Using SCADA and AMI to Identify Areas of Water Loss in Madison Water Utility

Isabel Reams

Madison Water Utility

Acknowledgements

Greg Harrington, *advisor and committee chair*

Joe DeMorett, *MWU water supply manager*

Chris Wilkins, *MWU control systems programmer*

Mohan Qin, *committee member*

Daniel Noguera, *committee member*

Madison Water Utility

Introduction

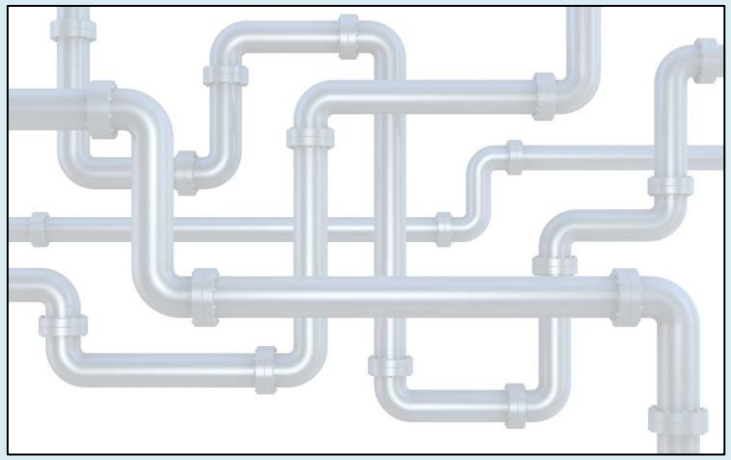
Objectives

1. Contribute to 100% Renewable Madison by identifying ways to reduce the amount of greenhouse gas emitted for MWU operations.
2. Identify the spatial and seasonal dependence of water loss in the distribution system.
3. Identify sources of water loss in the distribution system.

Water Loss

Inputs:

- Well 6
- Well 7
- Well 8
- Well 9
- Etc.



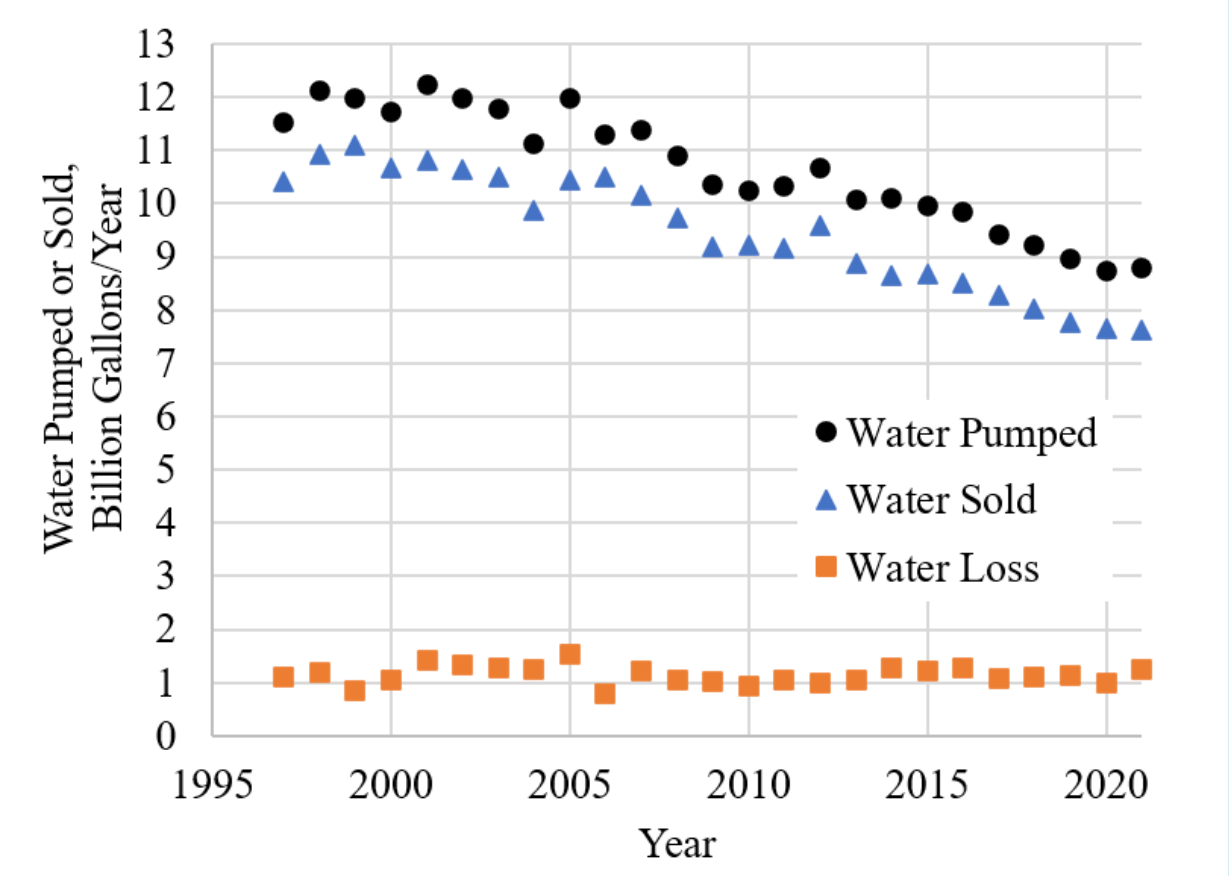
Outputs:

- Customer Use
- Water Main Flushing
- Fire Fighting
- Leaks
- Theft

Also: Meter Issues

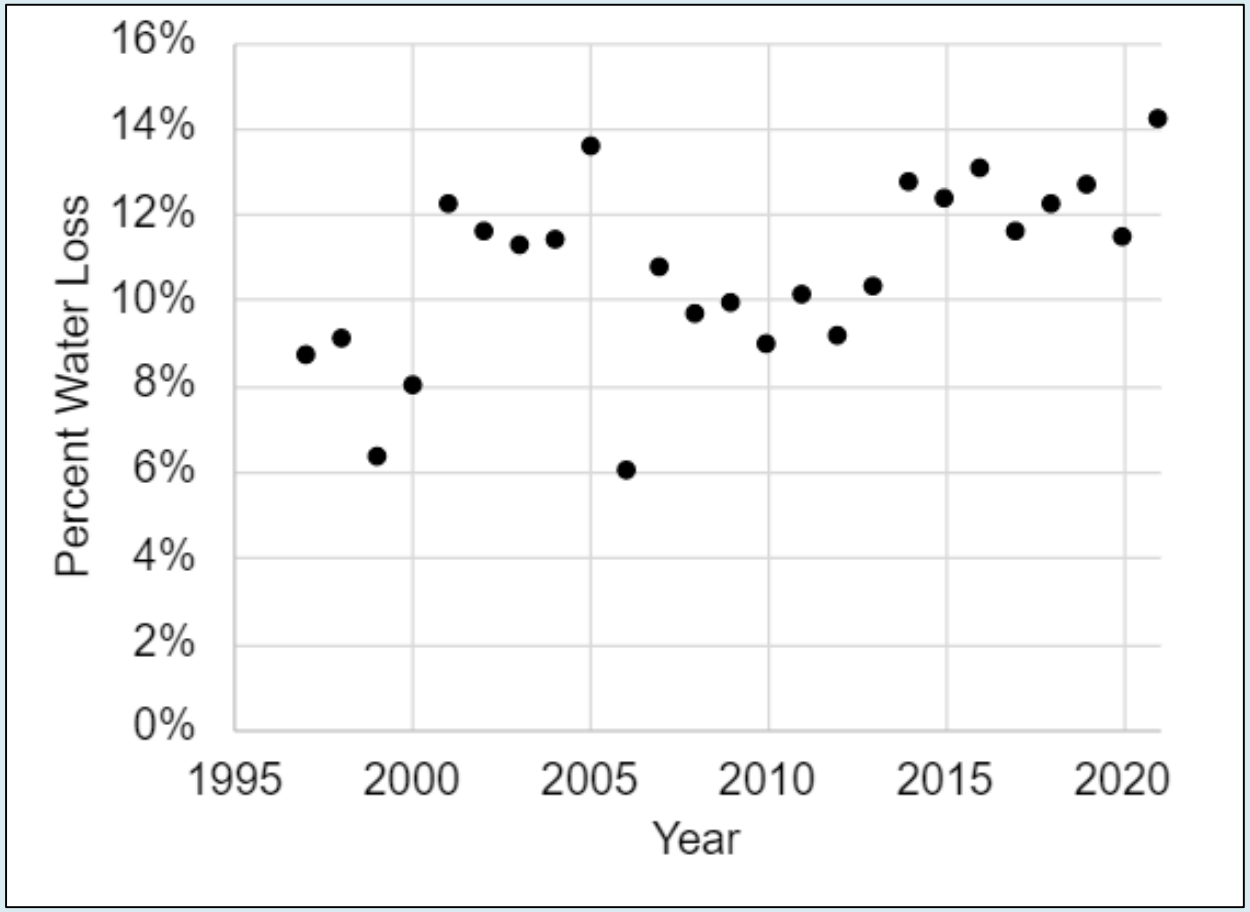
Madison's History With Water Loss

- Water use decreasing (despite population growth)
- About 1.1 billion gallons lost a year

