

# Sequential Sampling

Data Summit  
Region 5, U.S. EPA

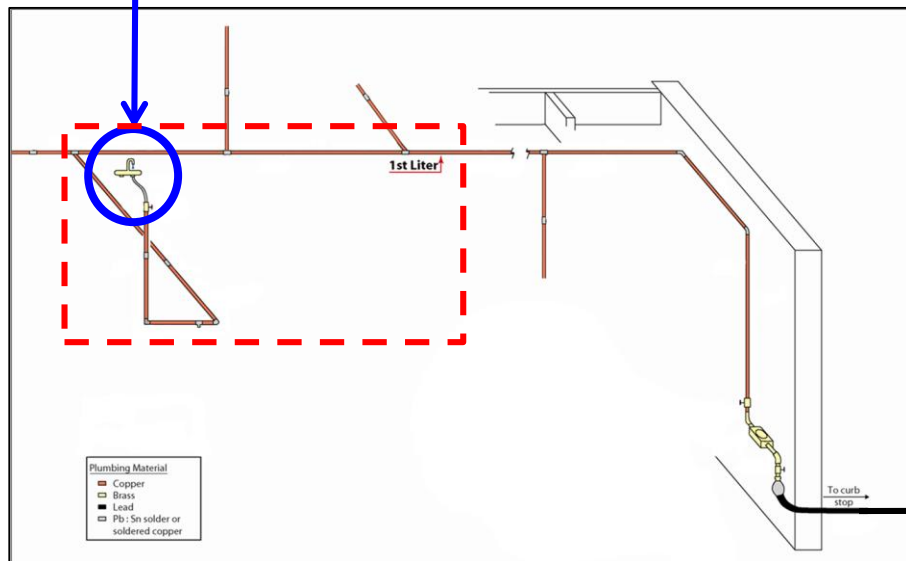
January 10, 2017



# What is Sequential Sampling?

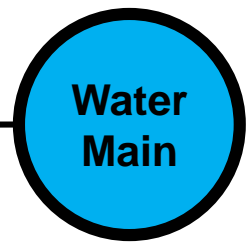
A set of samples, collected one right after another that captures all of the water in the plumbing from the kitchen tap to the water main

Kitchen tap



For comparison, the red dashed box indicates what is captured by one 1-liter sample

Service Line

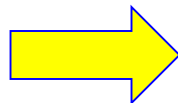


Residence

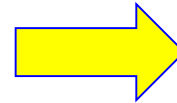


# Sampling Summary

**Initial Site Selection**



**Plumbing Surveys**



**Final Site Selection\***

**Initial Screen  
105 homes**

**Mix of Lead, Copper,  
Galv. Iron, Plastic Pipe**

**Target Pool:  
45 homes**

**\*The goal was to sample these same homes every round, but sites dropped out and new sites had to be added.**



# Sampling Summary

<b>2016</b>	<b>Round 1 (Jan-Mar)</b>	<b>Round 2 (May)</b>	<b>Round 3 (July)</b>	<b>Round 4 (Sept)</b>	<b>Round 5 (Nov)</b>
<b>No. Sites</b>	105	45	48	53	46
<b>Included Sites*</b>	73	35	42	48	41
<b>Total No. Samples</b>	1577	803	758	833	746
<b>Included Samples*</b>	1068	591	654	753	659

**\*Some sites/sample results were excluded from the data analysis because they are not appropriate for evaluating treatment effectiveness.**



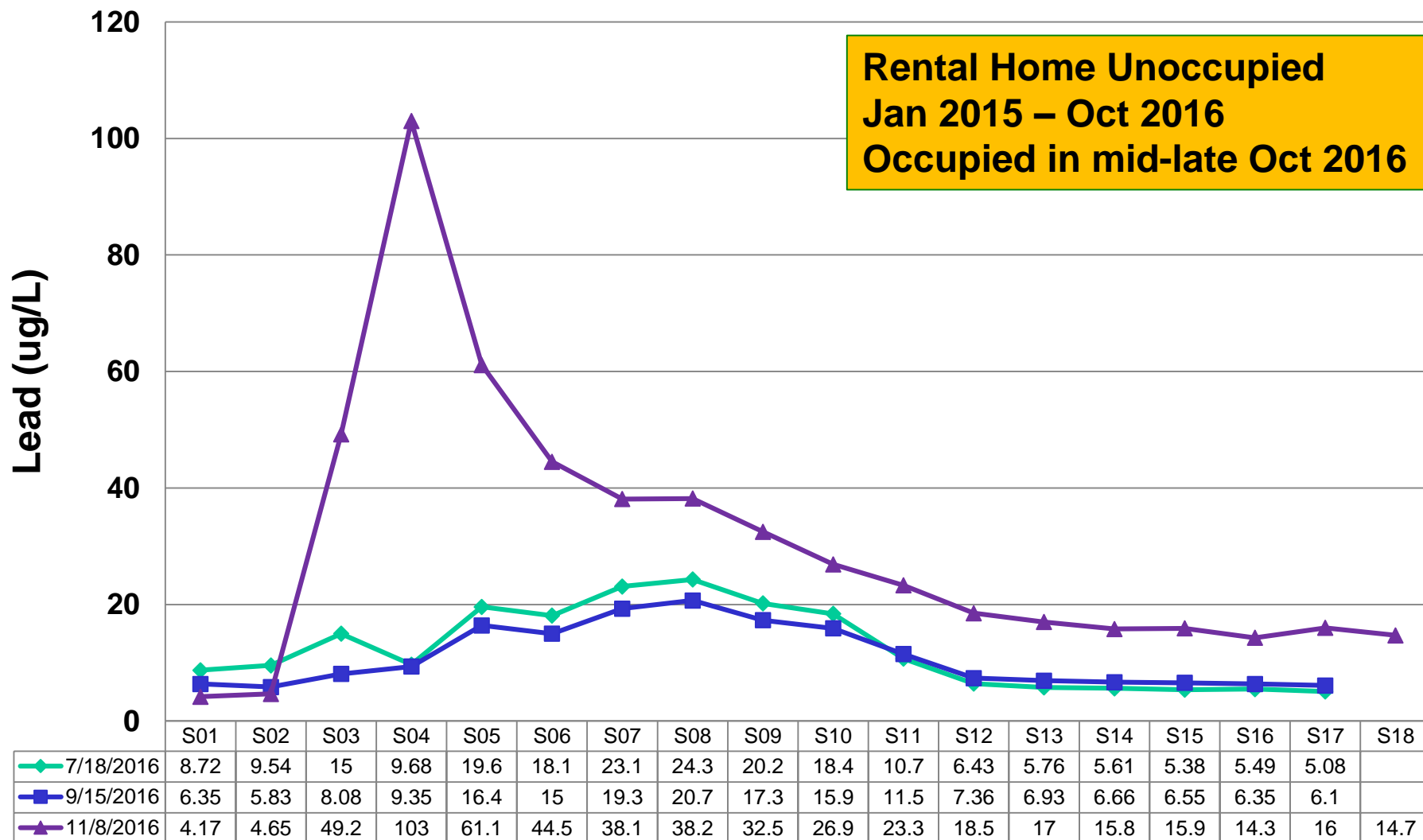
# Data Excluded from Analysis

- Filtered Water Sample
- LSL removed
- No Pre-Stagnation Flushing
- Non-lead Service line replaced
- Non-Residential Site
- Outside Flint (Genesee County Water)
- Physical Service Line Disturbance
- Uncertain/Insufficient stagnation time
- Unoccupied Home



# Data Excluded - Example

## Site ew





# Sampling Summary

- **Rounds 1, 3, 4 and 5**

- Two 125 mL bottles followed by a site-specific number of 1,000 mL samples

- **Round 2**

- Two 125 mL bottles followed by a site-specific number of 500 mL bottles, followed by a site-specific number of 1000 mL bottles

- **All rounds**

- Three addition distribution system (DS) samples were collected for Total P (125 mL); Sulfate, Chloride, Fluoride and Alkalinity (125 mL); and Metals (1,000 mL)

- **Round 5**

- At some sites, two additional DS samples were collected at different flow rates (target 2/3 full flow, 1/3 full flow)



# Analytes

- **Total Metals**

- Aluminum, Calcium, Cadmium, Chromium, Copper, Iron, Magnesium, Manganese, Nickel, Potassium, Sodium, Tin, and Zinc.

