Legionella Monitoring in NYC's Distribution System

ENOMA OMOREGIE
NEW YORK CITY DEPARTMENT OF HEALTH AND MENTAL HYGIENE
PUBLIC HEALTH LABORATORY

NATIONAL ENVIRONMENTAL MONITORING CONFERENCE 2019

Legionella spp. Monitoring in the New York City Drinking Water Distribution System (LMINDS)

- Joint study between the NYC Department of Environmental Protection and Department of Health and Mental Hygiene.
- Four primary study questions:
  - What is the prevalence and geographic distribution of *Legionella* in NYC's water distribution system?
  - What *Legionella* species inhabit the NYC distribution system, and how do they relate to species described in clinical and environmental studies?
  - How do environmental factors such as physiochemical water parameters, water age, disinfectant levels etc., and utility management practices correlate with the presence of *Legionella*?
  - Can utility management practices that reduce *Legionella* levels be identified?

What is *Legionella?*

- Gram negative bacterium that is part of the *Gammaproteobacteria*.

- Naturally occurring and often found in aquatic systems: rivers, streams, cooling towers, hot and cold domestic water systems etc.

- Grows optimally at around 35°C.

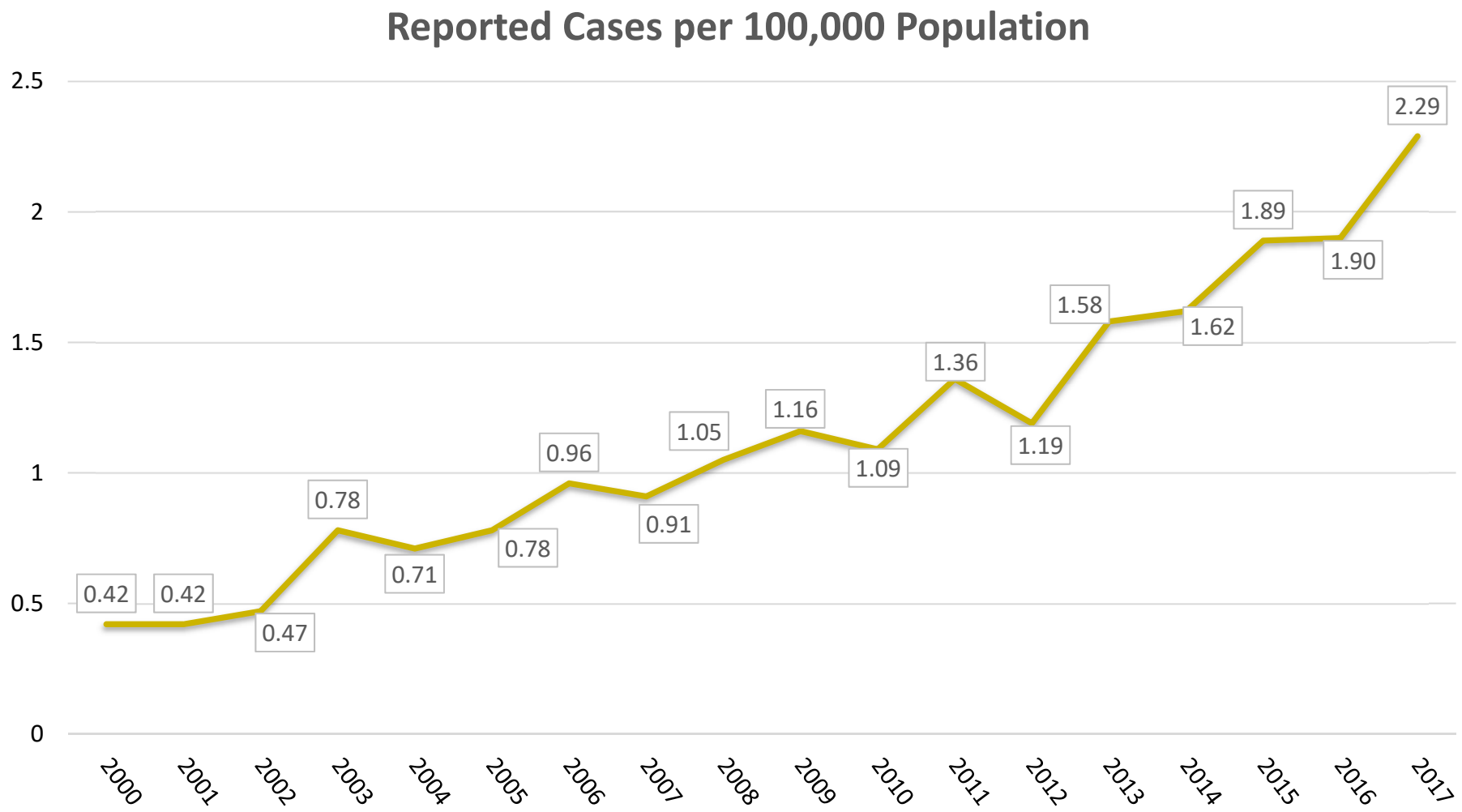
- Causative agent of legionellosis.

Source: CDC.gov; Chemology.com.au

Legionellosis is two distinct syndromes

- Legionnaires' disease, which is a serious type of pneumonia.
  - ~6,000 reported cases per year in the USA and NYC has about 200 - 440 cases per year.
  - 9% mortality rate.
  - Risk factors include smoking, chronic lung disease, age, and a compromised immune system.
- Pontiac fever, a milder respiratory disease that is usually self limiting.
- Transmission of Legionnaires' disease and Pontiac fever occur through inhalation of water droplets containing *Legionella*.

