# DOMESTIC WATER: LEGIONELLA & PATHOGEN CONTROL

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Where NATURE & SCIENCE meet.™

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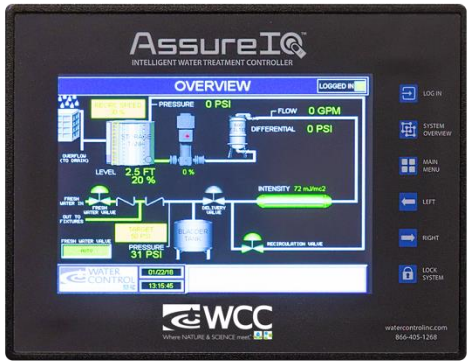
Legionella &
Pathogen Control

Water Reclamation

High-Purity Systems (RO/DI)

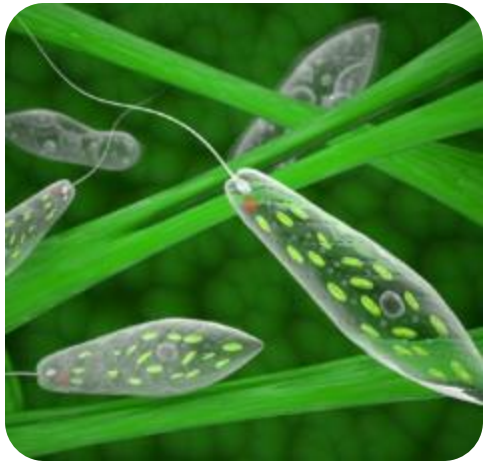
Water Softening & Filtration




Advanced PLC Controls

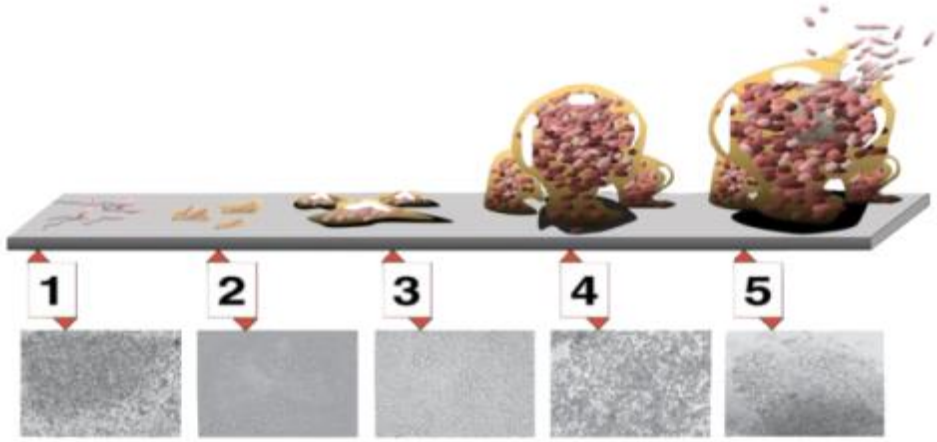
# MICROORGANISMS IN WATER

- Bacteria
- Viruses
- Protozoa



# BACTERIA

- Single cell organisms
- Enclosed within a cell wall
- Size 0.1 to 10 µ
- Waterborne spread biofilms
  - Shelter/habitat
  - Food source




# BACTERIA

- Approx. 40 billion bacteria in/on each of our bodies (10:1 bacteria:human cells)
- Most are not harmful, some pathogenic
- Require nutrients!
  - Organic matter, particulates, minerals, other microorganisms
  - Impossible to eliminate 100%
  - Control is the “name of the game!!”

# BIOFILM

"Drinking water distribution systems are colonized by saprophytic heterotrophic microorganisms (bacteria, fungi, yeasts, etc.) that grow on biodegradable organic matter. Potentially pathogenic microorganisms (e.g., Legionella spp.) and microorganisms of fecal origin (e.g., Escherichia coli) may also find favorable conditions and proliferate in these systems. This bacterial biomass (generally estimated at $10^8$ bacterial cells $liter^{-1}$ in flowing water and $10^6$ bacterial cells $cm^{-2}$ in the biofilm) is the start of a complex food chain involving mainly protozoa and macro-organisms."

Source: I. Sibille et al., American Society for Microbiology[6]

# TRANSLATION????

Bacterial Cells in flowing Water:

$10^8$/Liter = 3.8 x $10^8$/gal =

**380,000,000 Bacteria**

**per gallon of flowing water**

# TRANSLATION????

Bacterial Cells in Biofilm:

$10^6/cm^2 = 6.4 \times 10^6/in^2$

**243,000,000 Bacteria**

**in Biofilm per 1 ft of 1“ pipe**

# COMMON PATHOGENS IN DOMESTIC WATER

## (CDC ESTIMATE: 90,000 HOSPITALIZATIONS AND 7,000 DEATHS ANNUALLY!)

Escherichia coli

(Gastrointestinal)

Legionella pneumophila

(Respiratory)

Pseudomonas aeruginosa

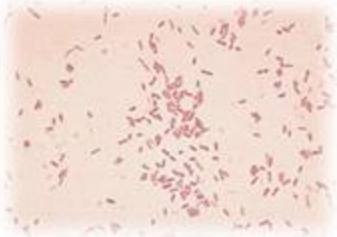
(General + Skin)

Non-TB Mycobacterium

(General Infections)

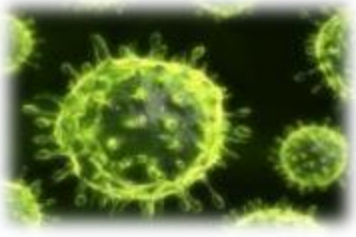
Staphylococcus aureus

(General Infections)