- **Total Phosphorus**

- **Total Alkalinity**

- **Anions**

- Sulfate, Chloride, and Fluoride

- **pH, Chlorine, Total Coliform\***

- \*Total Coliform samples were collected at homes with low/no chlorine residual detected

- **Additional Analytes**

- Antimony, Arsenic, Barium, Beryllium, Boron, Molybdenum, Selenium, Silver, Thallium and Vanadium

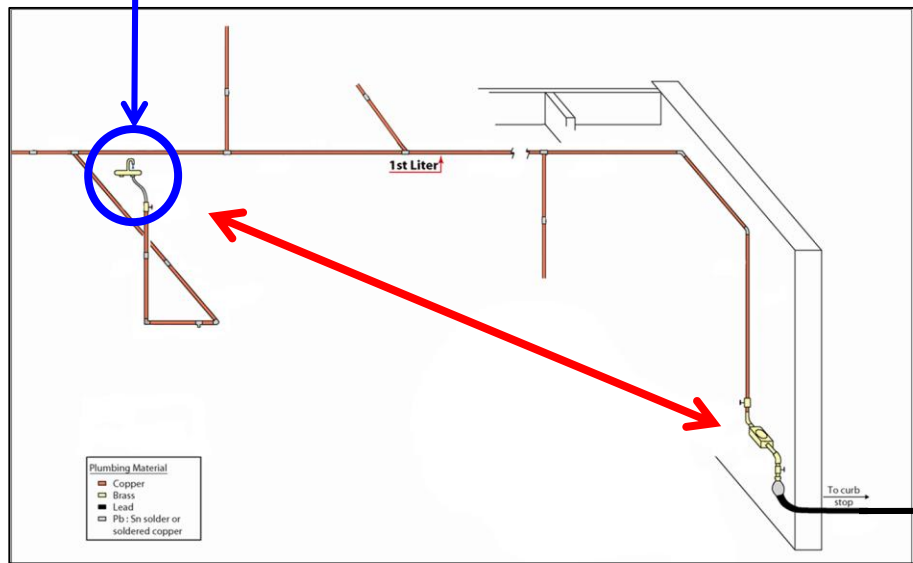




# Each Home is Different

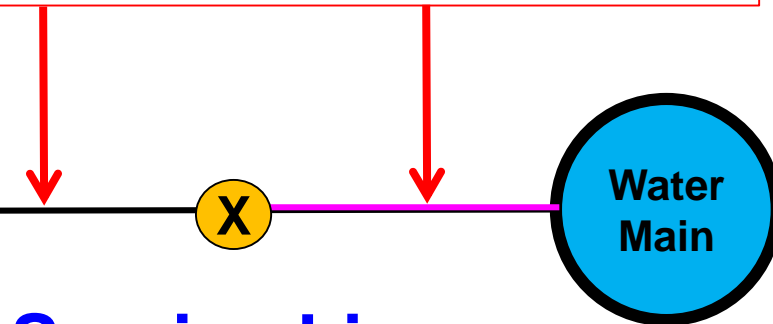
**Kitchen tap**

The distance from the kitchen tap to the service line is different



**Residence**

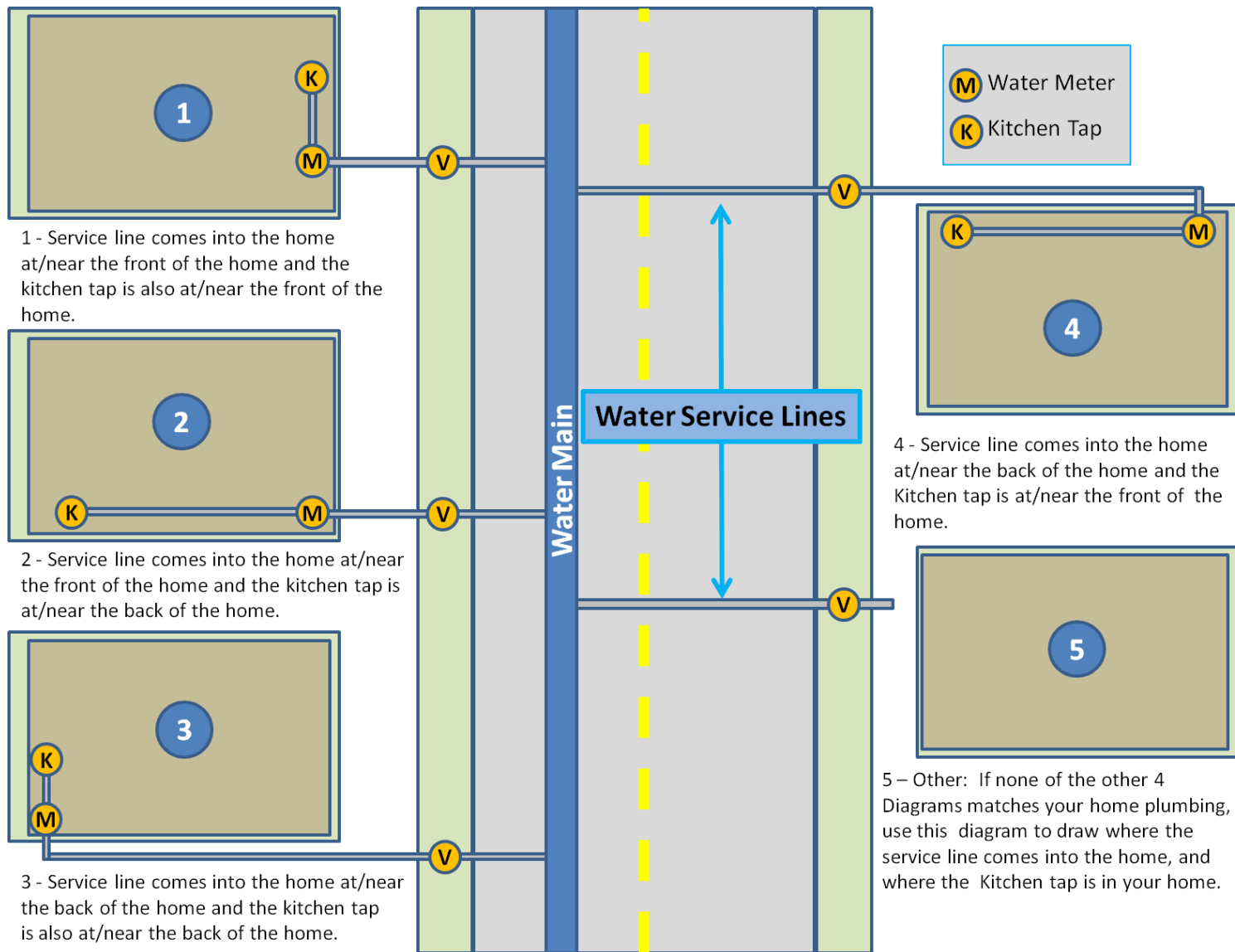
The service line material from the home to the shut-off can be different than the service line material from the shut-off to the water main.



**Service Line**



# Each Home is Different





# Where is Lead Coming From?

- Most of the lead is coming from the service lines
- Particulate lead yields highest concentration of lead
  - Particulate release is random/sporadic
  - Sample bottle that captures particulate may not reflect location of lead release
  - Other metals and constituents present in sample can help identify source of particulate lead
- Repeat sequential sampling events help to determine if lead is coming from specific locations or released on a random or sporadic basis
  - Evident in sequential sampling profiles



# Lead Service Line Replacement (2016)

Site	Pre-replacement Total Pb Mass (ug) <sup>1</sup>	Post-replacement Total Pb Mass (ug) <sup>1,2</sup>					% Total Pb Mass Reduction
	Jan – Mar <sup>2</sup>	Mar	May	July	Sept	Nov	
az	51					6	88
as <sup>3</sup>	218		5				98
f <sup>3</sup>	150	56	30	24	10	9	94
eg <sup>3</sup>	18	14					22
ec	30					7	77
cx <sup>3</sup>	511				12		98
ag	562			85			87
g	40					11	73
ed	176					8	95
ee	18	9					50
eh <sup>3</sup>	523					38	93

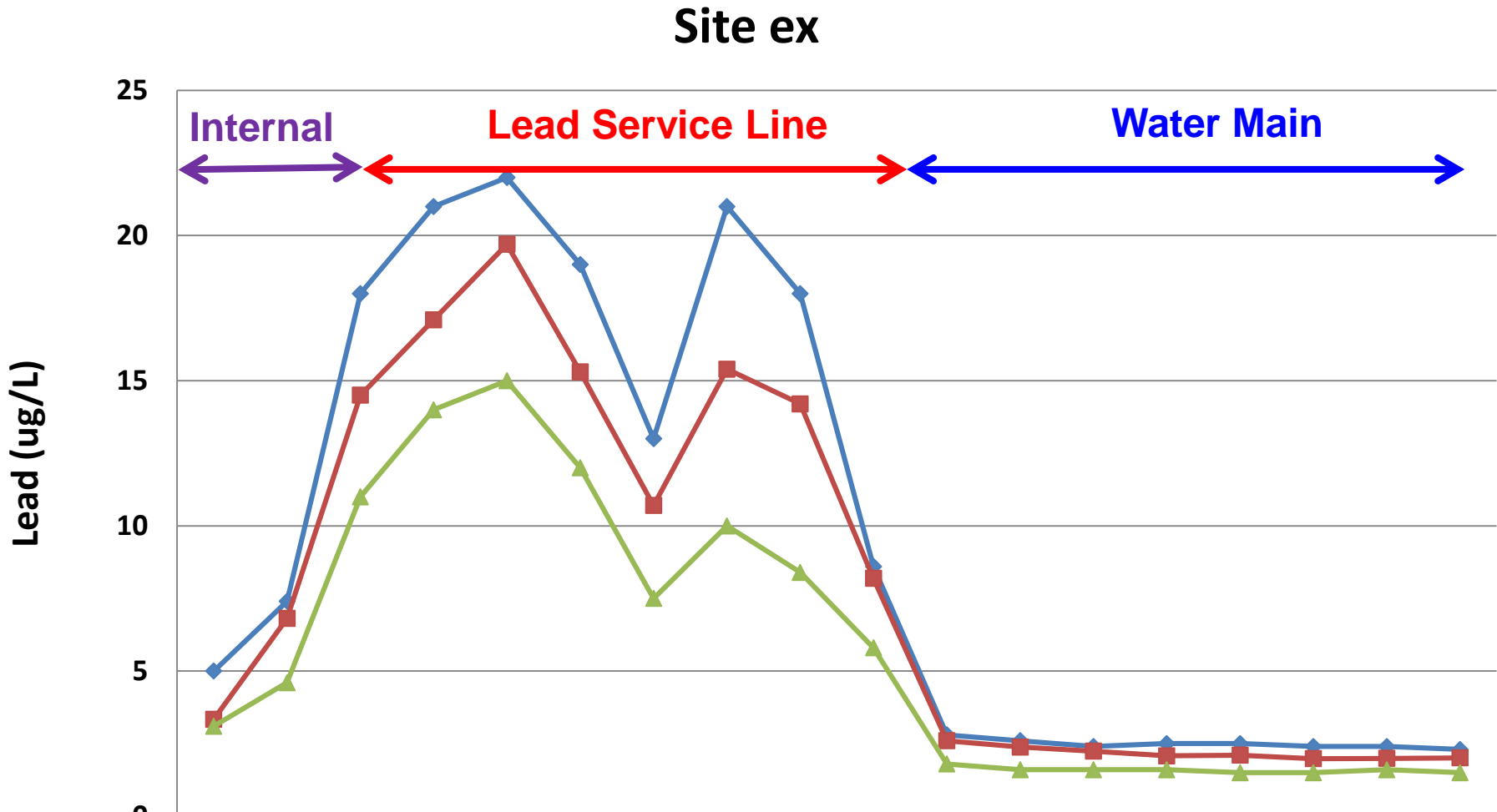
1 – Total mass = sum of lead mass in the set of sequential samples.

