



Water Sampling Techniques for Assessing Lead Levels In Drinking Water

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Policy and Health Affects for Lead

- CDC states that lead is a neurotoxin and has identified that no amounts in the blood stream are safe¹
 - 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 ($\mu\text{g}/\text{dL}$)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 $\mu\text{g}/\text{L}$
 - Action level of 15 $\mu\text{g}/\text{L}$ (90th percentile)
 - Treatment based target
 - Under the LCR's 40 C.F.R. Sections 141.80 to 141.91 tap sampling is required³
 - First Draw after minimum of 6 hr. stagnation
- American Association of Pediatrics recommends lead levels in water consumed by children do not exceed 1 $\mu\text{g}/\text{L}$ in 2016⁴



¹https://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>

³https://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>

Lead Sources

- Copper Pipe & Lead Solder
- Lead Service Line
- Galvanized Pipe
- Lead Goose Necks
- Faucet Fixtures



Water Sampling Approaches For Lead

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





Multiple Options Exist For Lead Sampling

	S a m p l i n g P u r p o s e	P r o t o c o l
F i r s t D r a w	<ul style="list-style-type: none">• Regulatory (US)• Treatment Assessment• Collects the initial lead exposure	<ul style="list-style-type: none">• 6+ hr stagnation• Collect first liter
R a n d o m D a y t i m e S a m p l i n g (R D T)	<ul style="list-style-type: none">• Regulatory (UK)• Treatment Assessment• Collects sample based on consumer habits	<ul style="list-style-type: none">• Random sample collection (variable stagnation times)• Collect first liter
F u l l y F l u s h e d	<ul style="list-style-type: none">• Lead Source Assessment• Treatment Assessment• Collects sample to indicated changed between distribution system and home tap	<ul style="list-style-type: none">• Several piping volumes flushed to omit stagnated water• Collect first liter
S e q u e n t i a l S a m p l i n g (P r o f i l e S a m p l i n g)	<ul style="list-style-type: none">• Lead Source Assessment• Collects multiple samples to map lead levels through the pipes	<ul style="list-style-type: none">• Defined stagnation time• Collect 10-20 samples of defined volume• (125 mL, 250 mL, 1 L, etc.)
C o m p o s i t e (M a n u a l & P a s s i v e)	<ul style="list-style-type: none">• Exposure Assessment• Collects the average lead exposure throughout day consumers face	<ul style="list-style-type: none">• Normal water use patterns• A device collects 5% of every draw from the tap for consumption• Used for 1 week

Other Options For Lead Sampling

	Sampling Purpose	Protocol
3 T's Sampling for Schools	<ul style="list-style-type: none"> • Lead Source Assessment 	<ul style="list-style-type: none"> • Overnight stagnation • Collect first 250 mL from all taps and fountains • Take follow up sample of overnight stagnation and 30 second flush if first sample > 20 ppb
Particle Stimulation Sampling	<ul style="list-style-type: none"> • Lead Type Assessment • Exposure Assessment 	<ul style="list-style-type: none"> • 5 min stagnation • Collect first liter and maximum flow rate, open and close tap five times, fill rest of bottle at normal flow rate. • Collect second liter at a normal flow rate • Collect third liter the same way as the first
Fixed Stagnation Time (30 MS)	<ul style="list-style-type: none"> • Regulatory (Ontario) • Treatment Assessment 	<ul style="list-style-type: none"> • 2-5 min. flush • 30 min stagnation • Collect first two liters
Service Line Sampling (Second Draw)	<ul style="list-style-type: none"> • Regulatory (US) • Lead Source Assessment 	<ul style="list-style-type: none"> • 6+ hr stagnation • Volume between tap and LSL flushed • Collect 1 L