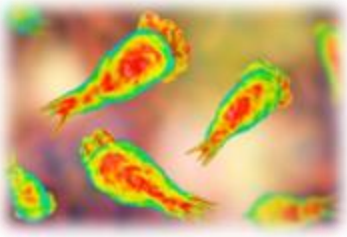
Aeromonas (multiple species)

(Stomach, Wound, Flesh-Eating Disease)



Viruses

(General)



Protozoa

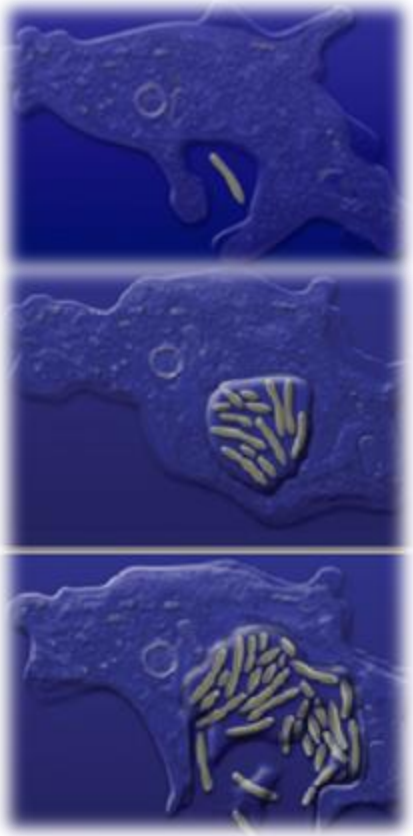
(General + Stomach + Brain)

# LEGIONELLA

- 1976 American Legion conference (within 1 week… 130 hospitalized, 34 dead)
  - Now 5,000 x more antibiotic resistant
- Legionnaire's disease (pneumonia-like)
  - General mortality: 1 in 10
  - Healthcare mortality: 1 in 3 or 4
  - Survivors face long-lasting side-effects
  - Immunodeficient susceptible
- Pontiac fever
  - Flu-like
- CDC estimate: > 30,000 cases in US/ Yr.
  - Only about 7,000 reported
  - Increase of 450% since year 2000

# LEGIONELLA PNEUMOPHILA

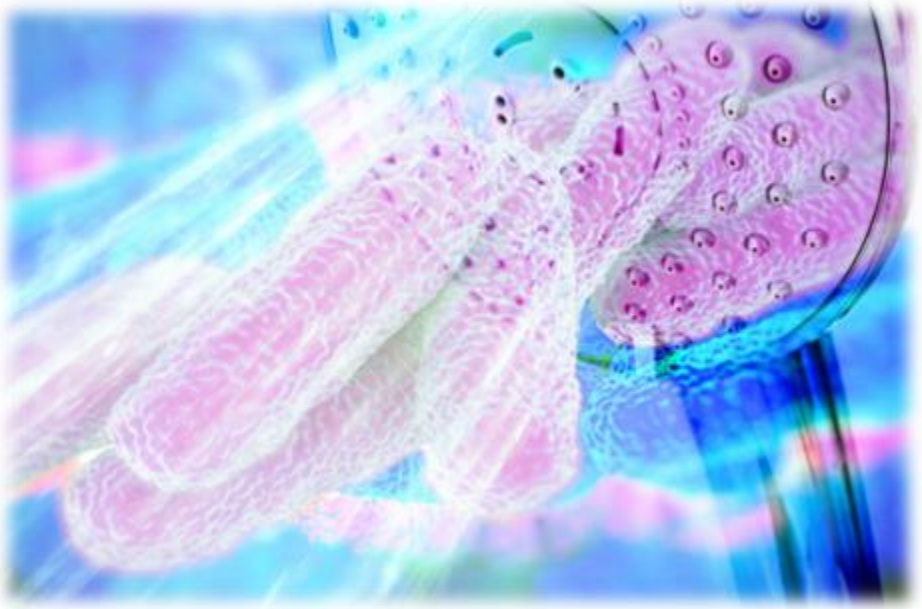
- Extremely common in virtually all public and private water supplies (small numbers)
- Lives and flourishes in biofilm
- Feeds on other bacteria
- Released during piping disturbances
- Amoeba KEY to reproduction
  - Legionella can survive 50 PPM of free chlorine for 18 hours inside a typical amoeba
  - Amoeba control critical
  - Chlorine not very effective on biofilm



# COMMON LEGIONELLA TRANSMISSION POINTS

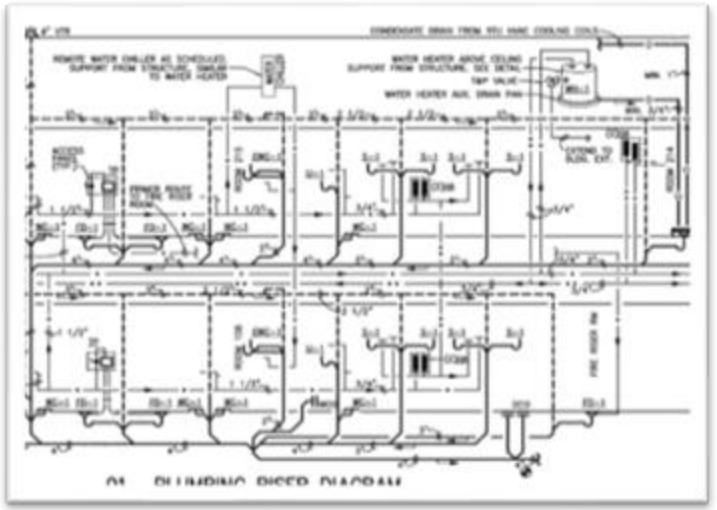
**The Real Danger: Inhalation!**

- Showers
- Faucets
- Humidification
- Misters
- Cooling towers
- Decorative fountains
- Ice machines
- Hot tubs
- Dental chairs