2 – Some homes were sampled multiple times before the lead line was replaced and some were sampled multiple times after the lead line was removed. Only the first and last sets of sequential samples are presented.

3 – Homes where all or mostly all premise plumbing is galvanized iron pipe.



# Repeating Peaks

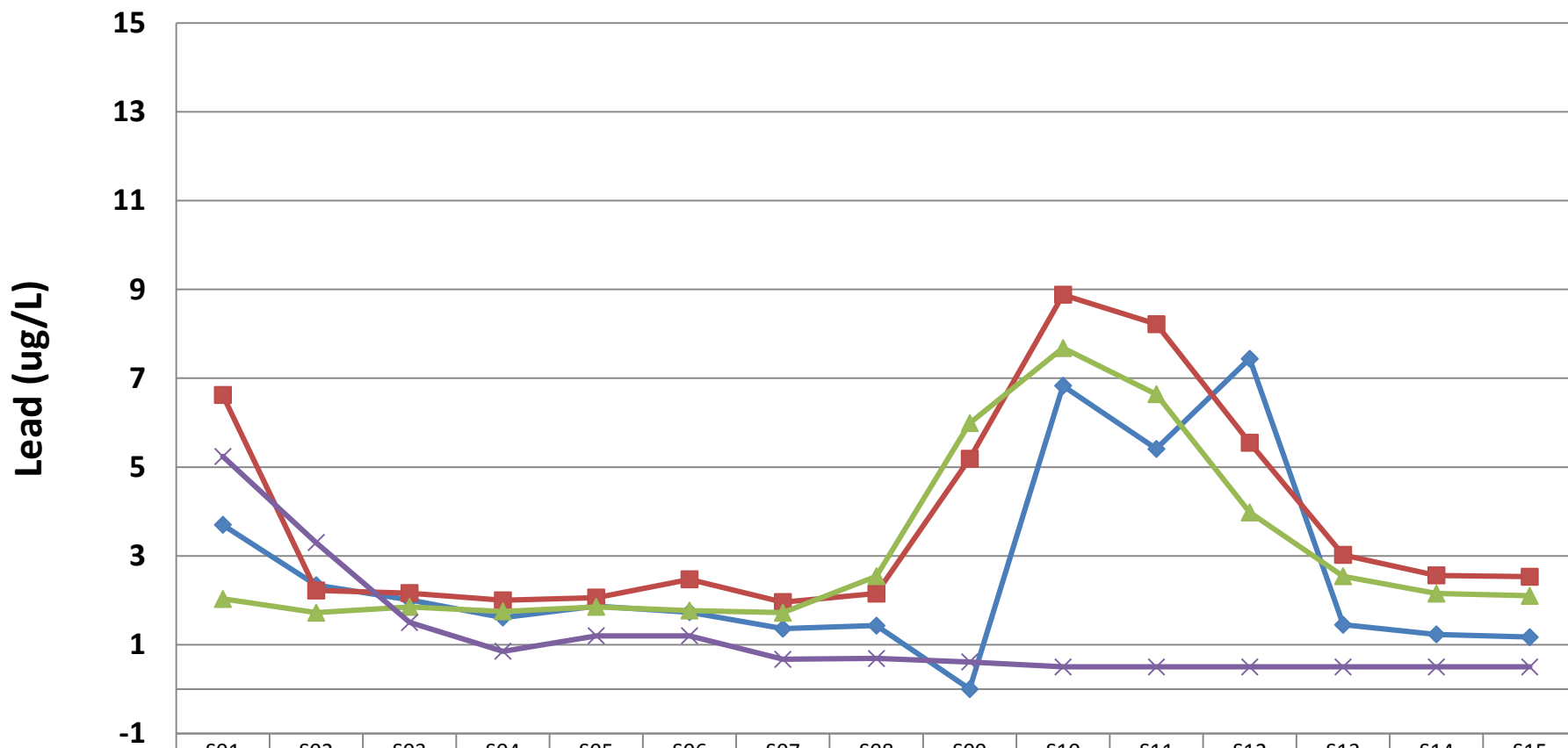


	S01	S02	S03	S04	S05	S06	S07	S08	S09	S10	S11	S12	S13	S14	S15	S16	S17	S18
7/20/2016	5	7.4	18	21	22	19	13	21	18	8.6	2.8	2.6	2.4	2.5	2.5	2.4	2.4	2.3
9/18/2016	3.34	6.81	14.5	17.1	19.7	15.3	10.7	15.4	14.2	8.19	2.6	2.38	2.24	2.08	2.1	1.98	1.99	2.01
11/13/2016	3.1	4.6	11	14	15	12	7.5	10	8.4	5.8	1.8	1.6	1.6	1.6	1.5	1.5	1.6	1.5



