# EPANET and Beyond

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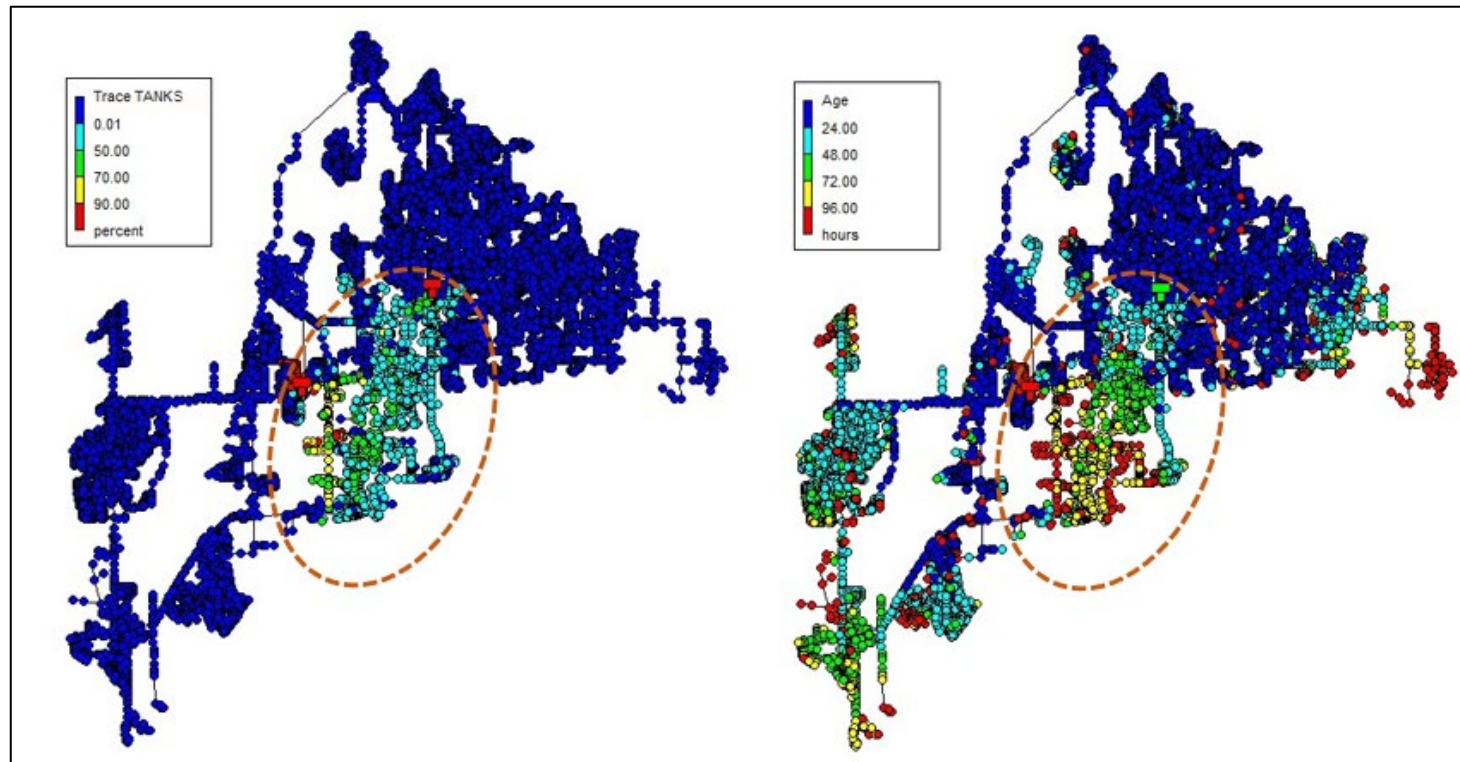Drinking Water Treatment and Distribution Branch

The EPANET Ecosystem

- EPANET
  - Core hydraulics engine
  - Single species water quality

- EPANET-MSX
  - Multispecies modeling
  - Recently added 1D dispersion

- WNTR (Water Network Tool for Resilience)
  - Failure state modeling
  - Python-based
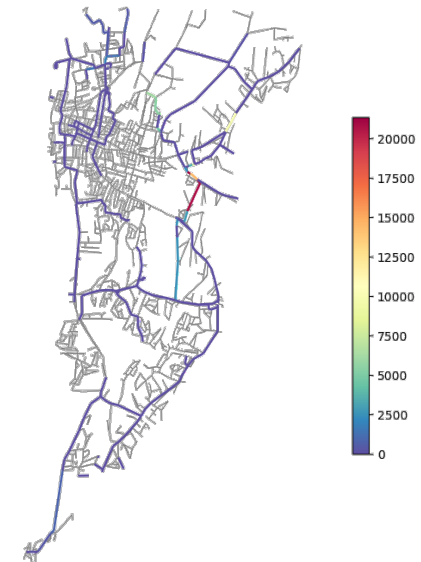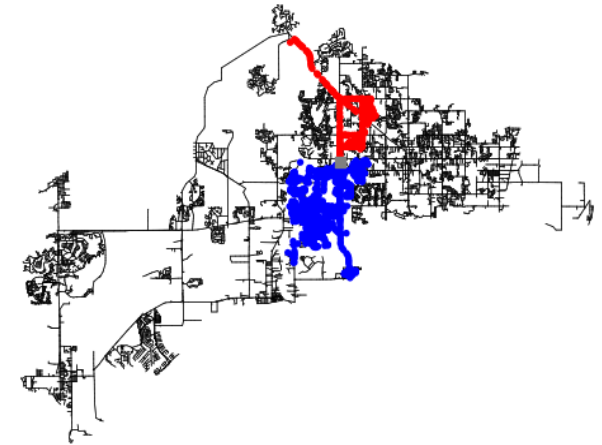
Basic EPANET Activities

Water Age vs. Tank Trace

Burkhart, Ben, and Robert Janke. "Understanding Water Age in Distribution Systems with EPANET." *Journal of the American Water Works Association* 115.2 (2023): 24-34.
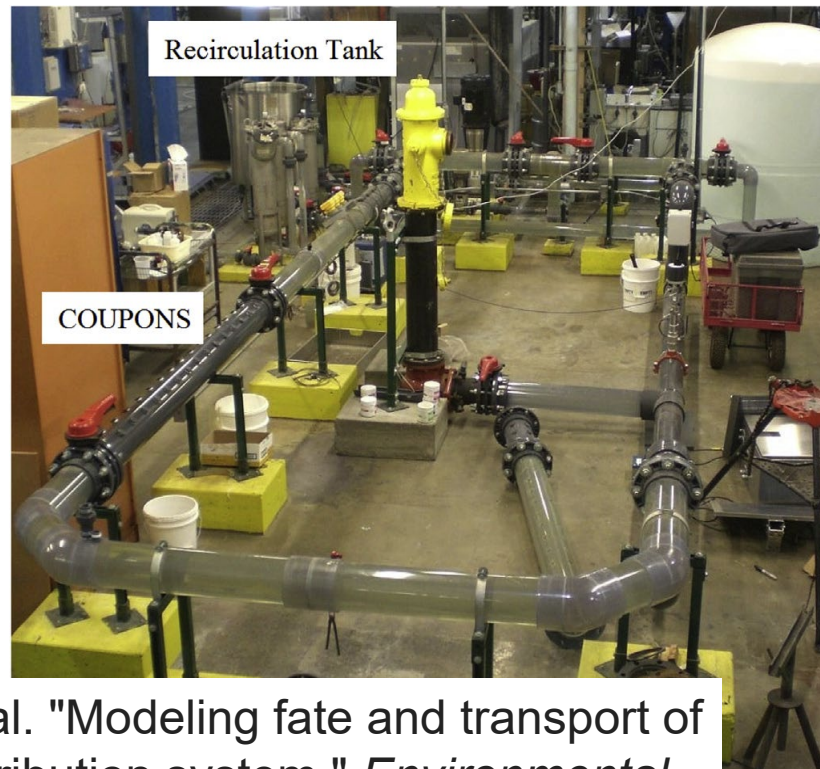
Common Uses of EPANET

