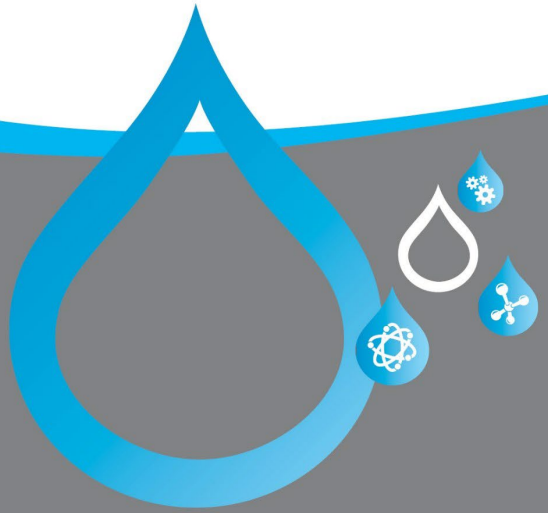
Lead Exposure, Service Line Identification, and Other Sampling Methods;

Comparison of two cities with opposite levels of corrosion control



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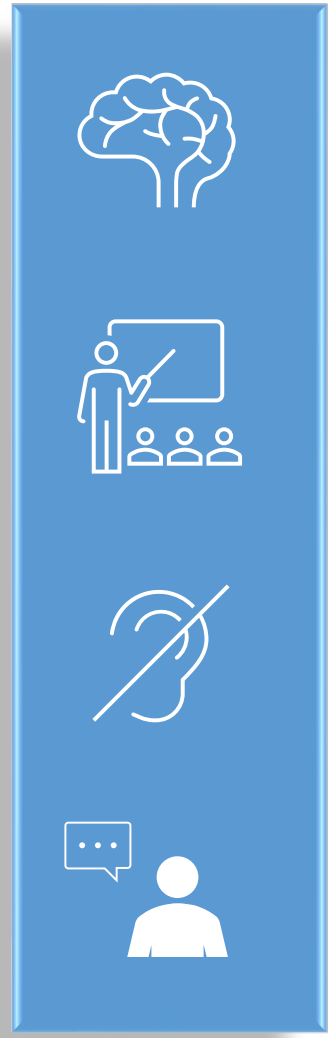
Health Affects and Policy for Lead

- CDC states that lead is a neurotoxin and has identified that no amounts in the blood stream are safe[1]
  - Lead affects
    - Brain and nervous system
    - Growth and development
    - Learning, behavior, hearing and speech
- CDC blood lead reference value (BLRV) of 3.5 micrograms per deciliter (µg/dL)[2]
- Lead is regulated by the Lead and Copper Rule(LCR) under the Safe Drinking Water Act (U.S. EPA, 1991)
  - Maximum contaminant level goal (MCLG) of 0 µg/L
  - Action level of 15 µg/L (90th percentile)
    - Treatment based target
  - Under the LCR's 40 C.F.R. Sections 141.80 to 141.91 tap sampling is required[3]
    - First Draw after minimum of 6 hr. stagnation
- American Association of Pediatrics recommends lead levels in water consumed by children do not exceed 1 µg/L in 2016[4]



[1]https://www.cdc.gov/biomonitoring/lead_factsheet.html#:~:text=No%20safe%20blood%20lead%20level,one%20millionth%20of%20a%20gram.
[2]https://www.cdc.gov/nceh/lead/data/blood-lead-reference-value.htm
[3]https://www.epa.gov/sites/default/files/2016-02/documents/epa_lcr_sampling_memorandum_dated_february_29_2016_508.pdf
[4]https://publications.aap.org/pediatrics/article/138/1/e20161493/52600/Prevention-of-Childhood-Lead-Toxicity?autologincheck=redirected

Why Sampling Type Matters

- There are many protocols, but each has a specific use answering one of those many questions
- Regulatory/Compliance/Treatment Sampling
- Exposure Assessment Sampling
- Sampling for Lead Sources
- No single universally applicable sampling approach for lead in drinking water exists