# Repeating Peaks

## Site g

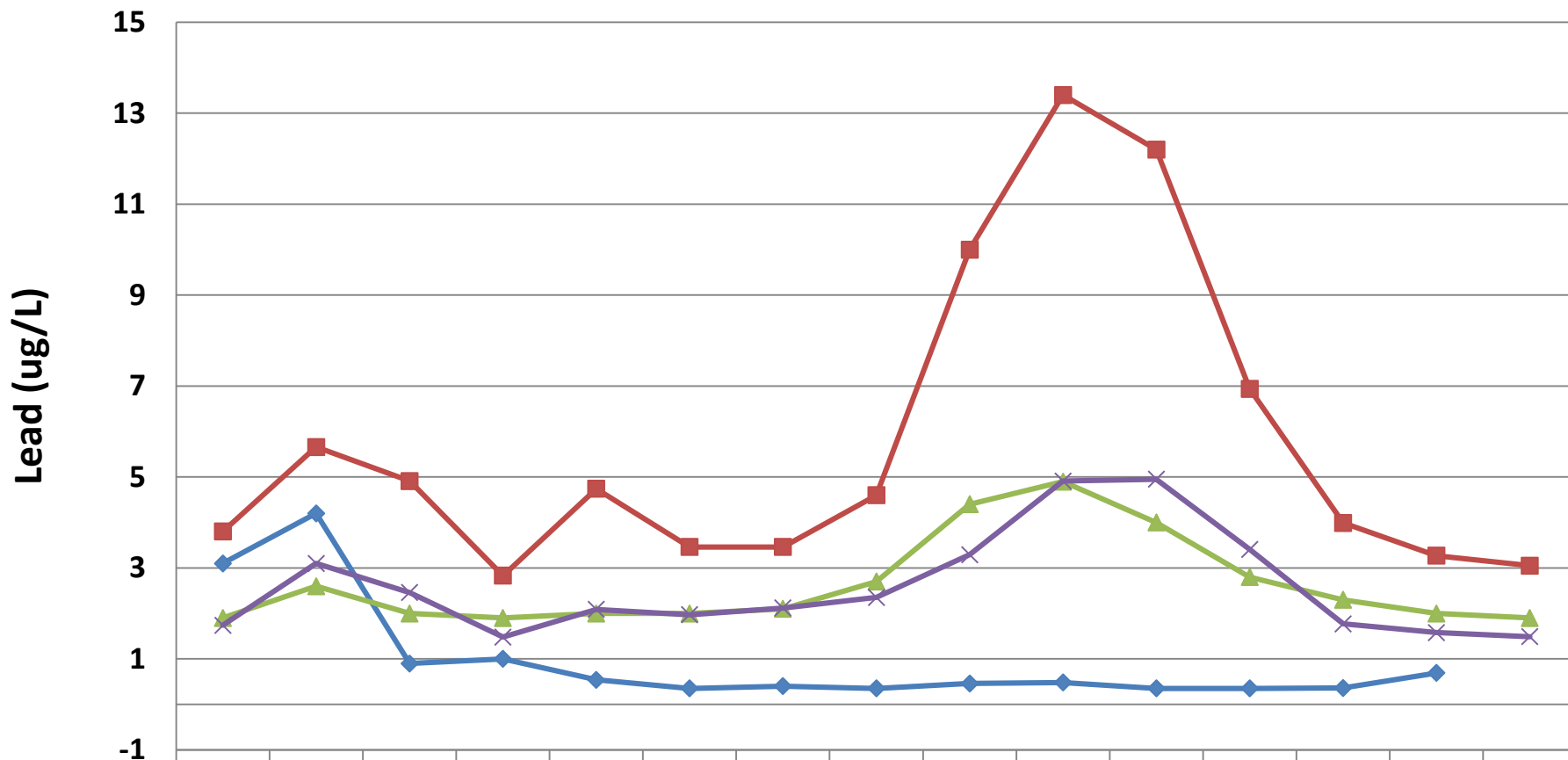


	S01	S02	S03	S04	S05	S06	S07	S08	S09	S10	S11	S12	S13	S14	S15
1/31/2016	3.7	2.34	2.01	1.61	1.87	1.73	1.36	1.43	0	6.83	5.41	7.44	1.45	1.23	1.17
7/18/2016	6.62	2.22	2.16	2	2.06	2.47	1.96	2.15	5.19	8.88	8.22	5.55	3.02	2.56	2.53
9/13/2016	2.03	1.72	1.85	1.75	1.85	1.77	1.72	2.54	5.99	7.68	6.64	3.98	2.54	2.15	2.1
11/8/2016	5.24	3.3	1.5	0.85	1.2	1.2	0.67	0.69	0.61	0.5	0.5	0.5	0.5	0.5	0.5



# Repeating Peaks

Site bf

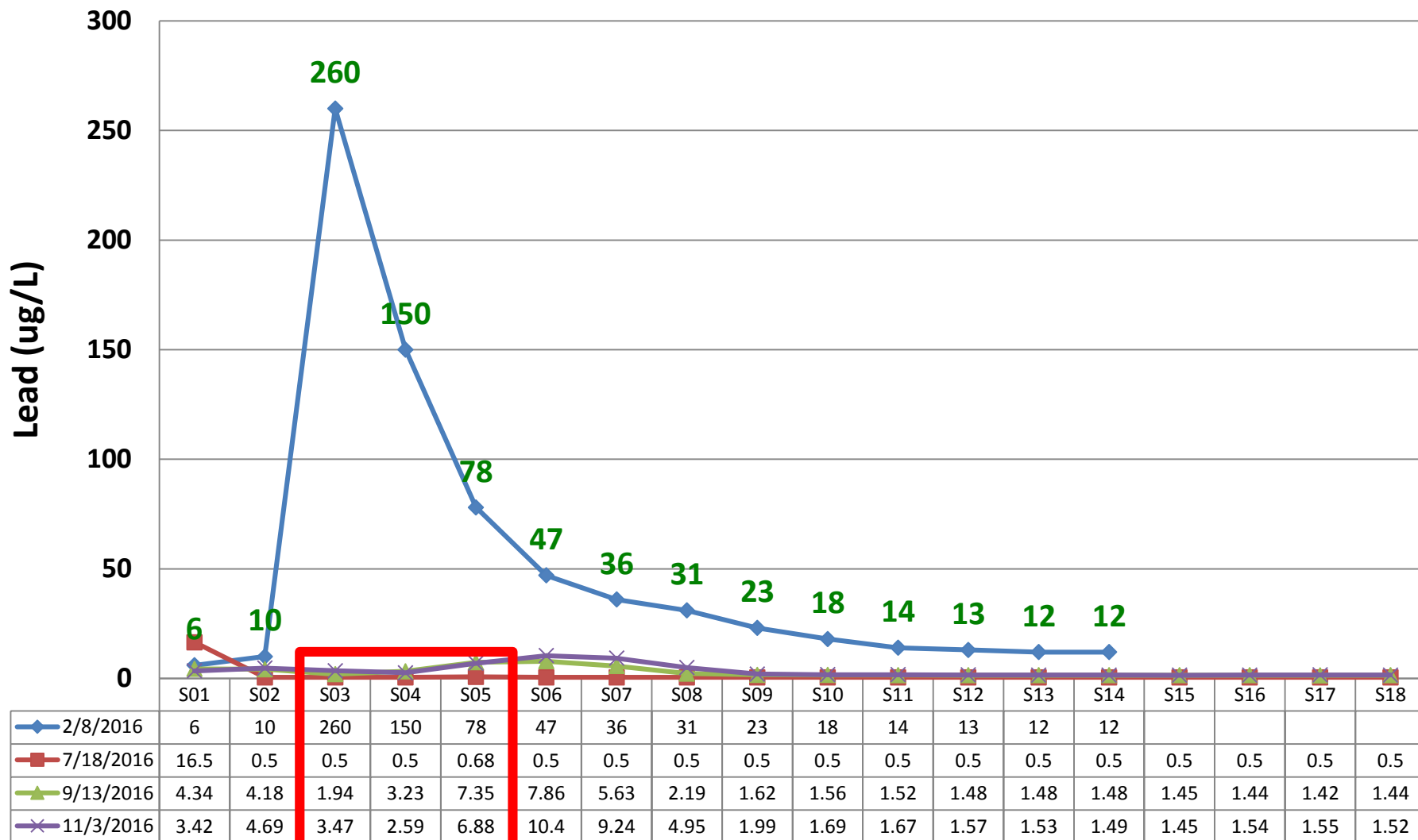


	S01	S02	S03	S04	S05	S06	S07	S08	S09	S10	S11	S12	S13	S14	S15
2/13/2016	3.1	4.2	0.9	1	0.54	0.35	0.4	0.35	0.46	0.48	0.35	0.35	0.36	0.69	
7/20/2016	3.8	5.66	4.91	2.83	4.74	3.46	3.46	4.6	10	13.4	12.2	6.94	3.99	3.27	3.05
9/14/2016	1.9	2.6	2	1.9	2	2	2.1	2.7	4.4	4.9	4	2.8	2.3	2	1.9
11/5/2016	1.74	3.1	2.46	1.48	2.09	1.97	2.12	2.35	3.29	4.91	4.95	3.41	1.77	1.58	1.49