- Fire flow analysis
- Understanding network pressures
- Tank operation optimization
- Booster chlorination
- Disinfectant residual management
- Water age management
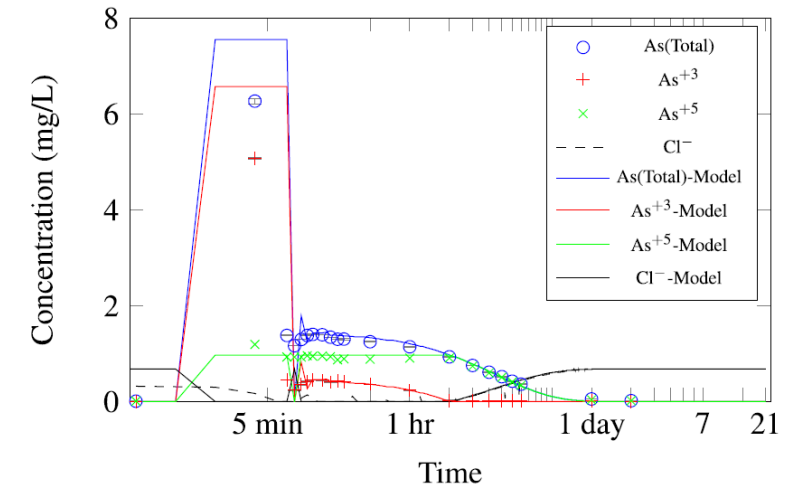- Pipe sizing

Advanced Uses of Modeling

- Digital Twins
  - Real-time system modeling
- Contamination source identification
- Sensor/Sample location identification
- Cyber-security
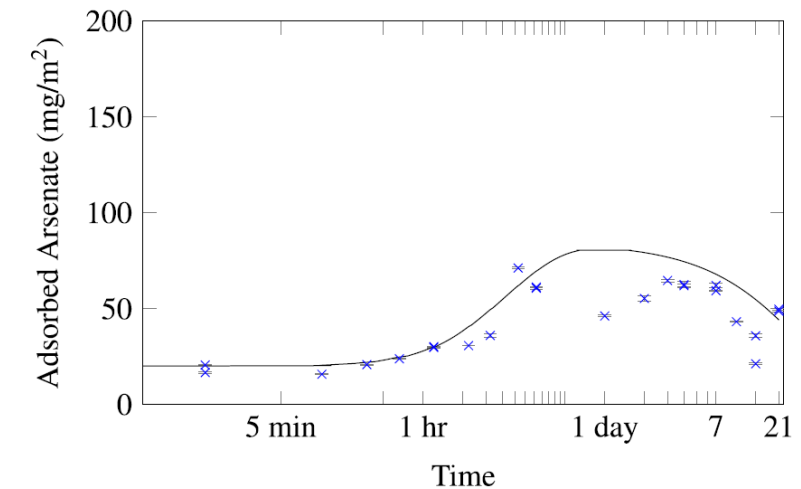
Multispecies Modeling (EPANET-MSX)

- Model of arsenite oxidation in chlorinated drinking water
- Shows adsorption and desorption over time of arsenic species

(a) Solution Concentration

(b) Adsorbed Concentration

Burkhardt, Jonathan B., et al. "Modeling fate and transport of arsenic in a chlorinated distribution system." *Environmental Modelling & Software* 93 (2017): 322-331.

https://github.com/USEPA/EPANETMSX/
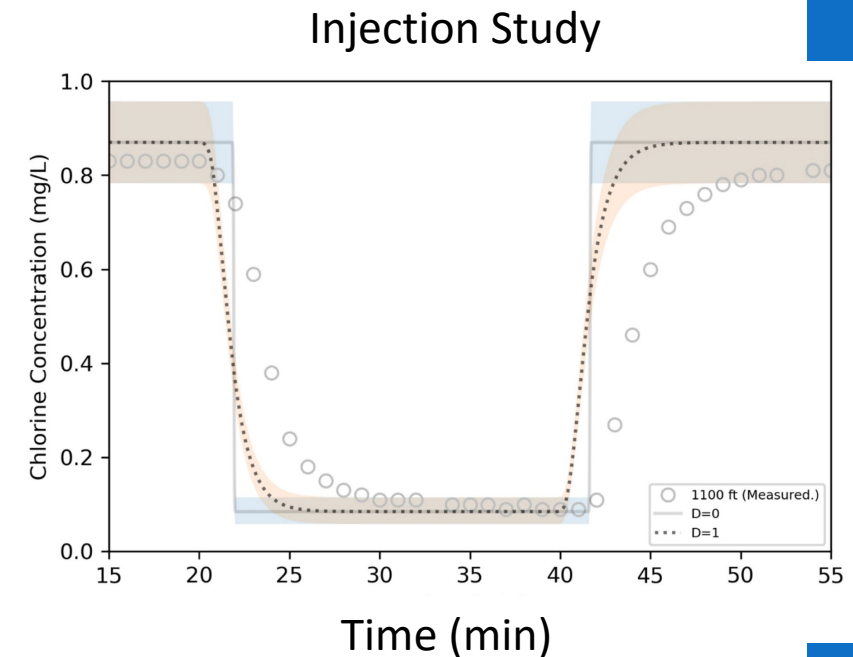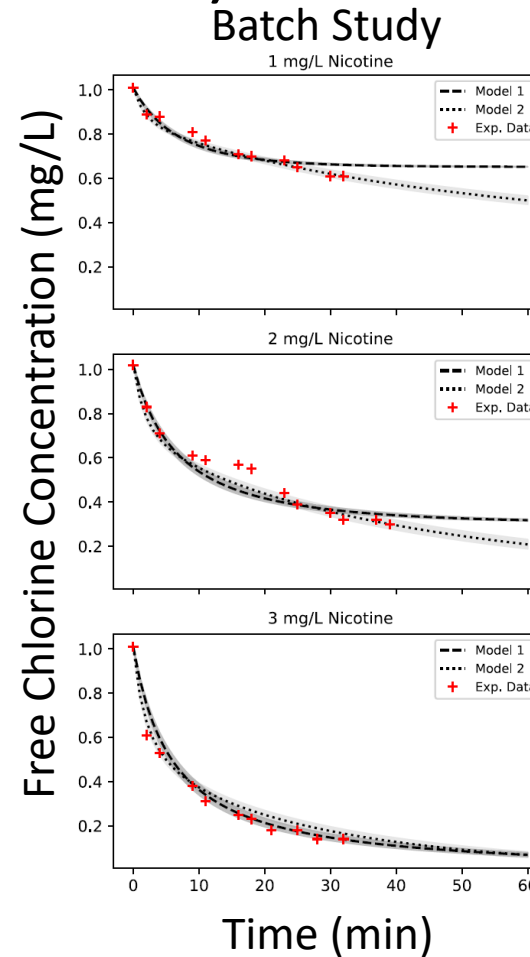
EPANET-MSX (cont)

- Model of nicotine reaction in chlorinated drinking water

- EPANET-MSX 2.0 added 1D dispersion

Batch Study

Injection Study

Burkhardt, Jonathan B., Benjamen Burkhart, and Feng Shang. "Modeling Nicotine-Induced Chlorine Loss in Drinking Water Using Updated EPANET-MSX." *Journal of Environmental Engineering* 149.12 (2023): 04023086.