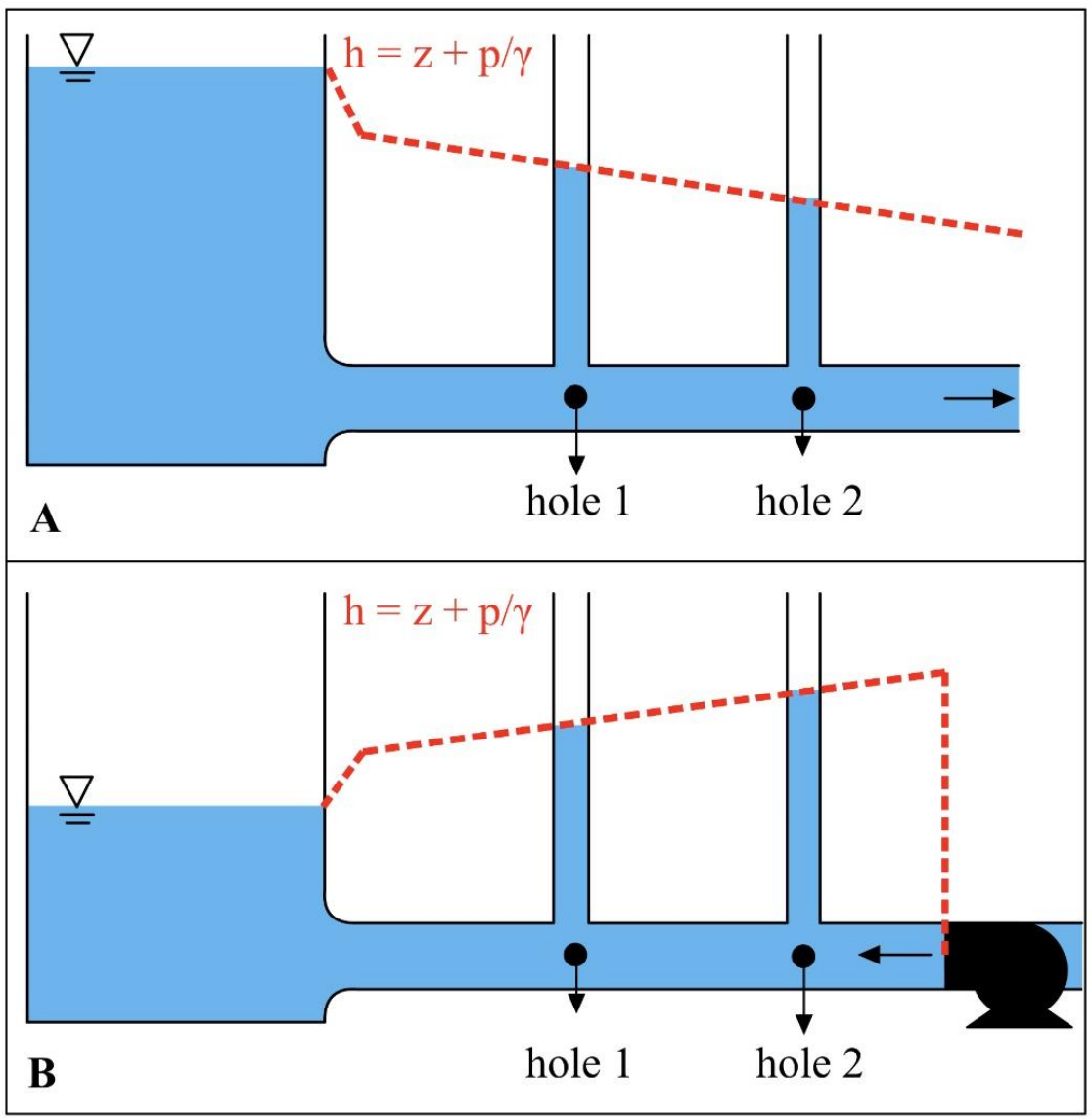


Madison's History With Water Loss

- Percent water loss increasing over time
- About 12% of water lost each year



Fundamental Basis of Water Loss



$$Q = A * \sqrt{2g(\Delta z)}$$

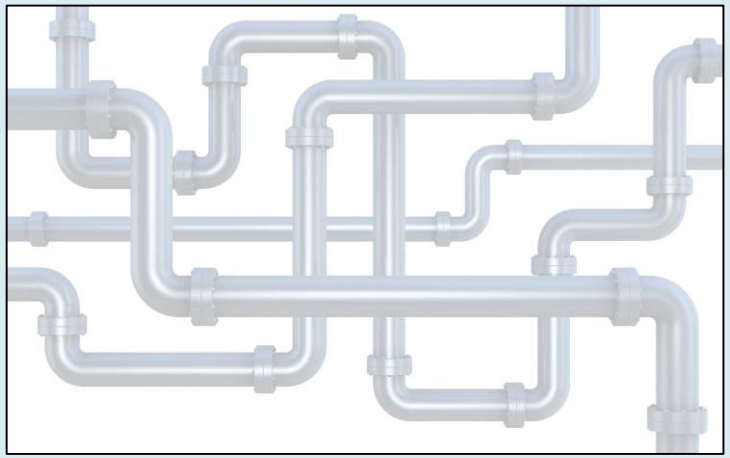
- Q = flow rate
- A = area of holes
- g = gravitational constant
- Δz = elevation difference between reservoir and hole

Big Data at Madison Water Utility

2 data systems – each taking millions of data points a day

Inputs:

- Well 6
- Well 7
- Well 8
- Well 9
- Etc.



Outputs:

- Customer Use
- Water Main Flushing
- Fire Fighting
- Theft
- Leaks

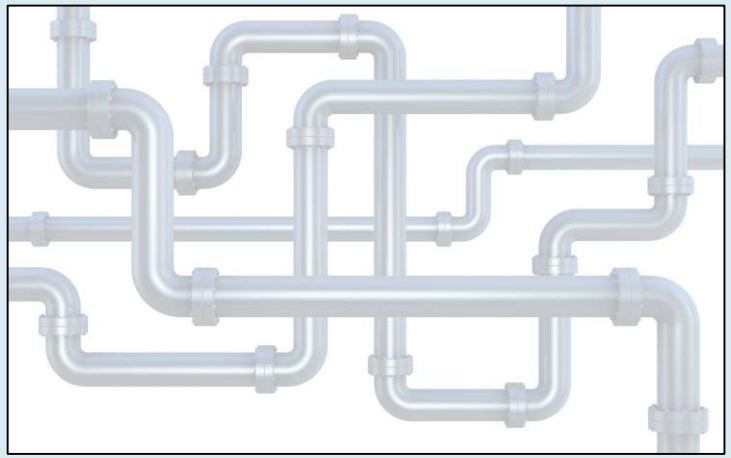
Big Data at Madison Water Utility

2 data systems – each taking millions of data points a day

Inputs:

SCADA

- Well 6
- Well 7
- Well 8
- Well 9
- Etc.



