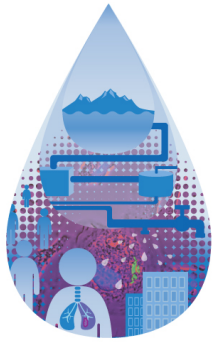
POLYTECHNIQUE MONTRÉAL

Where and When should Monitoring Occur?

Proactive monitoring to control *Legionella* in building water systems



Michèle Prévost
Polytechnique Montréal

NASEM Follow up meeting on environmental monitoring, Dec 10th 2020

The objective is reducing risks

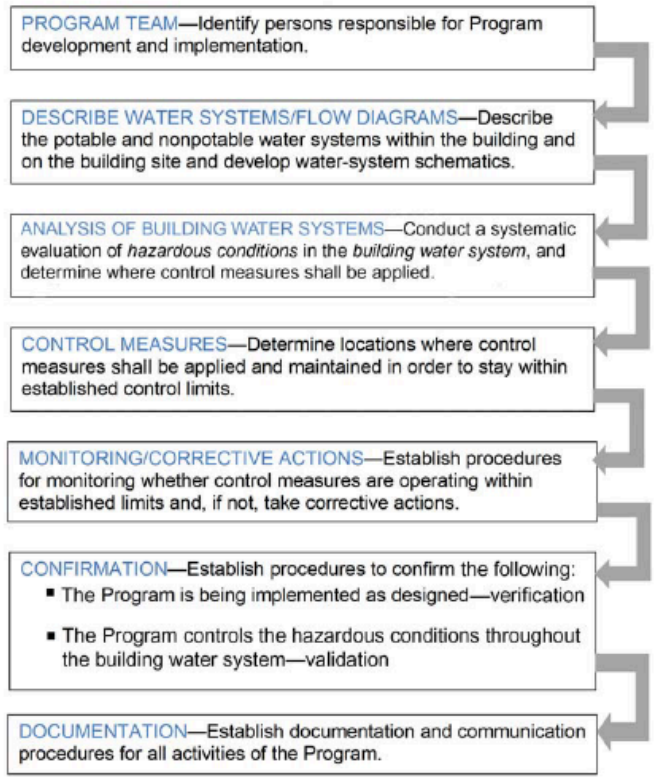
Water Management Programs & Water Safety Plans

Water Management Program: A risk management plan for the prevention and control of legionellosis associated with building water systems (ASHRAE 188 and 12)

- Analysis of building water systems
- Control measures, locations and limits
- *Monitoring program & corrective actions*
- Implementation and confirmation by a designated team

Water Safety Plan : A risk management approach to ensure the safety of water that establishes good practices in local water usage, distribution, supply and controls (HSE 2013)

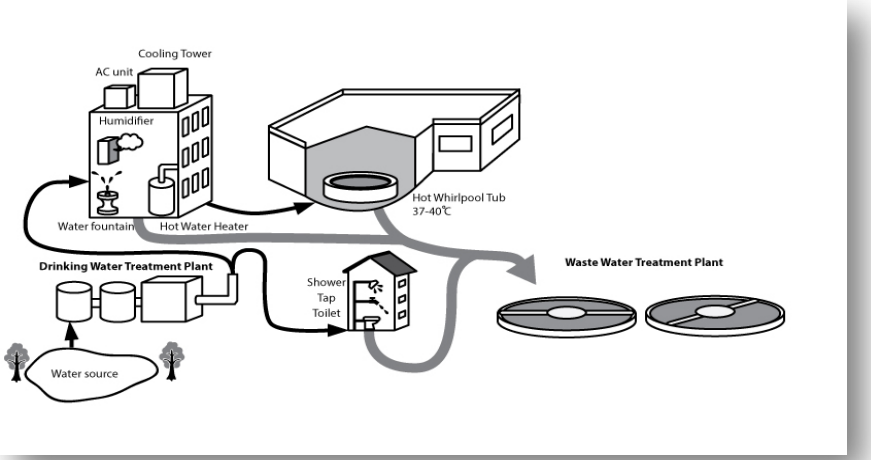
- Identify potential microbial hazards, consider practical aspects and detail appropriate control measures
- Assess risks posed to patients, employees and visitors
- Implement appropriate management systems to ensure the risks are adequately controlled



ASHRAE 188, 2018

Legionella testing across different water engineered systems

Conducted in a diversity of water systems



Objectives of monitoring

- Routine monitoring
- Determination of the need for treatment
- Compliance to a guideline or a regulation
- Mitigation validation
- Outbreak investigation
- Research

Different sampling approaches depending on the objective and the water system

Drivers to monitor for *Legionella* in managed engineered systems

Considered necessary by the risk assessment of the WMP!

Agreement in guidance & regulations to prioritize:

- Facilities where control measures, such as water temperatures or disinfectant residual levels, are not being maintained consistently within target limits throughout the building water systems
- Facilities with a history of LD associated with the building water systems, or if suspected or identified cases of LD
- Facilities that serve vulnerable populations such as health care facilities, and within these facilities, areas with highly vulnerable patients

How to sample?