Water Network Tool for Resilience (WNTR)

- Failure state modeling

- Functions for calculating metrics

- Automated scenario generation/simulation

- Simulates disasters

- Python-based
  - Can create/use complex input data to inform modeling

https://github.com/USEPA/WNTR
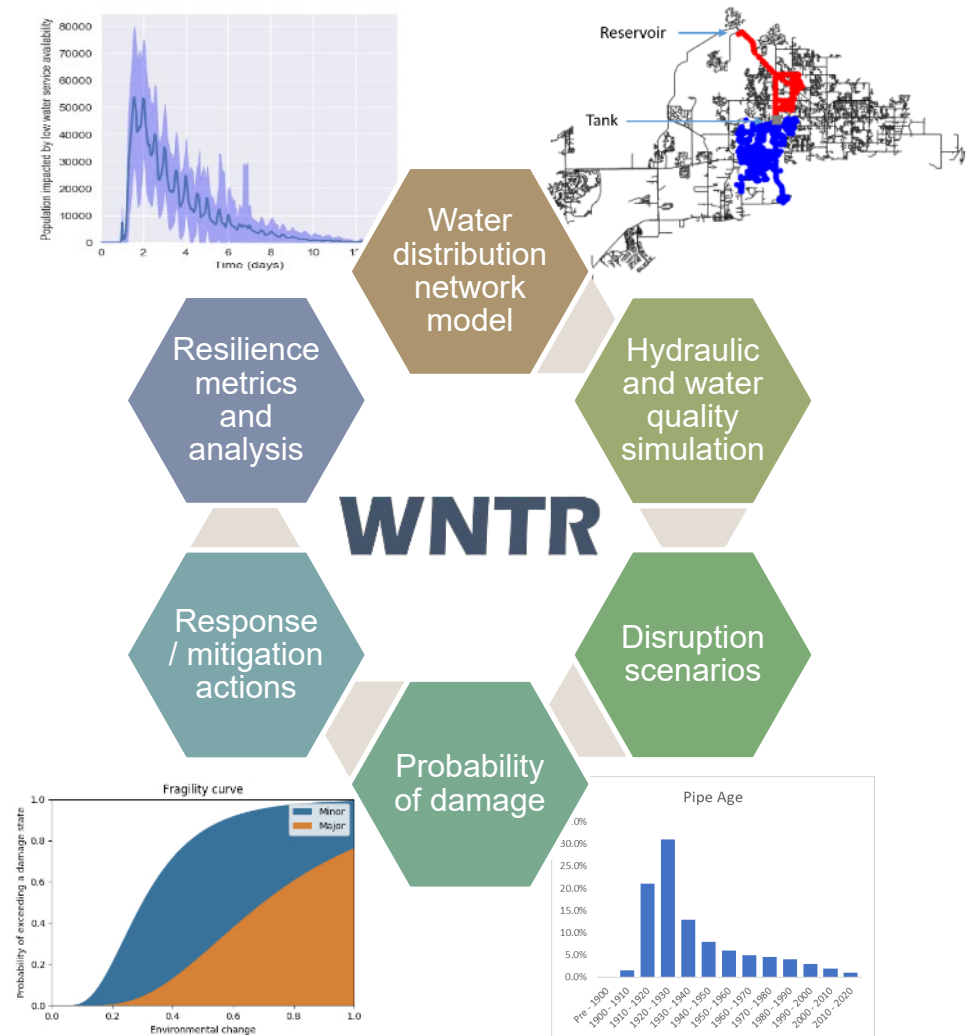
WNTR: Sample Site Selection
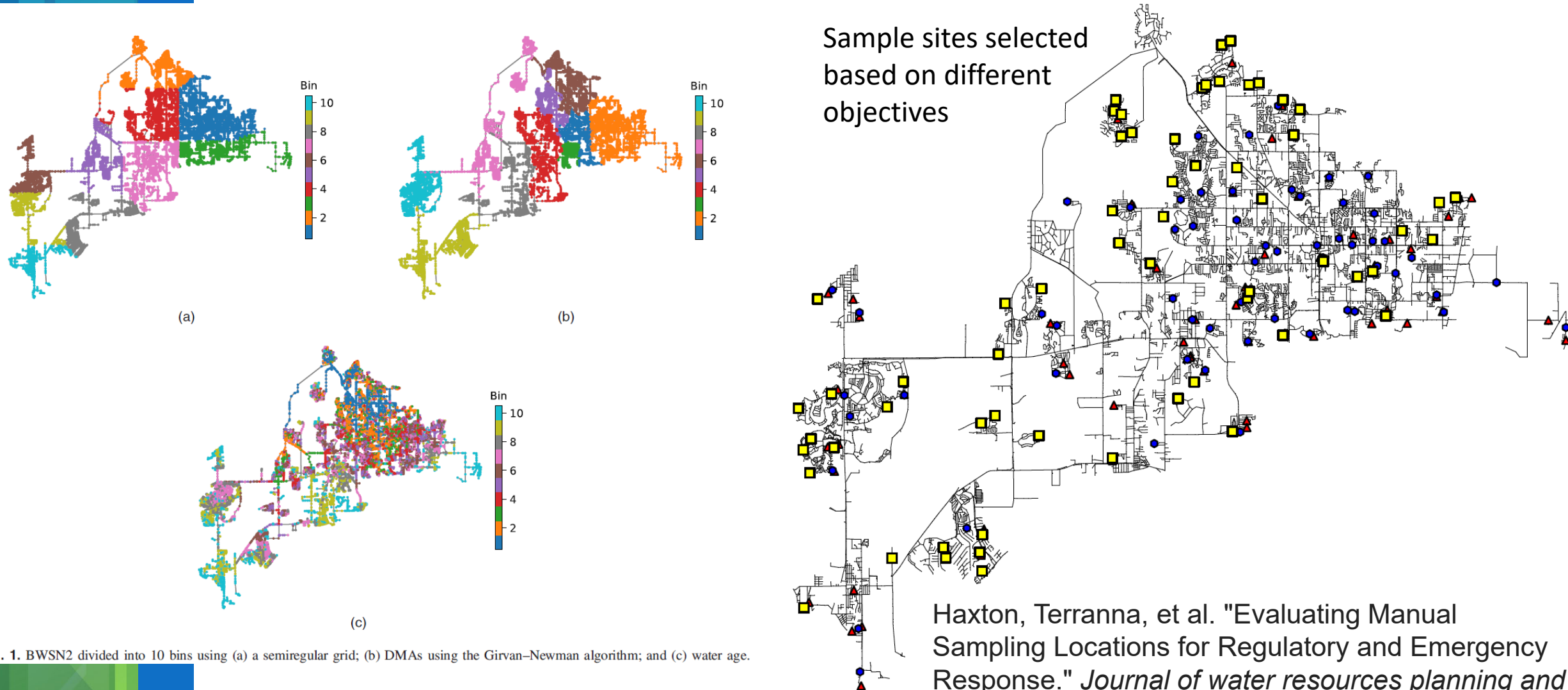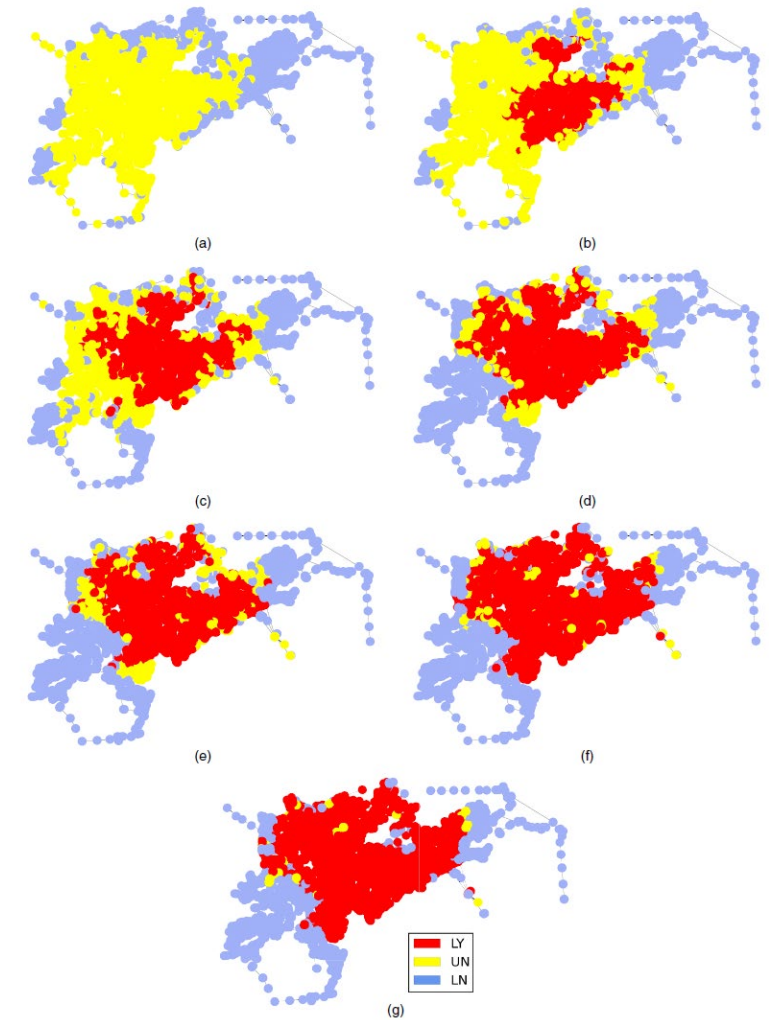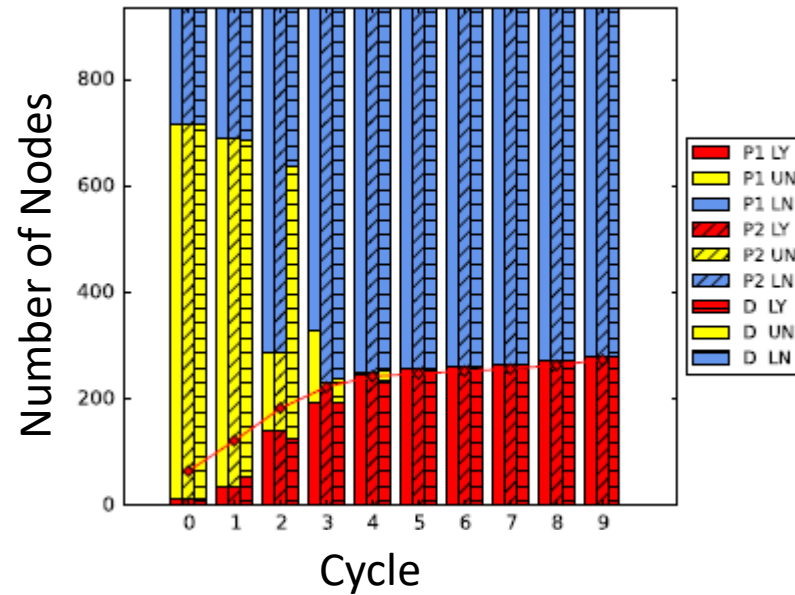
Sample sites selected based on different objectives