Legionnaires' disease cases have increased 5.5 X in the US since 2000

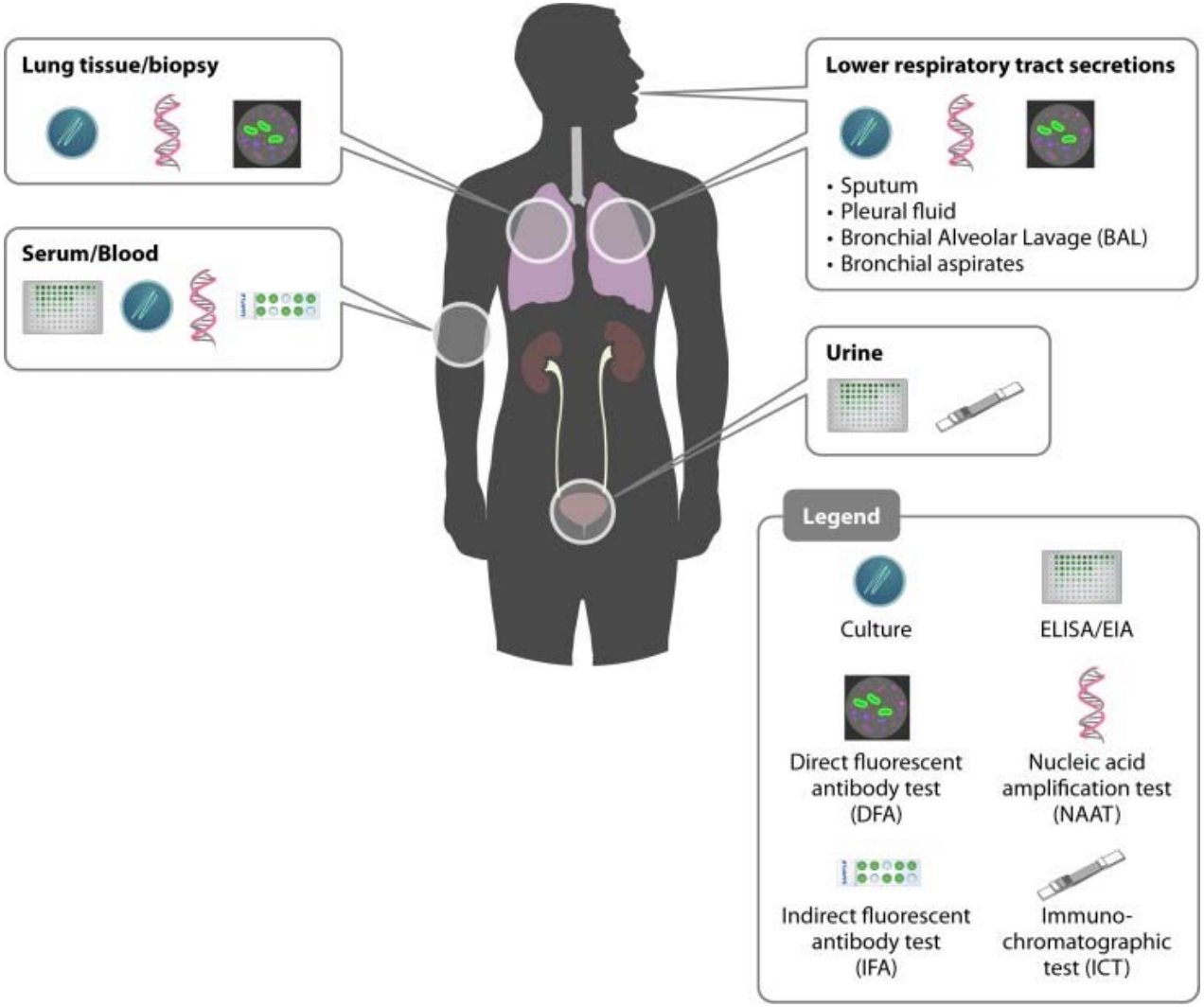


Source: National Notifiable Diseases Surveillance System

Legionella pneumophila SG 1 causes most of the reported cases in the USA and Europe

- At least 50 described species of *Legionella*, and many, but not all have been associated with disease.
  - *L. pneumophila* serogroups 1-16, *micdadei, longbeachae, dumoffii, gormanii, feeleii, bozemanae, jordanis, oakridgensis, sainthelensi, wadsworthii, hackeliae, anisa, maceachernii, birminghamensis, rubrilucens, tucsonensis, erythra, cincinnatiensis, parisiensis*…,
- *Legionella pneumophila* serogroup 1 is responsible for 72 – 92% of laboratory diagnosed cases in the USA and Europe.
- Likely some bias, as the mostly widely used test, UAT, only detects *Legionella pneumophila*.

Several diagnostic tests for determining a *Legionella* infection



Source: Mercante and Winchell, 2015

Water is often an implicated source of Legionnaire's disease cases

- Most cases of Legionnaires' disease are sporadic.
- However, outbreaks are often associated with poorly maintained distribution systems in buildings and hospitals; cooling towers; spas and even misters.




- Municipal distribution systems are generally not the source of Legionnaires disease outbreaks.

Source: gettyimages; chemology.com.au; pbs. Org; apnews.com

Legionella in municipal water distribution systems

ELSEVIER

International Journal of Hygiene and Environmental Health

Volume 222, Issue 4, May 2019, Pages 687-694

Spatio-temporal survey of opportunistic premise plumbing pathogens in the Paris drinking water distribution system

International Journal of Environmental Research and Public Health

MDPI

Int J Environ Res Public Health. 2014 Jul; 11(7): 7393–7405. PMCID: PMC4113883
Published online 2014 Jul 18. doi: 10.3390/ijerph110707393 PMID: 25046636

Detection of *Legionella*, *L. pneumophila* and Mycobacterium Avium Complex (MAC) along Potable Water Distribution Pipelines

Harriet Whiley,[1,*] Alexandra Keegan,[2,†] Howard Fallowfield,[1,†] and Richard Bentham[1]

Author information · Article notes · Copyright and License information Disclaimer

AMERICAN SOCIETY FOR MICROBIOLOGY | Applied and Environmental Microbiology

search

Advanced Search

Home Articles For Authors About the Journal Subscribe

Public Health Microbiology

Molecular Survey of the Occurrence of *Legionella* spp., *Mycobacterium* spp., *Pseudomonas aeruginosa*, and Amoeba Hosts in Two Chloraminated Drinking Water Distribution Systems

Hong Wang, Marc Edwards, Joseph O. Falkinham, III, Amy Pruden

American Water Works Association

Search

PUBLICATIONS AUTHOR RESOURCES CONTACT AWWA

AWWA WATER SCIENCE

ORIGINAL RESEARCH | Open Access

Occurrence of culturable *Legionella pneumophila* in drinking water distribution systems

Mark W. LeChevallier

First published: 02 June 2019 | https://doi.org/10.1002/aws2.1139

Water Science & Technology

ISSUES JOURNAL INFORMATION LIBRARIANS OPEN ACCESS BOOKS ABOUT

Volume 50, Issue 1
1 July 2004

Water Science & Technology

RESEARCH ARTICLE | JULY 01 2004

Investigation of opportunistic pathogens in municipal drinking water under different supply and treatment regimes

M. Pryor; S. Springthorpe; S. Riffard; T. Brooks; Y. Huo; G. Davis; S.A. Sattar
Water Sci Technol (2004) 50 (1): 83-90.
https://doi.org/10.2166/wst.2004.0025