Recommendations for sample collection, holding time and shipping

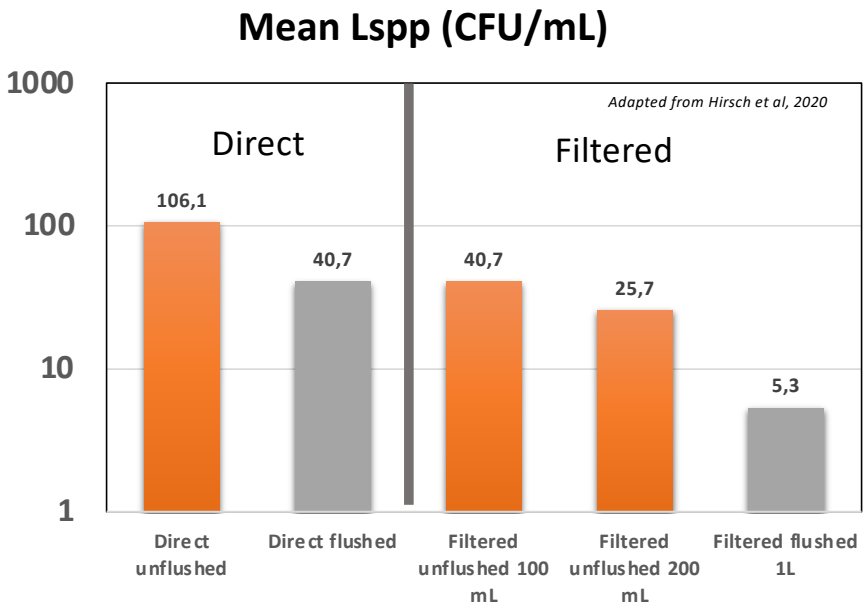
	CDC*	ISO	AIHA	ASTM	ASHRAE	HSE
Collection	Flush hot water for a few minutes until warm	No flush	Immediate and 2 min flush	No flush	No flush for outlet, flush for system	No flush and 1 minute flush
Volume	1L	1L	125mL-1L potable ; 125mL non potable	10-100mL non potable ; >1L for potable	250mL routine; 1L investigations	500mL -1L
Holding time and conditions & shipping	Not specified – refrigerate if not processed <72 h	Hold time 24h-transport at 5°C, ambient acceptable	Ship overnight in insulated container without ice	Ship overnight; refrigerate if not processed in 72 h	Ship at ambient within 24 h, if >48h consult lab	

* also biofilm swabs

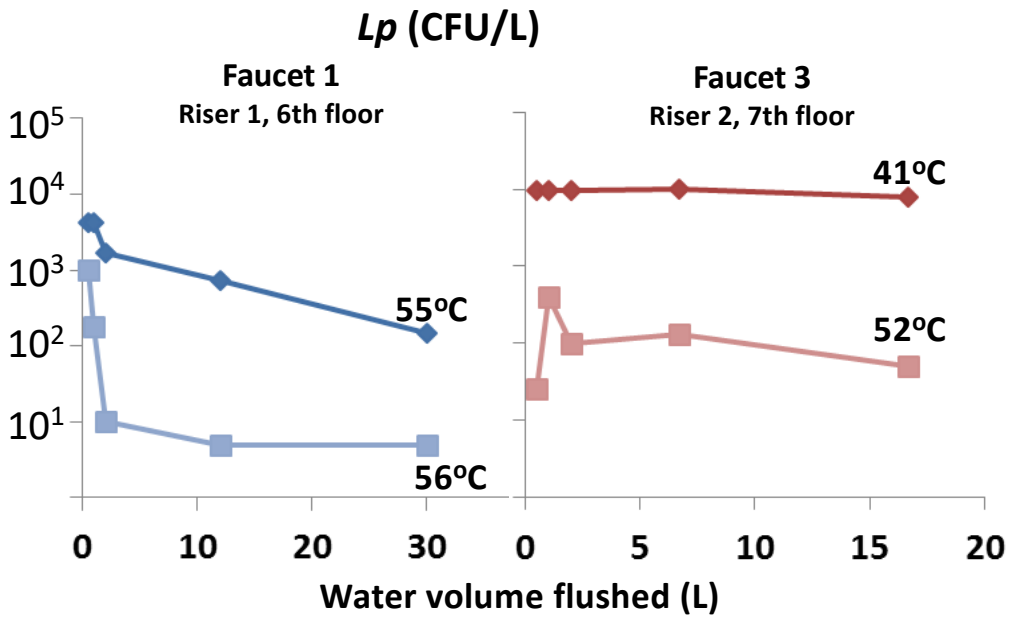
Adapted from Hirsch et al, 2020 and NASEM 2019

Sample volumes and sampling protocols in guidance vary widely

Impact of sample volume and filtration on concentrations of *Legionella*



Type of sample (flushed vs first draw) and use of filter are important



Concentrations may be much higher at first draw

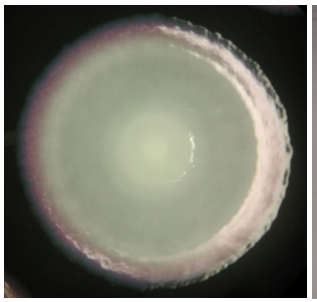
Bédard, E., et al., *Legionella pneumophila levels and sequence-type distribution in hospital hot water samples from faucets to connecting pipes.* Water Research, 2019. **156**: p. 277-286.