Fig. 1. BWSN2 divided into 10 bins using (a) a semiregular grid; (b) DMAs using the Girvan–Newman algorithm; and (c) water age.

Haxton, Terranna, et al. "Evaluating Manual Sampling Locations for Regulatory and Emergency Response." *Journal of water resources planning and management* 147.12 (2021): 04021081.

9

WNTR: Understanding System Contamination

Optimization formulation	Time to solution (s)
Distinguishability	505
P1	1.5
P2	0.75

Rodriguez, Jose S., et al. "Optimal sampling locations to reduce uncertainty in contamination extent in water distribution systems." *Journal of infrastructure systems* 27.3 (2021): 04021026.
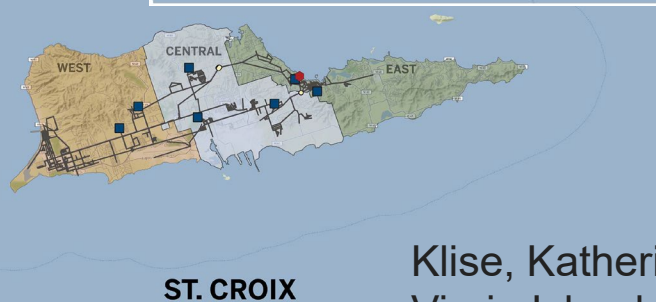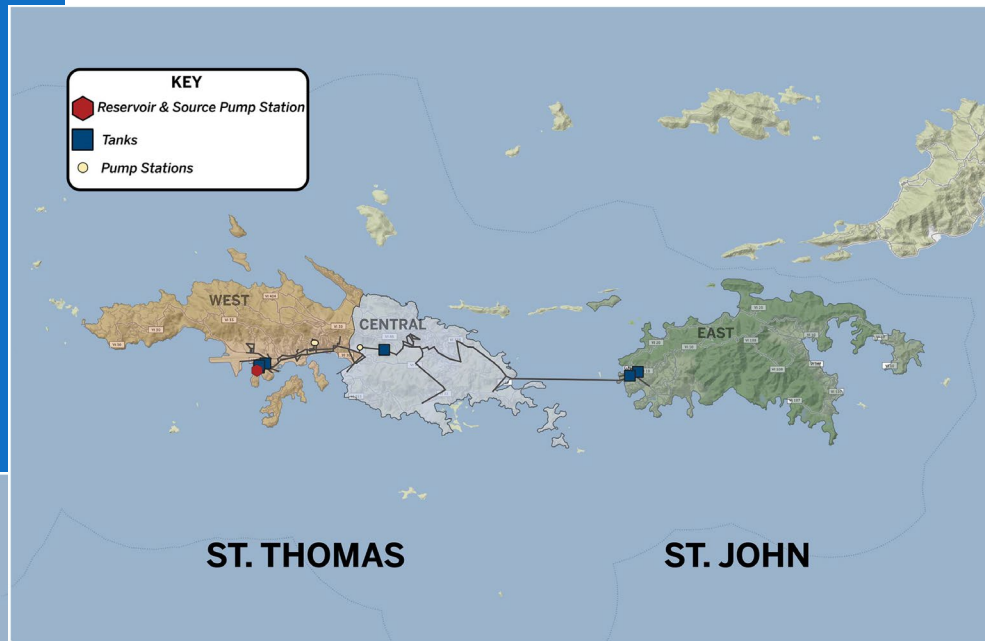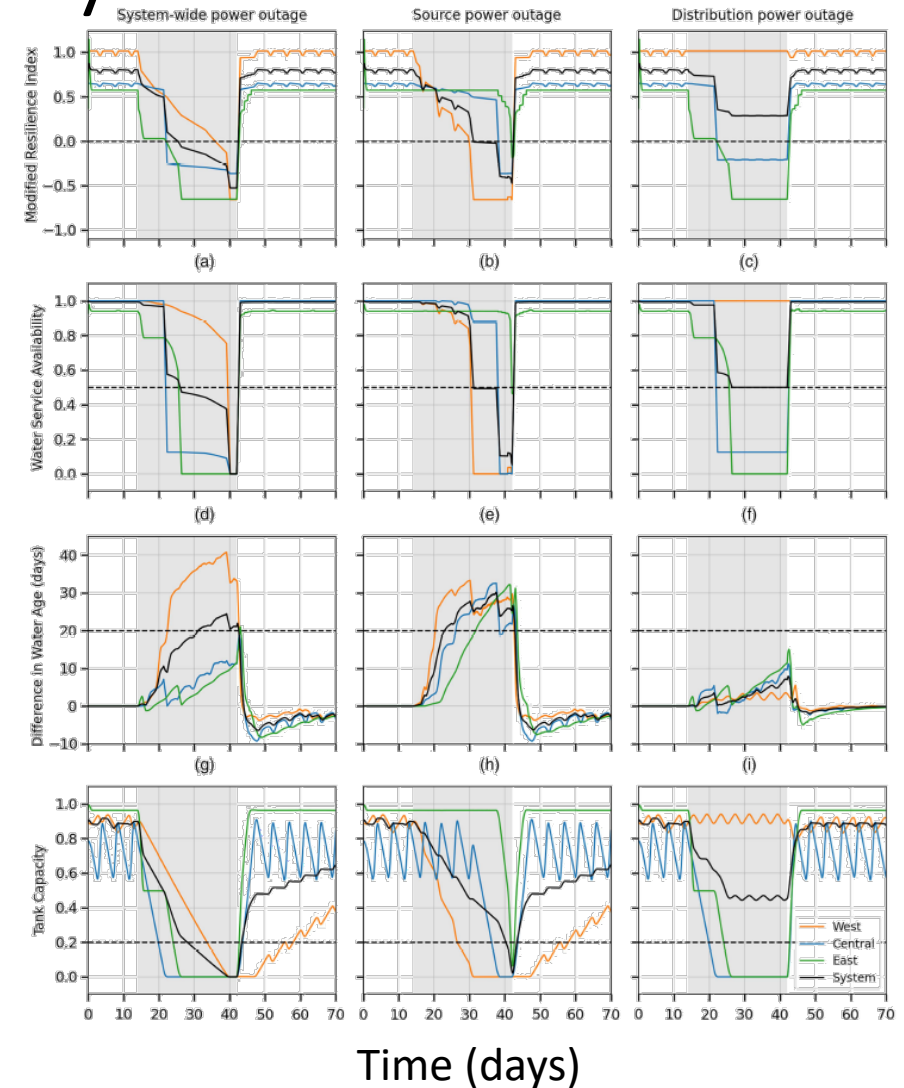
WNTR: Understanding System Resilience