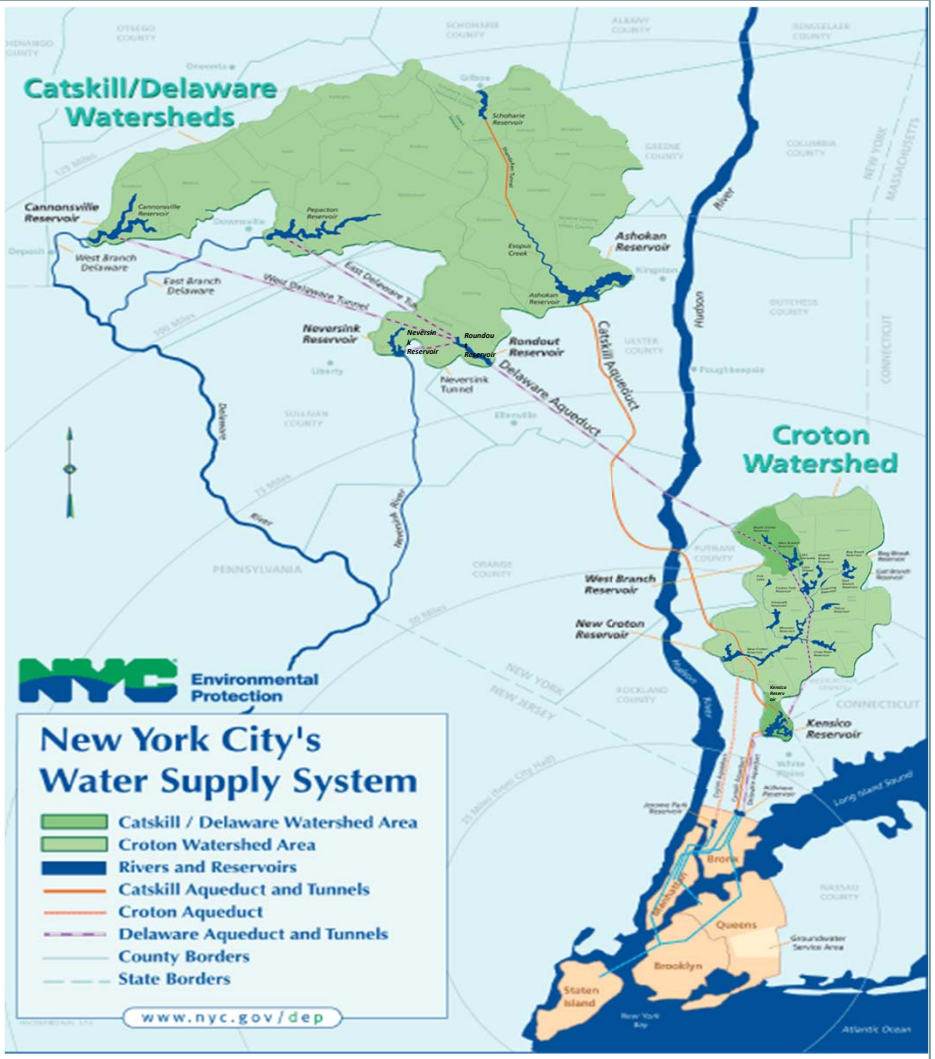
Share Tools

Legionella spp. Monitoring in the New York City Drinking Water Distribution System (LMINDS)

- Prior to this study, there was no comprehensive examination of *Legionella* in NYC's distribution system.
- Study questions:
  - What is the prevalence and geographic distribution of *Legionella* in NYC's water distribution system?
  - What *Legionella* species inhabit NYC's distribution system, and how do they relate to species described in clinical and environmental studies?
  - How do environmental factors such as physiochemical water parameters, water age, disinfectant levels etc. and utility management practices correlate with the presence of *Legionella*?
  - Can utility management practices that reduce *Legionella* levels be identified?

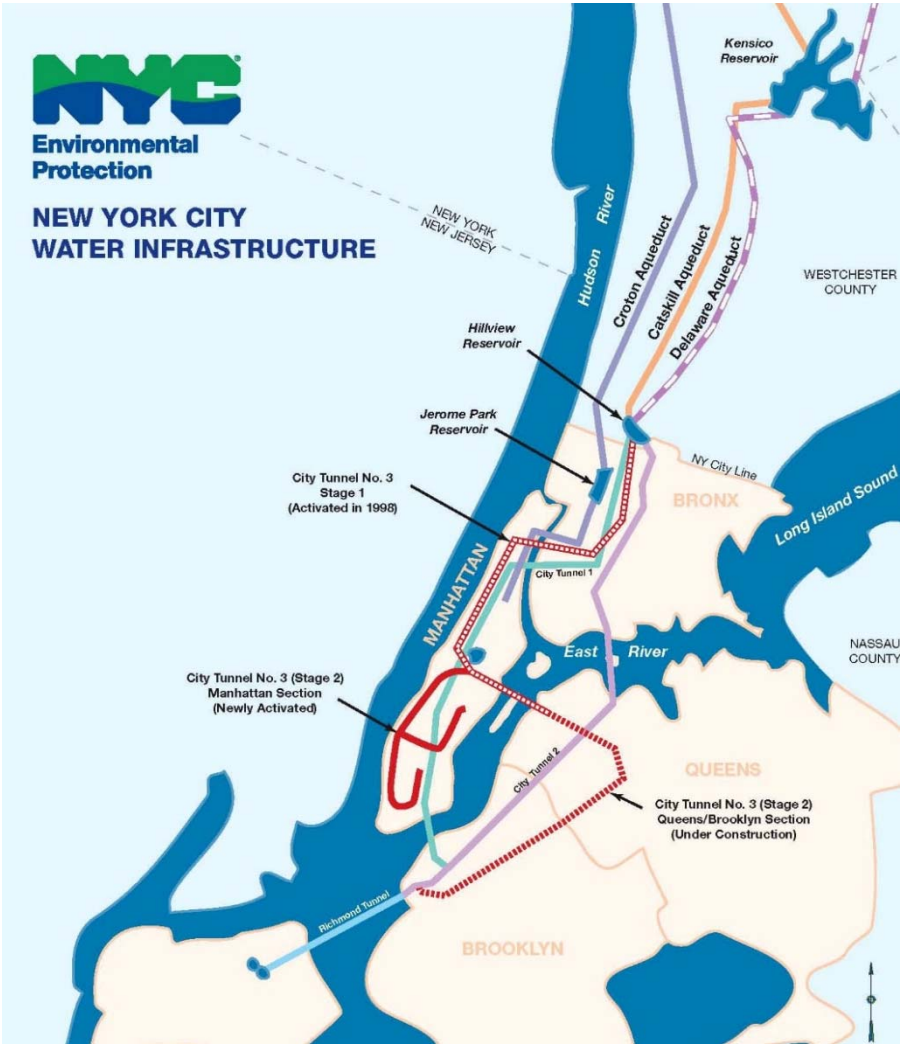
NYC drinking water is sourced from two watersheds

- Mainly a surface water supply.
- Catskill/Delaware and Croton watersheds.
- 19 reservoirs and 3 controlled lakes.
- Serves 9.6 million people.
- Delivers approx. 1.1 billion gallons per day.
- System Capacity: 570 billion gallons.
- Operated and maintained by NYCDEP.