# FAVORABLE CONDITIONS IN BUILDING WATER SYSTEMS LEGIONELLA

- Water temps: 68 – 122°F
- "Water Age"
  - Stagnation
  - Dead legs
  - Over-sized pipes
  - Low flow fixtures
- Scale and sediment
- Lack of a residual disinfectant

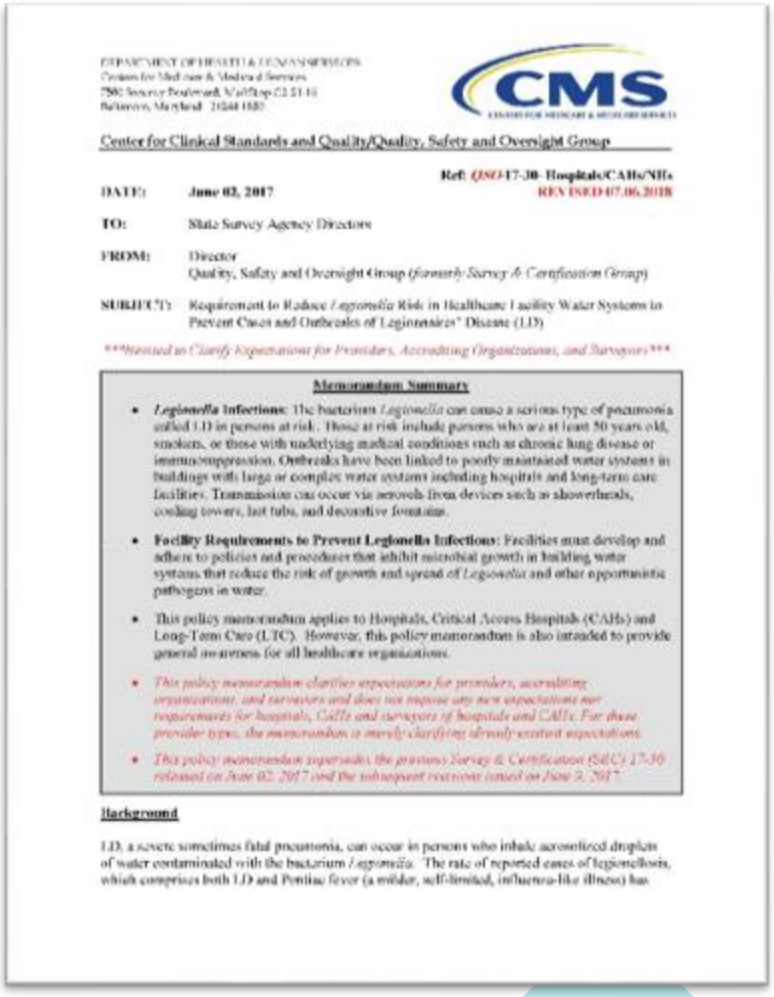


# LEGIONELLA PNEUMOPHILA

- Current Consensus #1 (flowing water):
  - 0 CFU/ml = “Ideal”
  - 0.1-1.0 CFU/ml = “Low Risk” (monitor)
  - 1.0-10 CFU/ml = “Normal Risk” (disinfect, test, manage)
  - >10 CFU/ml = “High Risk” (sanitize, disinfect, report)
  - Same guidelines for cooling towers
- Current Consensus #2:
  - If >30% of fixtures are positive = “High Risk”
    - (test at least 10 fixtures + heater + return)
- Adiabatic humidifiers: >1 CFU/ml = “High Risk”

# WHY ARE PEOPLE PAYING ATTENTION?

- 2017 CMS mandate
  - ASHRAE 188 standard to be implemented and enforced
  - Risk assessment / solution implementation required
- Joint Commission 2022
- OSHA recommendations
- CSA standards existing



DEPARTMENT OF HEALTH & HUMAN SERVICES
Centers for Medicare & Medicaid Services
7500 Security Boulevard, Mail Stop C2-21-16
Baltimore, Maryland 21244-1850

CMS
CENTERS FOR MEDICARE & MEDICAID SERVICES

Center for Clinical Standards and Quality/Quality, Safety and Oversight Group

Ref: QSO-17-30- Hospitals/CAHs/NHs
REVISED 07.06.2018

DATE: June 02, 2017

TO: State Survey Agency Directors

FROM: Director
Quality, Safety and Oversight Group (formerly Survey & Certification Group)

SUBJECT: Requirement to Reduce *Legionella* Risk in Healthcare Facility Water Systems to Prevent Cases and Outbreaks of Legionnaires' Disease (LD)

***Revised to Clarify Expectations for Providers, Accrediting Organizations, and Surveyors***

**Memorandum Summary**

- ***Legionella* Infections:** The bacterium *Legionella* can cause a serious type of pneumonia called LD in persons at risk. Those at risk include persons who are at least 50 years old, smokers, or those with underlying medical conditions such as chronic lung disease or immunosuppression. Outbreaks have been linked to poorly maintained water systems in buildings with large or complex water systems including hospitals and long-term care facilities. Transmission can occur via aerosols from devices such as showerheads, cooling towers, hot tubs, and decorative fountains.
- **Facility Requirements to Prevent Legionella Infections:** Facilities must develop and adhere to policies and procedures that inhibit microbial growth in building water systems that reduce the risk of growth and spread of *Legionella* and other opportunistic pathogens in water.
- This policy memorandum applies to Hospitals, Critical Access Hospitals (CAHs) and Long-Term Care (LTC). However, this policy memorandum is also intended to provide general awareness for all healthcare organizations.
- *This policy memorandum clarifies expectations for providers, accrediting organizations, and surveyors and does not impose any new expectations nor requirements for hospitals, CAHs and surveyors of hospitals and CAHs. For these provider types, the memorandum is merely clarifying already existing expectations.*
- *This policy memorandum supersedes the previous Survey & Certification (S&C) 17-30 released on June 02, 2017 and the subsequent revisions issued on June 9, 2017.*