Earthquakes

Fragility curve
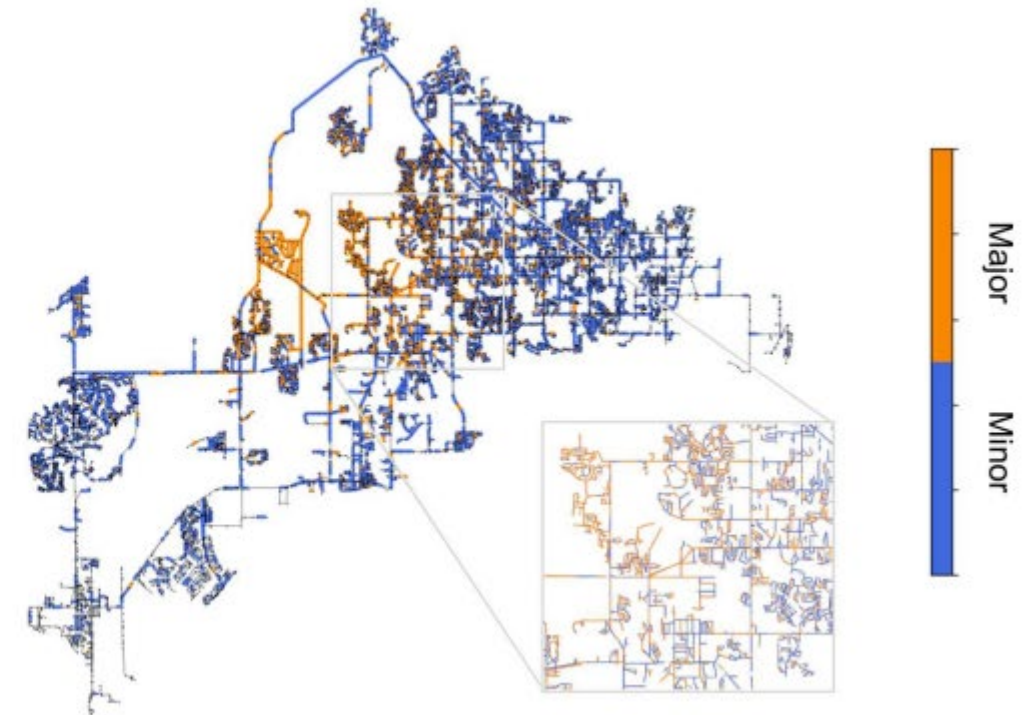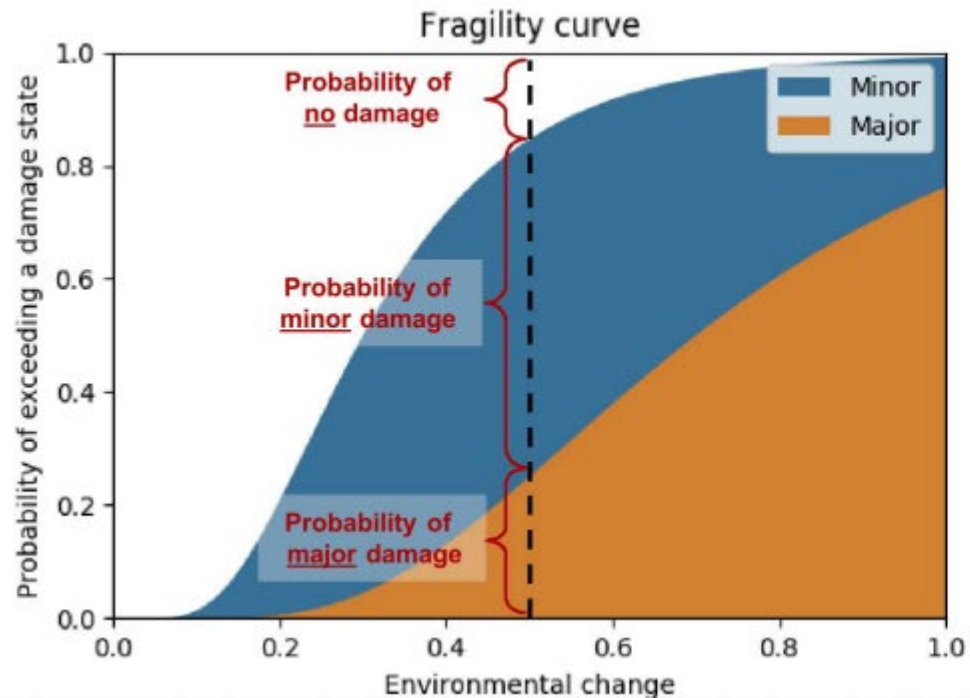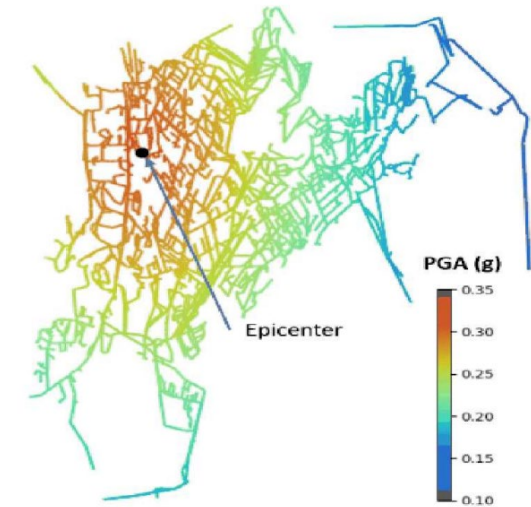
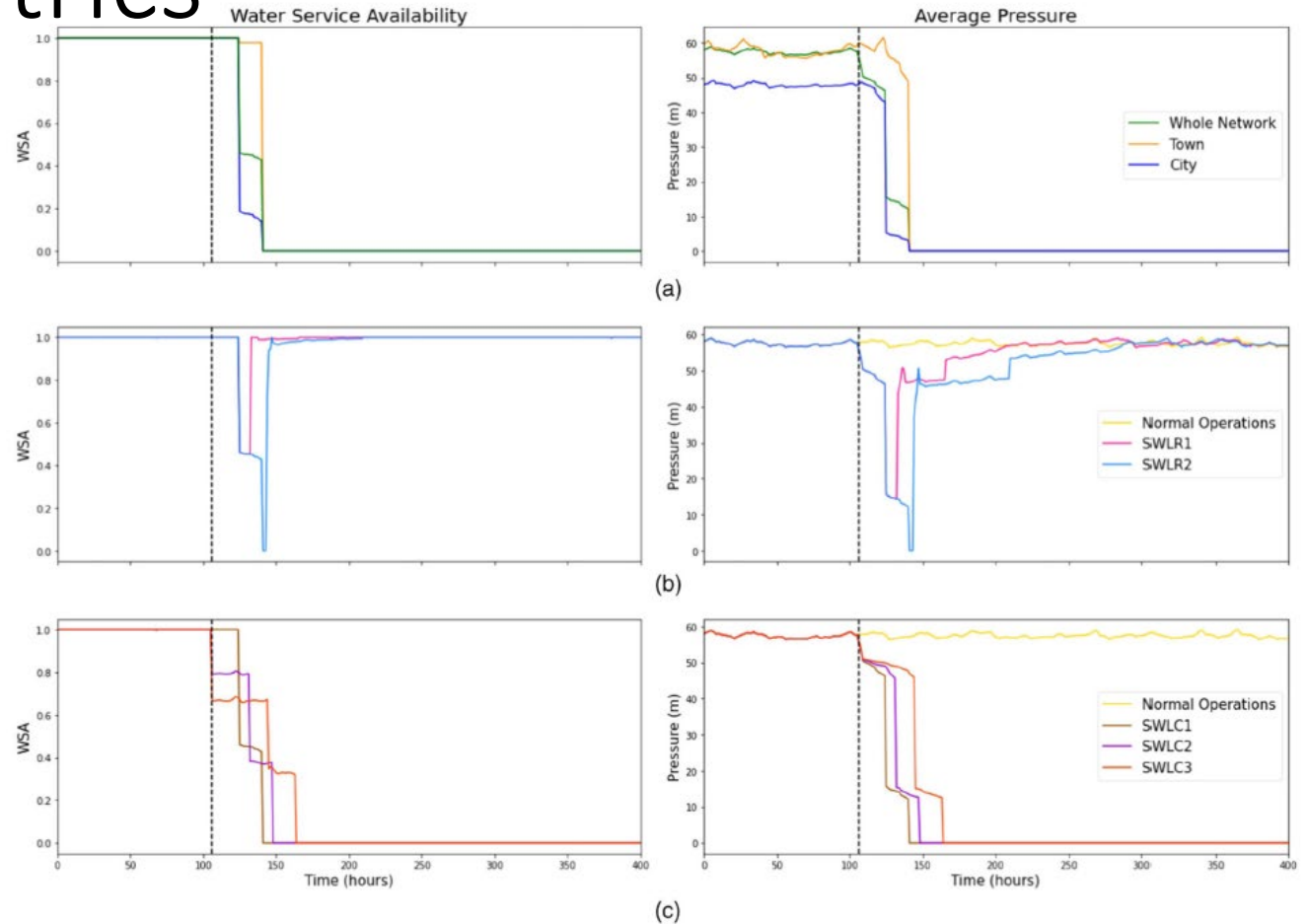# WNTR: Understanding System Resilience: Metrics