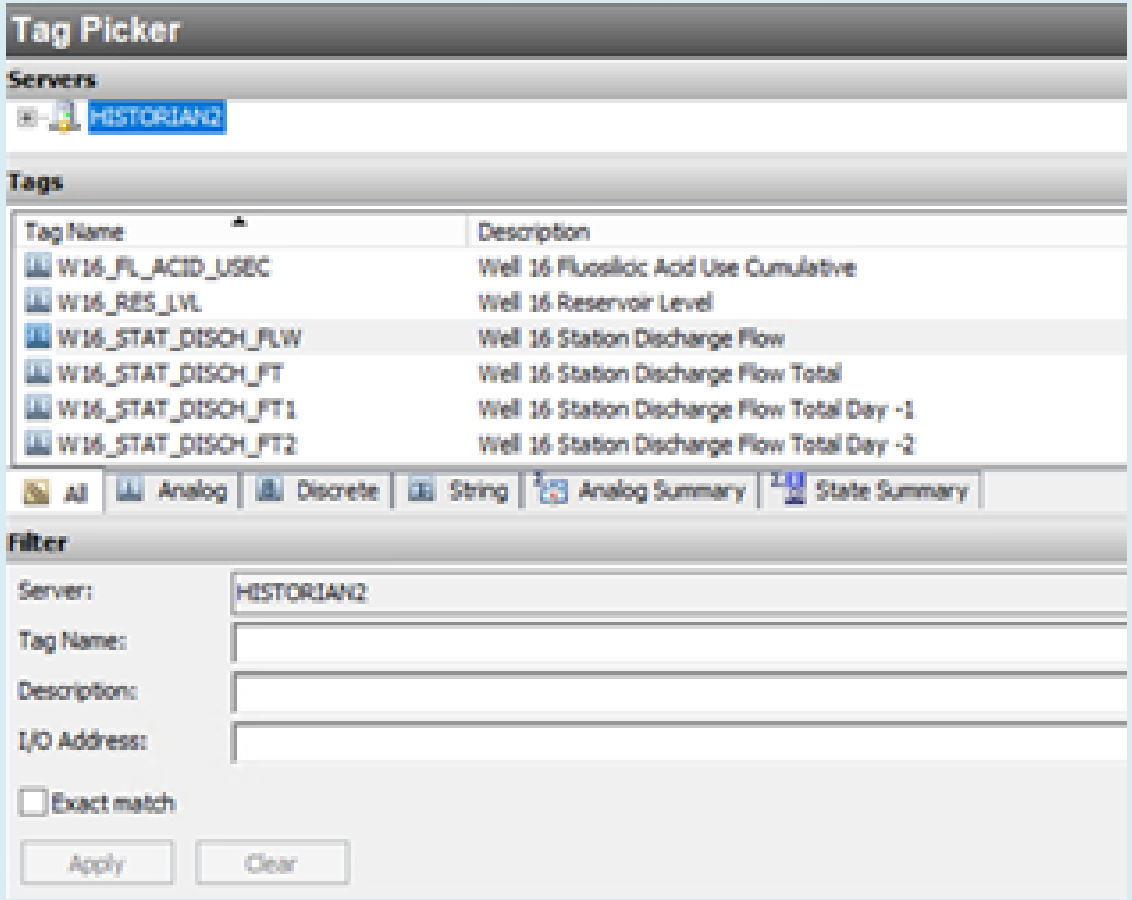
Outputs:

AMI

- Customer Use
- Water Main Flushing
- Fire Fighting
- Theft
- Leaks

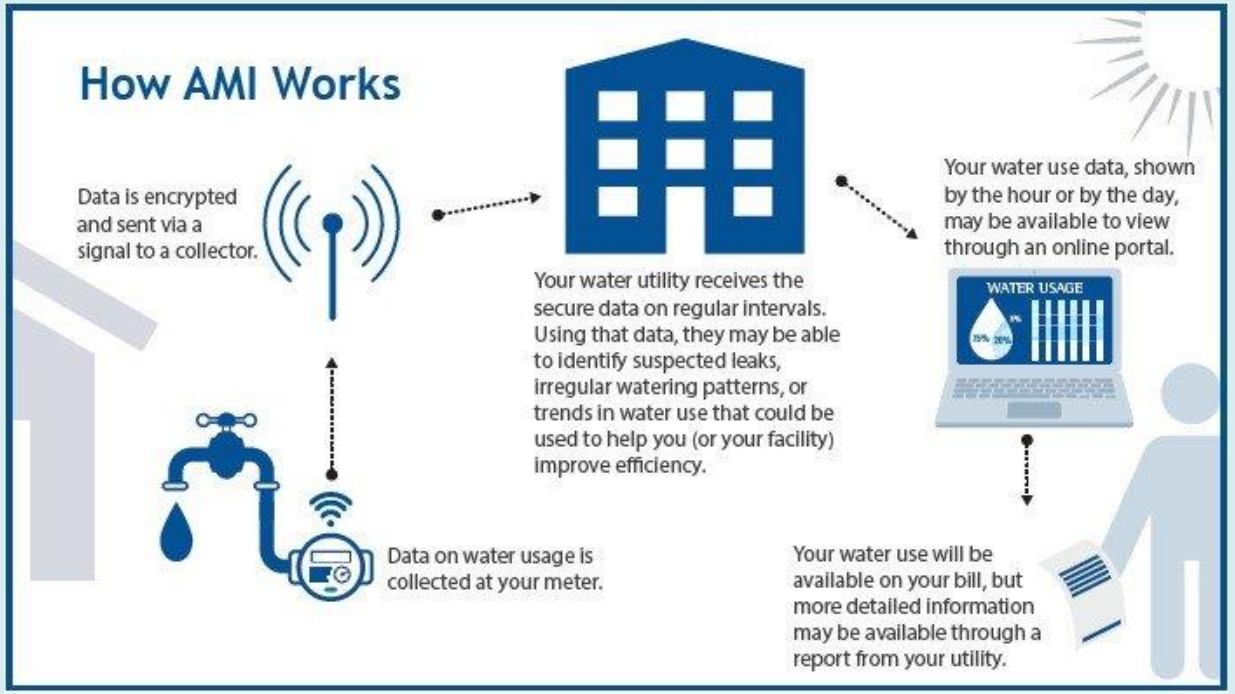
Supervisory Control and Data Acquisition (SCADA)

- Control operations remotely
- Collect data at wells, reservoirs, and booster stations:
  - Flow meters
  - Pressure sensors
  - Tank level indicators
  - Etc.



Advanced Metering Infrastructure (AMI)

- Customer flow meters
- Data sent automatically and wirelessly

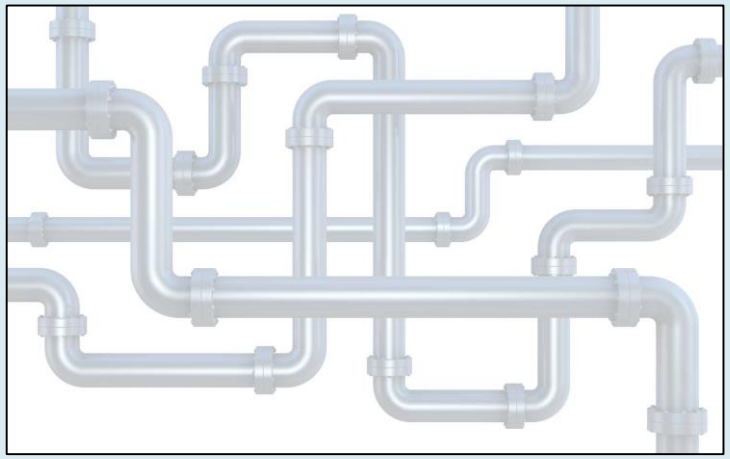


(EPA, 2023)

Methods Overview

Inputs:

- Well 6
- Well 7
- Well 8
- Well 9
- Etc.