**Background**

LD, a severe sometimes fatal pneumonia, can occur in persons who inhale aerosolized droplets of water contaminated with the bacterium *Legionella*. The rate of reported cases of legionellosis, which comprises both LD and Pontiac fever (a milder, self-limited, influenza-like illness) has

# CONTROLLING LEGIONELLA IN BUILDING SYSTEMS

**MOST IMPORTANT:**


- Eliminate “dead-legs” and other stagnation
- Stagnation = 16 hours
- Limit distances from HW recirculation loop
- Low flow fixtures: how low is low enough?
- Perform regular system flushing
  - Electronic fixtures, solenoid valves
  - Manual flushing
- Temperatures over 122°F inhibit growth
- TEST TEST TEST!
- DOCUMENT DOCUMENT DOCUMENT!

# USING TEMPERATURE TO CONTROL

- Recirculate greater than 140°F
- Periodic heat sanitizing (over 158°F)
  - Simple
  - Effective on free-floating Legionella
  - Scald risk
  - Mixing valves (GROWTH!)
  - Energy wasted
  - Hot water limitations?
  - Doesn't kill within biofilm

| | | |
|---|---|---|
| Below 20°C | (68°F) | Can survive but are dormant |
| 20 to 50°C | (68 to 122°F) | Growth rate |
| 35 to 46°C | (95 to 115°F) | Ideal growth range |
| Above 50°C | (122°F) | Can survive but do not multiply |
| 55°C | (131°F) | Dies within 5-6 hours |
| 60°C | (140°F) | Dies within 32 minutes |
| 66°C | (151°F) | Dies within 2 minutes |
| 70 to 80°C | (158 to 176°F) | Disinfection range |

**Temperature doesn't deal with the "cold" water lines or "mixed" fixture outlets. DEAD CELLS = FOOD!!!**

# REGULATORY HURDLES FOR OTHER METHODS

## 1974 Safe Drinking Water Act

- Building serving 25+ individuals becomes a "Community Water System" if "treatment" installed
  - "Treatment" definition varies by state
  - Normally excludes softeners and filters
  - Hot water systems sometimes included
  - Typically requires water testing
    - Copper, coliforms, arsenic, DBP's, etc.
  - Requires a certified and/or licensed operator (per state)

# ADDITIONAL METHODS OF CONTROL

## Chemical Disinfectants

- Differing levels of effectiveness
- Community water certification required
- Can attack plumbing systems (metals, rubbers, etc.)
- Regular maintenance requirements
  - Daily monitoring
  - Chemical replenishment
  - Replacement/cleaning of pumps, probes, elastomers, etc.


# ADDITIONAL METHODS OF CONTROL

- **Free chlorine** (0.5 – 1.5 PPM free residual)
  - Inexpensive (bleach)
  - Commonly used and understood
  - Works well with free-floating bacteria
  - Degrades in high temperatures
  - Ineffective on biofilms and amoeba
  - Byproducts (regulated)

# ADDITIONAL METHODS OF CONTROL

- **Monochloramine** (1 - 1.4 PPM residual)
  - Good results with biofilm control and penetration
  - Long-lasting residual
  - Expensive
  - Attacks rubber
  - Nitrification (nitrates = regulated)
  - Over-feed can cause significant damage to piping (especially copper)

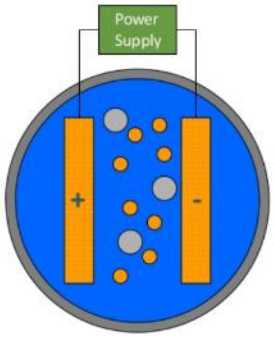
# ADDITIONAL METHODS OF CONTROL

- **Chlorine dioxide (ClO2)**
  - (0.4 - 0.7 PPM dose, 0.1 - 0.5 PPM residual)
  - Good control of free-floating Legionella
  - Mixed results with biofilm and amoeba
  - Expensive
  - Flammable and explosive (often on contact)
  - Toxic off-gas (filtration required)
  - Chlorite buildup (regulated)

Take care when mixing different disinfectants!

# ADDITIONAL METHODS OF CONTROL

- **Copper silver ionization**
  - Very effective on free-floating Legionella
  - Decent biofilm penetration
  - pH limitations (ineffective in high pH)
  - Expensive
  - Potential increase in Mycobacterium, per USEPA study
  - Regulated metals released into water
    - Weekly testing/maintenance
  - Metal buildup in system
  - Classified as “insecticide”