Power Outages

Klise, Katherine, et al. "Resilience Analysis of Potable Water Service after Power Outages in the US Virgin Islands." *Journal of Water Resources Planning and Management* 148.12 (2022): 05022010.

WNTR: Understanding System Resilience: Metrics

Loss of Source Water
&
Pipe Criticality

Chu-Ketterer, Lucinda-Joi, et al. "Performance and Resilience Analysis of a New York Drinking Water System to Localized and System-Wide Emergencies." *Journal of Water Resources Planning and Management* 149.1 (2023): 05022015.
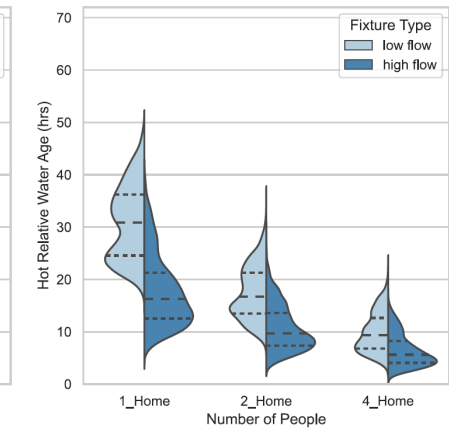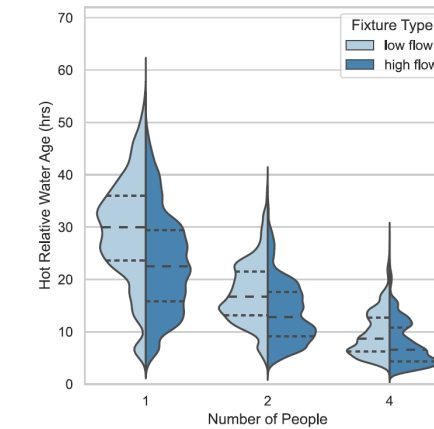
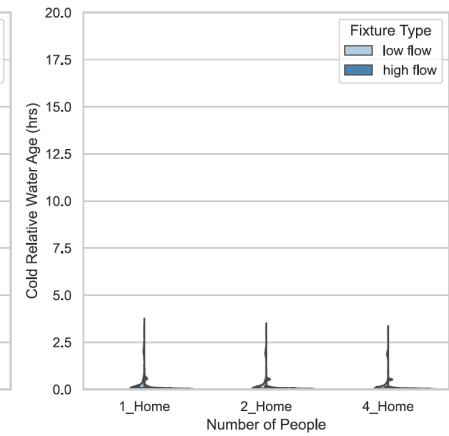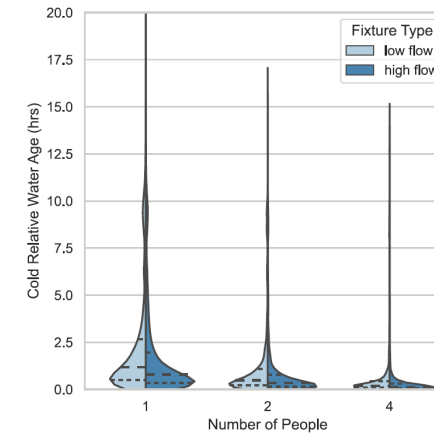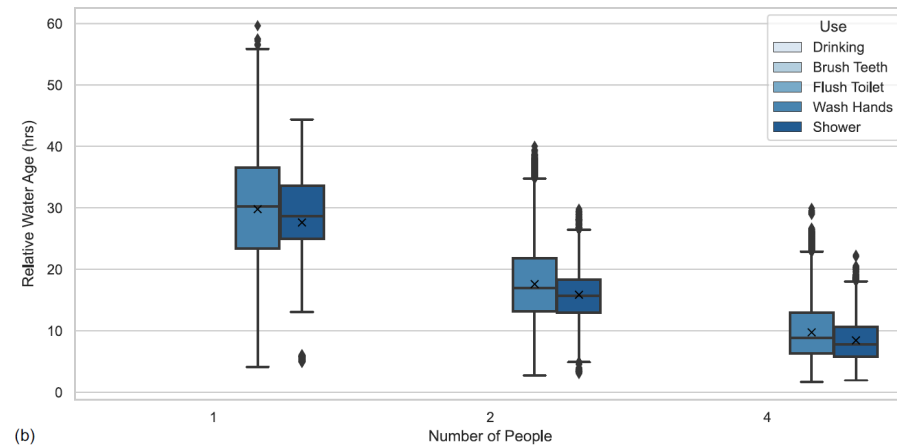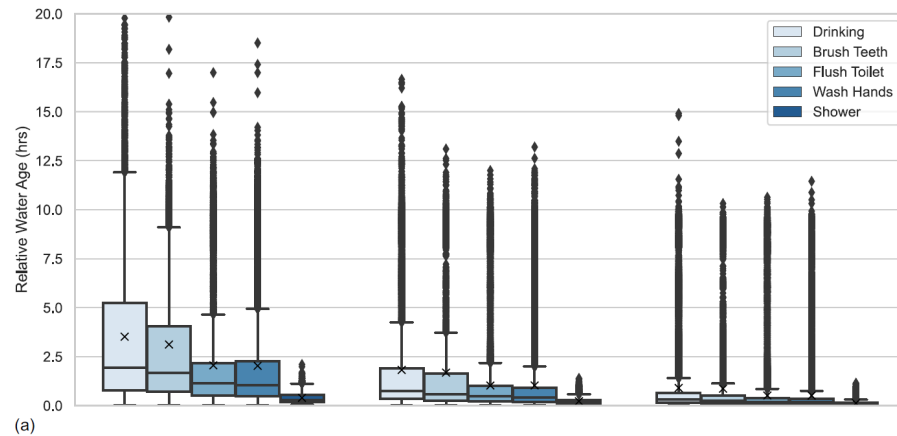13