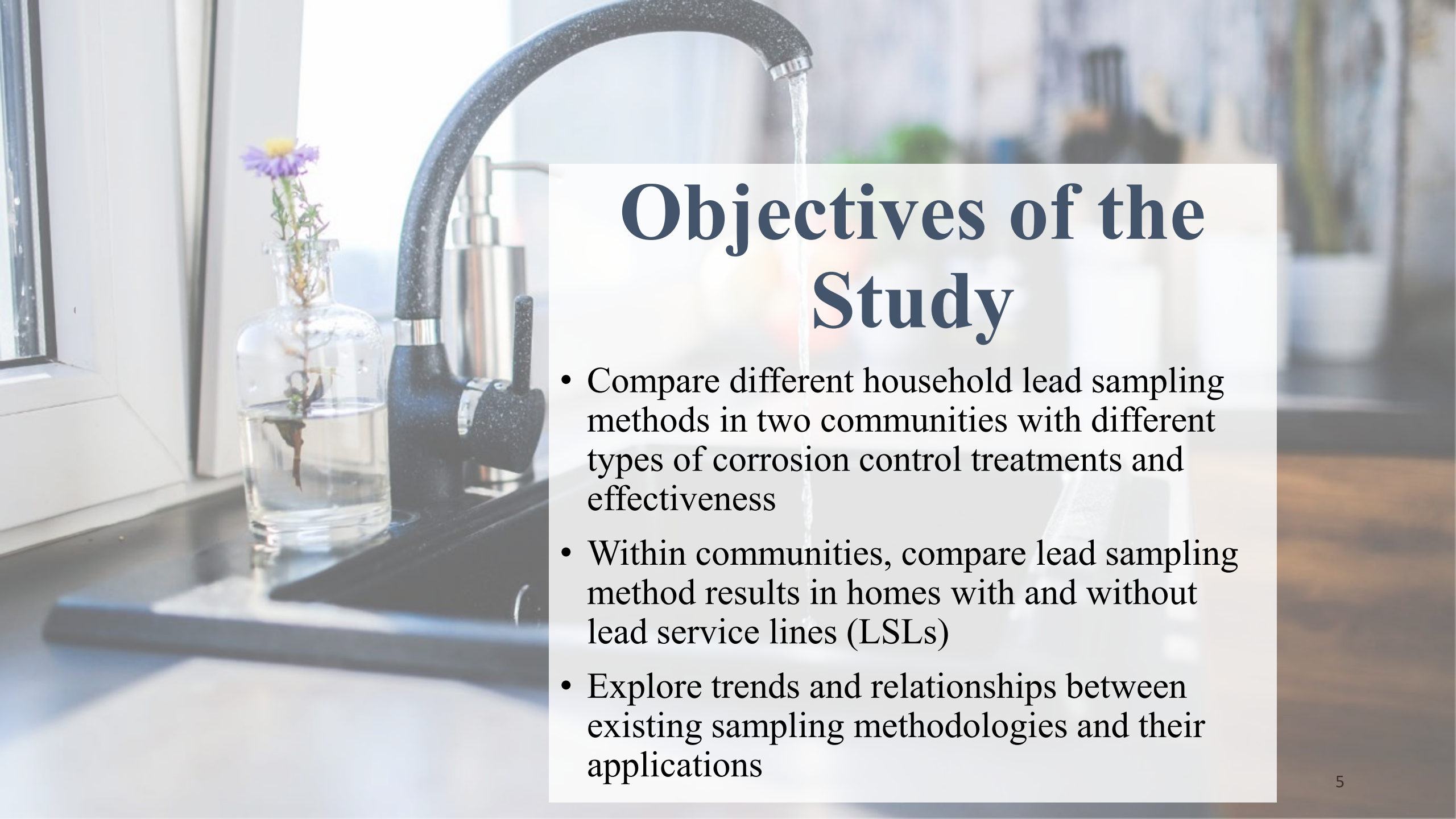
Sampling Considerations

Protocol Considerations:

- Sample volume
- Number of samples per site
- Number of sites
- Stagnation time
- First draw or flush
- Site choice
- Frequency of sampling
- Wide mouth bottles

Sampling Variabilities:

- Flow rate
- Water temperature
- Time of year
- Pre-flushing
- Aerator removal
- Particulate release
- Accurate quantification
- Stagnation time differences



Objectives of the Study

- Compare different household lead sampling methods in two communities with different types of corrosion control treatments and effectiveness
- Within communities, compare lead sampling method results in homes with and without lead service lines (LSLs)
- Explore trends and relationships between existing sampling methodologies and their applications

Water Quality Background During Sampling Events

*These values are the average values during the sampling period

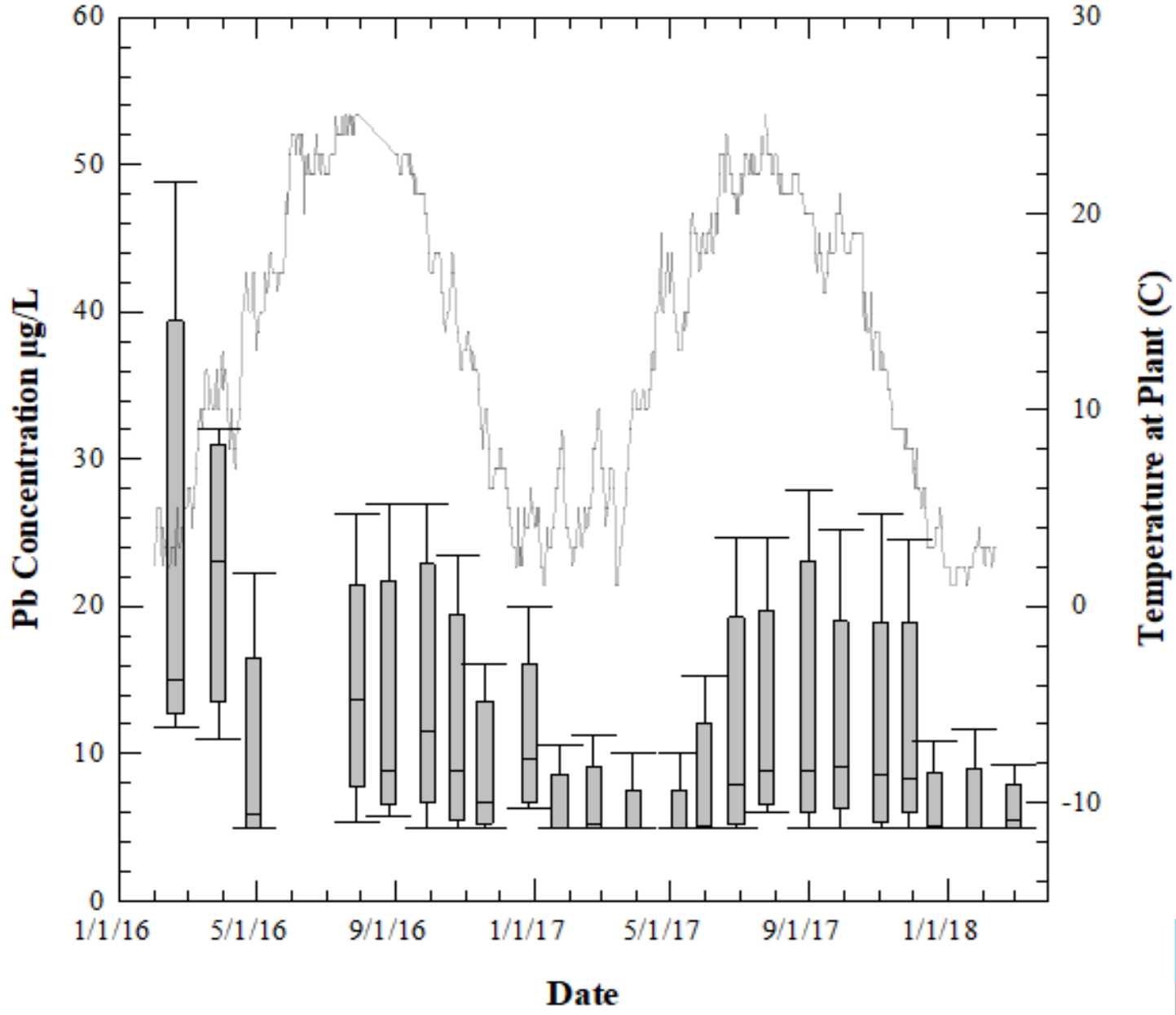
	Plant Chlorine (free) (mg/L)	Finished Total Alkalinity (mg $CaCO_3$/L)	Finished pH (S.U.)	Finished Temperature (°C)	Finished Calcium Hardness (mg/L)	Orthophosphate (mg PO_4/L)
City A (7-9/2021)	1.35	80	7.32	22	114	1.22
City B (10-12/21)	1.45	72	8.21	11	110	n/a