Sampling Considerations

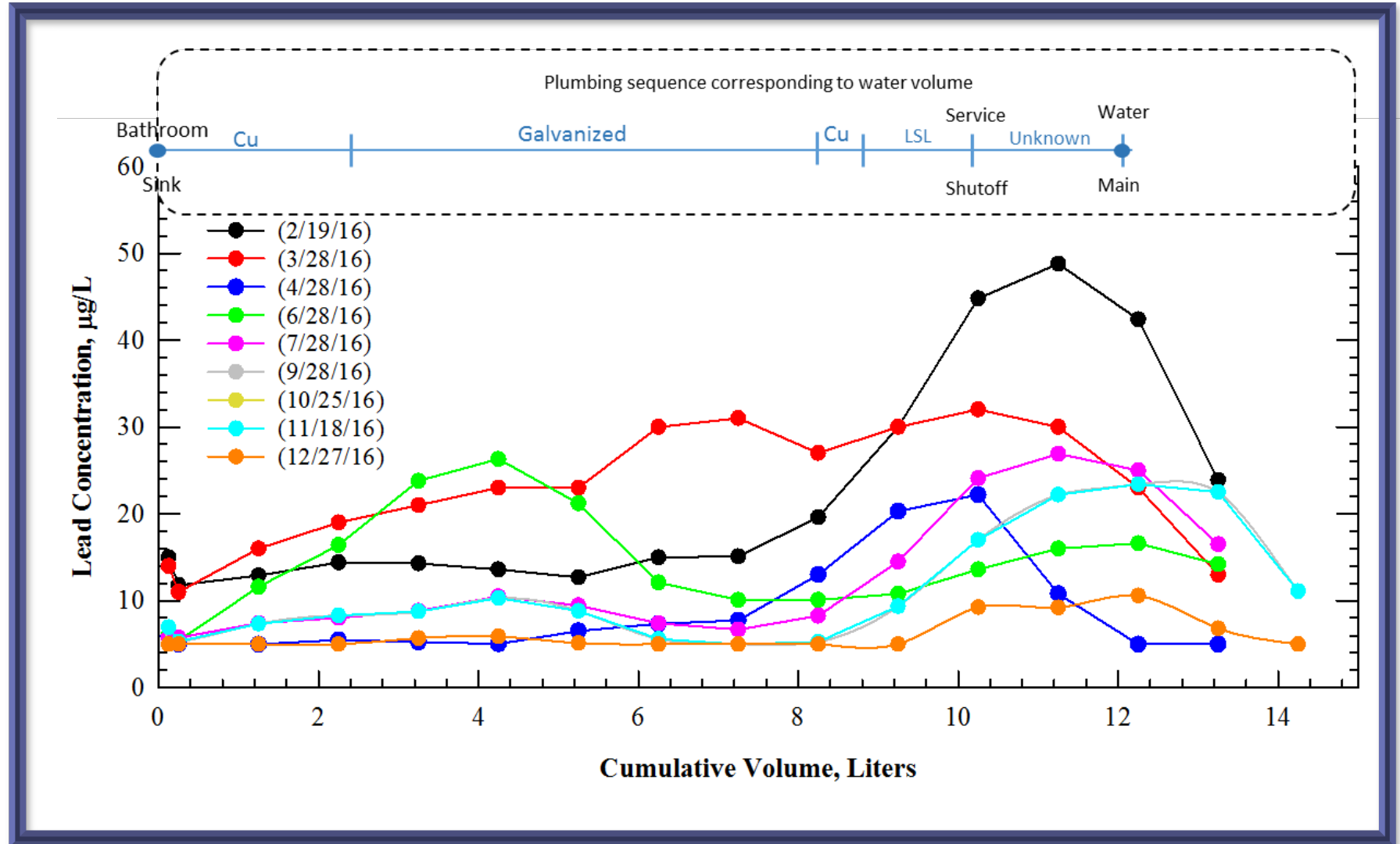
Protocol Considerations:

- 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

Sequential and First Draw Sampling



Passive Composite Pb Sampling Device

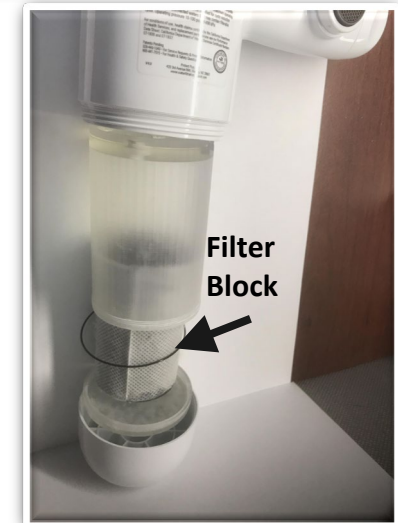
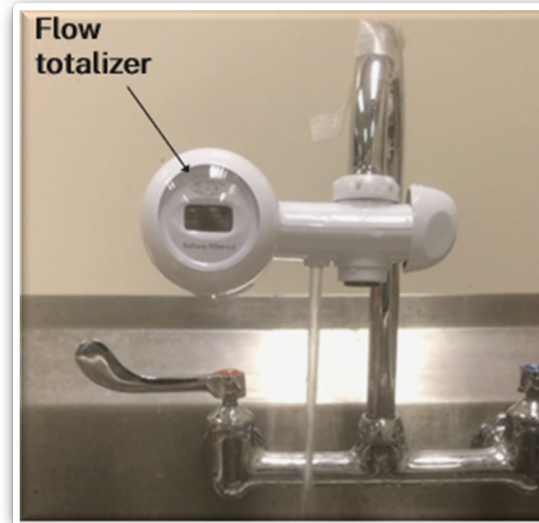
- The device measures the amount of water, in gallons, that is filtered
 - Total flow is determined
- The device accumulates filtered Pb.
 - Total Pb on device is measured
- From the total flow and accumulated Pb, the average concentration of Pb in the water that would have been consumed (exposure) can be calculated.

Pros:

- Protects consumers from Pb while in place
- Can determine the average Pb level that would have been consumed per gallon drank from a single tap
- Considers relatively long-term lead exposure

Cons:

- Device is on the faucet for sampling time
- Cost to extract lead from the device is uncertain