Monitoring approaches to control *Legionella*

1) Test for *Legionella*

- *Legionella pneumophila* vs *Legionella spp.*
- Certified standard culture methods vs. new enzymatic culture methods
- Molecular methods : PCR, qPCR and ddPCR

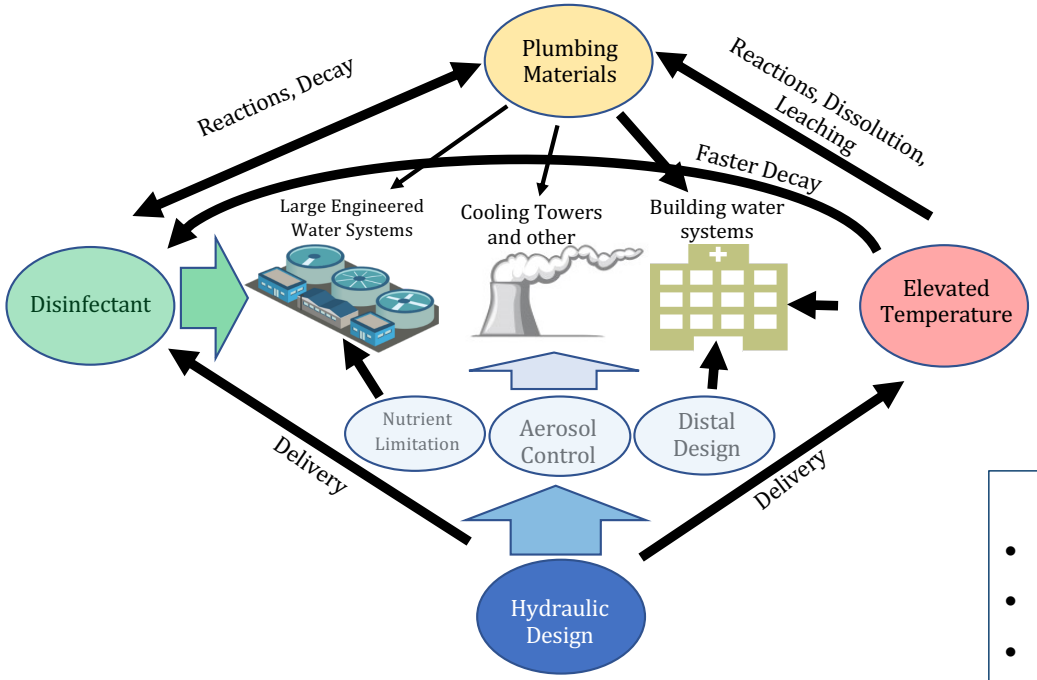
Costs, response time, regulations/guidance and relation to risk



2) Apply a process control approach

- **Define and monitor operational setpoints**
  - Temperature at water heater, in recirculation and at outlets
  - Disinfectant residual – on-site treatment
  - Indicators: bacterial activity (ATP), HPCs, to validate procedures
- **Online monitoring**
  - T°, disinfectant, ORP, pH, conductivity, etc.

Chapter 4:
STRATEGIES FOR *LEGIONELLA* CONTROL AND THEIR APPLICATION IN BUILDING WATER SYSTEMS



Building water systems

- Cooling towers
- Building water systems
- Wastewater treatment facilities
- Fountains, sprinklers
- Spas, etc.

Use information provided on

- Main control strategies for *Legionella*
- Their application to different building and device types
- Confounding influence of green buildings and water/energy conservation

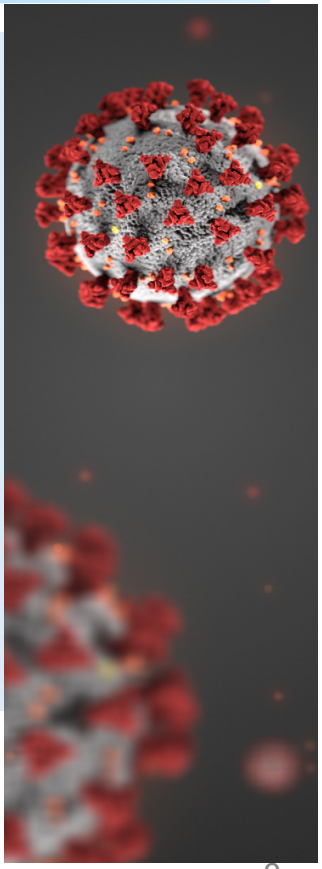
To determine when, where and how to monitor these systems

When and where to test for *Legionella*

NASEM report: sites with potential for growth and exposure

- **Limited resources: concentrate on where risk is likely to be significant**

- Buildings serving vulnerable populations
- At risk areas of buildings
  - Dead-ends, low usage areas, showers, electronic faucets, TMVs, etc.
- At risk situations
  - Treatment deficiencies (loss of onsite disinfection, low temperatures, etc.)
  - Short and extended closures
  - Commissioning, start-up, shutdown, cocooning



Ideally within the framework of a Water Management Program to ensure that risk is reduced

Prioritizing which building water systems to monitor

Examples of low risk situations

HSE (2013)