Corrosion Control:

- City A treats with a finished dose of around 1.2 mg/L orthophosphate
- City B treats with pH and alkalinity adjustment (no orthophosphate, n/a= not applicable)

Previous Research Seasonal Variations in Lead Sampling

- Sampling time of year must be considered when comparing lead results
- Temperature of the water correlates with amounts of lead being released



Drinking Water Lead Sampling Types Examined

Sample Type	Sampling Purpose	Protocol
First Draw (FD)	•Regulatory (US) (90th percentile) •Treatment Assessment •Collects the initial lead exposure	•6+ hr stagnation •Collect first liter
Random Daytime Sampling (RDT)	•Regulatory (UK) •Treatment Assessment •Collects sample based on consumer habits	•Random sample collection (variable stagnation times) •Collect one liter
Fully Flushed (FF)	•Potential Lead Source Assessment •Treatment Assessment •Collects sample to indicated changed between distribution system and home tap	•Several piping volumes flushed to omit stagnated water •Collect one liter
Sequential Sampling (Profile Sampling)	•Lead Source Assessment •Collects multiple samples to map lead levels through the pipes	•Defined stagnation time •Collect 10-20 samples of defined volume • (125 mL, 250 mL, 1 L, etc.)
Manual Composite (MC)	•Exposure Assessment •Collects the average lead exposure throughout time period consumers may be exposed	•Normal water use patterns •100 mL water collected into 1 L bottle every time consumer uses tap for drinking or cooking •24 hrs or until 1 L bottle is full

Sampling Scope of Study Sites

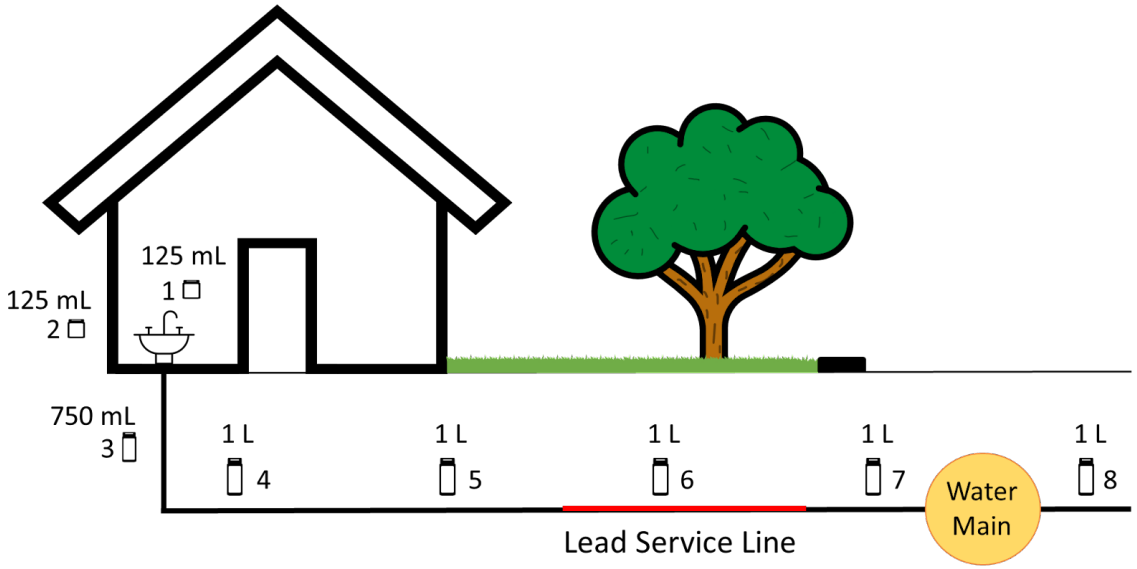
Parameter	City A	City B
Sites with LSL's	22	19
Sites without LSL's	17	11
Number of Sequential Profiles	39	40
Number of Manual Composite Samples	39	28
Number of Random Daytime Samples	39	28
Number of Sites that have associated ultrafiltration results	0	10

Sampling Methodologies

- **Fully flushed** 1-liter samples were taken following the sequential profile
  - Water was flushed for 5 minutes prior to sampling
- **Random daytime** samples were taken by homeowner
  - Told to fill a 1-liter bottle at any time during the day