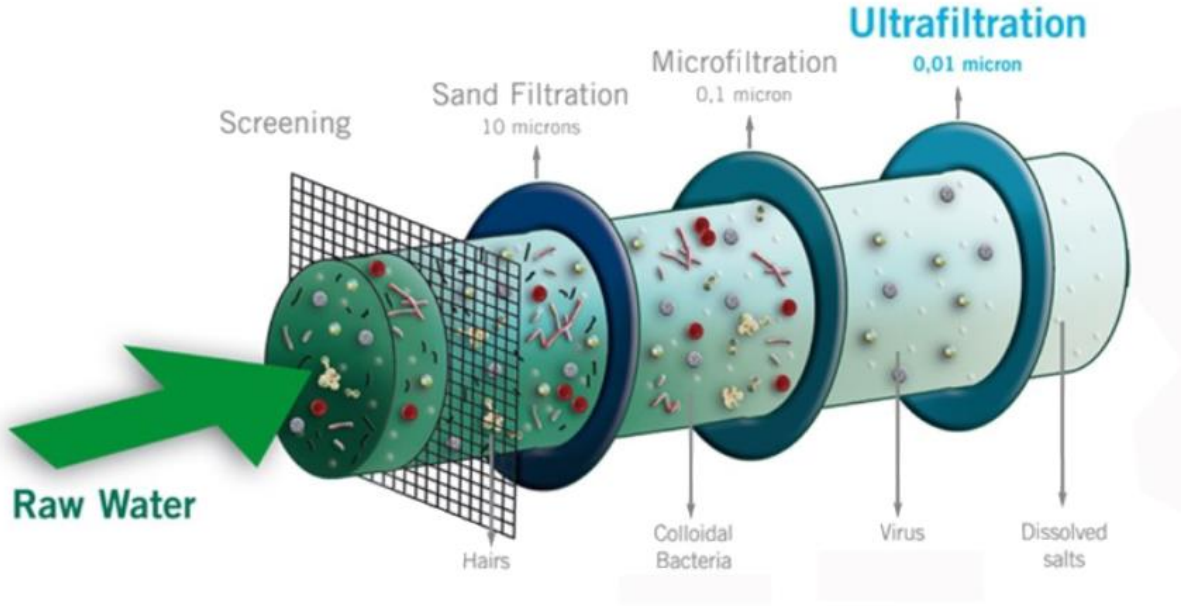


# ADDITIONAL METHODS OF CONTROL

- **UV irradiation**
  - Very high kill rate for Legionella + Amoeba
  - Simple and inexpensive
  - Requires direct contact with water
  - Destroys chlorine
  - Particulates = incomplete disinfection
  - Dead bacteria = FOOD!


- **Point-of-use filtration (0.1 micron or less)**
  - Highly effective
  - Good emergency solution
  - Expensive
  - Maintenance-intense (4-6 week life)

# NEW SOLUTION: ULTRAFILTRATION

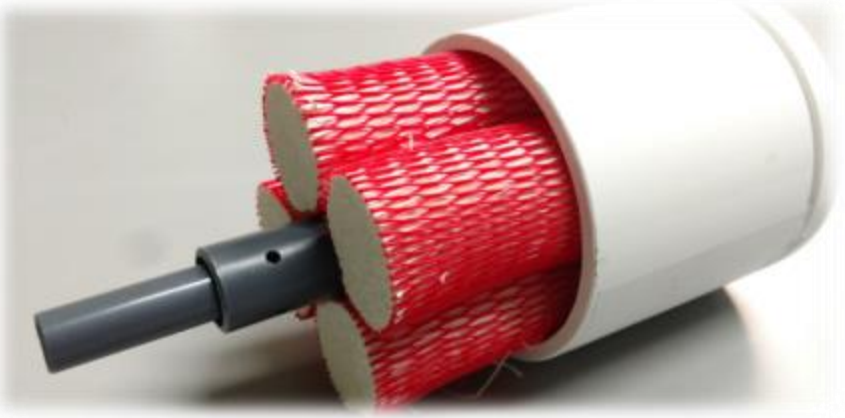


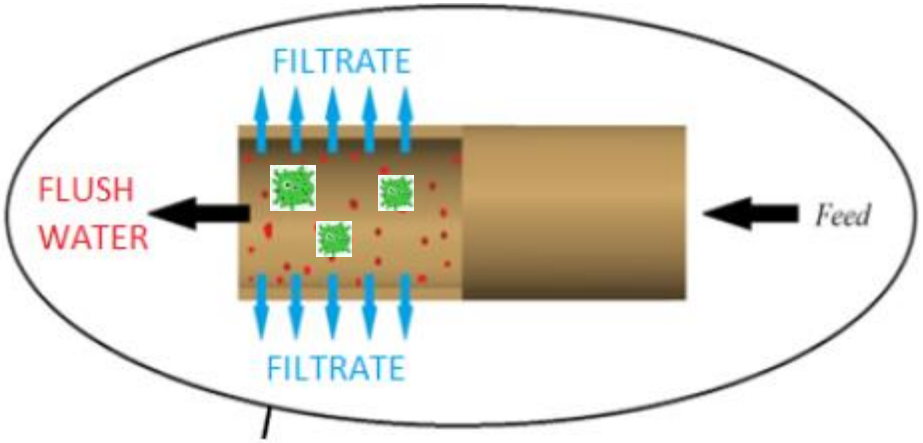

- Filtration 0.02 - 0.01 micron
- 99.999+% removal of bacteria and amoeba
- 99.99+% removal of viruses
- Dissolved minerals and chemicals unaffected!

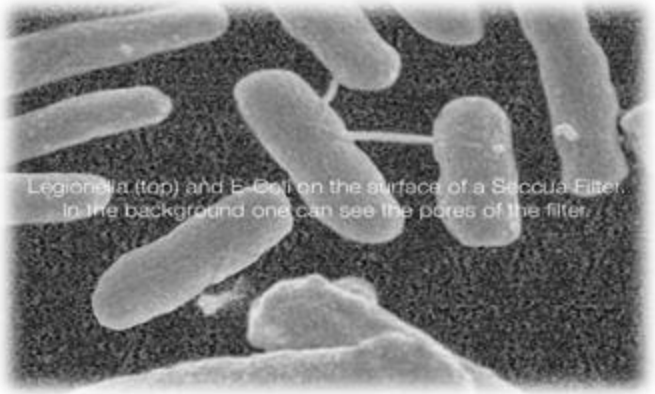
# NEW SOLUTION: ULTRAFILTRATION

# NEW SOLUTION: ULTRAFILTRATION

HUF™






Thousands of fibers per module!