Drinking water is fed through tunnels

- Water is supplied by 4 water tunnels.
- Water from Cat\Del is UV treated and chlorinated.
- Water from Croton is filtered, UV treated and chlorinated.
- Monitored daily through 962 sampling stations installed throughout the distribution system.
- In 2018 DEP:
  - Collected 37,500 samples
  - Performed 414,000 analyses



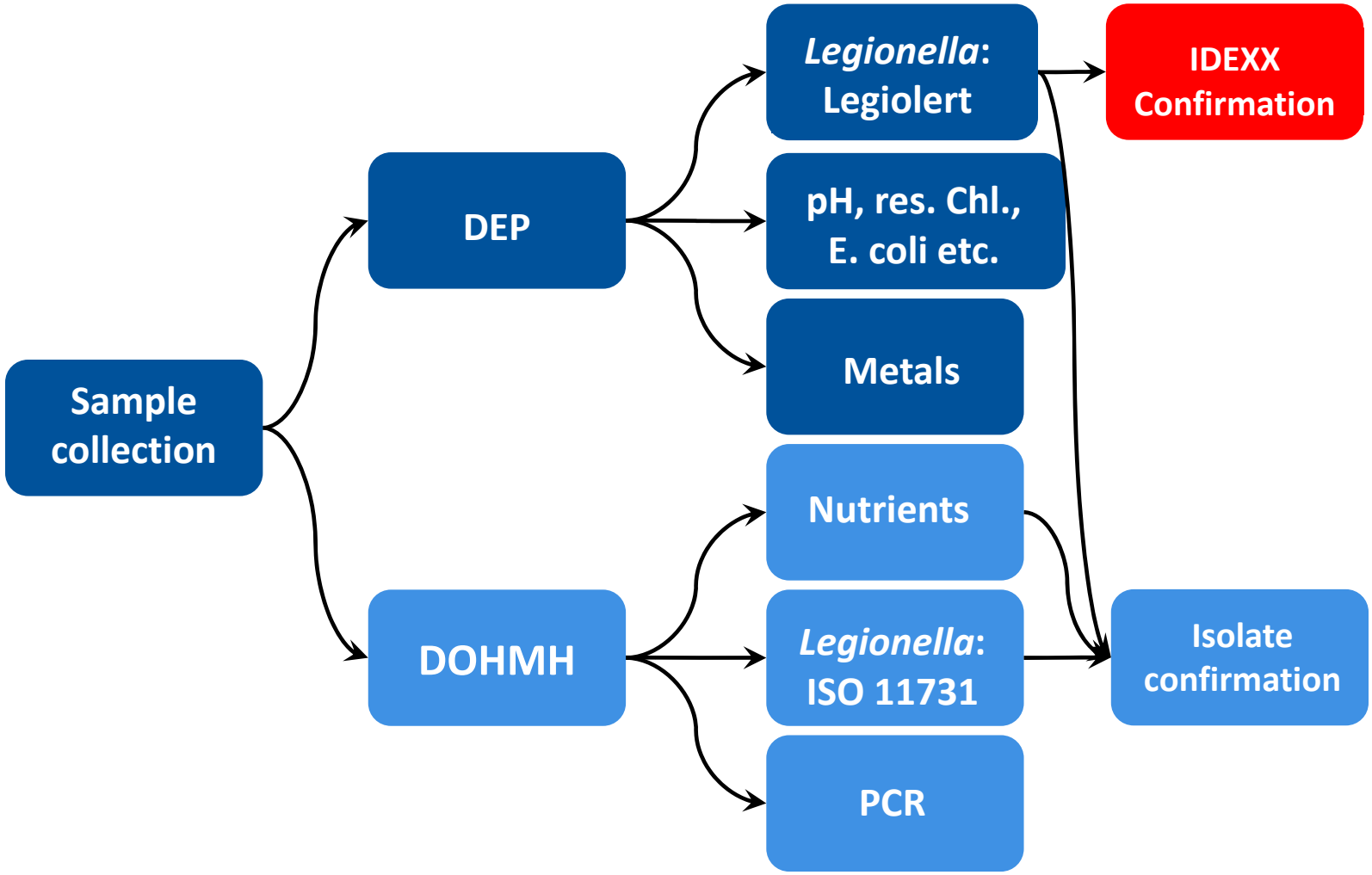
Water was collected from 19 stations 7 biofilm locations

- 19 different water sampling sites.
  - **Raw water** from both water sources.
  - **Pre-finished water** from both water sources.
  - **Distribution (treated) water** from both water sources.
- 7 different biofilm sampling sites.
- Monthly: Nov. 2017 to Oct. 2018.
- Monitored physicochemical and microbiological parameters.

Water sampling site

Biofilm sampling site

Sample analysis shared between DEP and DOHMH



Legionella detection using culture

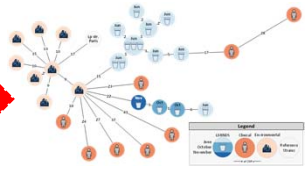
Sample filtration:
Legionella concentration

Sample culture:
Legionella detection and isolation

MALDI – TOF:
Isolate confirmation

Illumina sequencing:
Isolate genome sequencing

SNP analysis:
Phylogenetic analysis



- Live organism recovered and identified.

Legionella detection in water samples using culture

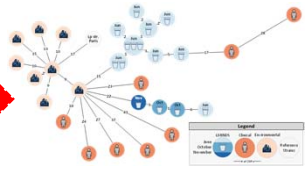
Sample filtration:
Legionella concentration

Sample culture:
Legionella detection and isolation

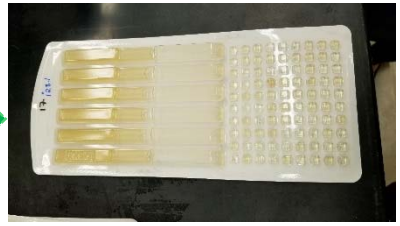
MALDI – TOF:
Isolate confirmation

Illumina sequencing:
Isolate genome sequencing

SNP analysis:
Phylogenetic analysis



Legiolert:
Legionella detection and isolation



- Live organism recovered and identified.