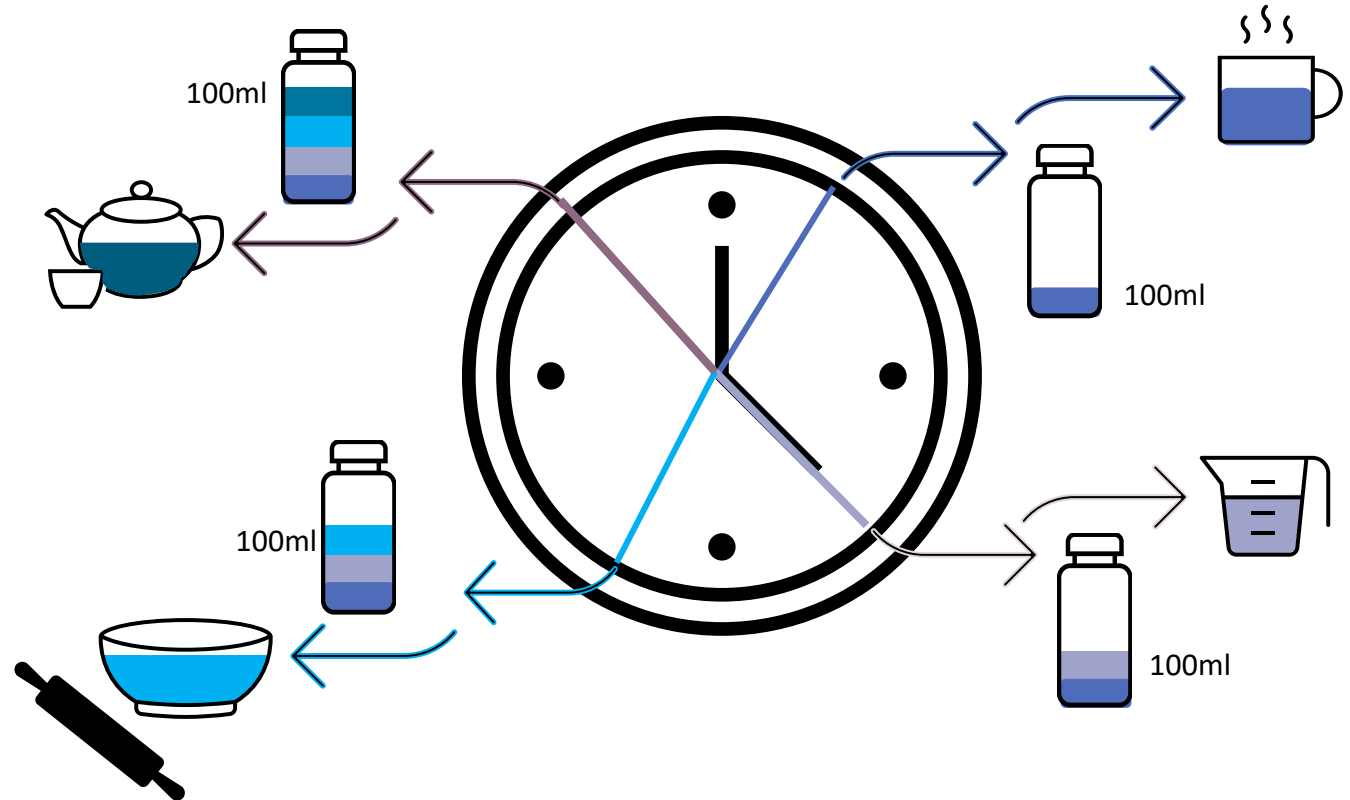
Manual Composite Pb Sampling

Definition: Every time the consumer uses the tap for consumption, they collect 100 mL. This process continues until the day ends or 1000 mL is reached (see figure). The sample is then homogenized and analyzed.