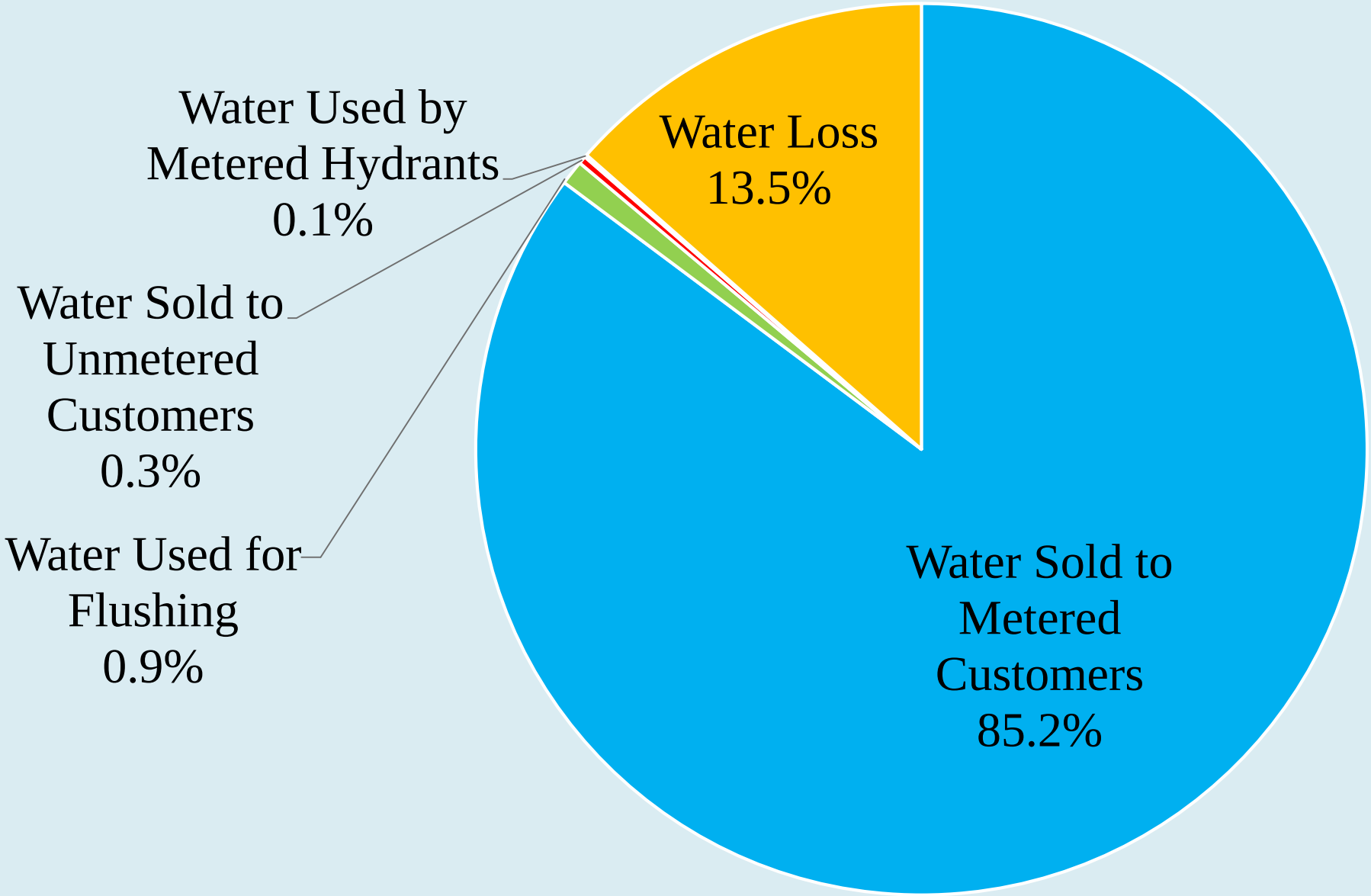


Outputs:

- Customer Use
- Water Main Flushing
- Fire Fighting
- Theft
- Leaks

Inputs – Authorized Consumption = Water Loss

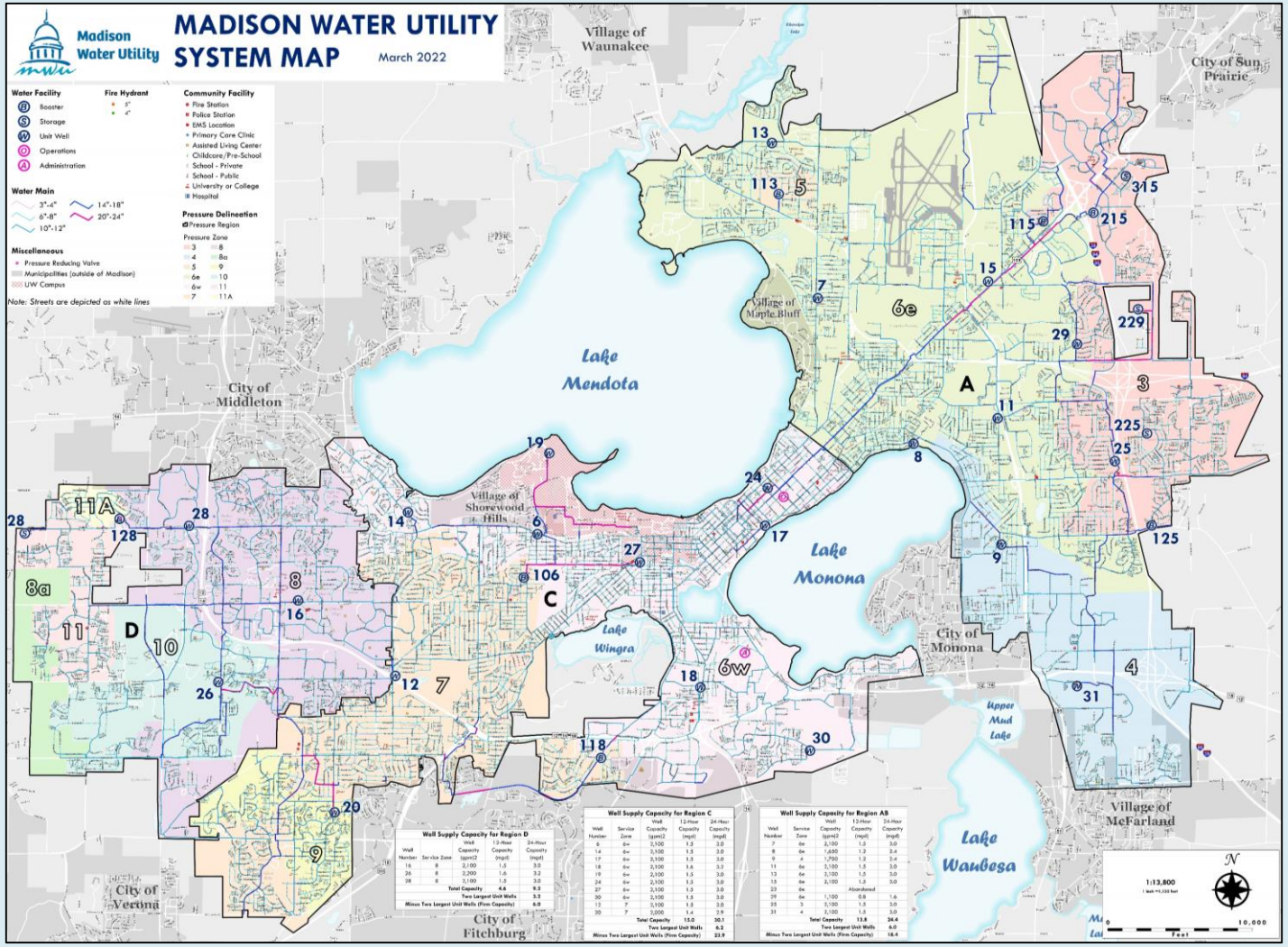
Fate of Water Pumped by MWU in 2022



Water Loss in 2022

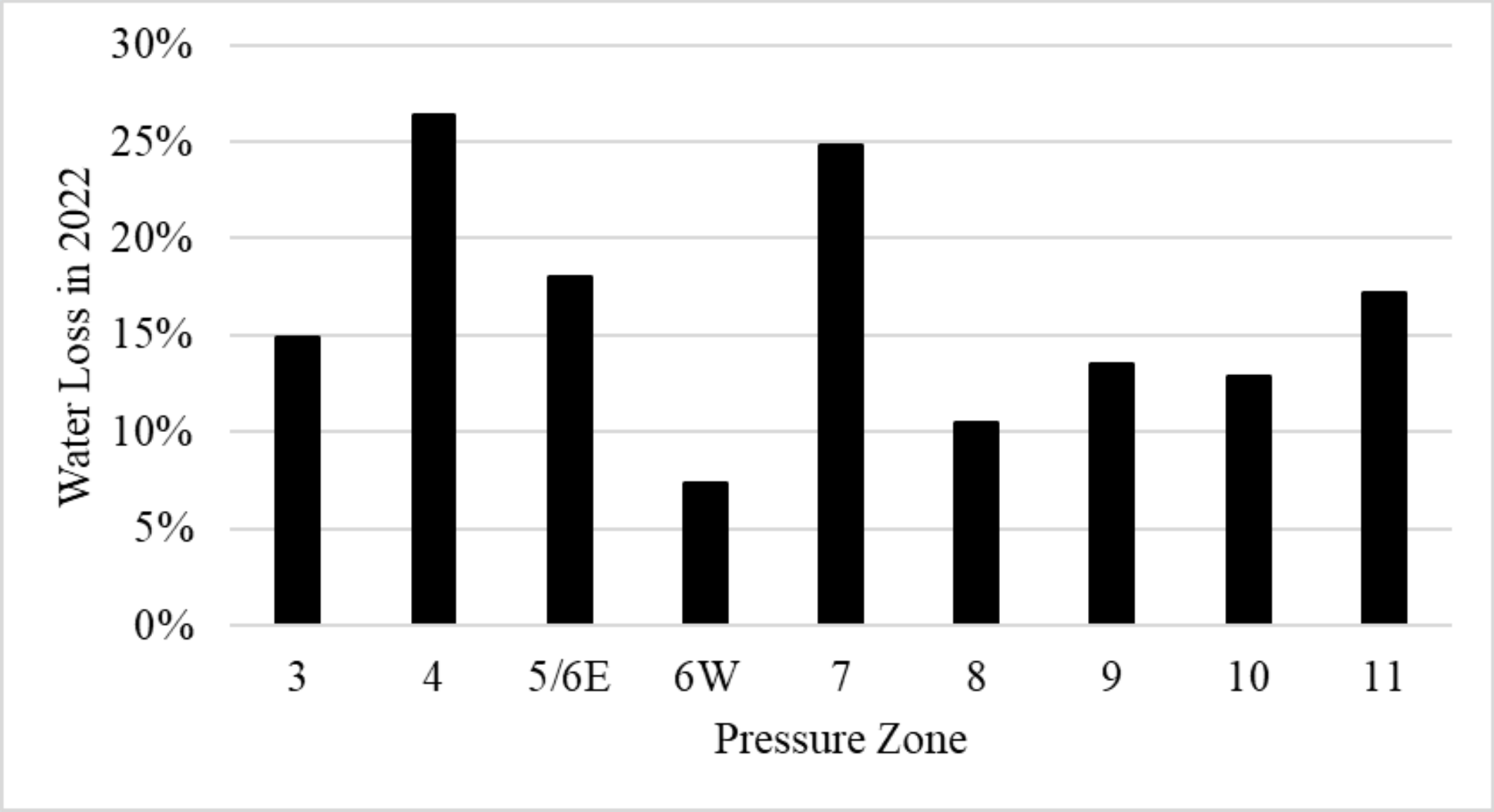
- 1.23 billion gallons water lost
  - Compare to 1.14 billion gallon average in preceding 26 years
- 13.5% of water lost
- Average of 7 gallons/day for a 10 ft length of water main