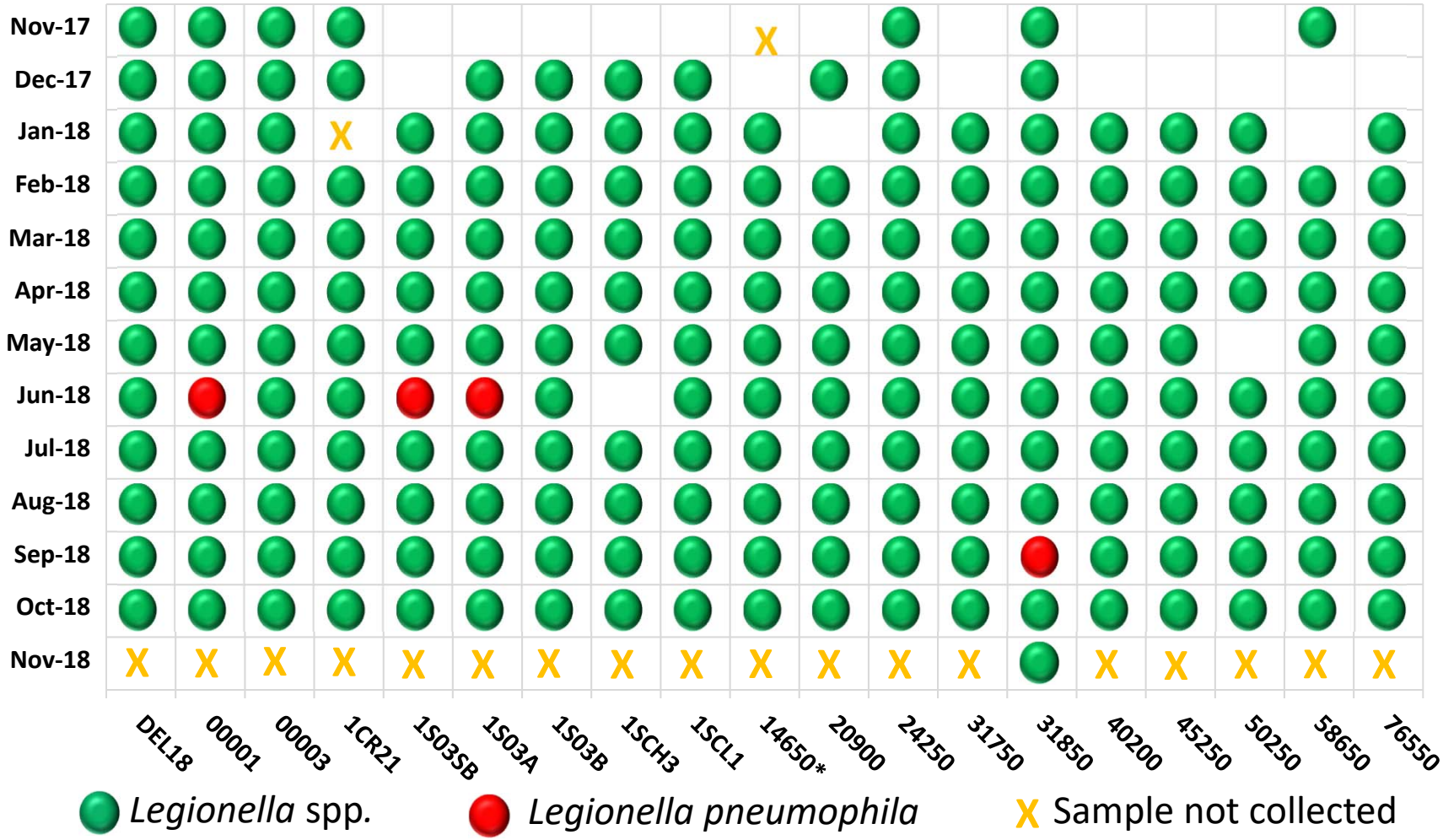
Legionella detection in water samples using PCR

Sample filtration:
Legionella concentration

PCR:
Legionella detection

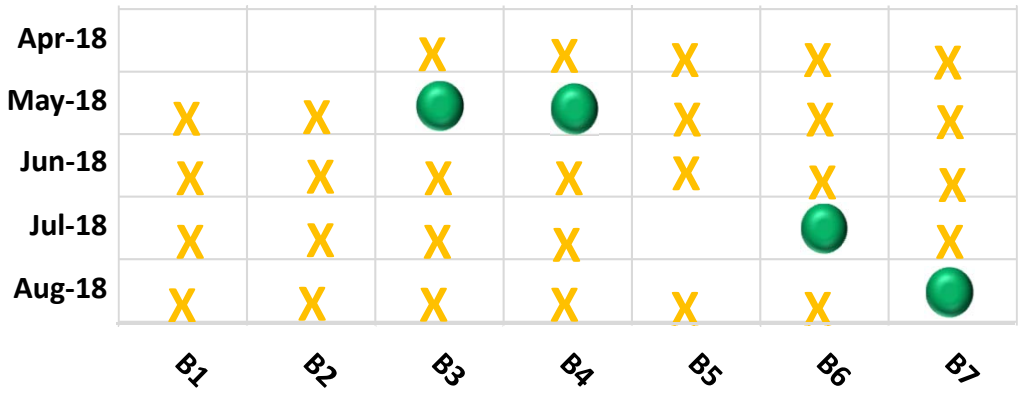
- DNA from *Legionella* present.

PCR: Legionella DNA is present in 88% (202/230) of water samples



* In November 2017 site 77650 was sampled in place of 14650

PCR: *Legionella* DNA is present in 4/7 biofilm samples

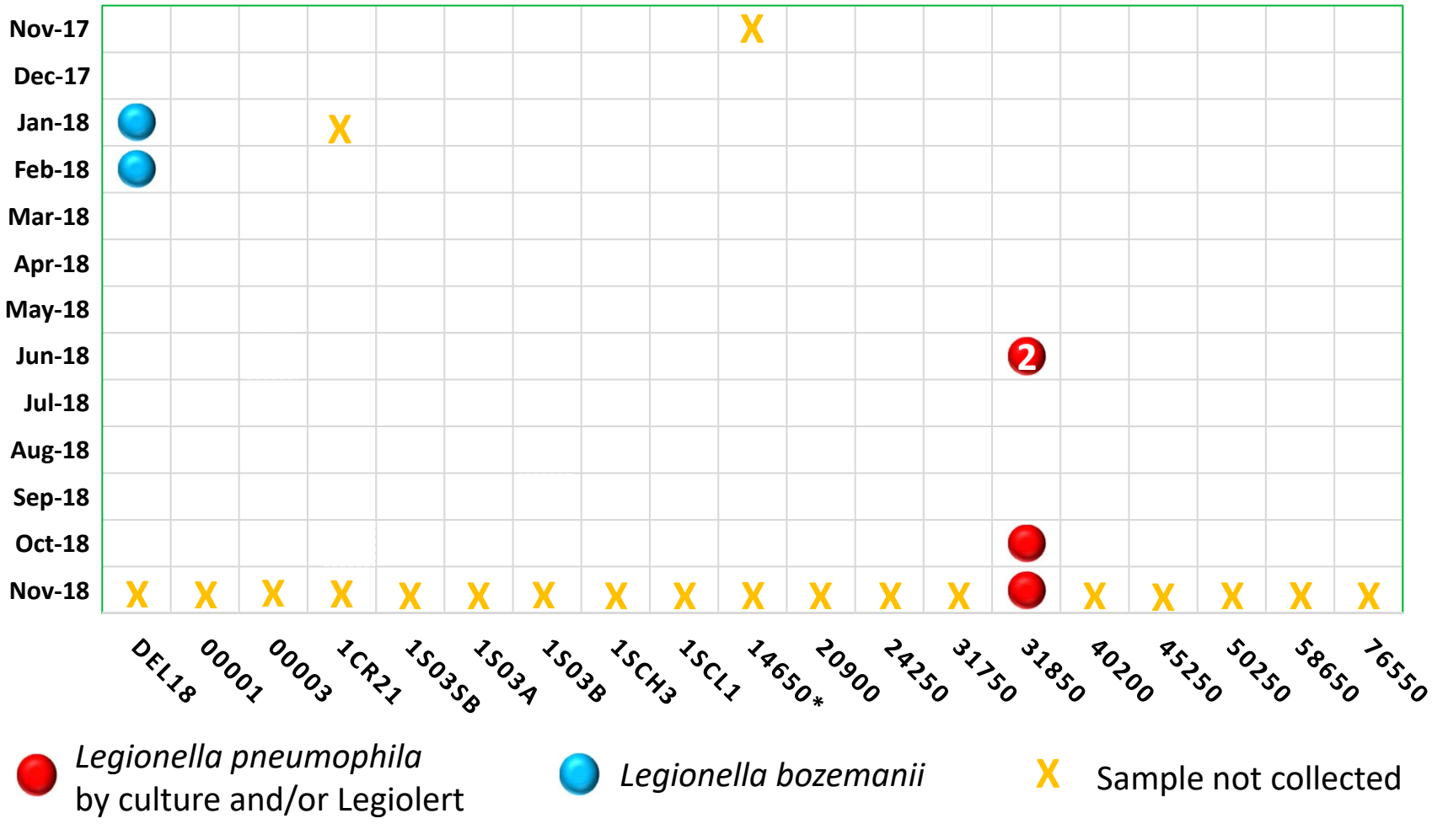


Legionella spp.