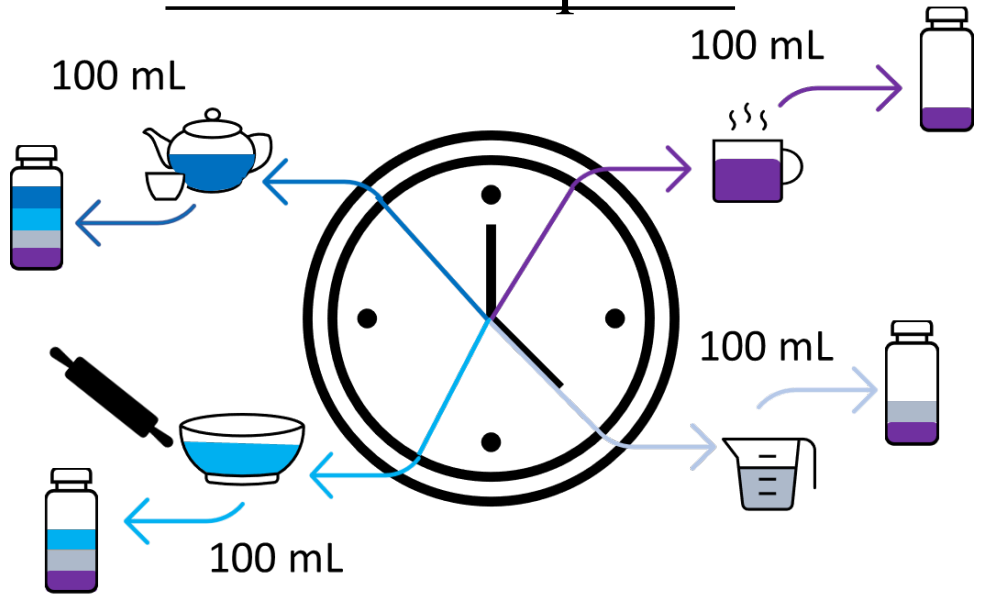
Sampling Methodologies

Sequential Sampling



- 19 samples were taken in succession after 6+ hour stagnation
- 125 mL, 125 mL, 750 mL, 1 L, 1 L …
- Some samples later filtered via an ultrafilter to differentiate between soluble and non-soluble lead

Manual Composite



- Homeowners were given a 1L bottle and told to put 100 mL of sample into it every time water is used for drinking or cooking
- Should be done for one whole day or until bottle is full

Sequential Profile Parameters

Weighted Average by Volume (WAV)

$$WAV = \frac{\sum_{i=1}^{n}(C_i)(V_i)}{\sum_{i=1}^{n} V_i}$$

n = Total Number of Samples taken
C = Lead Concentration for whole sequential
V = Sample Volume for whole sequential

First Draw Equivalent (FDE)

$$FDE = \frac{\sum_{i=1}^{n}(C_i)(V_i)}{\sum_{i=1}^{n} V_i}$$

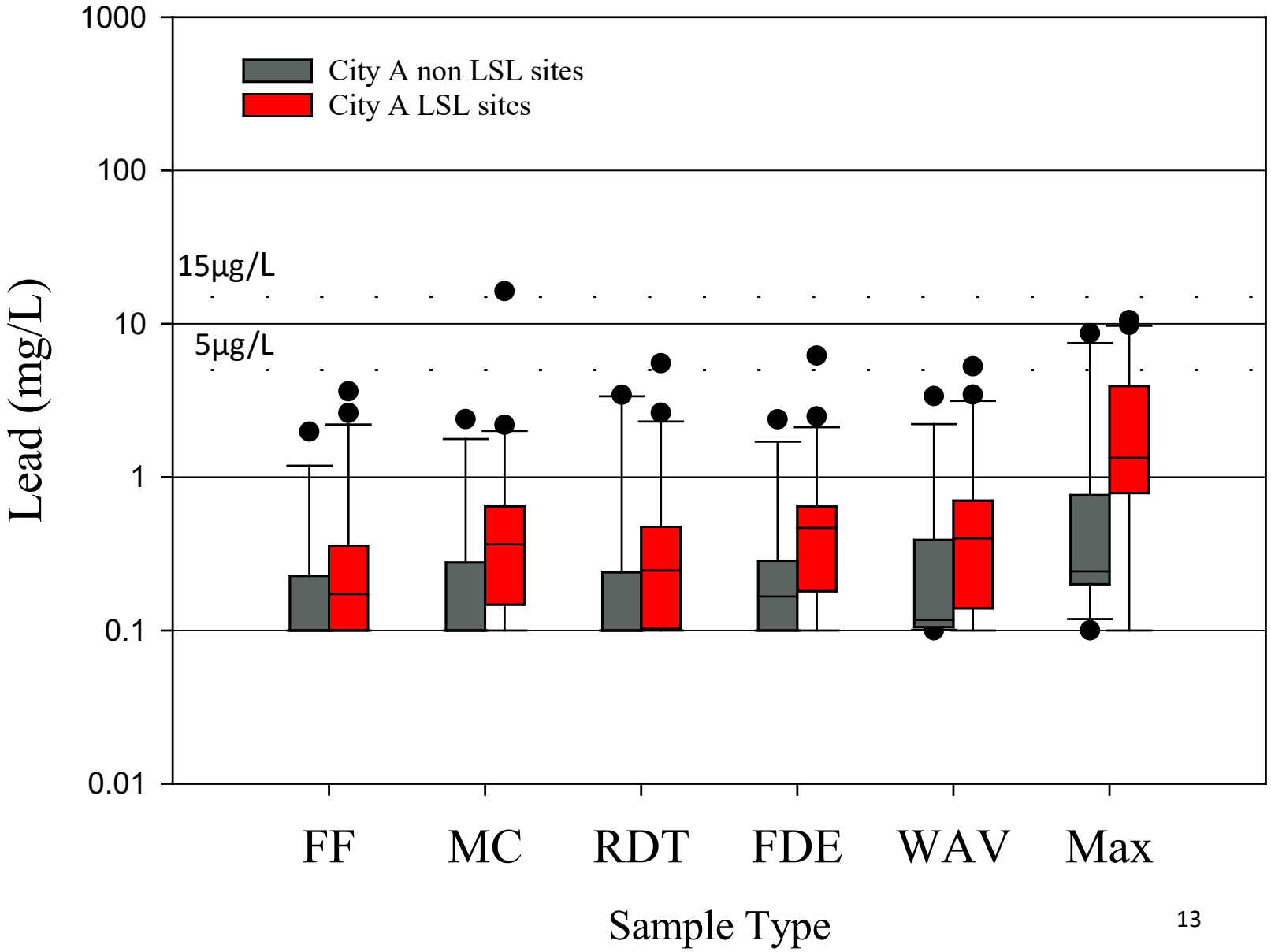
n = Number of Samples taken in first liter
C = Lead Concentration for samples within the first liter
V = Sample Volume for samples within the first liter

Sampling Results City A (treats with orthophosphate)

- Lead in log scale
- Dots are outliers
- Whiskers represent 10th and 90th percentile
- Boxes are 25th and 75th quartiles
- Middle line is median