Spatial Dependence – Pressure Zones



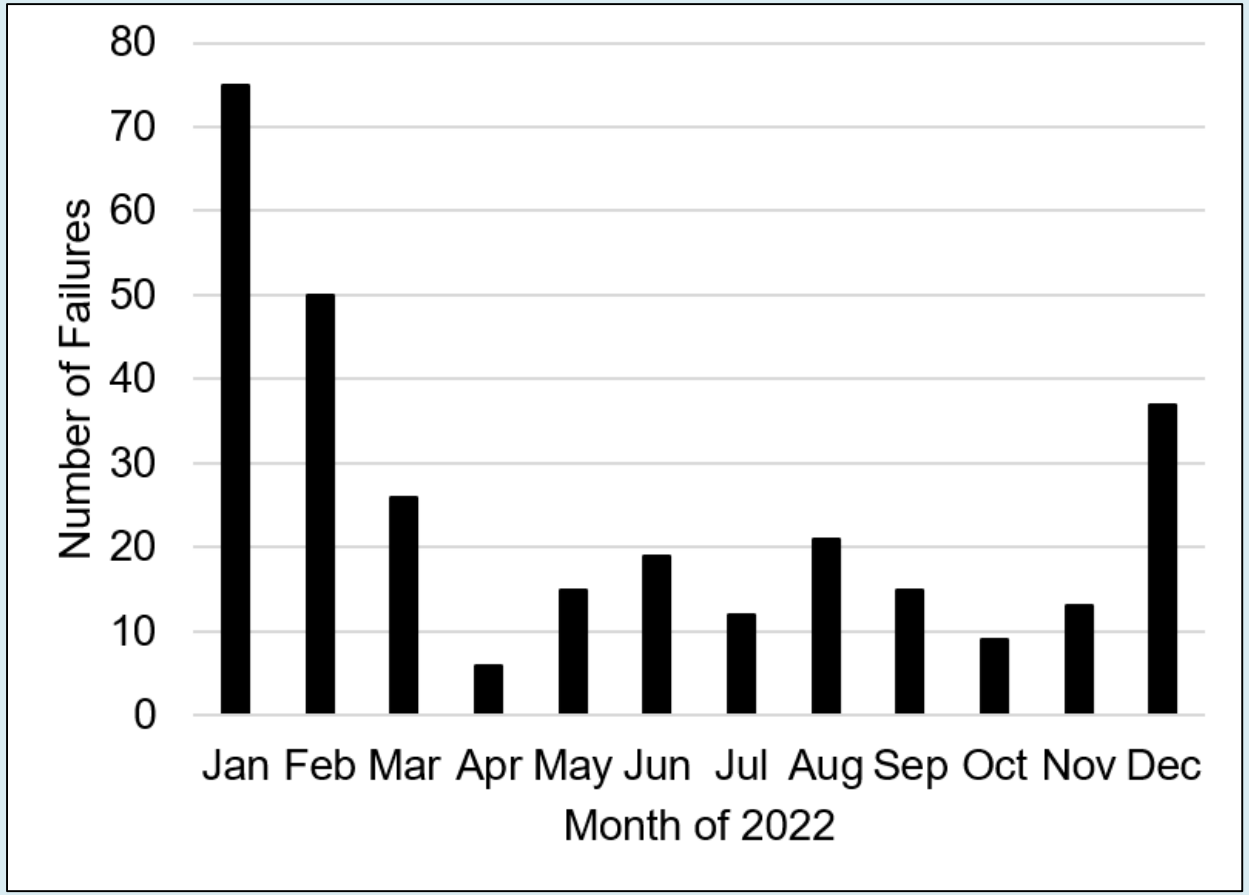
- 10 distinct pressure zones
- Hydraulic head-delineated