Legionella pneumophila

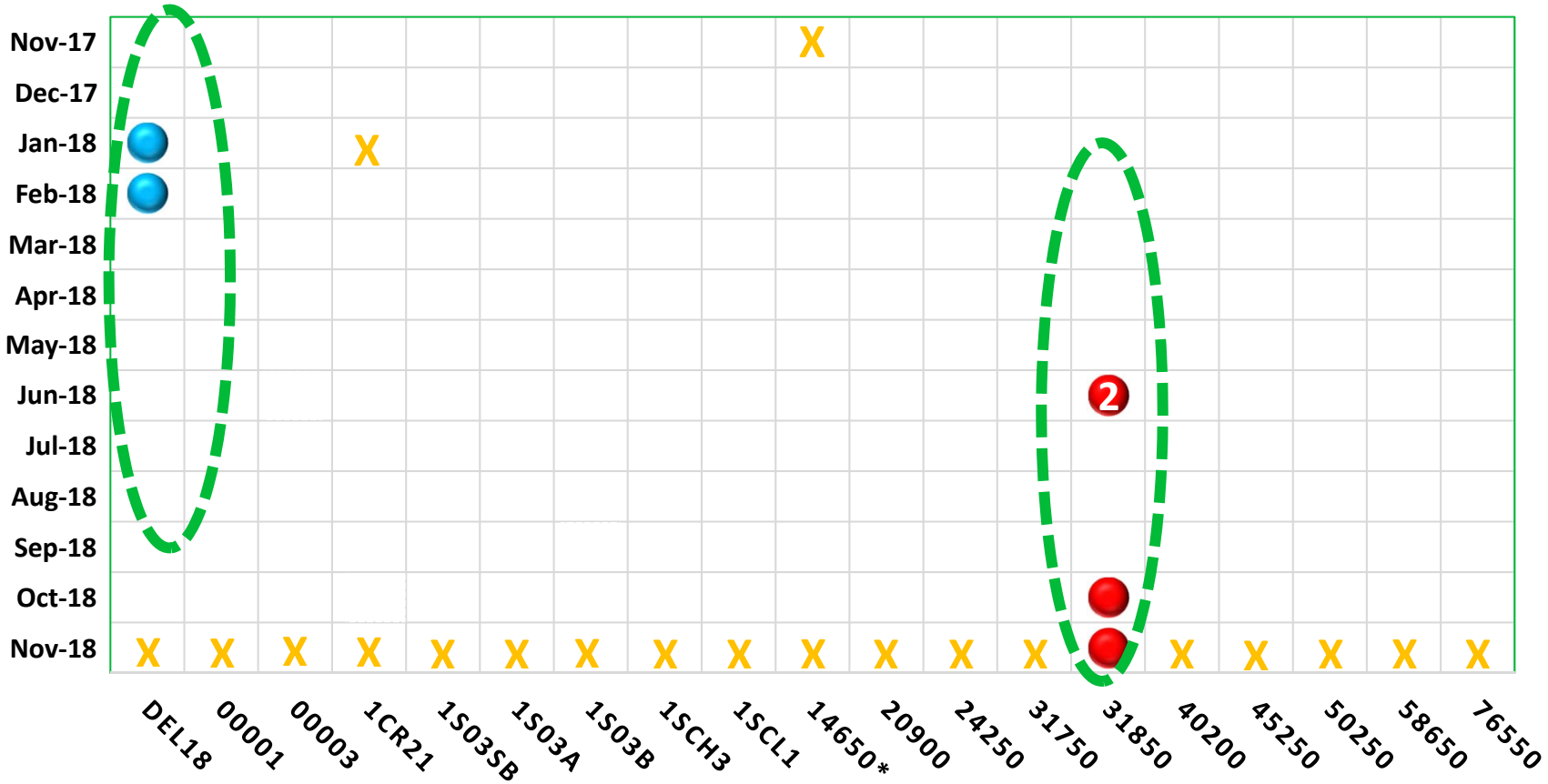
X Sample not collected

Culture: *Legionella* detected in 2.5% (6/230) water samples



* In November 2017 site 77650 was sampled in place of 14650

Culture: *Legionella* detected in 2.5% (6/230) water samples

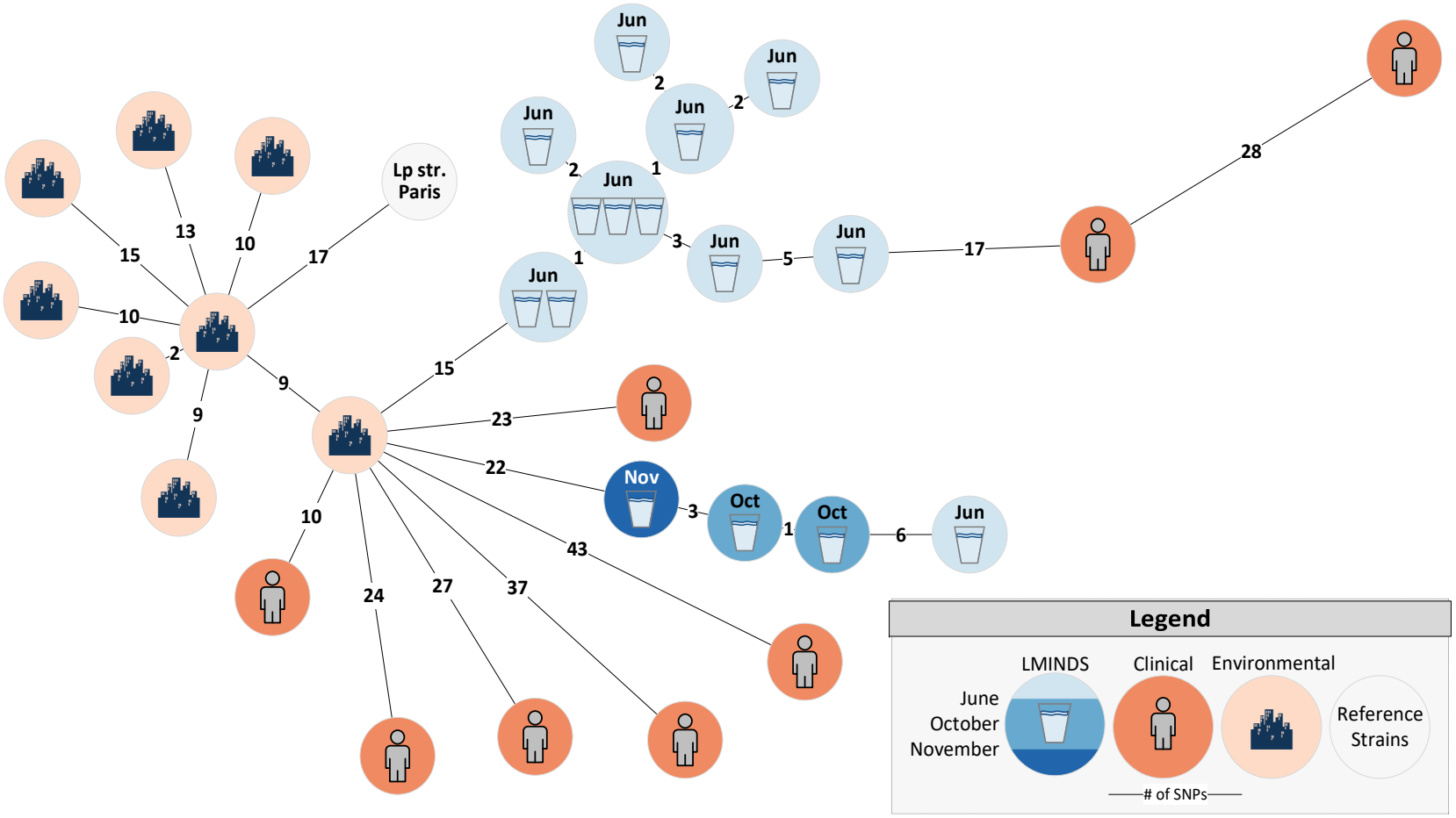


* In November 2017 site 77650 was sampled in place of 14650