- small buildings without people ‘at risk’ from legionella & where daily water usage is inevitable and sufficient to turn over the entire system
- hot water is fed from instantaneous heaters or low storage volume water heaters (supplying outlets at 50 °C)
- only outlets are toilets and hand washbasins (no showers)

CDC

In most situations, it’s appropriate to sample only the hot water. However, there are situations where taking some cold water samples is helpful. For example, in hot climates, the cold water may be warm enough for rapid Legionella amplification (>77°F)

Building water systems can be quite complex

Diversity of materials submitted to varying water quality, temperature and flow conditions facing issues such as corrosion, loss of residual, stagnation…

Legionella sampling strategy for **large building water systems**

- *Legionella* testing often recommended or required (ASHRAE, CDC, HSE)
  - Identify at risk areas and select testing sites after monitoring temperature, disinfectant residuals, and identifying areas with low flow or intermittent stagnation, etc.
  - Include potable sources, hot and cold water components: tanks, mains, risers, horizontal distributors, recirculation, heat exchangers, points of use, etc.
- Some general features in common, but strategy must be tailored to each building
- Once the water system performance is known, determine the frequency for sampling

FOCUS on points vulnerable *to Legionella* growth AND exposure

Know your building water systems

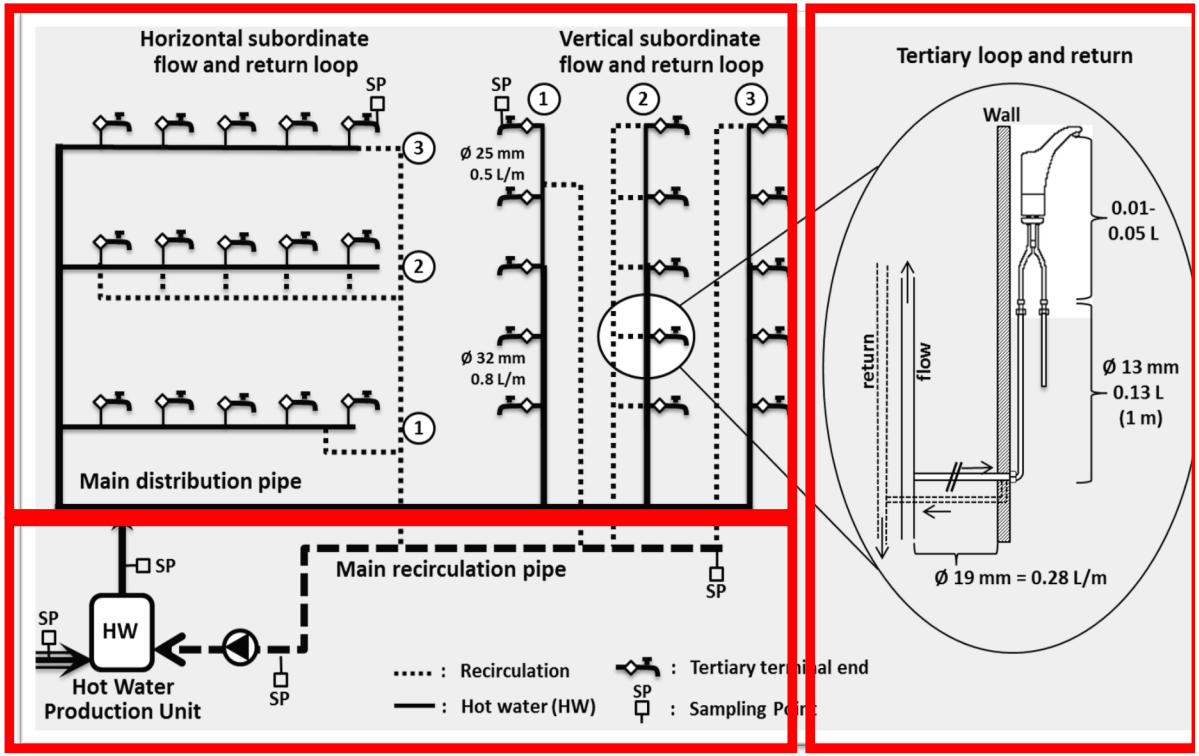
- Understanding your building water system to determine where to monitor
- Implement control and evaluate risk in the main, secondary and tertiary piping

Hot water systems

- Nearest outlet and base of water heater
- Nearest & furthest outlets **on each branch** for single pipe systems
- Nearest & furthest outlets **on each loop** of a circulating system

Cold water systems

- Point of entry in building & water storage tanks
- From nearest & furthest outlets

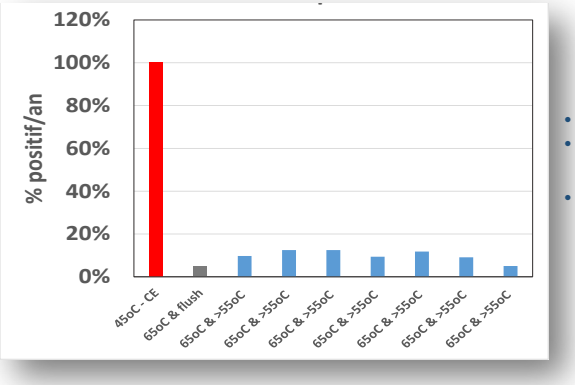


Bédard et al. 2014

Testing: the most definite way to verify if controls are working

Temperature control

- Longitudinal studies in hospitals across several countries
- Large compliance monitoring databases in German hot water systems after the implementation of regulation