# Non-repeating Peaks

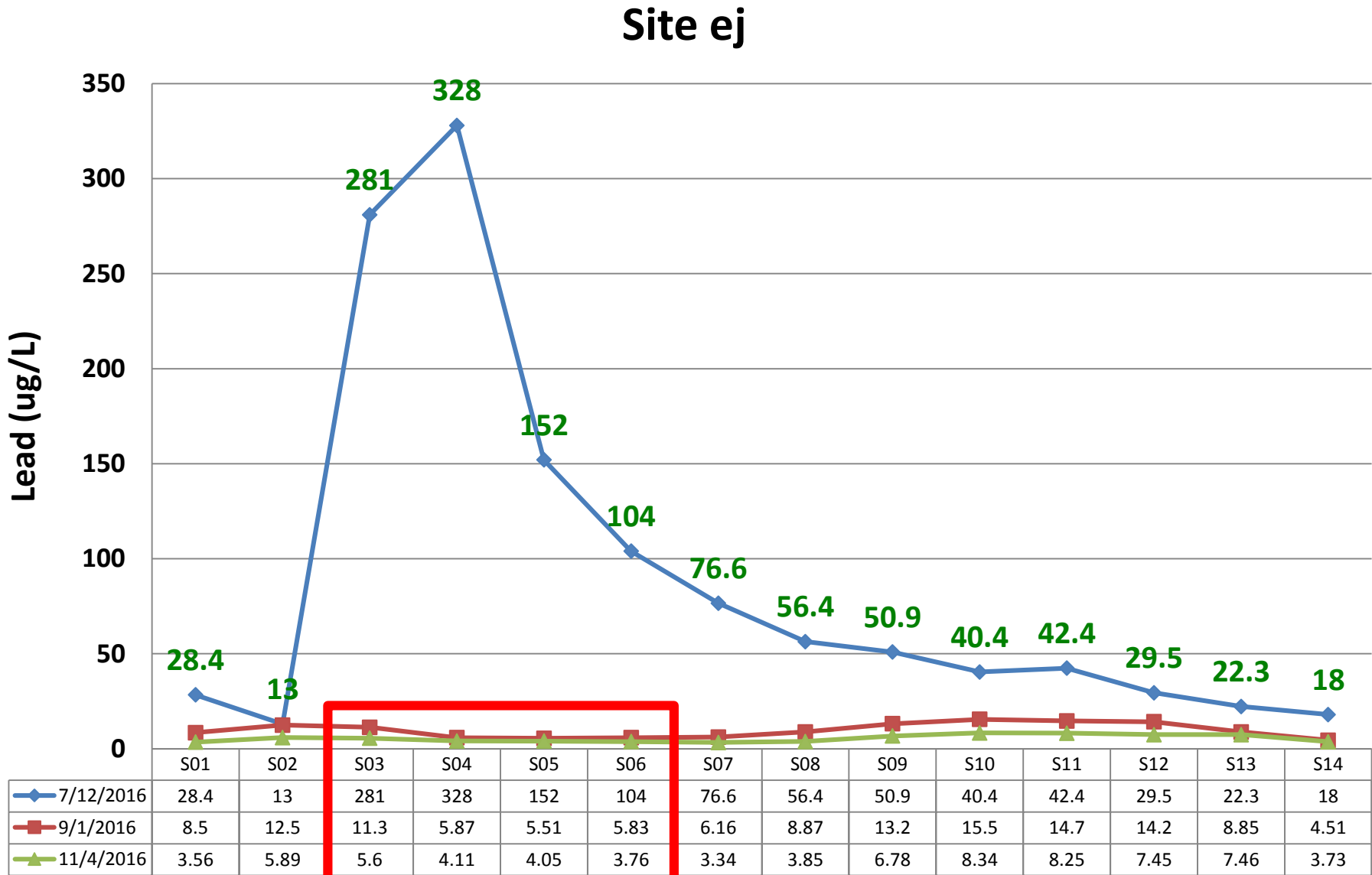
## Site ab







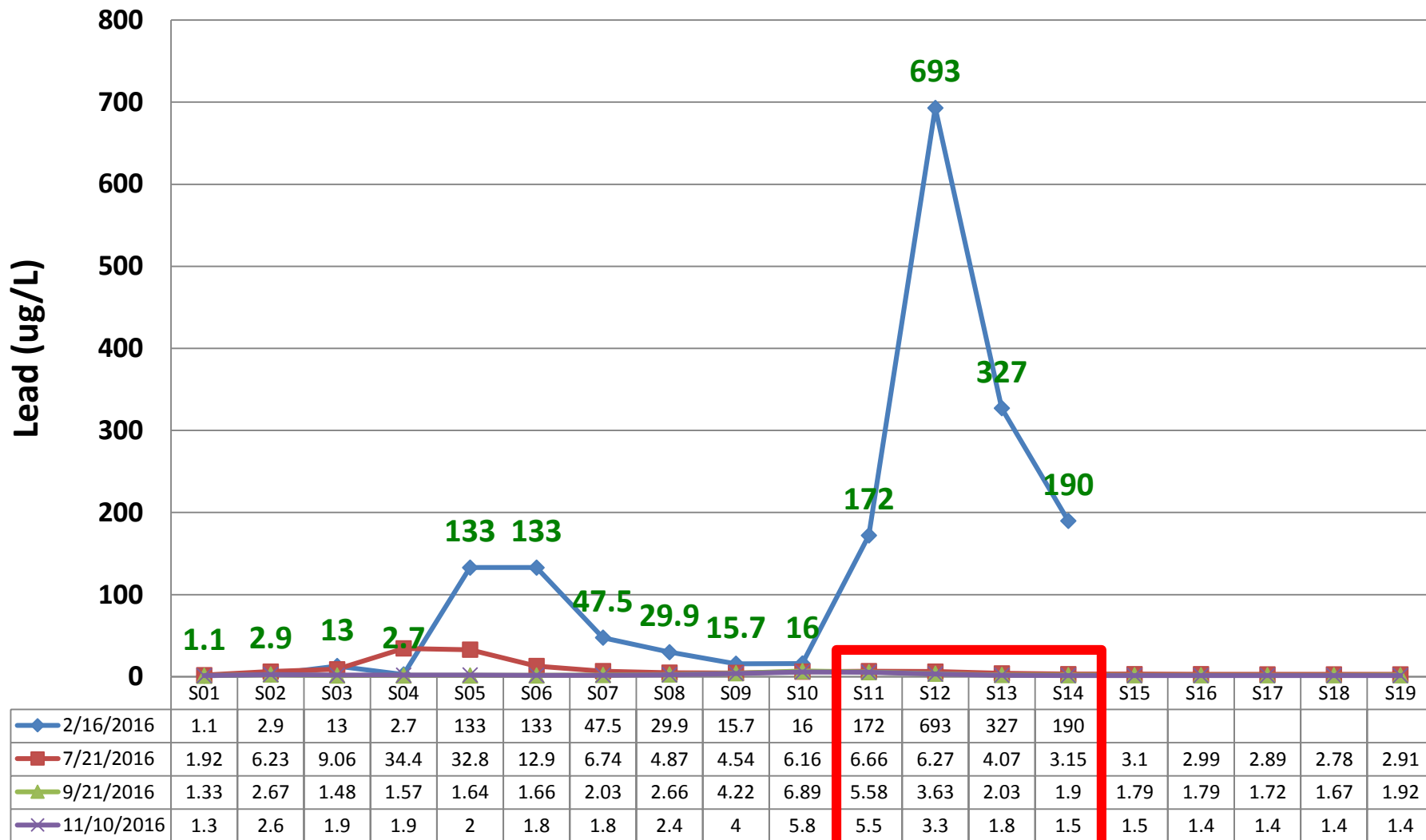
# Non-repeating Peaks





# Non-repeating Peaks

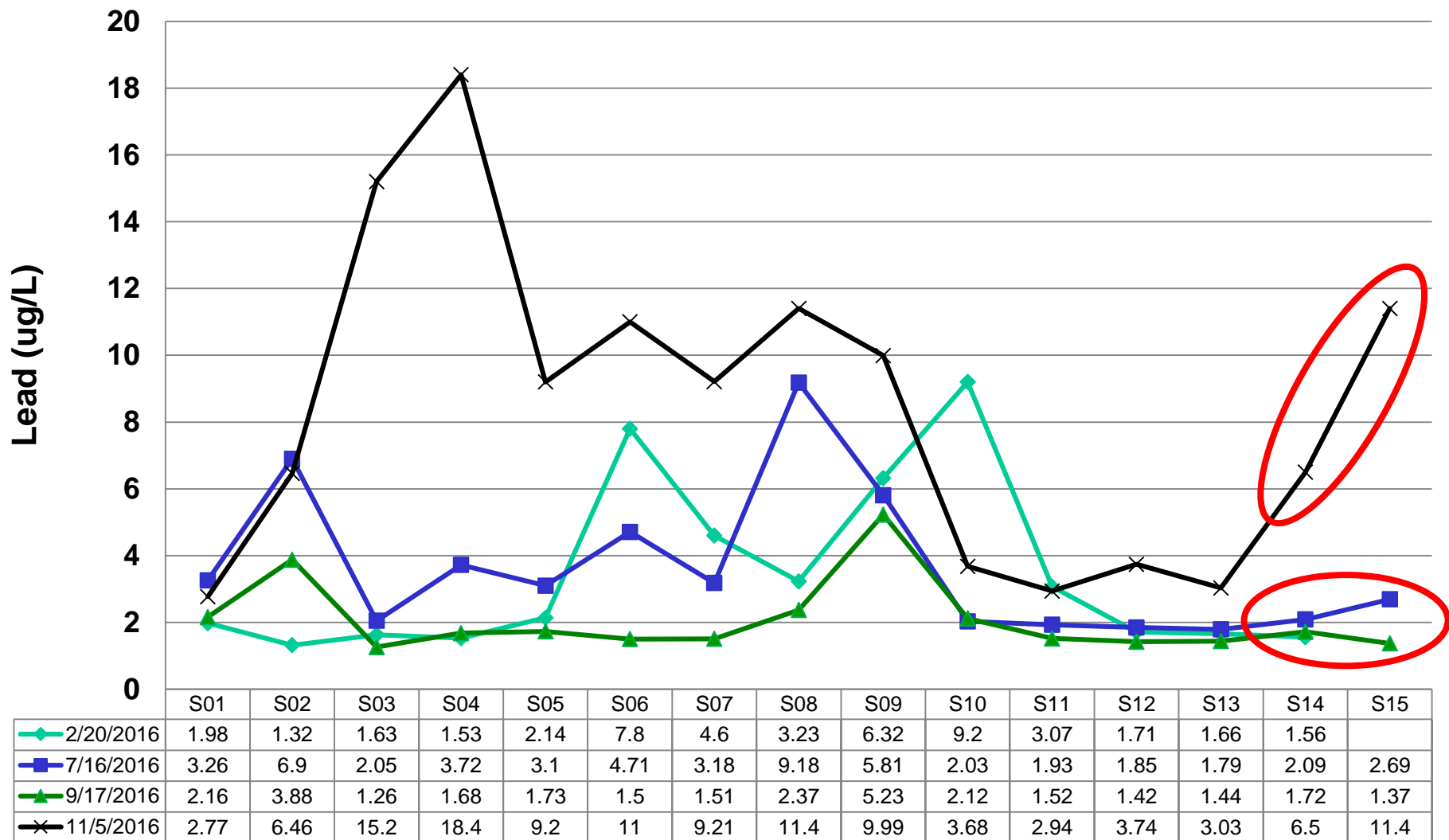
Site bs





# Non-repeating Peaks

## Site cw





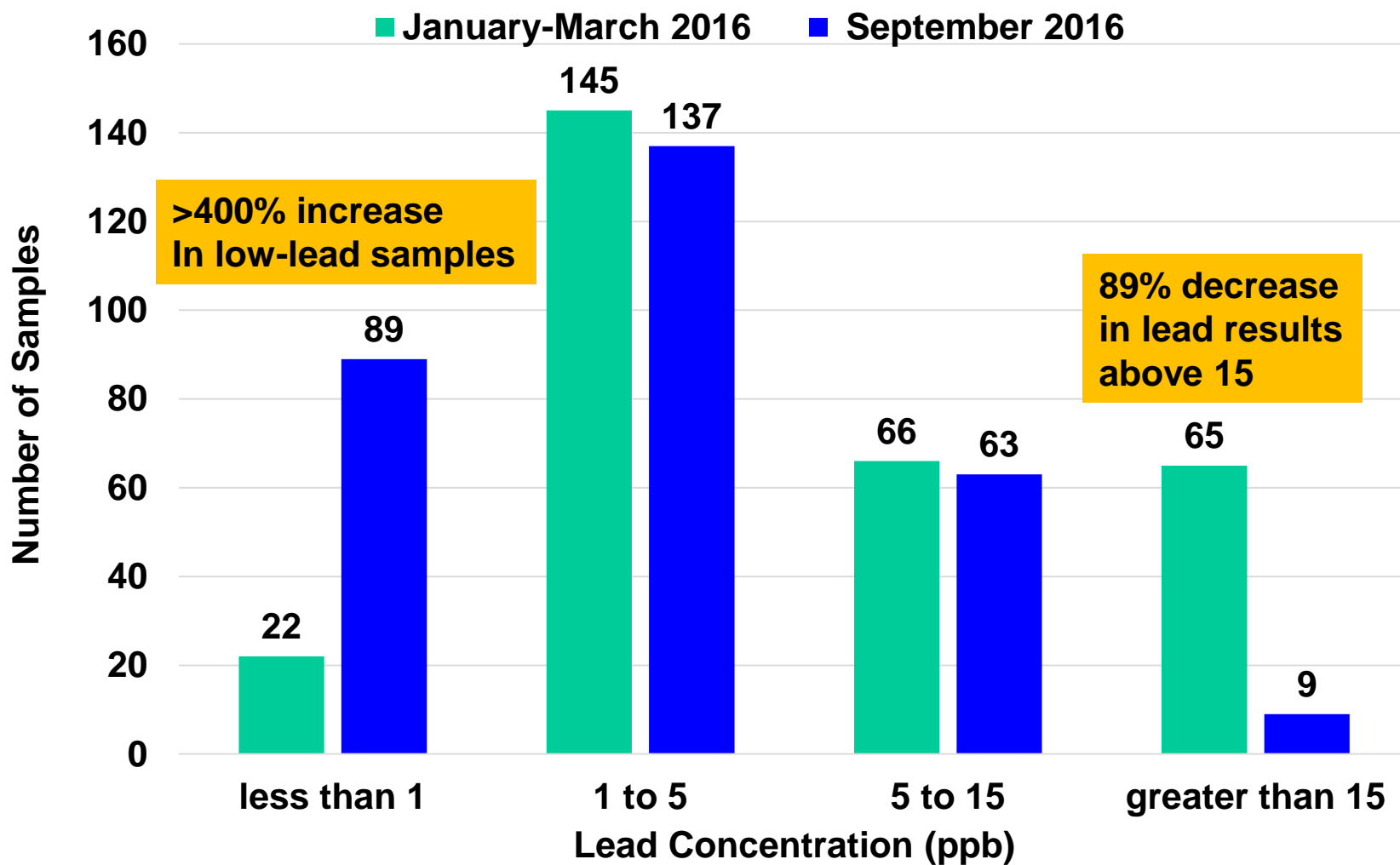
# Data Assessment

- Paired Sites
  - Comparison of sites that sampled in Round 1 and Round 4
  - Comparison of sites that sampled in Round 1 and Round 5