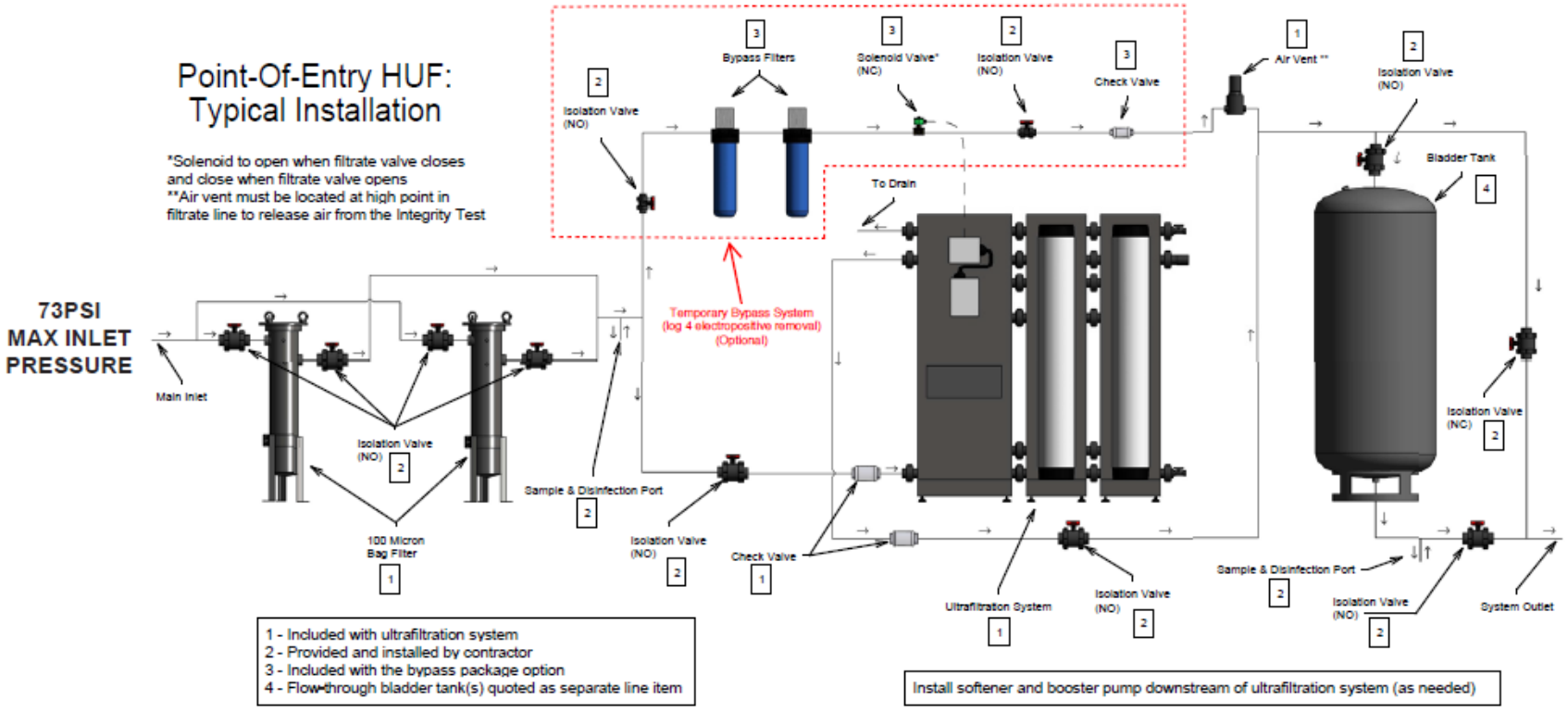
# POINT-OF-ENTRY TREATMENT

## Whole-Building Ultrafiltration: A Firewall for pathogens!

- Prevent entry of 99.999+% of bacteria/nutrients!
- Eliminates boil water advisory shutdowns
- Reduced biofilm growth (no bugs, less food)
- Protection from city contamination
- Disinfectants more effective!
- Self-cleaning (20 second cycle, 1 – 2 times daily)
- BAS-connectable
- Automatic membrane integrity testing (EPA-approved)
- 10-22 year typical membrane life

**GT-1 System**

# POINT-OF-ENTRY TREATMENT




**(A single “rack” has 1 controller and up to 4 membranes)**

# HEALTHCARE INSTALLATION

# STANDARD POINT-OF-ENTRY SYSTEMS

## TYPICAL SYSTEM SPECIFICATIONS

| System | # of membranes | Continuous Flow GPM[1] | | | | Short Term Peak GPM[2] (flush valve % of total fixture units)[3] | | | Standard Hydro Tank Vol (gal) | Req. Space (LxWxH)[4] (inch) | Connections (inch)[6] | Flush Volume (gal)[7] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 5 PSID | 10 PSID | 15 PSID | 20 PSID | 60 sec draw (0-25%) | 45 sec draw (26-50%) | 30 sec draw (51+%) | | | | |
| Virex Pro | 2 | 6 | 8 | 10 | 12 | 39 | 47 | 65 | 106 | 70 x 32 x 78 [5] | 1 NPT | 1 |
| Phoenix GT-1 | 1 | 40 | 56 | 69 | 79 | 119 | 132 | 158 | 158 | 124 x 36 x 84 [5] | 2 FLG | 4 |
| Phoenix GT-2 | 2 | 71 | 101 | 124 | 143 | 196 | 213 | 249 | 211 | 146 x 48 x 84 [5] | 3 FLG | 9 |
| Phoenix GT-3 | 3 | 94 | 132 | 162 | 187 | 293 | 328 | 398 | 211 x 2 | 204 x 48 x 84 [5] | 3 FLG | 13 |
| Phoenix GT-4 | 4 | 108 | 153 | 187 | 215 | 373 | 426 | 532 | 211 x 3 | 262 x 48 x 84 [5] | 4 FLG | 17 |