Pros: Provides an average lead exposure for the consumer specific to that location and consumer use patterns

Cons: Requires high involvement from consumer, may not show cases of very high lead levels, and short term

Best Usage: To determine the average lead exposure a household faces



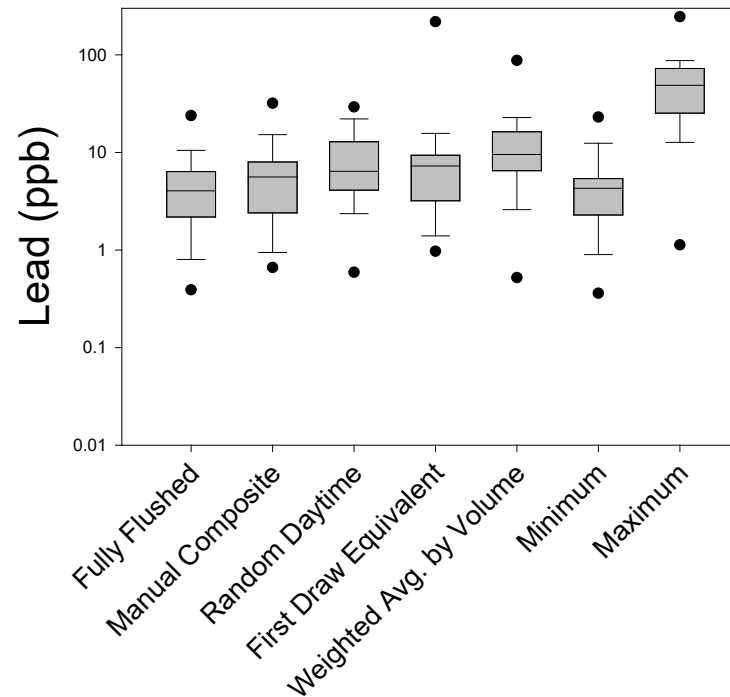
Community Case Study #1: LSL Contribution