- Lead levels at homes where lead service lines have been replaced
- Lead levels at homes where lead service lines remain
- Phosphorus and Iron Levels
- Remaining Challenges



# Lower Lead in Sept vs Jan-Mar 2016

## EPA Sequential Sampling Results

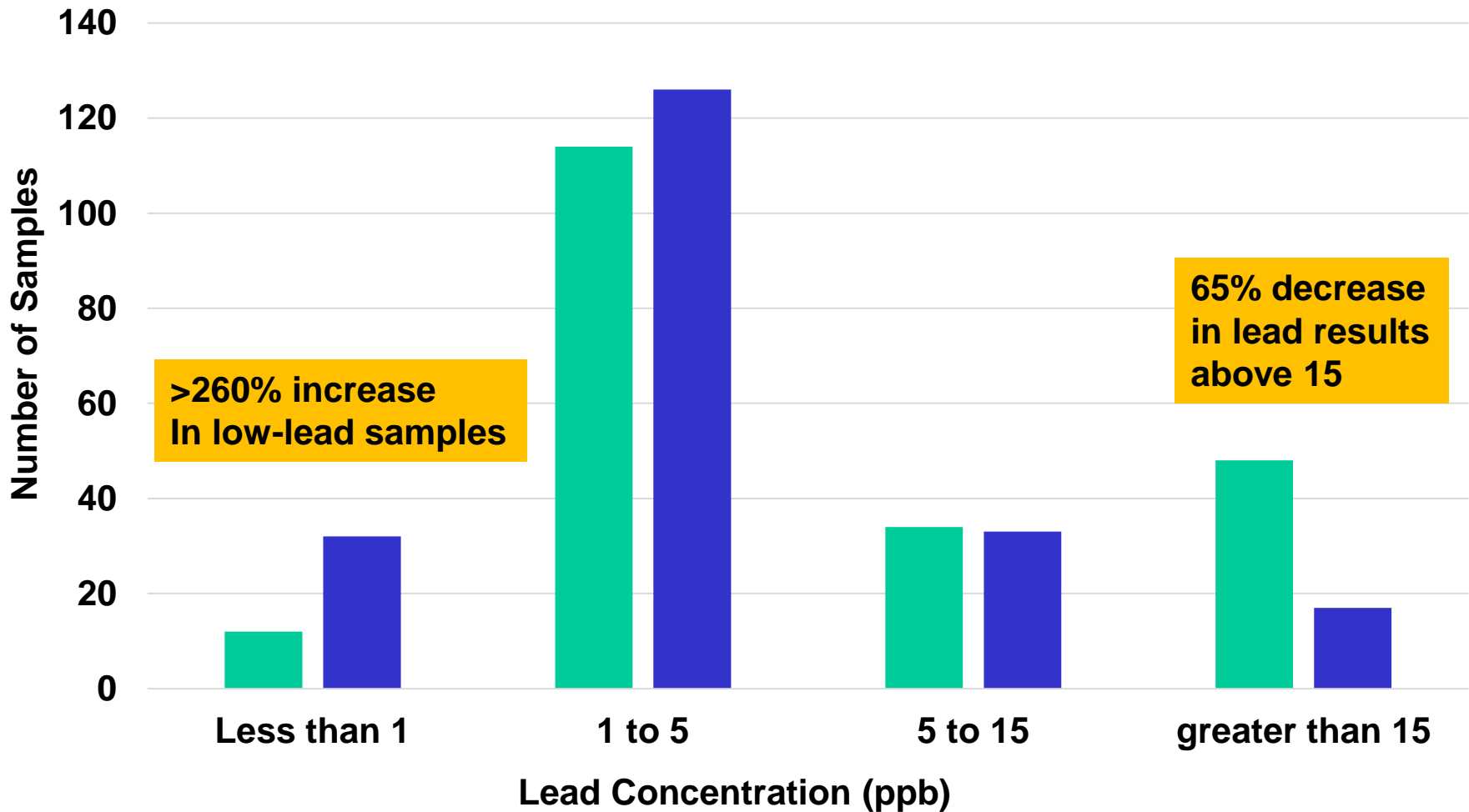




# Lower Lead in Nov vs Jan-Mar 2016

## EPA Sequential Sampling Results

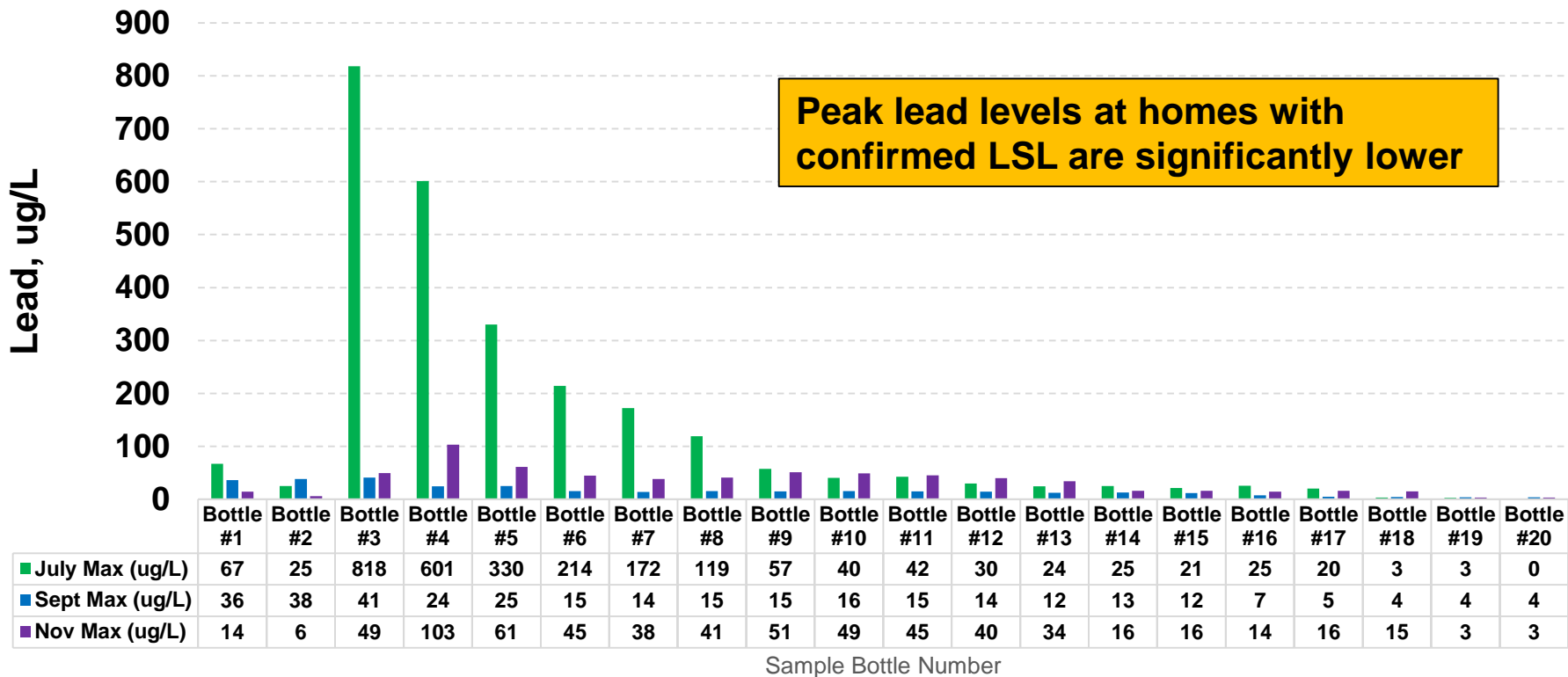
■ Round 1 (Jan-Mar 2016)    ■ Round 5 (Nov 2016)