Parameter	Code
Fully Flushed	FF
Manual Composite	MC
Random Daytime	RDT
First Draw Equivalent	FDE
Weighted Average by Volume	WAV
Maximum	MAX

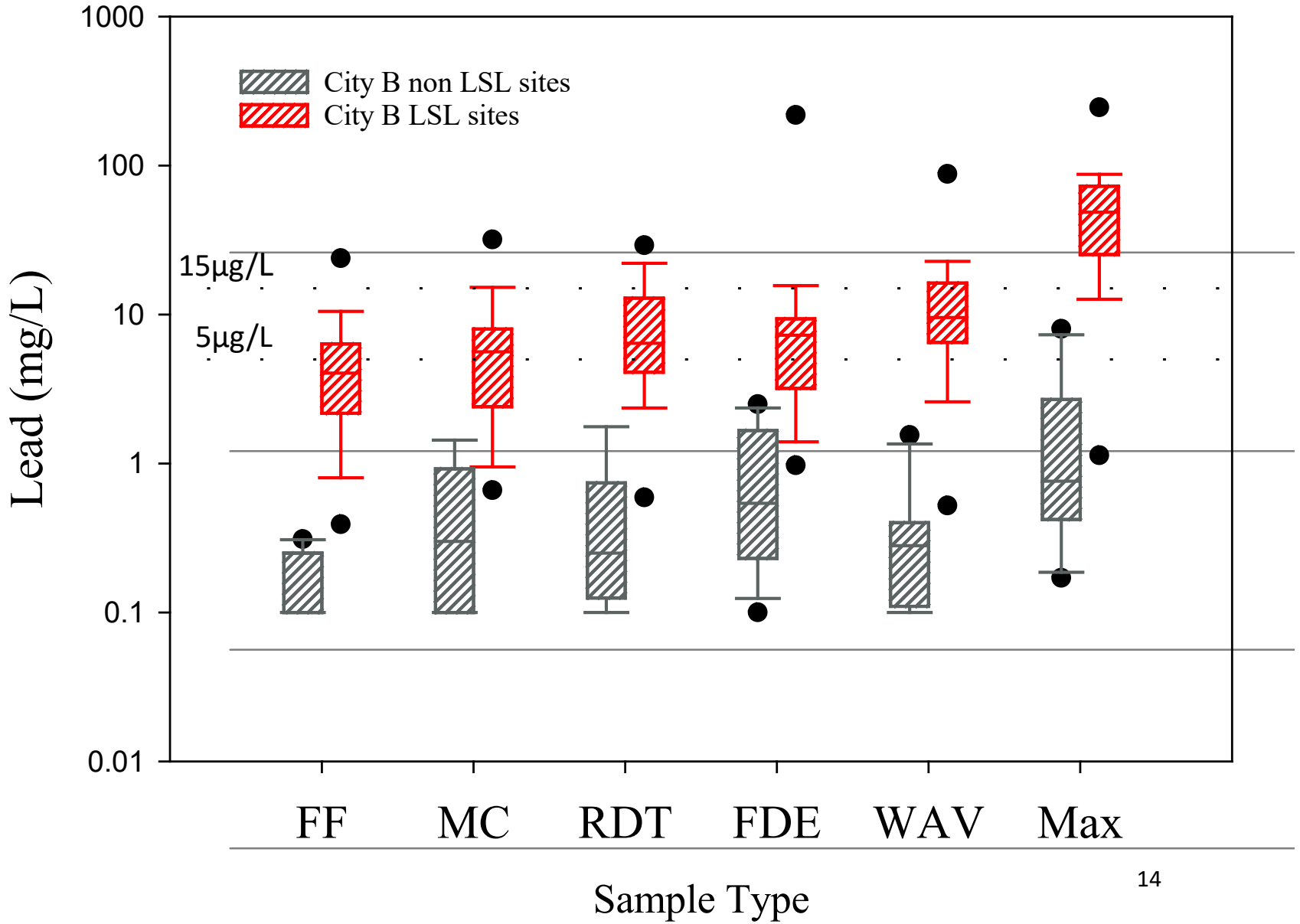
Median Values	FF	MC	RDT	FDE	WAV	Max
City A non LSL	0.1	0.1	0.1	0.2	0.1	0.2
City A LSL	0.2	0.4	0.3	0.5	0.4	1.3



City B (treats with alkalinity and pH adjustment)

Parameter	Code
Fully Flushed	FF
Manual Composite	MC
Random Daytime	RDT
First Draw Equivalent	FDE
Weighted Average by Volume	WAV
Maximum	Max