Premise Plumbing Modeling

- Similar modeling needs to larger water distribution systems

- Primarily stagnant/sporadic usage patterns
  - Needs pattern generation
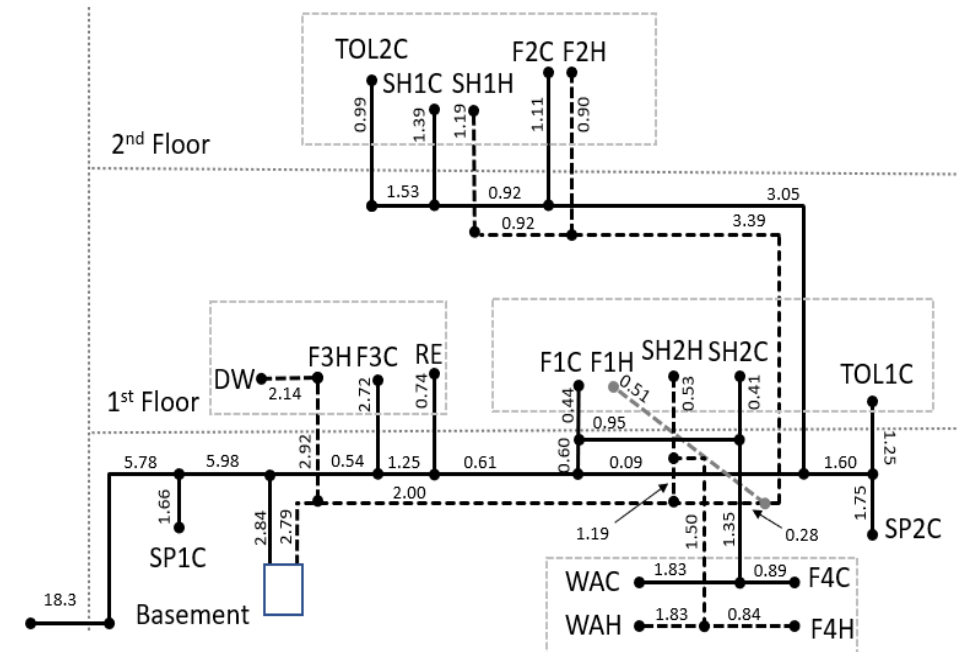
Burkhardt, Jonathan B., et al. "Relative Water Age in Premise Plumbing Systems Using an Agent-Based Modeling Framework." *Journal of Water Resources Planning and Management* 149.4 (2023): 04023007.

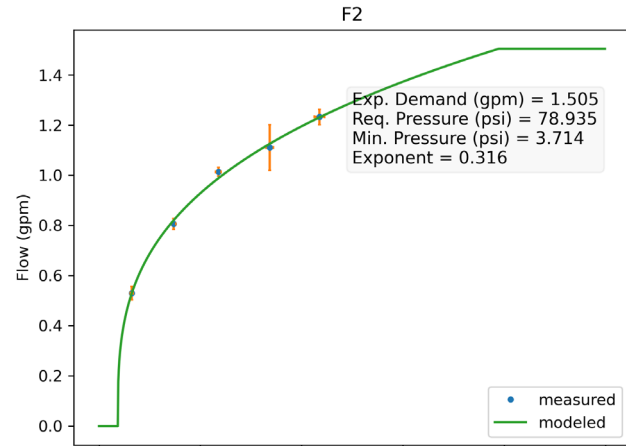https://github.com/USEPA/PPMtools
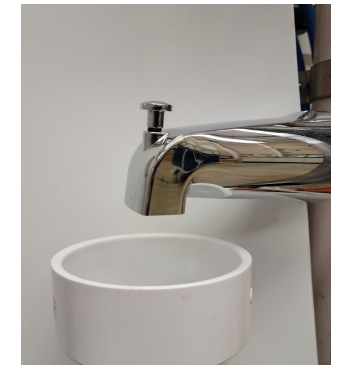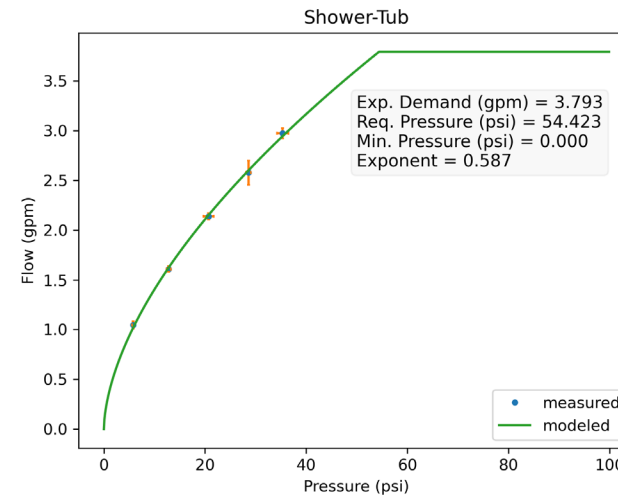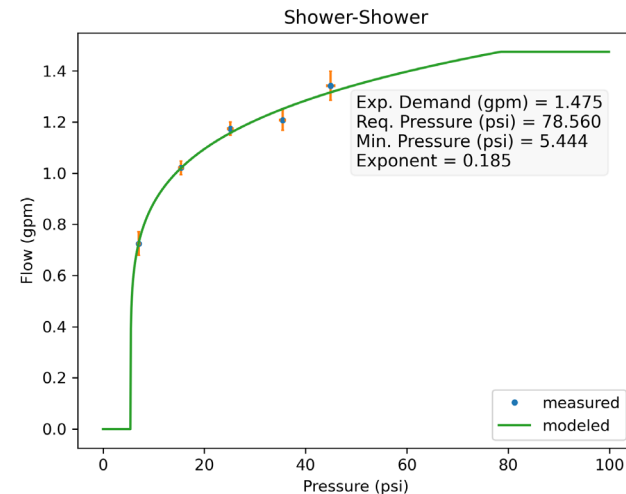
14

Premise Plumbing Modeling (cont)