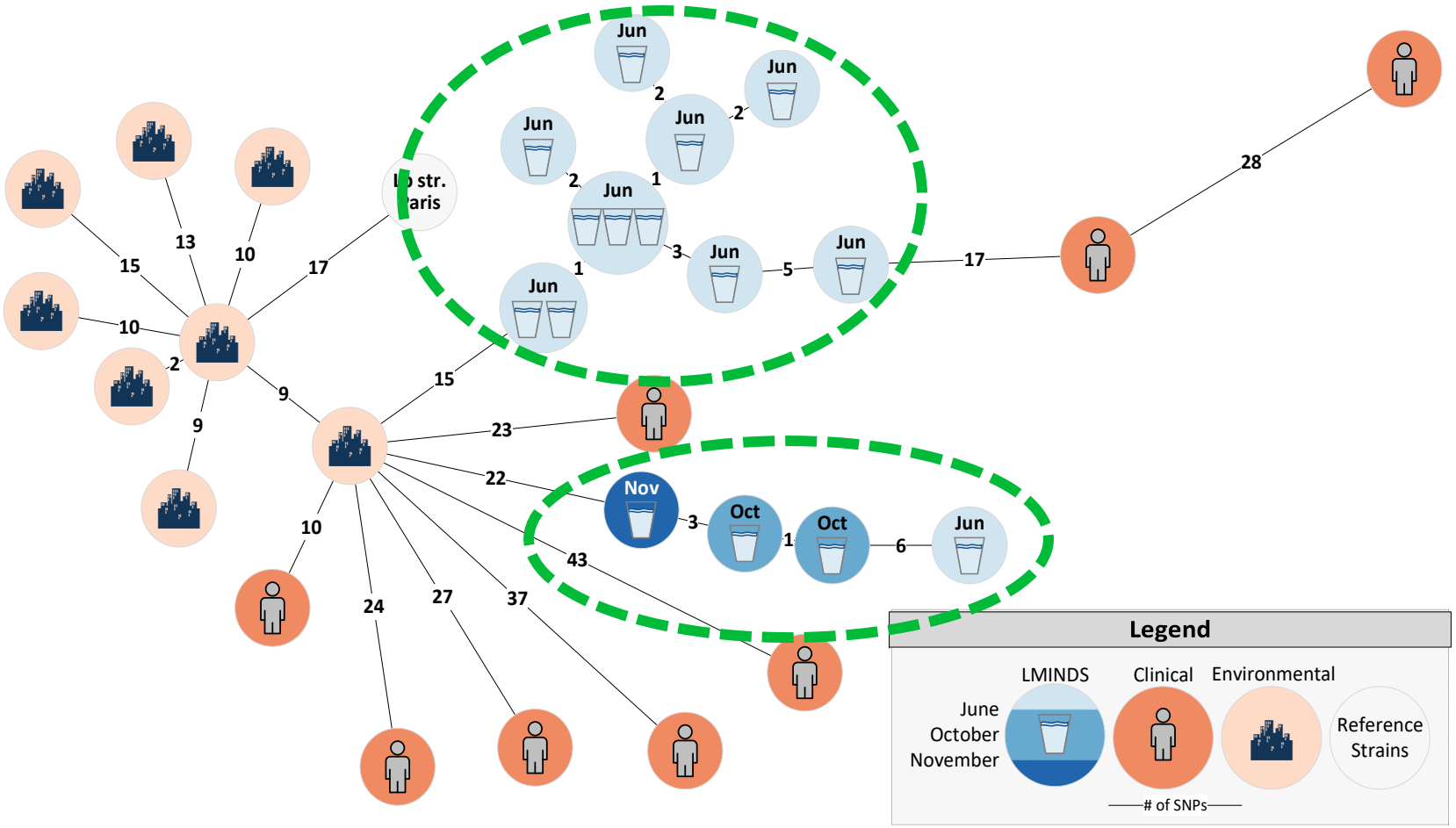
Recovered *L. bozemanii* and *L. pneumophila* isolates

- Both *L. bozemanii* and *L. pneumophila* have been associated with disease.
- Recovered isolates were sequenced and compared to isolates implicated in disease or part of environmental investigations.
- None of isolates matched previously recovered isolates.