- ***L. pneumophila*** **sg 1 outbreak (31 cases)**
- **Increase T from 45°C to 65°C at the heater and >55°C at the POU**
- **Thermal regime for 10 years = lower % positive taps & cases**

Darelid et al. 2002

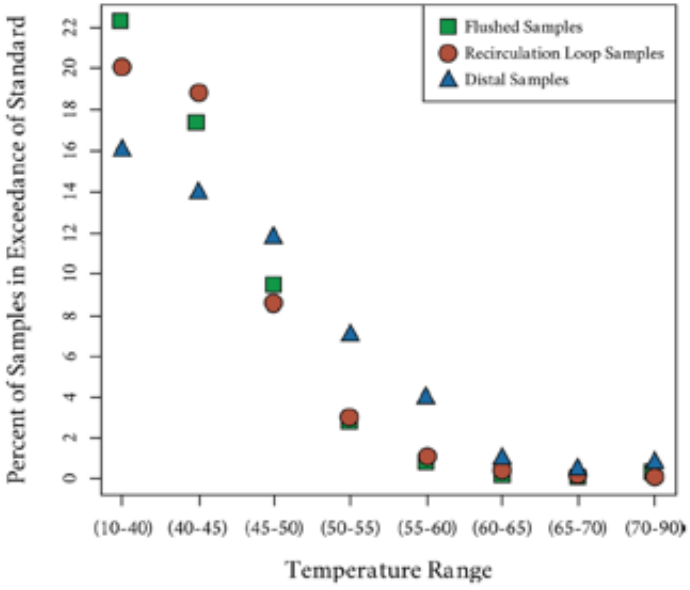


FIGURE 4. *This chart shows the relationship between water temperature (x-axis) and the percent of samples exceeding the German standard of 100 CFU/100mL for Legionella spp. (y-axis) from public buildings in Germany over a seven-year period. Squares indicate flushed samples, circles indicates samples from the recirculation loop of the hot-water system, and triangles are samples taken from the distal ends of the plumbing. SOURCE: Kistemann and Wasser (2018).*

Legionella sampling in large building water systems

Decision flowchart using temperature monitoring results

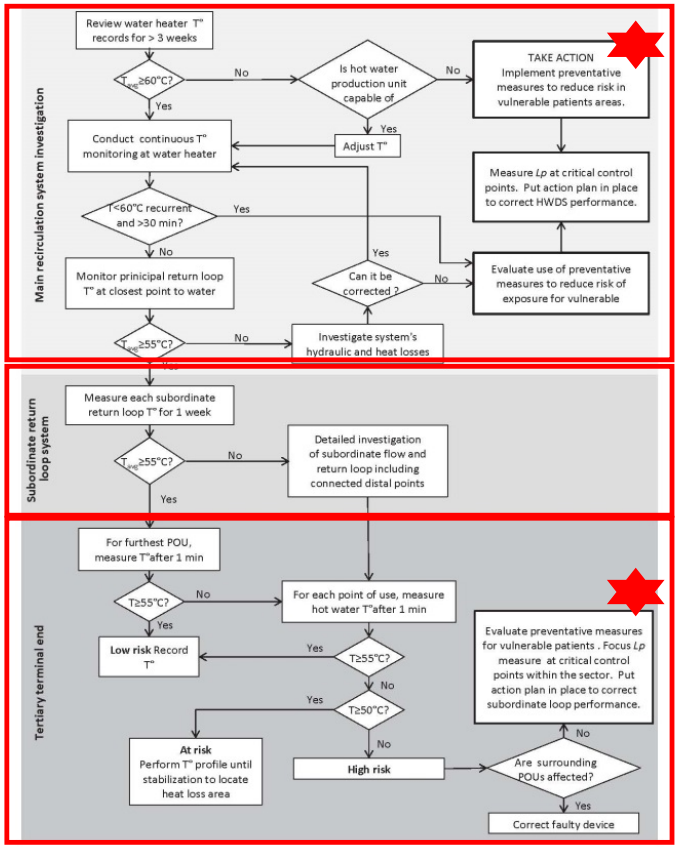


Fig. 5 Diagnostic flowchart for the initial assessment of *Legionella* risk in an existing HWDS

Tiered approach using temperature diagnostic

1. Main recirculation system that indicates the overall system risk level
2. Subordinate return loops to identify large building areas or sectors at risk
3. Tertiary terminal ends, to identify local issues with defective faucets or showers