Burkhardt, Jonathan B., et al. "Relative Water Age in Premise Plumbing Systems Using an Agent-Based Modeling Framework." *Journal of Water Resources Planning and Management* 149.4 (2023): 04023007.
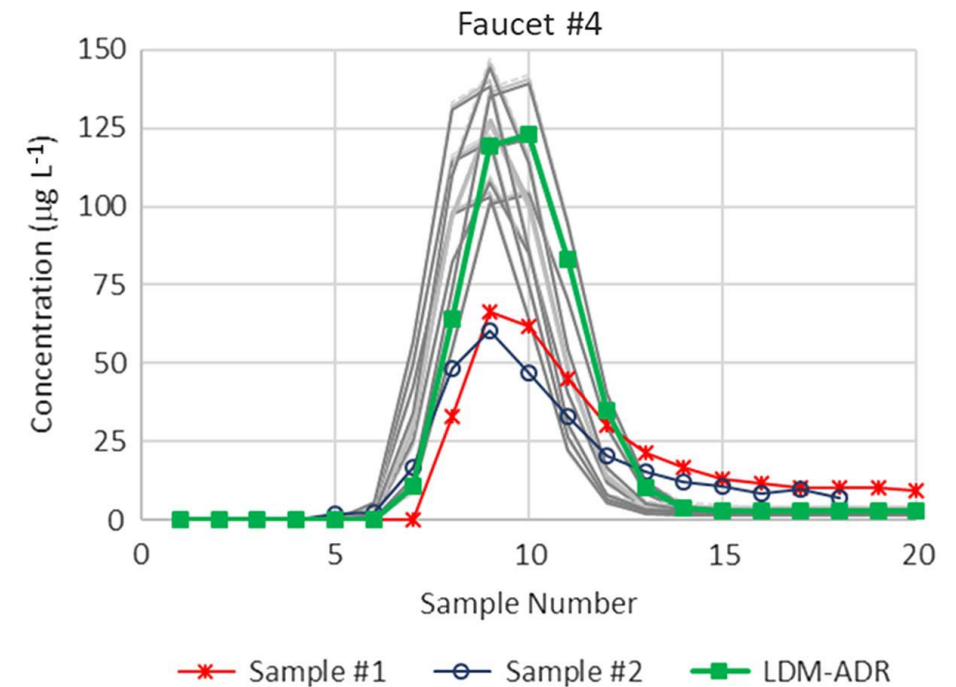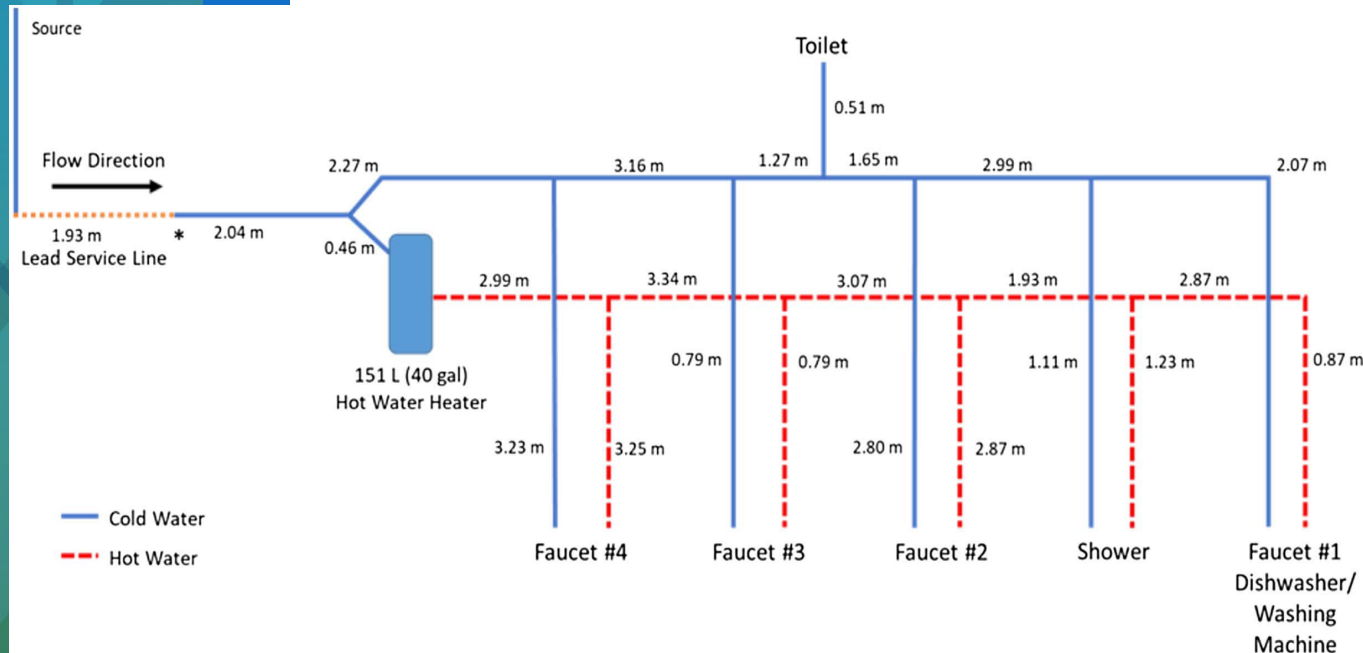
Premise Plumbing Modeling Needs

- Fixture flow rates are driven by available pressure
  - Each fixture type has different behavior

Burkhardt, Jonathan B., et al. "Pressure dependent analysis in premise plumbing system modeling." *AWWA Water Science* 5.3 (2023): e1344.

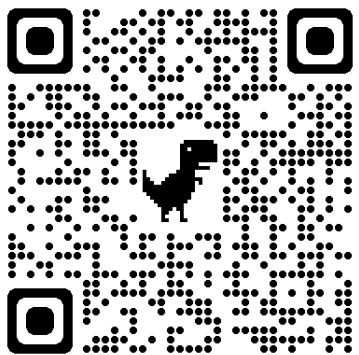# Modeling Lead from Lead Service Lines

Burkhardt, Jonathan B., et al. "Framework for modeling lead in premise plumbing systems using EPANET." *Journal of water resources planning and management* 146.12 (2020): 04020094.
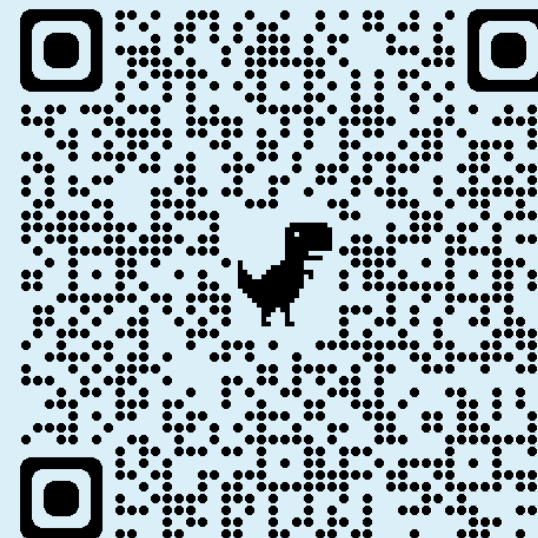
Finding EPA Opportunities

- https://www.epa.gov/careers
- https://www.usajobs.gov/ (all federal agency jobs)
- https://www.usajobs.gov/Search/Results?l=Cincinnati%2C%20Ohio&a=EP00&p=1&k= (EPA, Cincinnati only)
- https://www.zintellect.com/ (non federal, recent grads, ORISE/ORAU roles, many federal agencies)

Thank You!

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Water Treatment and Distribution Tools Website

https://www.epa.gov/emergency-response-research/water-modeling-tools-decision-support
https://www.epa.gov/water-research/epanet
https://github.com/USEPA/WNTR