[1]Assumes 50°F, reasonable-quality city water supply and normal membrane fouling
[2]Equals possible GPM flow for indicated draw duration @20 PSID, using 25% of nominal hydro tank volume
[3]Percentage of total calculated fixture units derived from flush valves and other "short-cycle" fixtures
[4]Other configs. possible. Includes (bag) pre-filter(s) and standard hydro tanks
[5]Virex Pro filter unit is wall-mounted. All other systems (including pre-filters and hydro tanks) are floor-mounted
[6]Drain line connection is 1" on Virex Pro and 2" on all GT models
[7]Standard flush duration is 10 seconds (may be increased, dependent on feed water quality)

Phoenix GT

Virex Pro

Hydropneumatic Tank
(Photo courtesy of Wessels)

Pre-Filter Assembly

# POINT-OF-ENTRY ULTRAFILTRATION

## New Construction = A "No-Brainer"

- Protect investment from day 1
- Minimize biofilm growth (permanently)
- Manage the cause – not the symptoms
- Significant liability protection!
- No damage to piping and fixtures
- No harm to human health
- Minimal maintenance
- Install prior to initial building "fill"

# POINT-OF-ENTRY ULTRAFILTRATION

## A PICTURE IS WORTH 1,000 WORDS!

### New Hospital (Opened December 2016)

*Biofilm comparison after 14 months:*
*Raw water vs filtrate in stagnant parallel pipe!*

# POINT-OF-ENTRY ULTRAFILTRATION

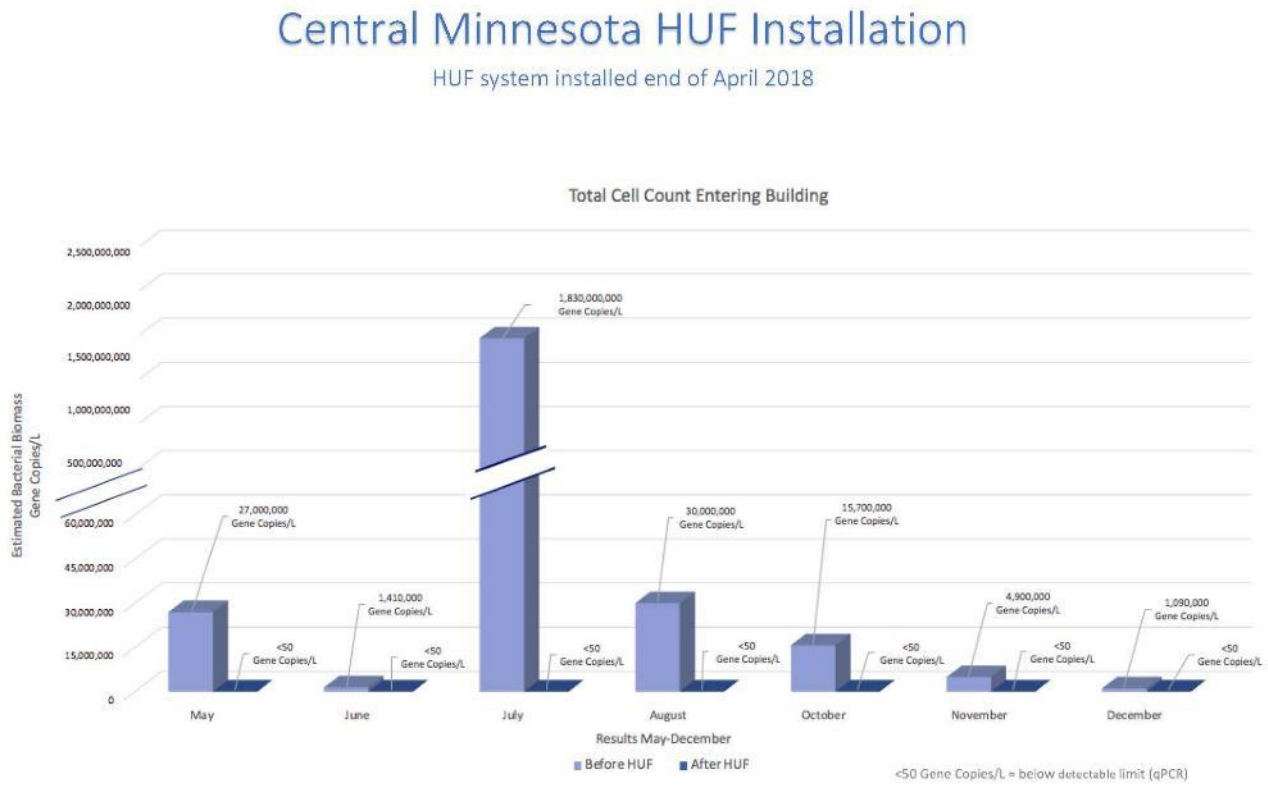
## Existing Buildings:

