves multiple areas **OR** Detection in more than one location within a water system	Detection in a few of many tested locations within a water system	No *Legionella* detected in a single round of testing	No *Legionella* detected in multiple rounds of testing	No *Legionella* detected in multiple rounds of testing with methods that detect viable and non-viable bacteria of any *Legionella* species

Type[ϒ] of *Legionella* (species and serogroup) associated with Legionnaires' disease:

Highly Associated	Less Associated
L. pneumophila serogroup 1; Non-Lp1 *L. pneumophila*; Presence of multiple different *Legionella* species or serogroups	Any non-*pneumophila* *Legionella* species including "blue-white" fluorescent *Legionella*

U.S. Department of Health and Human Services
Centers for Disease Control and Prevention

[*]This figure is intended for use during routine testing only. Test results are performance indicators and are not a measure of risk of human illness. This figure is not intended for use if a building or device is associated with Legionnaires' disease (LD) cases or an outbreak.

[†]See "Routine testing for *Legionella*" for guidance regarding suggested response activities. Comparable results may lead to different suggested response activities when other factors are considered (e.g., if there is evidence of poorly controlled growth at a healthcare facility).

[Δ]Considering the type of *Legionella* identified along with other *Legionella* testing performance indicators provides a clearer picture of water system control than the results of any single indicator. For example, facility owners and operators may consider implementing immediate interventions for a healthcare facility with: A. detectable but <10 colony-forming units per milliliter (CFU/mL), B. non-Lp1 *Legionella pneumophila*, C. observed at steady concentrations, but D. detected at multiple distal locations including a central water heater.

[‡]Concentrations expressed as CFU/mL are for test results generated by traditional spread plate culture methods. If other test methods are used, consult testing lab or manufacturer instructions for appropriate interpretation.

[§]Common source location examples include water heaters, hot water returns, storage tanks, and cooling tower basins.

[ϒ]If a facility has a history of associated LD cases, then sequencing isolates obtained during routine testing may provide performance indicators regarding outbreak strain persistence (if that strain is detected).

Legionella Control Toolkit | Routine Testing | Page F5

Table 1. *Legionella* Control Measures for Potable Water Systems

Controlling Legionella in Potable Water Systems-Toolkit (cdc.gov)

	Water Parameter	Control Measure	Recommendations
S	**S**ediment and Biofilm	Flushing, cleaning, and maintenance	• Flush after an intrusion event (e.g., water main break). • Clean and maintain water system components such as water heaters, mixing valves, aerators, showerheads, hoses, and filters regularly as indicated by water quality measurements.
T	**T**emperature	Control limits	• Store hot water above 140°F (60°C) and maintain circulating hot water above 120°F (49°C). • Store and maintain circulating cold water below the growth range most favorable to *Legionella* (77–113°F, 25–45°C). Note that *Legionella* may grow at temperatures as low as 68°F (20°C).
A	Water **A**ge	Flushing	• Flush low-flow pipe runs and dead legs at least weekly. • Flush infrequently used fixtures regularly.
R	Disinfectant **R**esidual*	Control limits	• Chlorine: Detectable residual as directed by WMP. • Monochloramine: Detectable residual as directed by WMP.

* Disinfectant residual recommendations apply to disinfectant delivered by the municipal water authority. Supplemental disinfection system control limits are not prescribed here and must be dictated by the water treatment professional and water management program.

Mitigation Strategies

- General strategies **STAR**
  - **S** Reduce scale, sediment, corrosion, biofilm
  - **T** Maintain water temperatures to limit *Legionella* growth
  - **A** Water age - prevent water stagnation from dead legs and infrequent use
  - **R** Disinfectant residual – may need supplementation
- Follow ICAR strategies
  - reduce aerosolization risk from water/premise plumbing
  - reduce the development of biofilms
  - reduce contamination of medical devices
  - appropriately respond to water disruption and water intrusion.

ICAR Tool for General Infection and Control (IPC) Across Settings - Module 11: Water Exposure Facilitator Guide (cdc.gov) Controlling Legionella in Potable Water Systems-Toolkit (cdc.gov)

CDC Mitigation Recommendations

- Use pipe insulation to maintain hot and cold water temperatures throughout the water system.
- Eliminate sections of no- or low-water flow called dead legs.
- Install thermostatic mixing valves as close as possible to fixtures to prevent scalding while permitting circulating hot water temperatures above 120°F (49°C).
- Recognize that low-flow and mechanically complex fixtures (e.g., electronic sensor faucets) can increase the risk of Legionella growth.
- Identify water system components that speed the decay of disinfectant residuals (e.g., UV devices, water softeners, carbon filters, heaters).
- Use appropriately sized hot and cold water storage tanks fitted with recirculating pumps to maintain flow and avoid unfavorable temperature gradients.
- Consider installing sampling ports throughout your water system in locations to facilitate water parameter monitoring and WMP validation

Controlling Legionella in Potable Water Systems-Toolkit (cdc.gov)