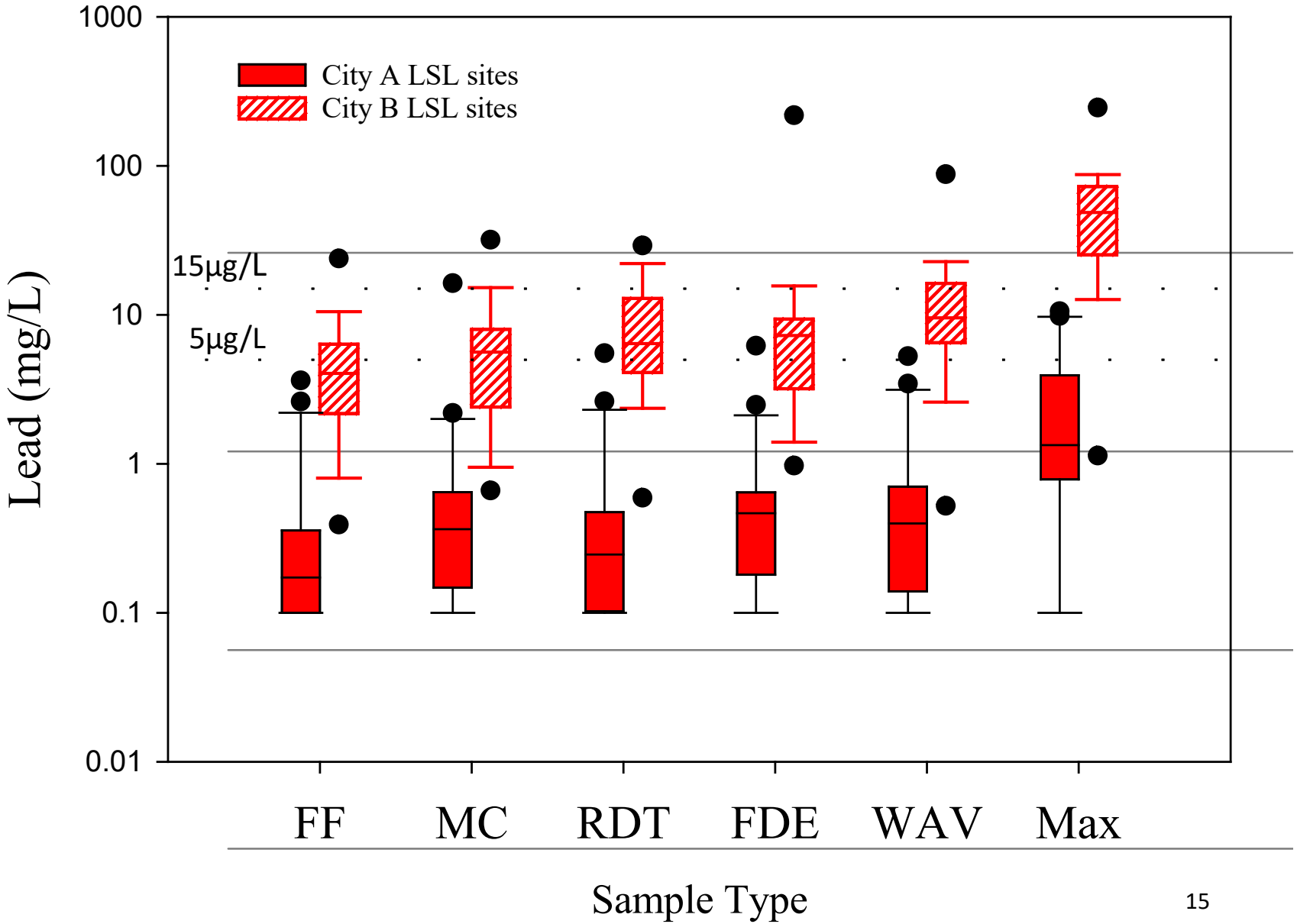
Median Values	FF	MC	RDT	FDE	WAV	Max
City B non LSL	0.3	0.3	0.3	0.5	0.3	0.8
City B LSL	4.1	5.6	6.4	7.3	9.6	49



City A and B Comparison of LSL sites

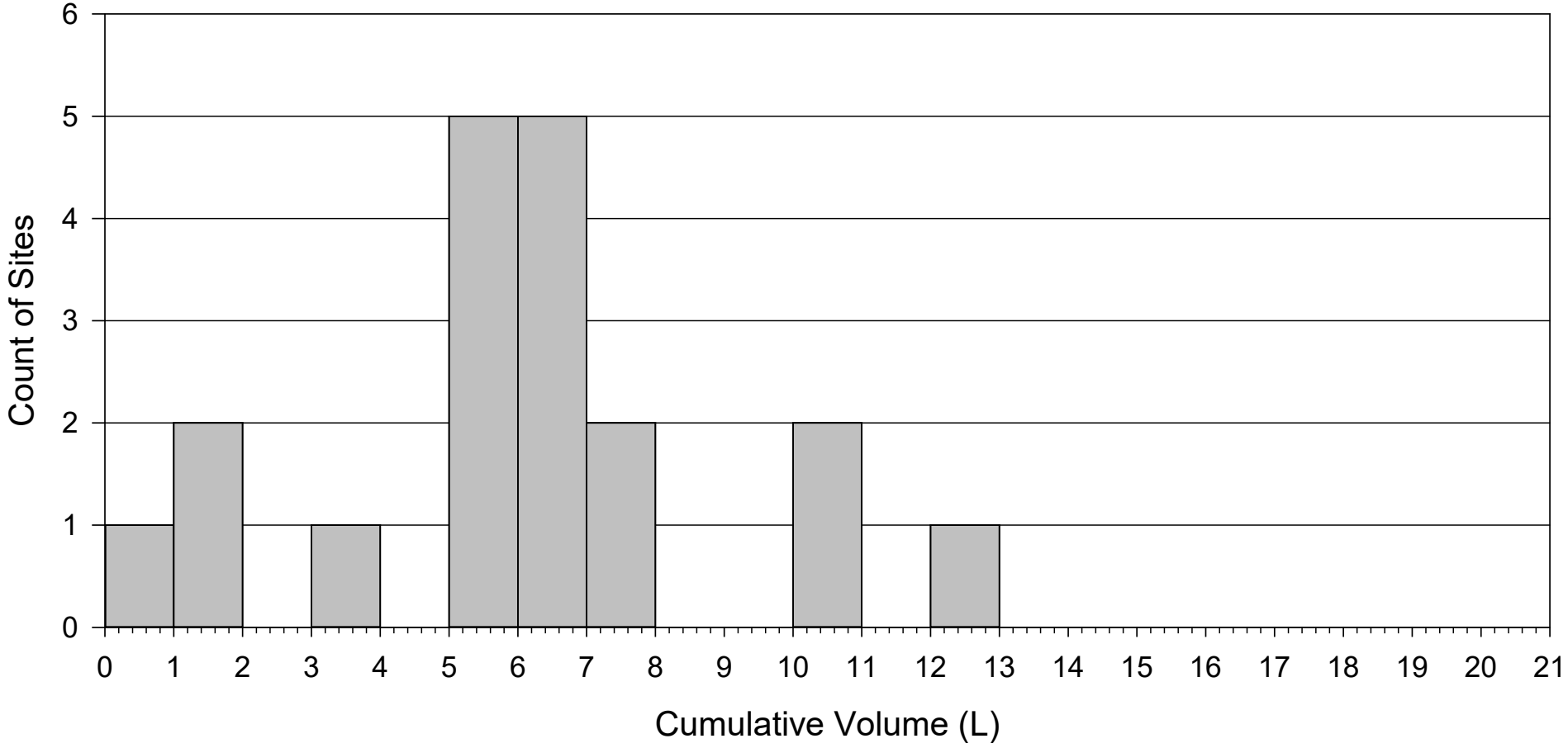
Parameter	Code
Fully Flushed	FF
Manual Composite	MC
Random Daytime	RDT
First Draw Equivalent	FDE
Weighted Average by Volume	WAV
Maximum	Max