Homes:

- 19 LSL Homes
- 11 Non-LSL Homes
 - 2 had lead solder

Fully Flushed and Sequential Profile Result Comparisons

Homes with LSL



Homes Without LSL

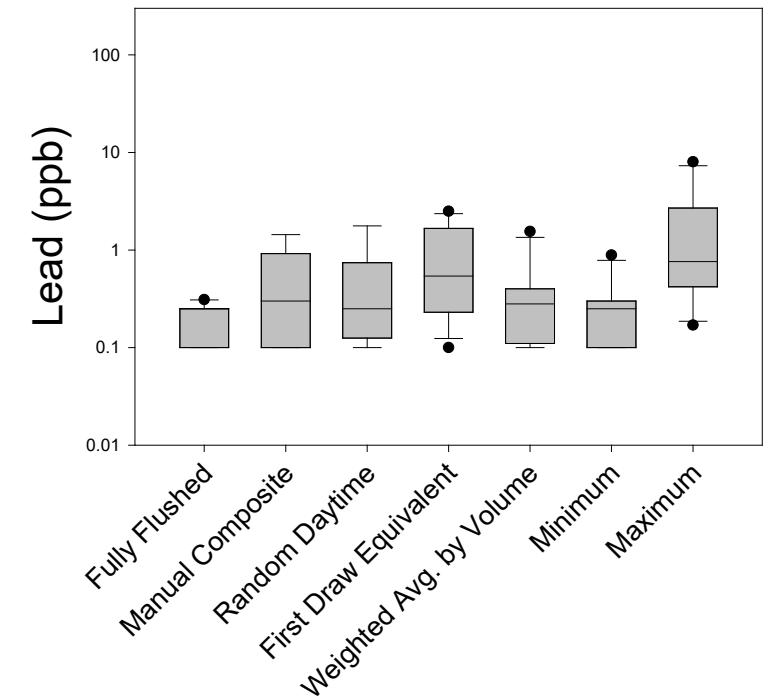


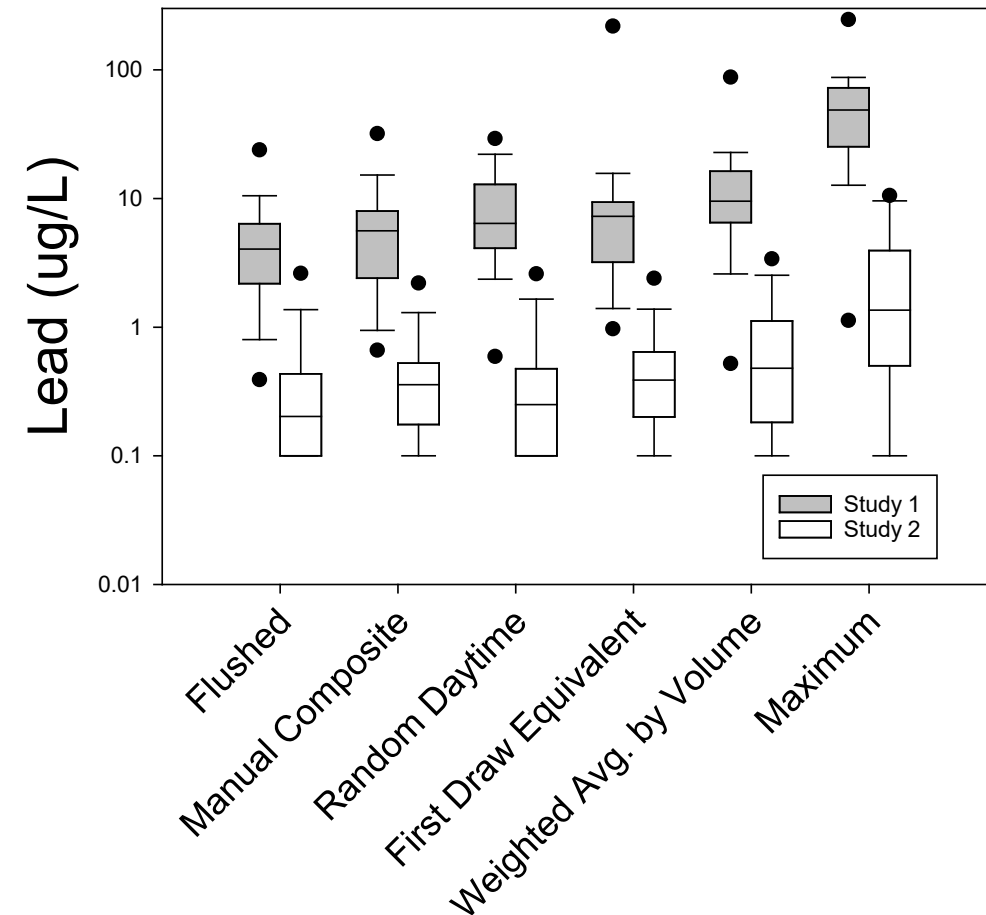
Figure. Boxplot Comparison Between LSL and non-LSL homes in log scale.