Recovered *L. pneumophila* isolates do not match those associated with disease in NYC



Recovered *L. pneumophila* isolates do not match those associated with disease in NYC



All samples passed (EPA and NYS) water quality requirements

Raw

	Temp (°F)	pH (SU)	Turbidity (NTU)	Coliform (MPN / 100mL)	*E. coli* (MPN / 100mL)	HPC (CFU/mL)	TOC (mg/L)
Min	38.7	7.08	0.41	<1	<1	<1	1.37
Max	69.0	8.31	1.17	>200.5	144.5	107	6.19
Avg	54.8	7.61	0.70	N/A	N/A	N/A	2.47

Prefinished

	Temp (°F)	Residual Chlorine (mg/L)	pH (SU)	Turbidity (NTU)	Coliform (MPN / 100mL)	*E. coli* (MPN / 100mL)	HPC (CFU/mL)	TOC (mg/L)
Min	35.8	0.12	6.38	0.48	<1	<1	<1	1.32
Max	66.0	0.63	8.83	1.03	<1	<1	1	1.86
Avg	51.8	0.40	7.43	0.75	<1	<1	N/A	1.61

Distribution

	Temp (°F)	Residual Chlorine (mg/L)	PO4 (mg/L)	pH (SU)	Turbidity (NTU)	Coliform (MPN / 100mL)	*E.coli* (MPN / 100mL)	HPC (CFU/mL)	TOC (mg/L)
Min	35.8	0.02	1.47	7.11	0.10	<1	<1	<1	1.27
Max	76.0	1.21	2.41	7.81	1.27	1.0	<1	5	2.25*
Avg	53.5	0.60	2.09	7.39	0.75	N/A	<1	N/A	1.58

Relationship between env. parameters and the presence of *Legionella* could not be established

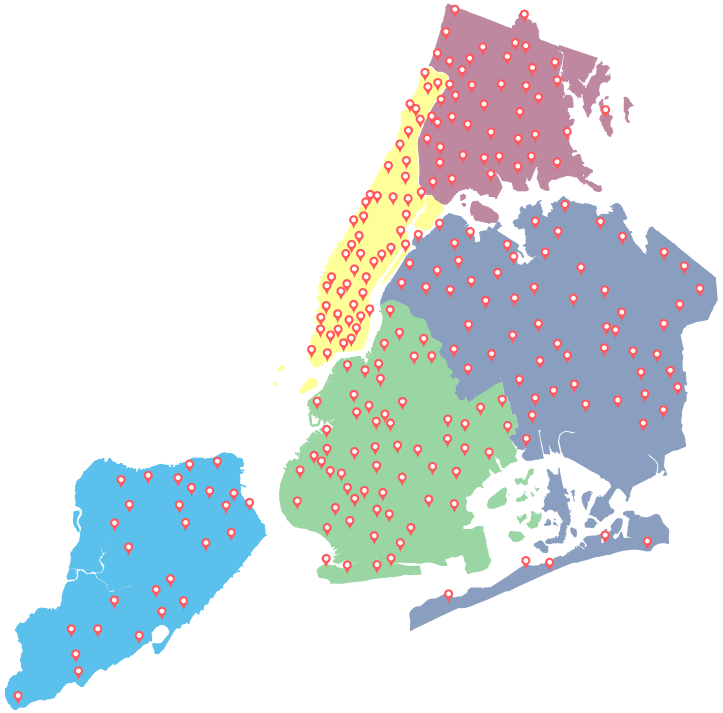
- Only 6/230 water samples were positive for *Legionella* using culture, which is insufficient to establish a correlation.
- The effect of environmental parameters on *Legionella* detection using PCR was indirectly examined using the Mann-Whitney U test:
  - Several environmental parameters were found to be statistically different between samples that were positive or negative for *Legionella* sp. DNA.
  - Nature of the differences was difficult to interpret and requires further investigation.

Summary

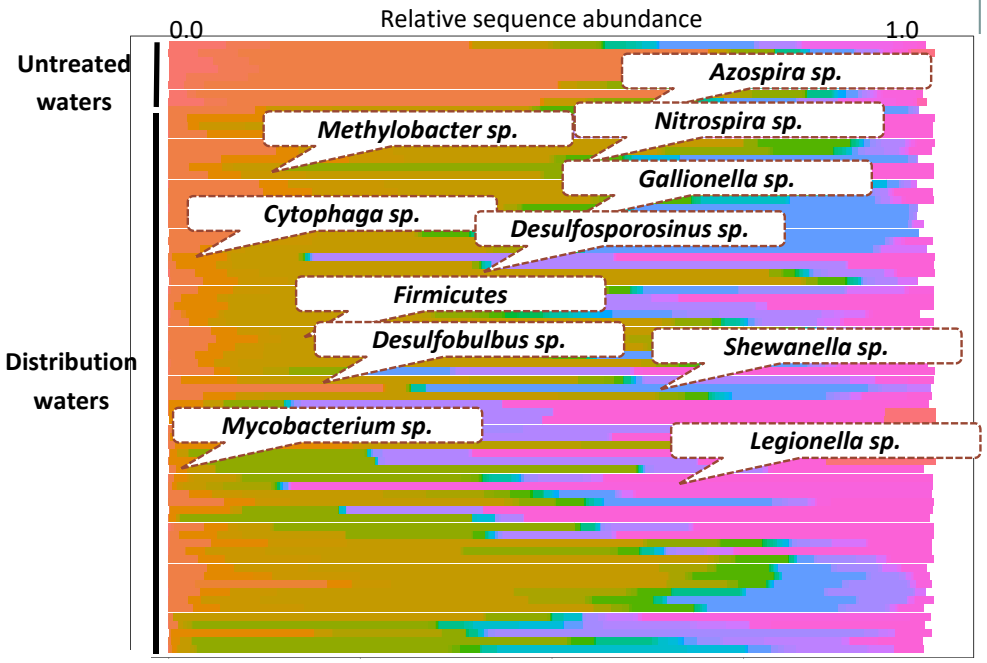
- Despite the prevalence of *Legionella* DNA in the NYC distribution system, detection by culture was rare.
- Culture detection was limited to raw water, and water from a site that may have been impacted by ongoing construction.
- *Legionella* isolates were not closely related to isolates previously implicated in *Legionella* outbreaks in NYC.
- We could not correlate the presence of *Legionella* with environmental parameters.
- The lack of culture positive samples suggest that the current disinfection practices are effective in protecting against the presence of recoverable *Legionella* spp. in the New York City water supply.

Ongoing work

- Testing all revised total coliform rule (RTCR) sites.



- Examining the drinking water microbiome.



Acknowledgements

NYC Department of Health and Mental Hygiene, Public Health Laboratory

- Jennifer Rakeman-Cagno, Laboratory Director
- Scott Hughes, Associate Director
- Cecilia Kretz, CDC LLS fellow
- Edimarlyn Gonzalez, Chief WGS unit
  - Angela Liang, Kolin Clark
- Sabine Glaesker, Supervisor MTL
  - Bun Tha, Tanya Geiz
- Yayu Chaung, Supervisor (acting) Water Chemistry
  - Shari Nyberg, Shamima Alam
- John Novak, Legionella Unit
  - Inessa Rubinstein, Yelena Chekoff, Stephen Silver

NYC Department of Environmental Protection, Distribution Water Quality Operations

- Salome Freud, Chief of Division
- Kevin Booker, Laboratory Director
- Adam Szczerba, Asst. Supervisor Field Section
  - DEP field Section
- Aspa Capetanakis, Director of Microbiology
- Rupa Aggarwal, Supervisor Microbiology
  - DEP Microbiology Section
- Kyaw San, Supervisor Chemistry
  - DEP Chemistry Section