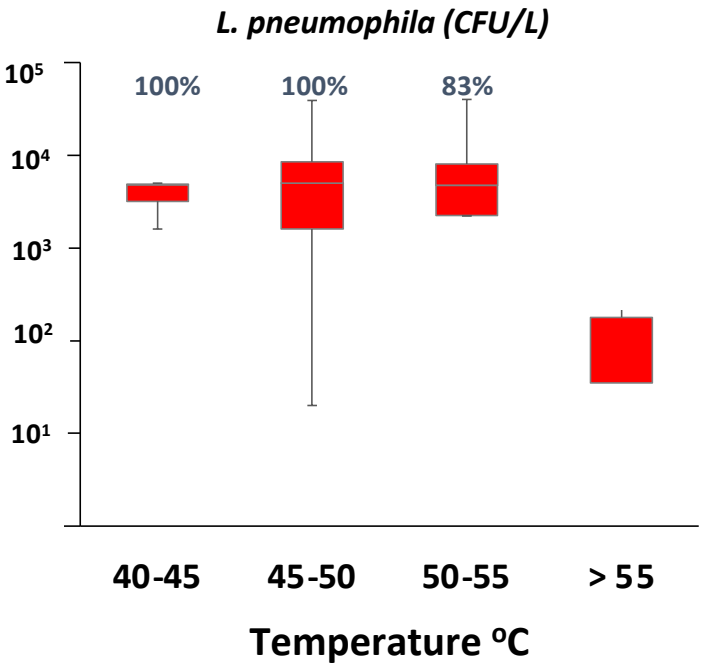
Staged response in terms of corrective and preventative actions, including *Lp* monitoring

Bédard, E., et al., *Temperature diagnostic to identify high risk areas and optimize Legionella pneumophila surveillance in hot water distribution systems.* Water Research, 2015. **71**: p. 244-256.

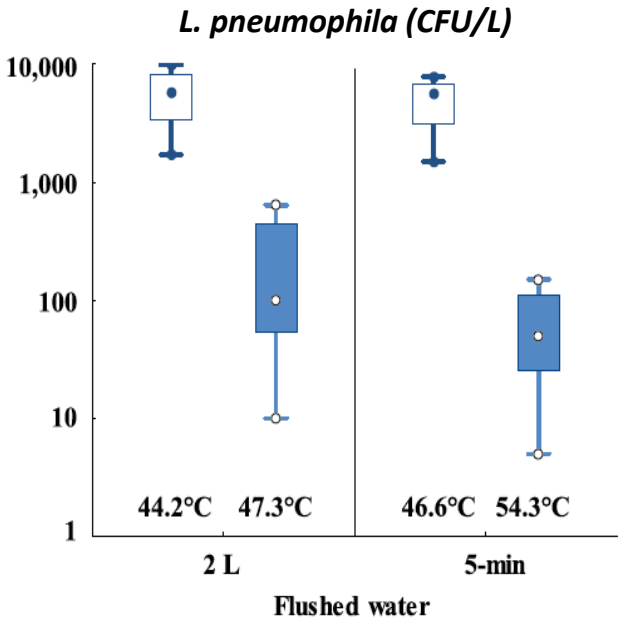
Using temperature to identify areas at risk in HCFs

Pediatric hospital 450 beds

Distal points



Risers

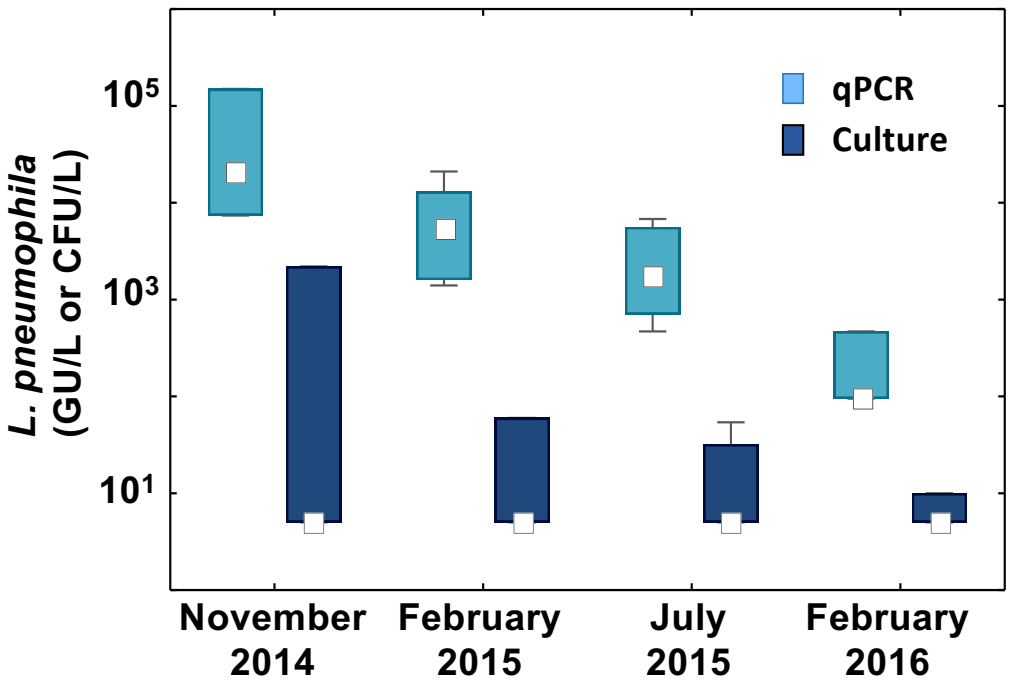


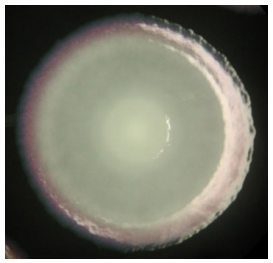
Bédard, E., et al., *Legionella pneumophila levels and sequence-type distribution in hospital hot water samples from faucets to connecting pipes.* Water Research, 2019. **156**: p. 277-286.