Community Case Study #1 vs #2

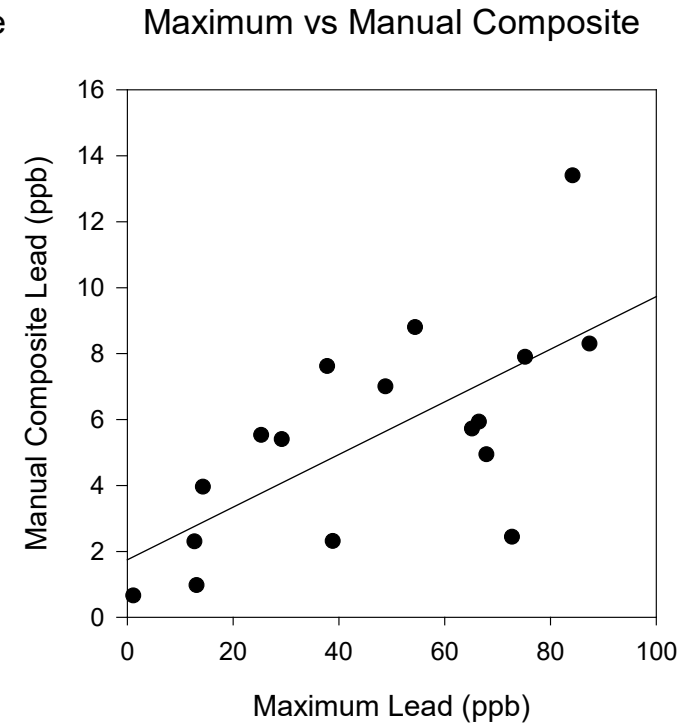
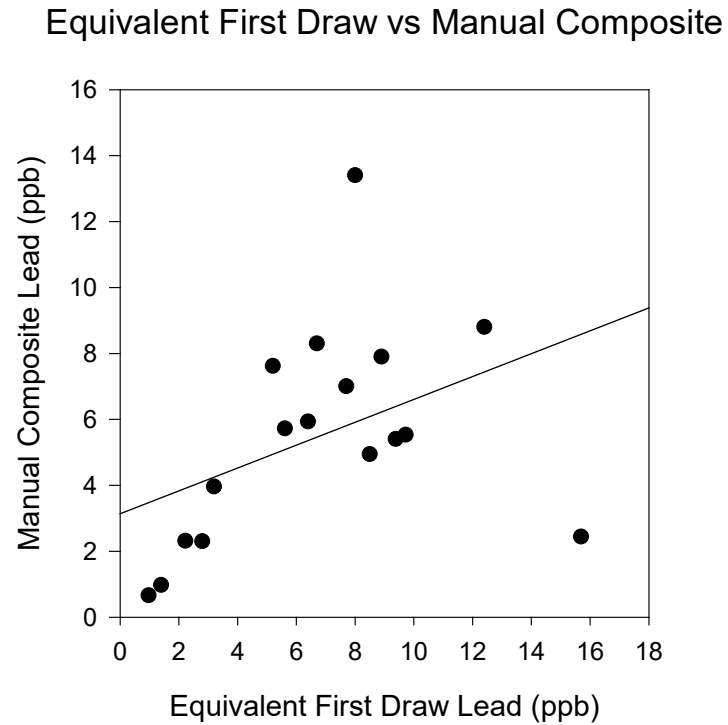
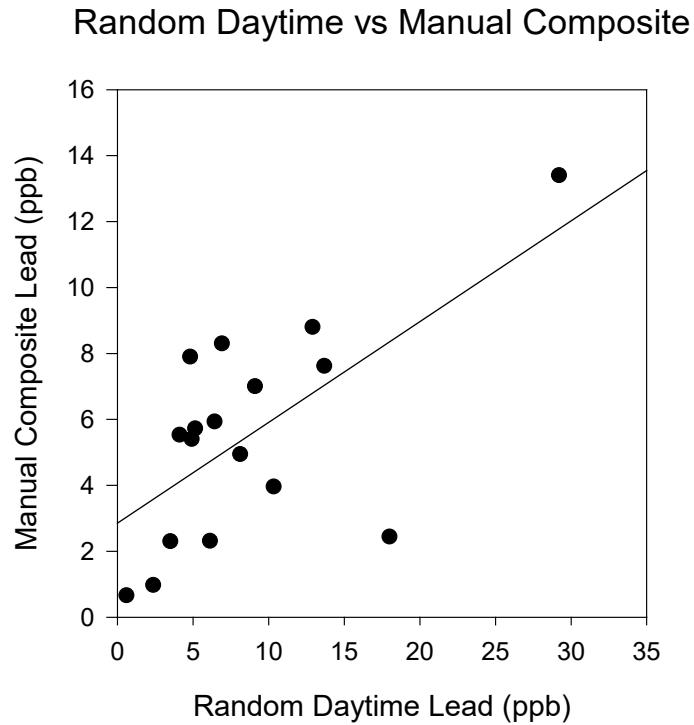
Comparison of Two Communities