# LSL Sites (July-Nov 2016)

## Maximum Lead Levels - Confirmed LSL Sites Only

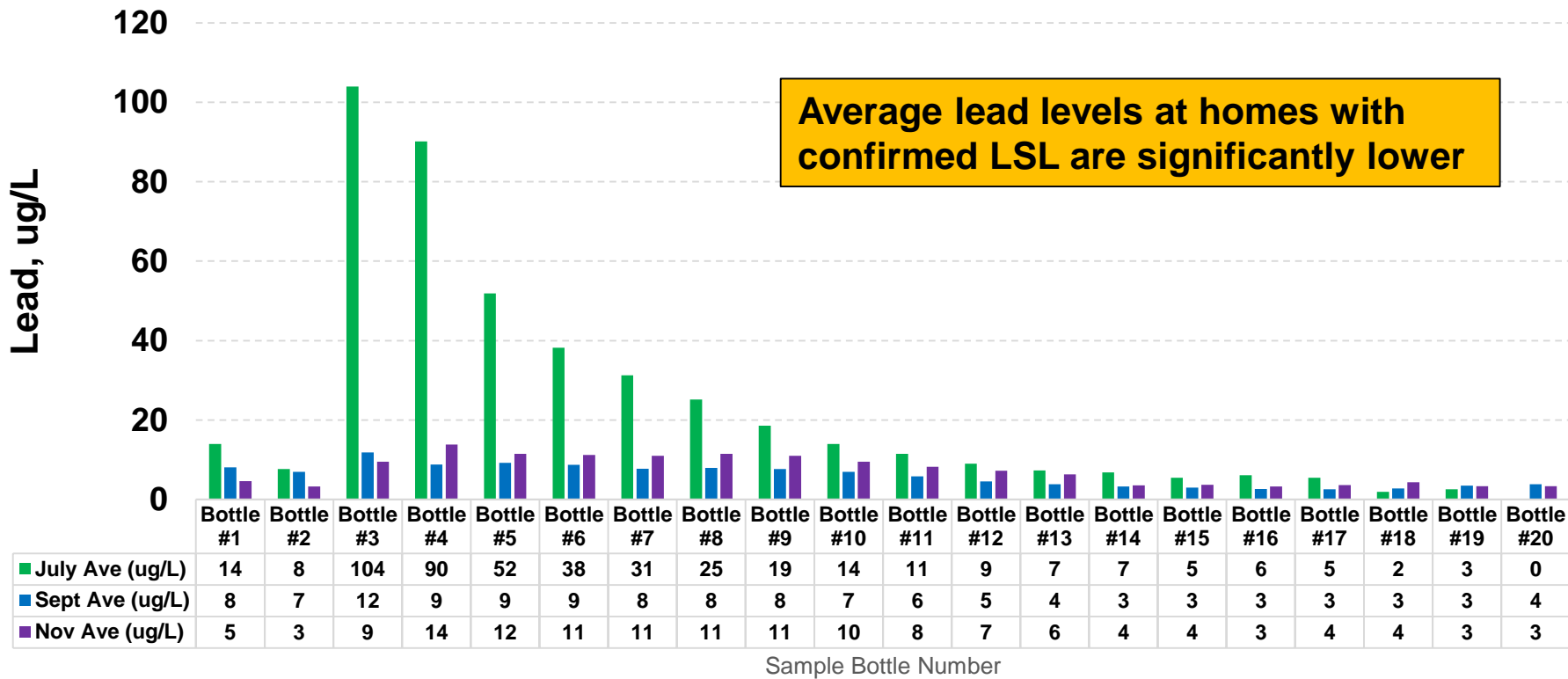


Bottle Number	Bottle #1	Bottle #2	Bottle #3	Bottle #4	Bottle #5	Bottle #6	Bottle #7	Bottle #8	Bottle #9	Bottle #10	Bottle #11	Bottle #12	Bottle #13	Bottle #14	Bottle #15	Bottle #16	Bottle #17	Bottle #18	Bottle #19	Bottle #20
July Count	12	12	12	12	11	12	12	11	11	11	11	11	11	10	8	8	6	3	1	0
Sept Count	16	15	15	15	15	15	16	16	16	16	15	16	15	15	14	14	13	6	2	1
Nov Count	12	11	12	12	12	12	12	12	12	12	12	11	12	11	10	11	10	7	1	1



# LSL Sites (Jul-Nov 2016)

## Average Lead Levels - Confirmed LSL Sites Only



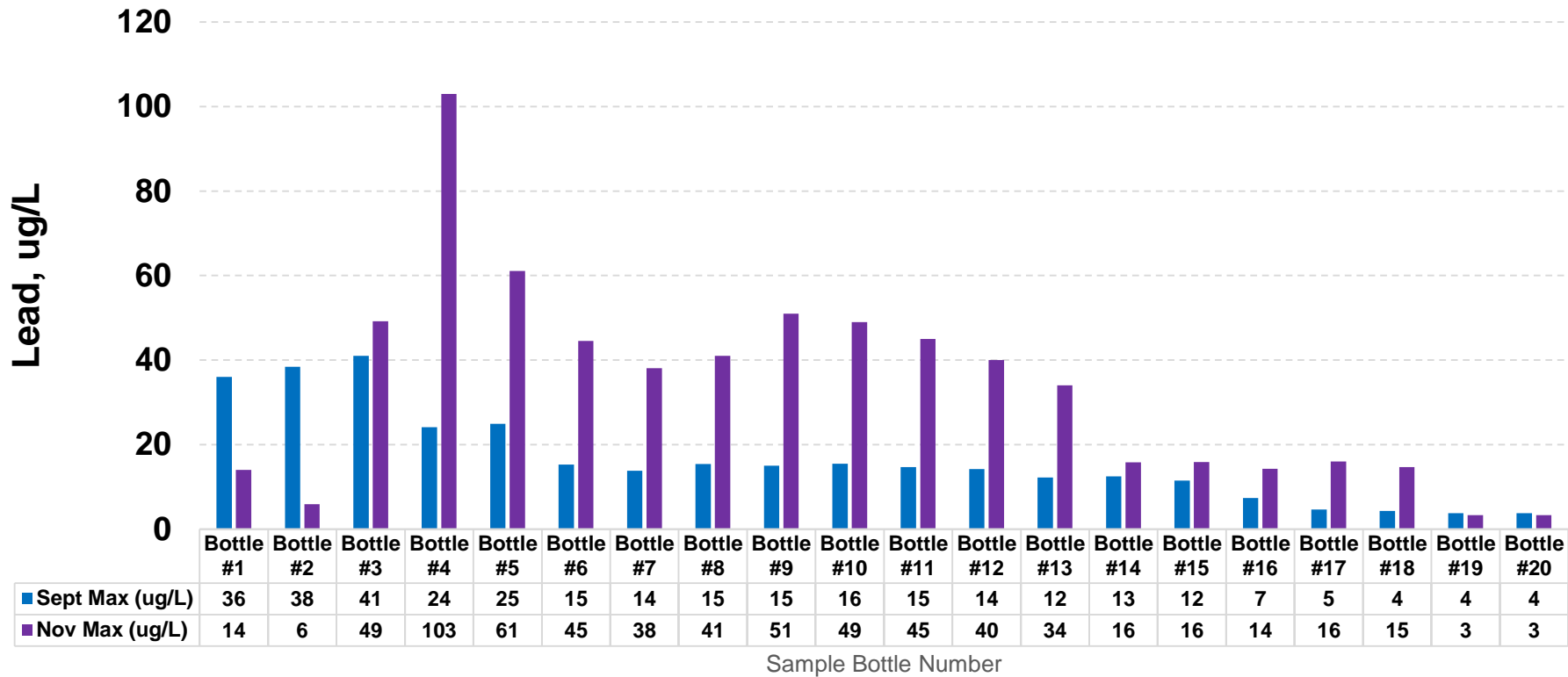
Bottle Number	Bottle #1	Bottle #2	Bottle #3	Bottle #4	Bottle #5	Bottle #6	Bottle #7	Bottle #8	Bottle #9	Bottle #10	Bottle #11	Bottle #12	Bottle #13	Bottle #14	Bottle #15	Bottle #16	Bottle #17	Bottle #18	Bottle #19	Bottle #20
July Count	12	12	12	12	11	12	12	11	11	11	11	11	11	10	8	8	6	3	1	0
Sept Count	16	15	15	15	15	15	16	16	16	16	15	16	15	15	14	14	13	6	2	1
Nov Count	12	11	12	12	12	12	12	12	12	12	12	11	12	11	10	11	10	7	1	1