Median Values	FF	MC	RDT	FDE	WAV	Max
City A LSL	0.2	0.4	0.3	0.5	0.4	1.3
City B LSL	4.1	5.6	6.4	7.3	9.6	49

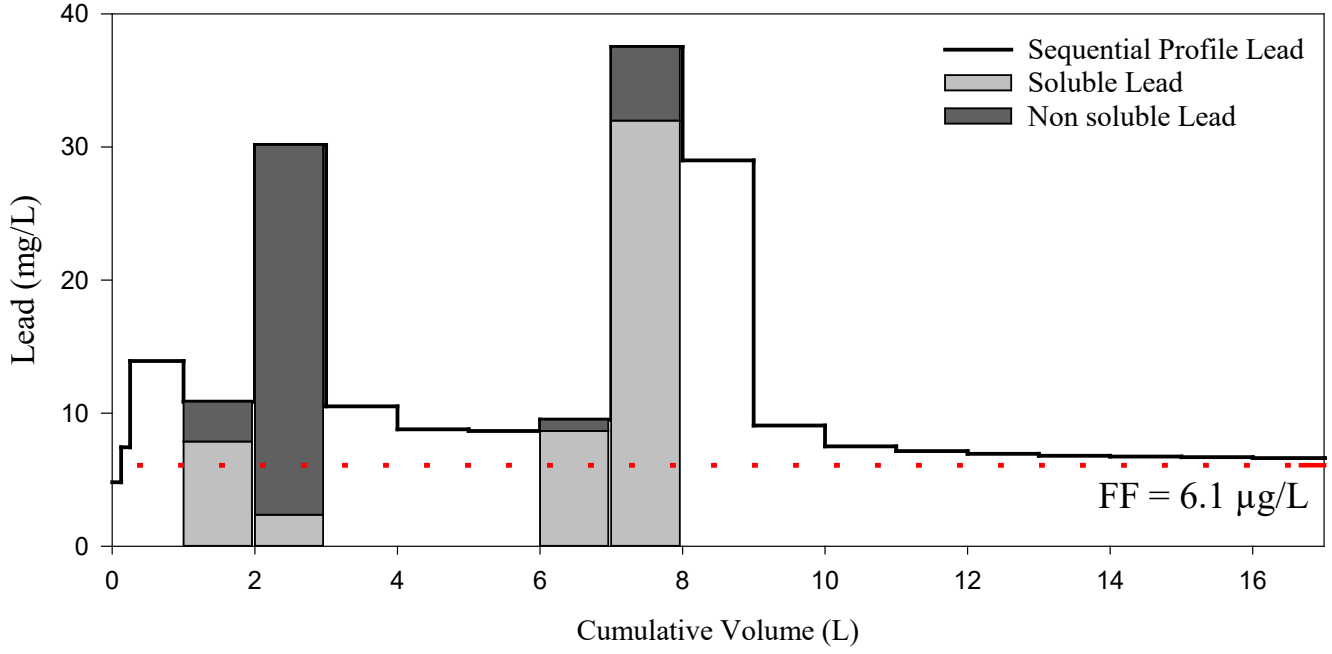


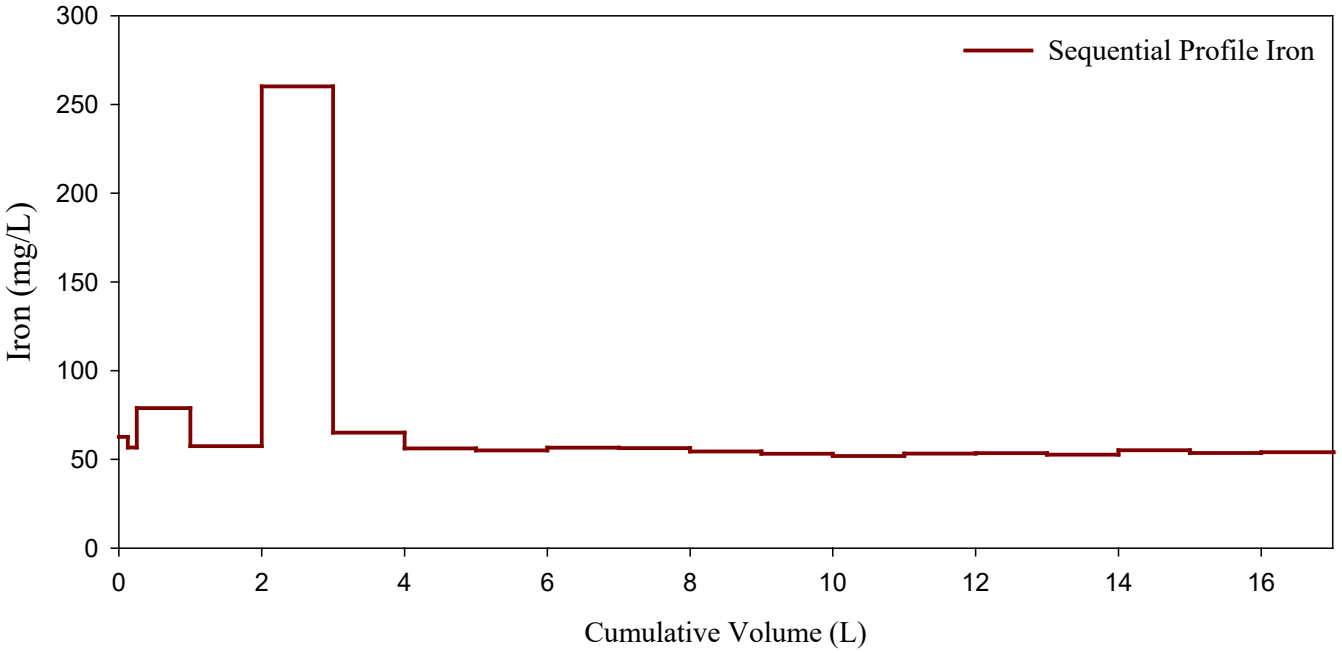
Volume Where Max Peaks Occurred in Sequential Profile in City B