Impact of analytical method on assessment of control measures

Long Term Effect (15 months) of corrective measures in 400 bed regional hospital after LD (LpSG5) outbreak

Sampling 'at risk' points





Multiple corrective actions

- Thermal disinfection ≥ 70°C
- Increased water heater outlet (55 → 60°C)
- Weekly flushing of taps with hot water
- Heat exchangers taken offline
- Identify low flow areas – eliminate of dead ends

Boppe, I., et al., *Investigative approach to improve hot water system hydraulics through temperature monitoring to reduce building environmental quality hazard associated to Legionella.* Building and Environment, 2016. **108**: p. 230-239.

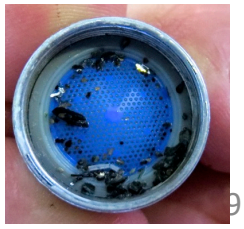
qPCR can provide valuable insight in long term efficacy of control measures

Challenges in monitoring building water systems

- Finding pipes without up to date drawings!
  - Absence of a Water Management Plan
- Absence of logs and on line monitoring of water temperatures at control points
  - Needed to determine if operation meets control measures
- Almost no measurement of disinfectant residuals
  - Not viable option in hot water without *in situ* treatment
- Accessing sampling locations in the main & secondary piping and at the return point of recirculating loops

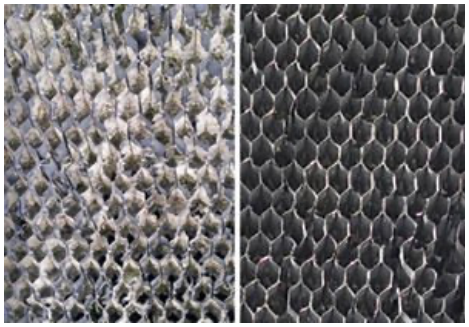
Challenges in collecting samples in building water systems

- Identification of all devices
- Activating faucets and showers to collect samples
  - Pedal activated, e activated, low flow, spray flow
- Mitigated faucets and showers
  - Individual and group TMVs
- Removing and cleaning aerators and shower heads



Defining a *Legionella* sampling strategy for cooling towers (CT)

- *Legionella* testing most often recommended/required (ASHRAE, CDC, NY)
  - Identified cause of waterborne outbreaks
  - Introduction of regulations effective
- Detailed procedures for safe operation and maintenance including at risk periods (standby, shutdown, restart, etc.)
- Inspection to identify components most at risk to amplify and transmit *Legionella*



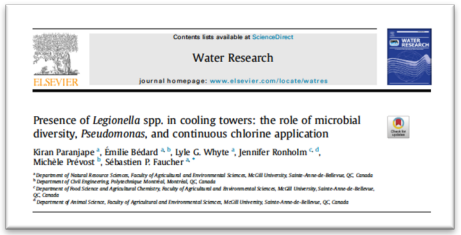
- **Some general features common, but must be tailored to each CT**
- **WMP determines sampling frequency and locations**
  - Common frequency for *Legionella* monitoring in monthly
  - Process monitoring is continuous or weekly

FOCUS on points vulnerable *to Legionella* growth AND exposure

Defining a *Legionella* sampling strategy for CTs

Complex treatment regimes

- Scale, corrosion and sediment control
- Oxidant and non-oxidant biocides
- Continuous VS discontinuous treatment
- Remedial and emergency disinfection



Contents lists available at ScienceDirect

Water Research

journal homepage: www.elsevier.com/locate/watres

Presence of *Legionella* spp. in cooling towers: the role of microbial diversity, *Pseudomonas*, and continuous chlorine application

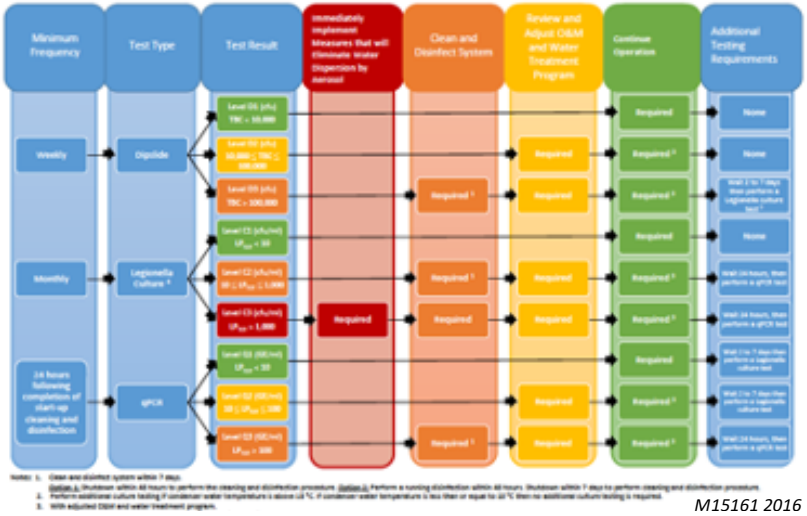
Kiran Paranjape [a], Émilie Bédard [a, b], Lyle G. Whyte [a], Jennifer Ronholm [c, d], Michèle Prévost [b], Sébastien P. Faucher [a, *]