- An instant firewall to disrupt biofilm lifecycle
  - Drastic reduction in new nutrients and organisms
  - More effective disinfectant residuals over time
- Bacteria levels spike temporarily as biofilm sloughs – and then plummet
- Use disinfectants (typically chlorine), temp, and flushing to purge/control
- Address piping and water age issues
- Ongoing testing required

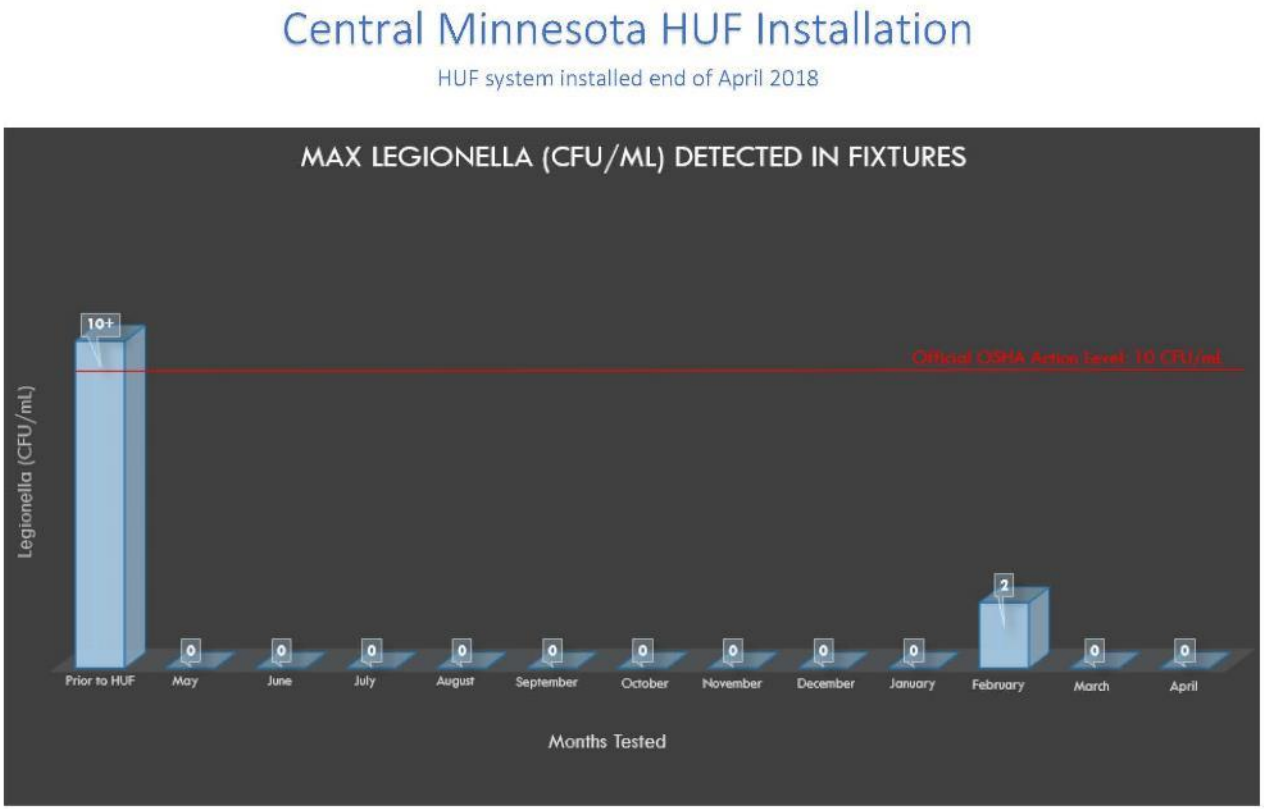
Hospital Installation

Control Panel

# 2018 POINT-OF-ENTRY ULTRAFILTRATION STUDY



# 2018 POINT-OF-ENTRY ULTRAFILTRATION STUDY




Avg 0.3 ppm free chlorine in facility (city-supplied)

# ESTIMATED PRICE COMPARISON VS OTHER METHODS

**HUF** (Point-of-Entry, GT-4)

- $157K system w/bypass
- $1K annual repl. filters x 4 years
- $1K annual service (optional) x 4 years

- **= $165,000 over 5 years**

**Monochloramine:** 300GPM System

- $80K system (incl. year 1 chemicals)
- $21K annual chemical x 4 years
- $7500 annual repair x 4 years (P&L)

- **= $194,ooo over 8 years**

**Copper-Silver:** 300GPM System

- Est: $130K system (incl. year 1 cells)
- $15K annual repl. cells x 4 years
- $3K annual service x 5 years

- **= $185,000 over 8 years**

**Electropositive Cartridge Filters:**
300GPM Skidded System w/redundancy
(a "skid system" with our bypass filters)

- $80K system (w/controls)
- $22K annual repl. cartridges x 5 years
- $8K annual service x 5 years

- **= $230,000 over 5 years**

**After 10+ years (typical), HUF Requires $30K replacement membranes (approx. 3 hours labor)**

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Water Reclamation

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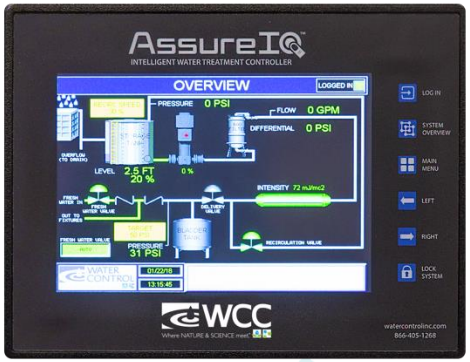


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