Water Loss in 2022

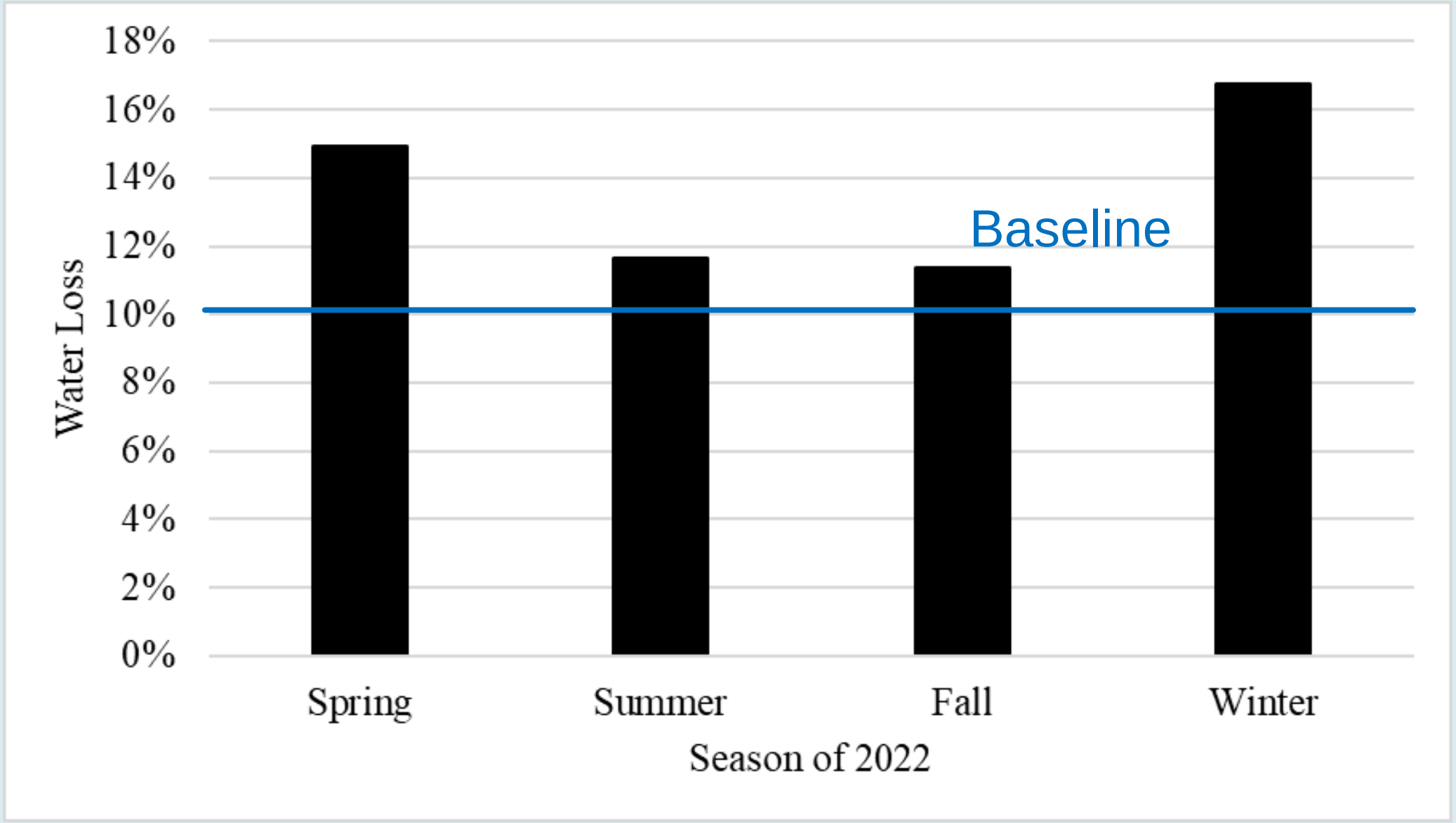


Seasonal Dependence

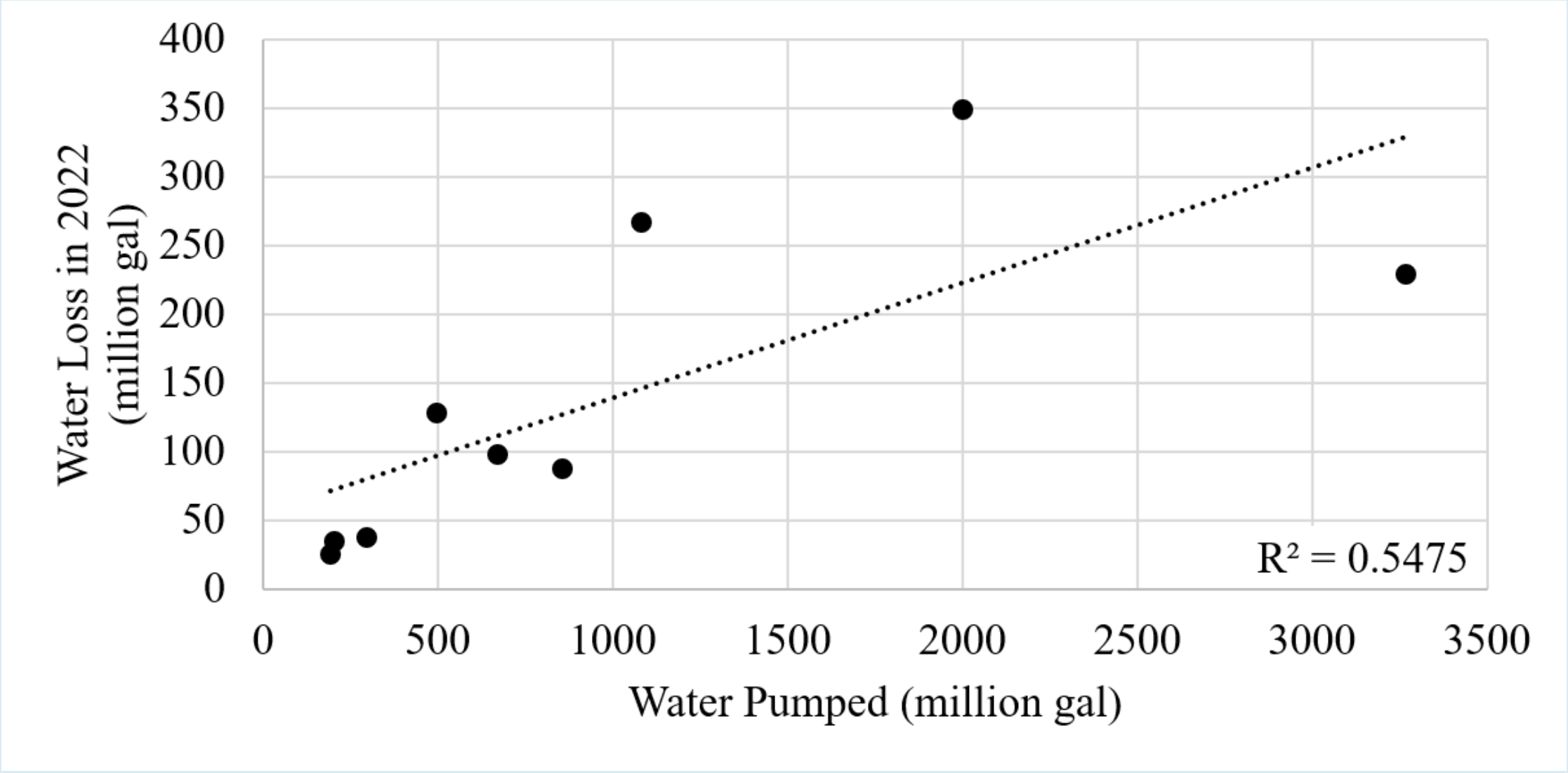
- Most detected failures are in the winter
  - Is most loss in the winter?
  - Is most loss from main and service line breaks?