	Study #1	Study #2	Study #1	Study #2
Water Quality Type	Average		Range	
pH	8.2	7.3	7.7-8.8	7.0-7.7
Total Alkalinity (mg/L)	72.6	81.7	46-94	64-98
Chlorine System Total (mg/L)	1.2	1.2	0.4-1.9	1.2-1.3
Orthophosphate (mg/L)	NA	1.2	NA	1.0-1.9

Fully Flushed and Sequential Profile Result Comparisons



Box plot comparison of two cities of home with LSL in log scale

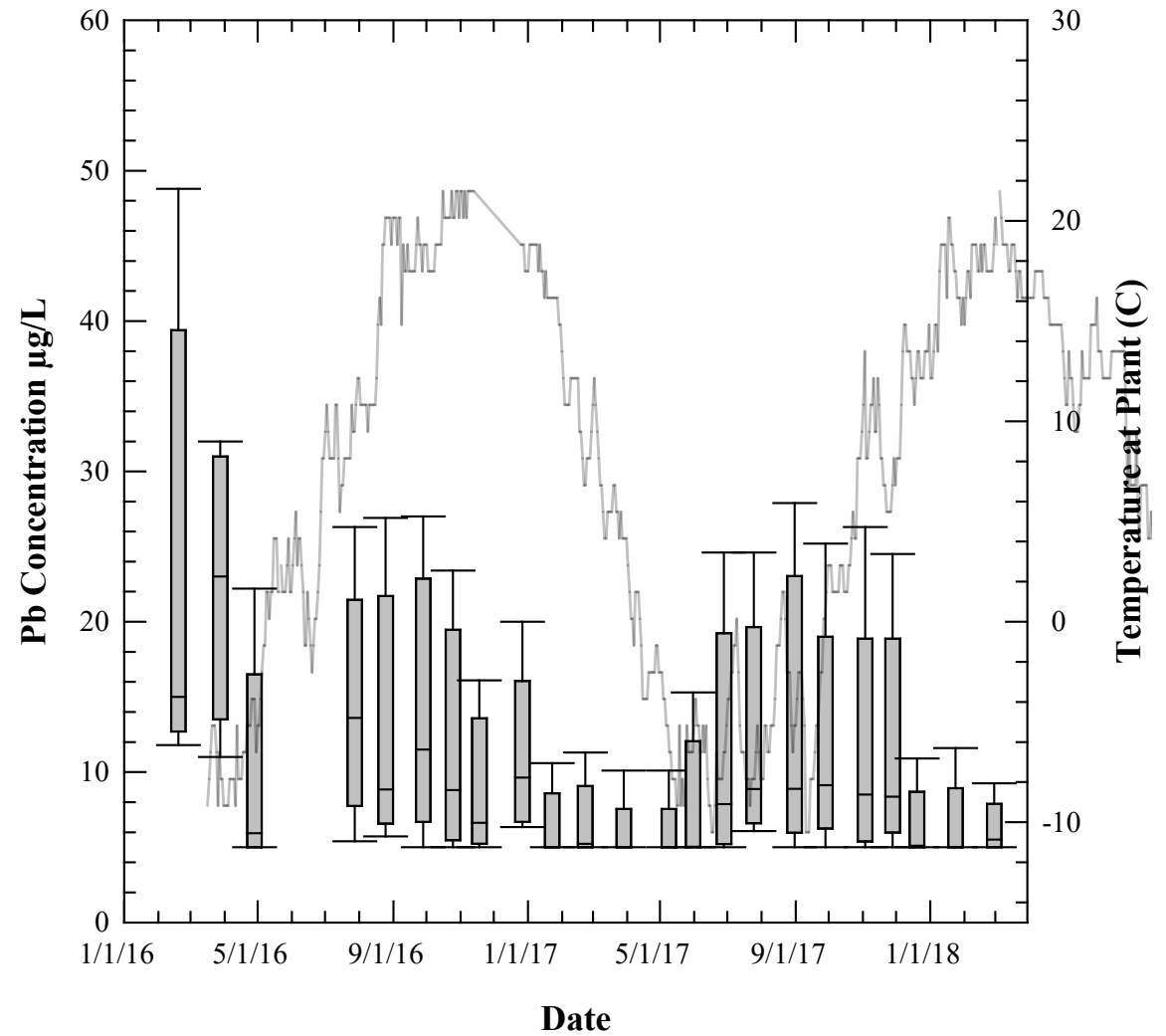


Comparison of Sampling Outcomes to Manual Composite

*Note: there was one outlier removed from graphs

Case Study #1

Seasonal Variability in Sequential Sample Results: Homes with LSLs



Limitations to Pb Sampling

- Different sampling procedure test for different conditions
 - EX:
 - Manual Composite are used to test exposure
 - Sequential Profile are used for lead source assessments
 - First Draw is used to test stagnated and regulatory purposes
- Improper choice of sampling method to address the exposure question may provide an inaccurate conclusion
- Revisiting homes increase cost and time
 - Manual composite vs. first draw
- Access to the home/ homeowner involvement
- Inconsistent homeowner sampling
- One-time Pb result rather than overtime
- Identifying Pb sampling locations



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References

[U.S.EPA, Drinking Water Regulations: Maximum Contaminant Level Goals and National Primary Drinking Water Regulations for Lead and Copper. In 40 CFR Parts 141 and 142, U.S.EPA, Ed. 1991; Vol. 56:32112.](#)