- Sequential profiles can help locate lead service lines and other lead sources along a plumbing path



City B Case Study: Sequential Profiles give Valuable Insight





1) Peak soluble lead located between 6-8 liters, indicates an LSL

2) Peak of non soluble lead located between 2-3 liters, along with iron peak, suggests galvanized pipe in premise plumbing

3) When soluble lead is dominant, peak concentration in profile is still lower than concentration in lead service line

4) Lead cannot be flushed away; best case scenario is fully flushed (FF) level

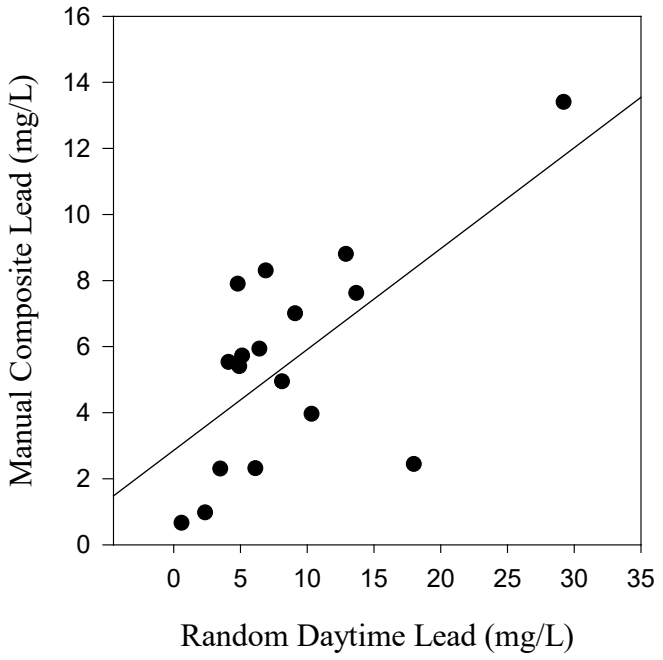
5) Lead reduction strategies should consider lead source

*Soluble lead is defined in this case as lead that passed through an ultrafilter

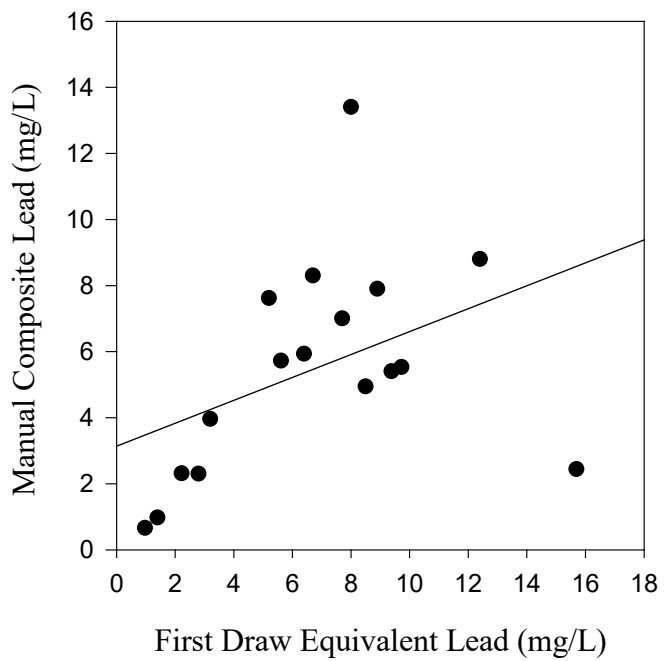
Potential Relationships Between Sampling Approaches

- City B **preliminary** data examples
- Continuing to investigate potential relationships between different drinking water lead sampling types

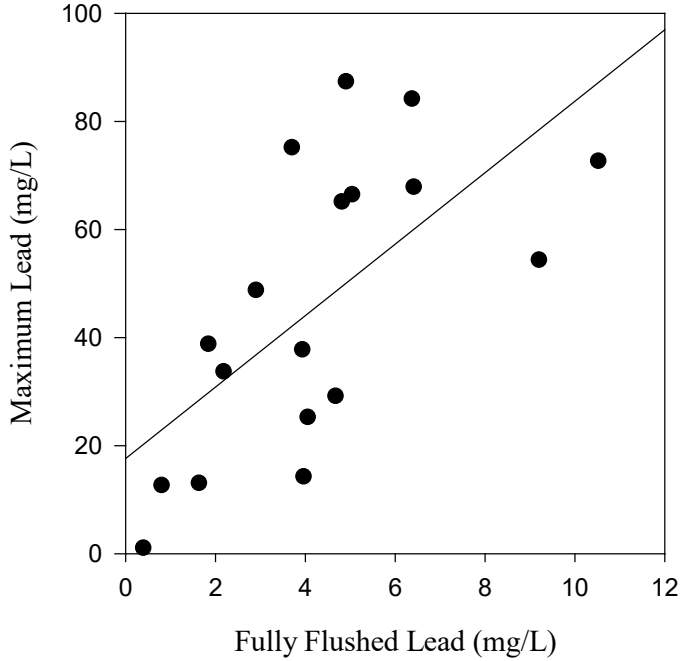
Random Daytime vs Manual Composite



First Draw Equivalent vs Manual Composite



Fully Flushed vs Maximum



Conclusions

- Effective corrosion control can help reduce lead release in all sampling types, including exposure-based, in homes with lead service lines
- Different sampling approaches will lead to different lead results; how lead is sampled matters
- Sequential profiles are useful in identifying lead sources
- Fully flushed samples represent the lowest potential lead concentrations; can be useful in identifying lead service lines, rebound rates will vary
- Continuing to study potential relationships and correlations between different sampling types

Disclaimer

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