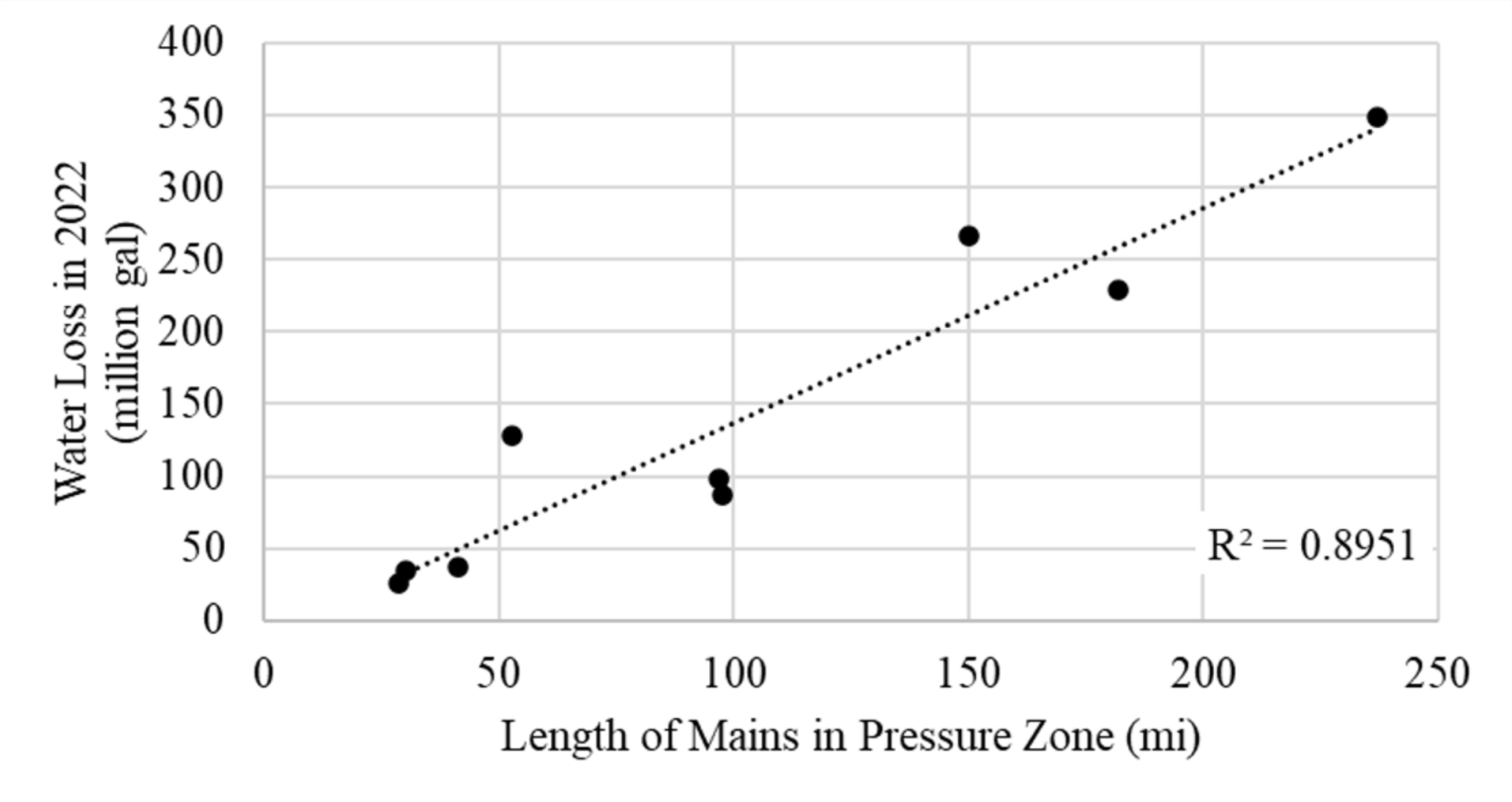
Water Loss in 2022



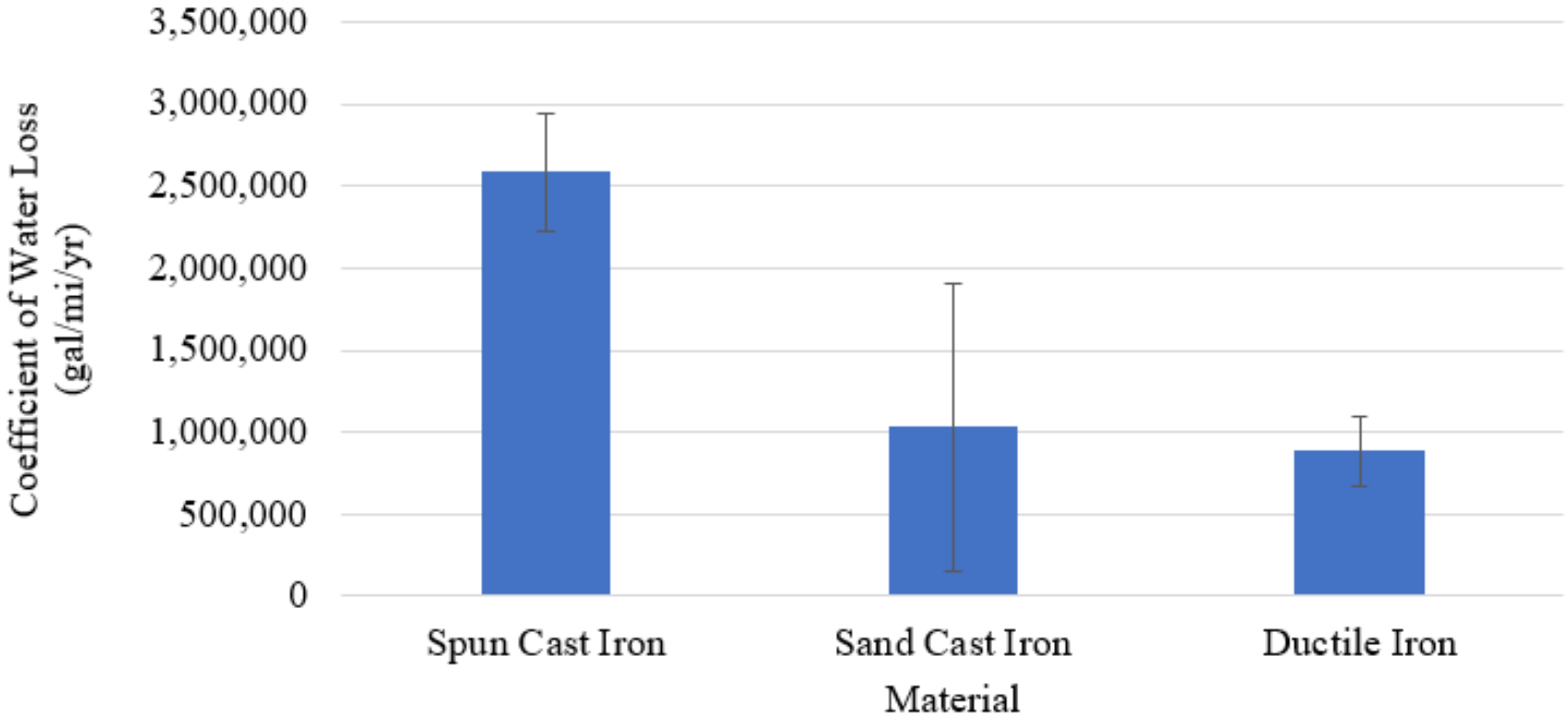
Water Loss vs Water Pumped



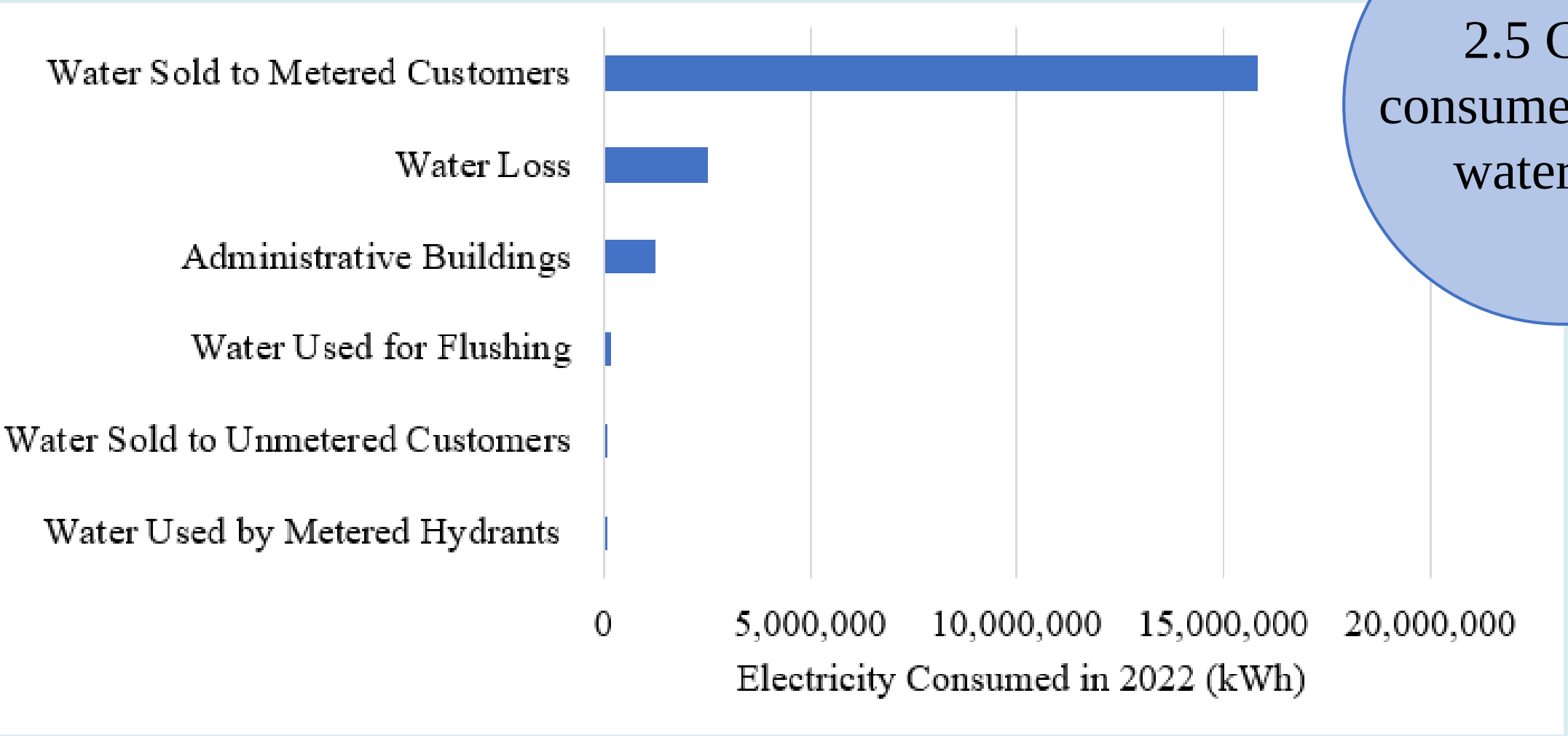
Water Loss vs Length of Mains



Estimated Water Loss Along Water Mains of Different Materials in 2022

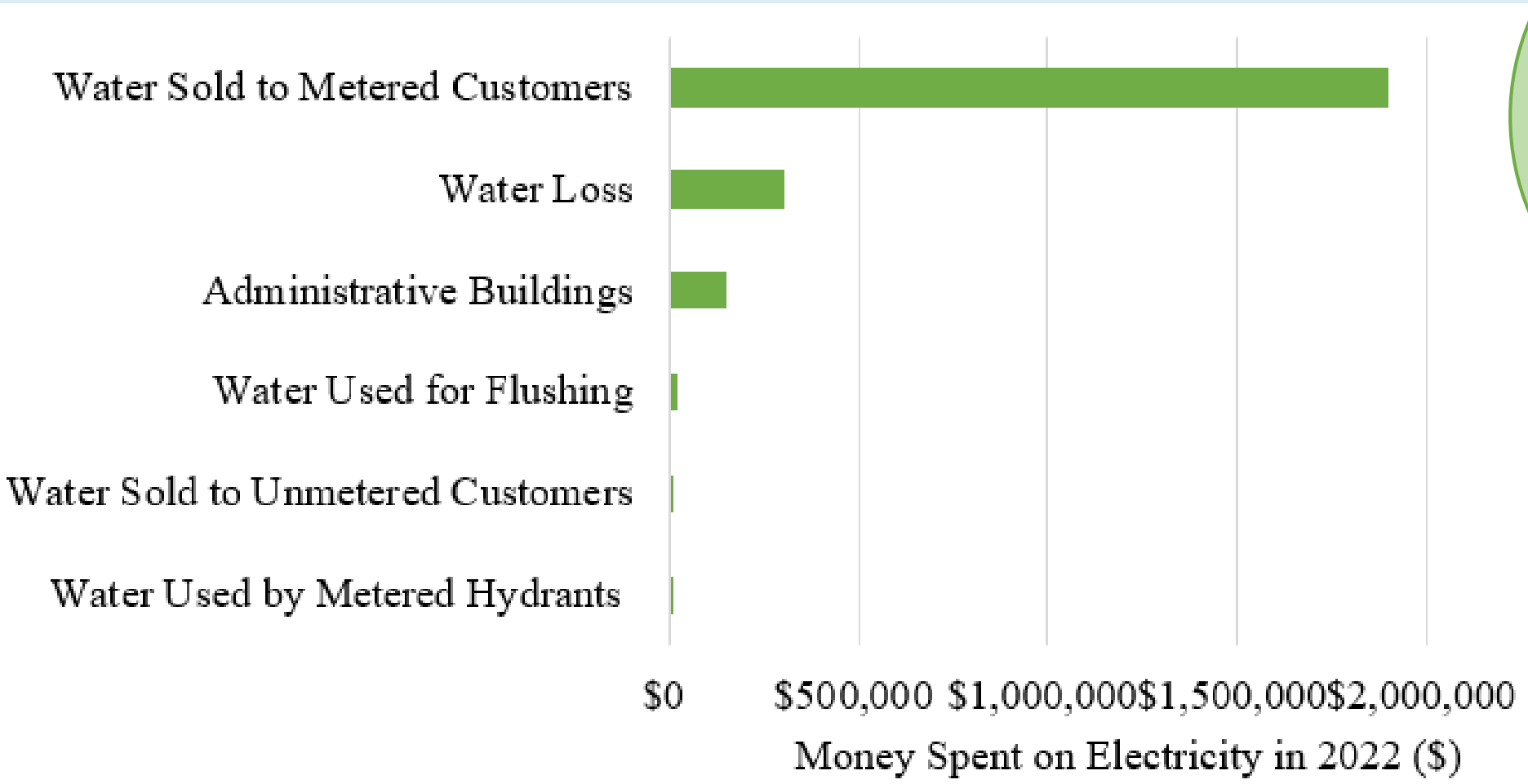


Electricity Consumption



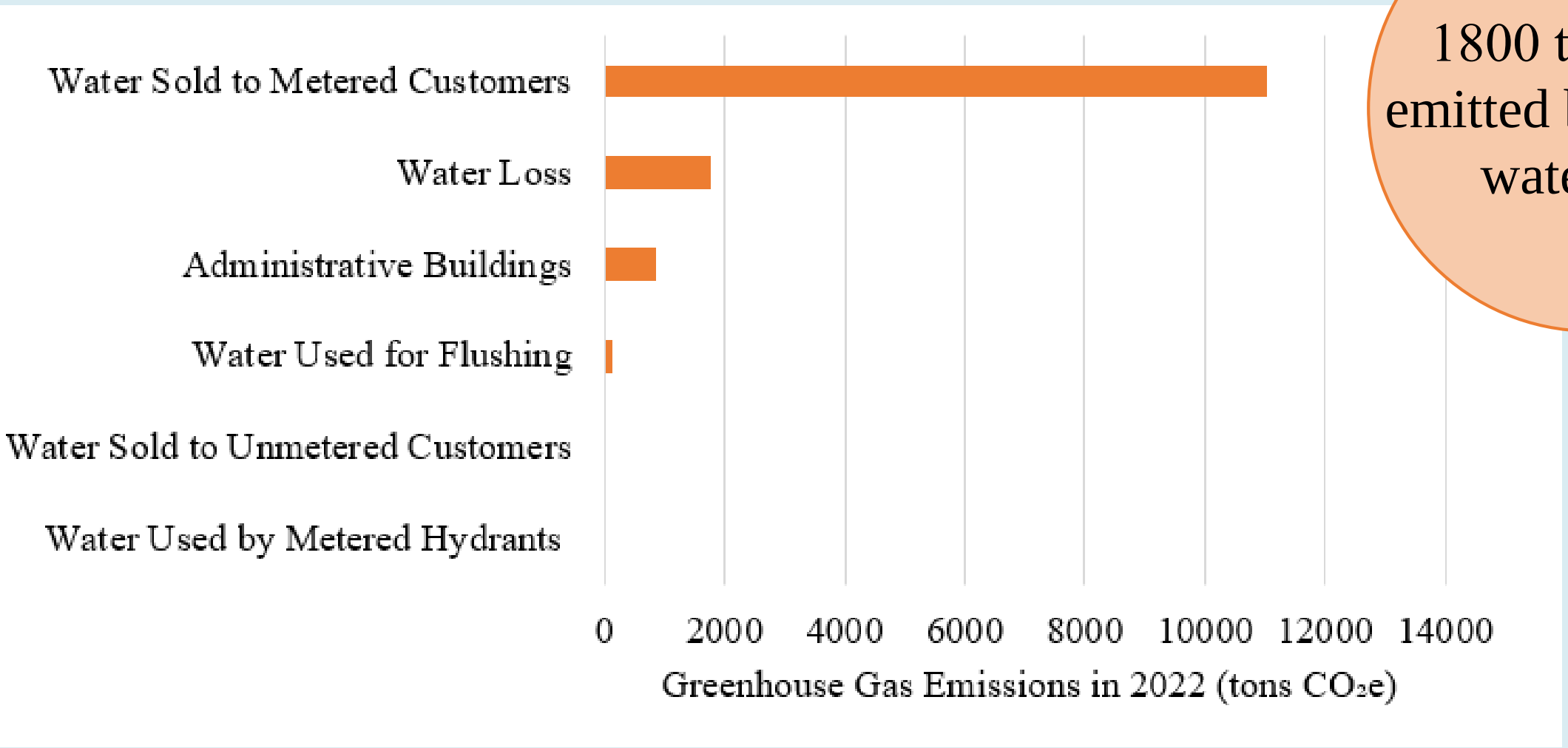
2.5 GWh consumed due to water loss

Electricity Consumption from a Financial Perspective



$300k spent on electricity for water loss

Greenhouse Gas Emissions



1800 tons CO_2 emitted because of water loss

Sensitivity Analysis

- Replacing all spun cast iron with ductile iron would reduce water loss to about 8.9%
  - 34% reduction from 2022 water loss
- Class AB Wisconsin Utilities
  - 15% reported less than 5% water loss
  - This would be a 43% reduction for MWU

Conclusions

- MWU experienced a water loss of 1.23 billion gallons in 2022, 13.5% of the total water pumped
- Water loss was greatest in the winter. Percentage water loss was 16.7% during the winter, about 5% higher than during the summer and fall
- Water loss varied greatly with pressure zone, from 7.3% in zone 6W to 26.4% in zone 4
- Water main materials have an impact on water loss
  - 885,527 gal loss/mile of ductile iron
  - 1,029,082 gal loss/mile of sand cast iron
  - 2,578,480 gal loss/mile of spun cast iron

Conclusions

- Age of water mains is slightly correlated with water loss because different materials have trended in new construction and water main replacement over the years
- 2.5 GWh of electricity were wasted due to water loss in 2022
  - Reduction to 5% water loss would reduce electricity use by 1.6 GWh per year
- 1754 tons of CO_2 were emitted in the generation of the electricity wasted due to water loss in 2022
  - Reduction to 5% water loss would reduce CO2 emissions by 1105 tons of CO2 per year

General Recommendations

- Continue to prioritize the replacement of spun cast iron water mains, when possible
  - For every mile of spun cast iron replaced with ductile iron pipe, an estimated 1.7 million gallons of water loss will be prevented each year.
- Work with the city's Engineering Division to ensure that water main material is an important factor in prioritizing street replacement

Research Recommendations

- Conduct a water loss study using well influence zones rather than pressure zones. This could yield greater levels of certainty on water loss as a function of pipe material.
- Implement pressure sensors throughout the water main network. High density pressure sensor networks have been shown to increase sensitivity of main break detection (Lee et al., 2016; Ma et al., 2022).
- Develop computer software to automatically link data from SCADA and AMI for close to real-time analysis of water loss.

What questions do you have?