System shutdowns

- Seasonal, emergency decontamination

Process control approach:

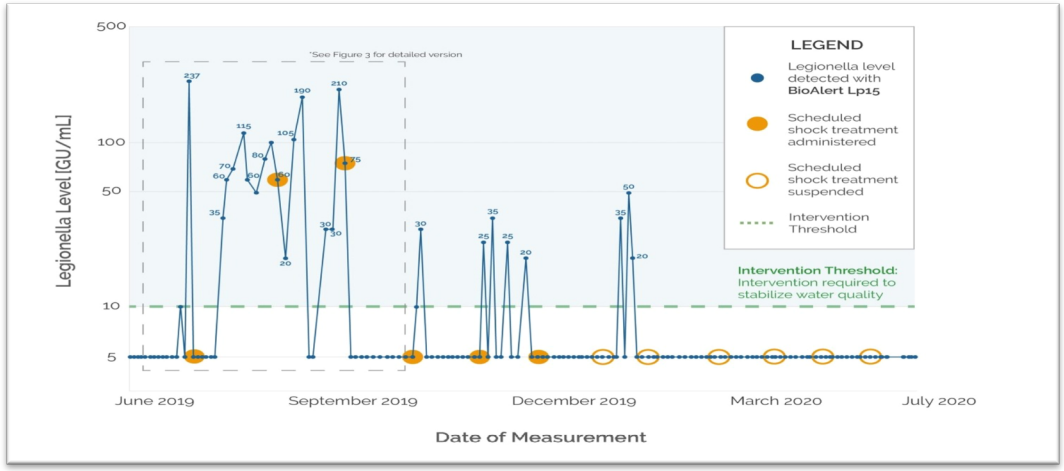
- **Operator use of disinfection indicators**
  - Dipslides, not correlated with *Lp* or *Lspp*
- **Growing use of rapid methods such as qPCR**
  - Investigations, adjustments, post-disinfection confirmation



M15161 2016

On line monitoring of *Legionella pneumophila* in cooling towers

- **Well established practice of automated control of scaling and corrosion using for ORP, pH, conductivity**
- **Innovative approaches to adjust treatment to minimize Lp**
  - Autonomous qPCR based on line detection
  - Identify drifts immediately and adjust treatment
  - Low interference from industrial matrices and dispersants



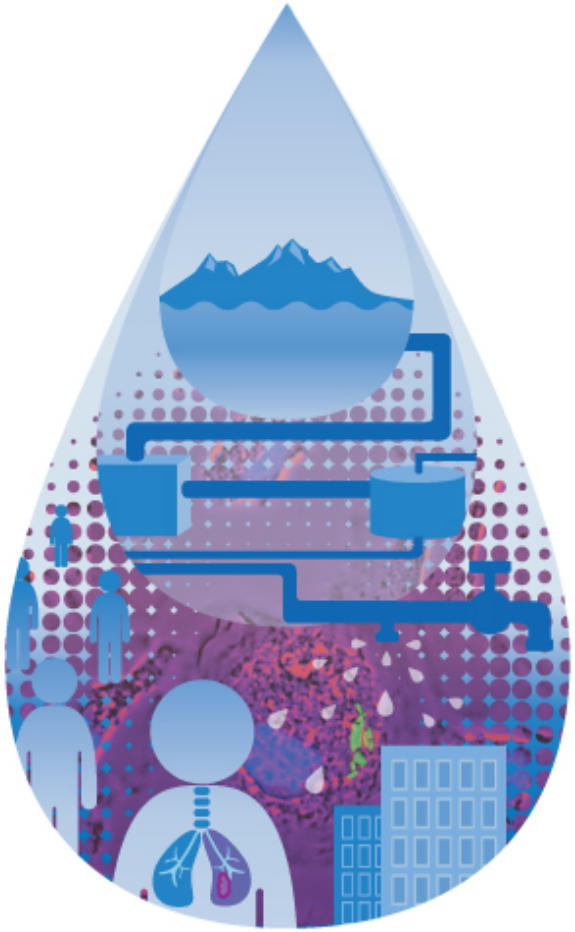
BIOALERT SOLUTIONS

CDC's ELITE Program

LOD : 5 GU / LOQ 10 GU
Same day results

Responding to positive *Legionella* samples

- **Expect some positives**
  - % positives ranges for culture (5-33%) and qPCR (28-100%) in water systems
- **Interpret as per building specific 'acceptable' levels (or regulations)**
  - Thresholds adapted the building users and features
    - Showers vs faucets vs toilets
    - Absence in a transplant unit versus low levels in public building faucets
  - Covid-19 Legionella monitoring may force the definition of 'acceptable' levels
- **Refer to Water Management Plan**
  - Implement corrective actions if needed
  - Develop reference levels for your system
  - Communicate with users and regulators



Thank you for your attention

Questions?

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