# LSL Sites (Sept-Nov 2016)

## Maximum Lead Levels - Confirmed LSL Sites Only

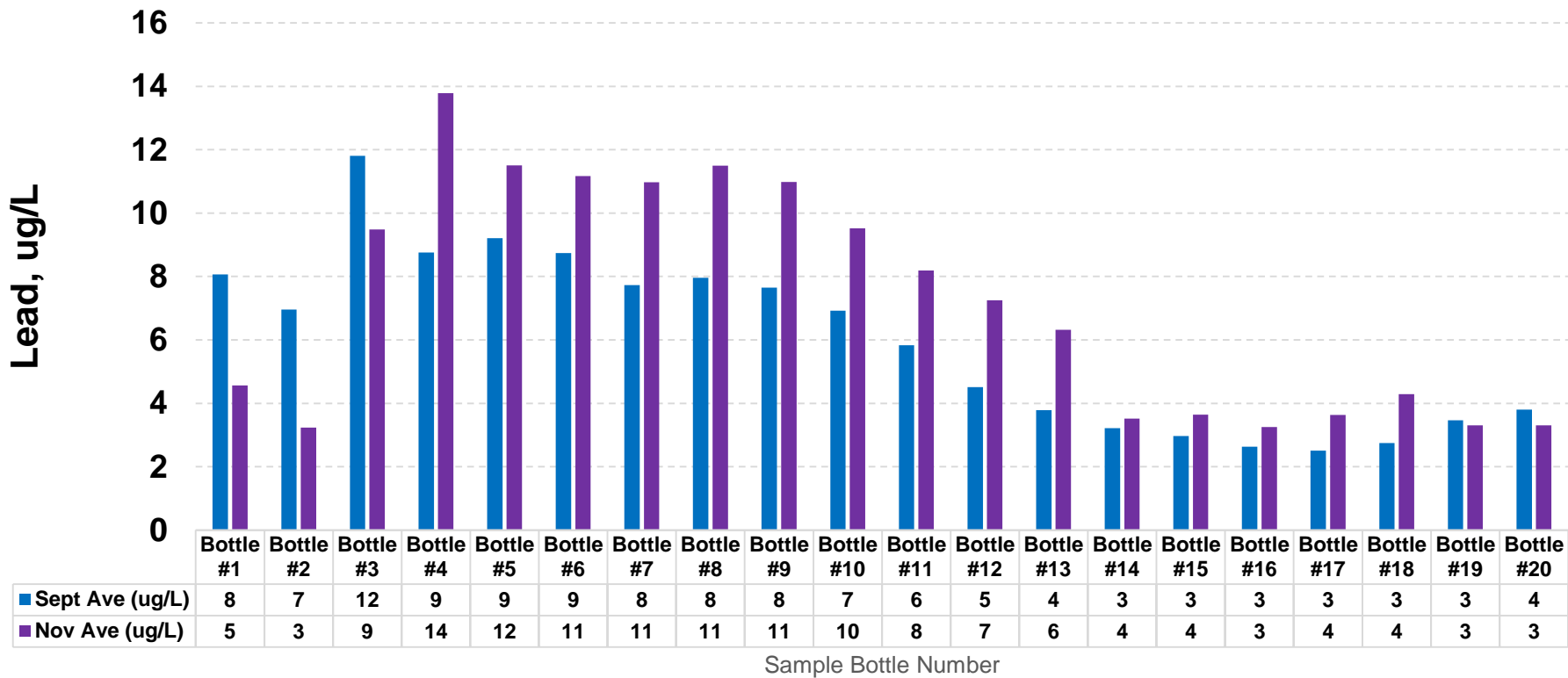


Bottle Number	Bottle #1	Bottle #2	Bottle #3	Bottle #4	Bottle #5	Bottle #6	Bottle #7	Bottle #8	Bottle #9	Bottle #10	Bottle #11	Bottle #12	Bottle #13	Bottle #14	Bottle #15	Bottle #16	Bottle #17	Bottle #18	Bottle #19	Bottle #20
Sept Count	16	15	15	15	15	15	16	16	16	16	15	16	15	15	14	14	13	6	2	1
Nov Count	12	11	12	12	12	12	12	12	12	12	12	11	12	11	10	11	10	7	1	1



# LSL Sites (Sept-Nov 2016)

## Average Lead Levels - Confirmed LSL Sites Only

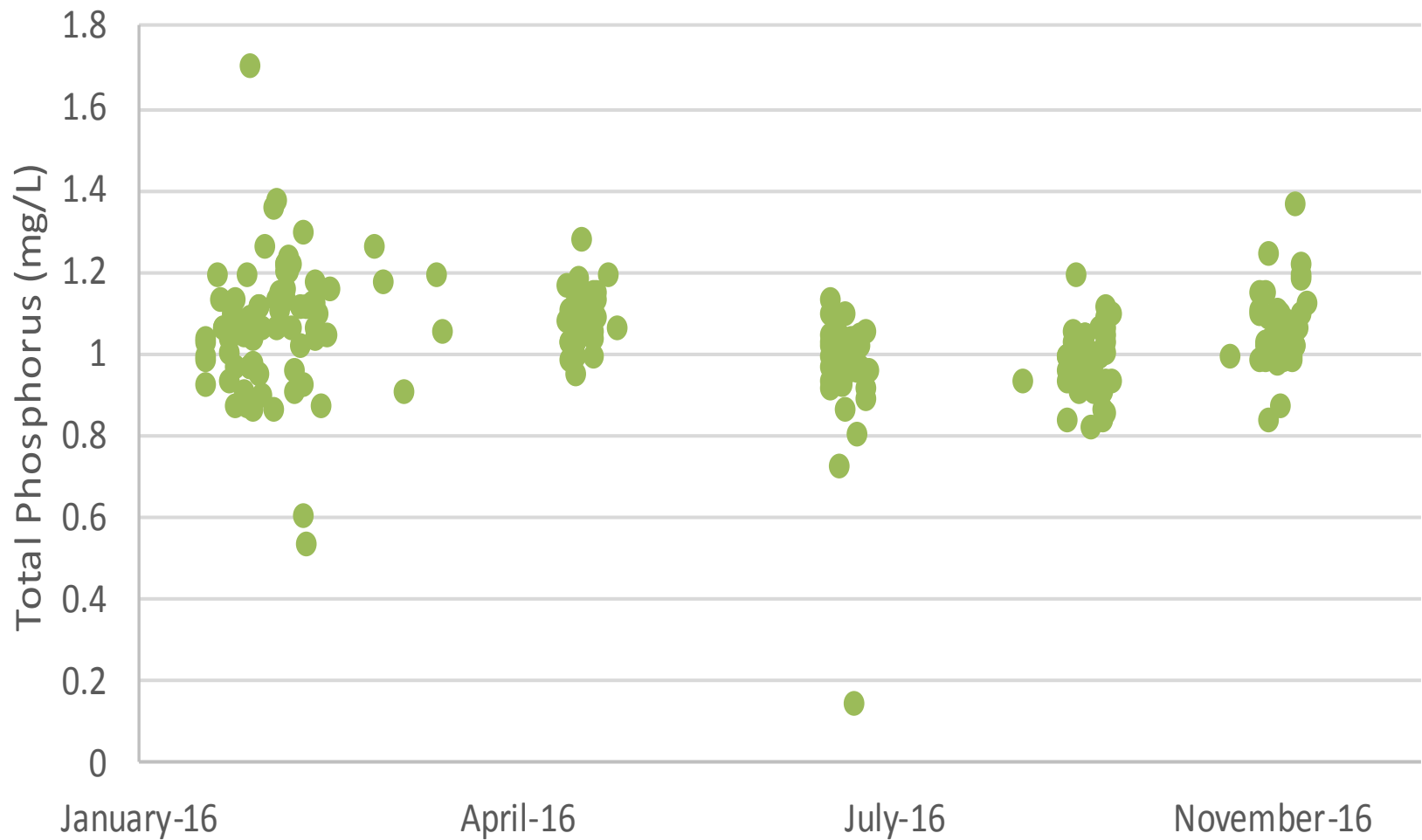


Bottle Number	Bottle #1	Bottle #2	Bottle #3	Bottle #4	Bottle #5	Bottle #6	Bottle #7	Bottle #8	Bottle #9	Bottle #10	Bottle #11	Bottle #12	Bottle #13	Bottle #14	Bottle #15	Bottle #16	Bottle #17	Bottle #18	Bottle #19	Bottle #20
Sept Count	16	15	15	15	15	15	16	16	16	16	15	16	15	15	14	14	13	6	2	1
Nov Count	12	11	12	12	12	12	12	12	12	12	12	11	12	11	10	11	10	7	1	1



# Phosphorus

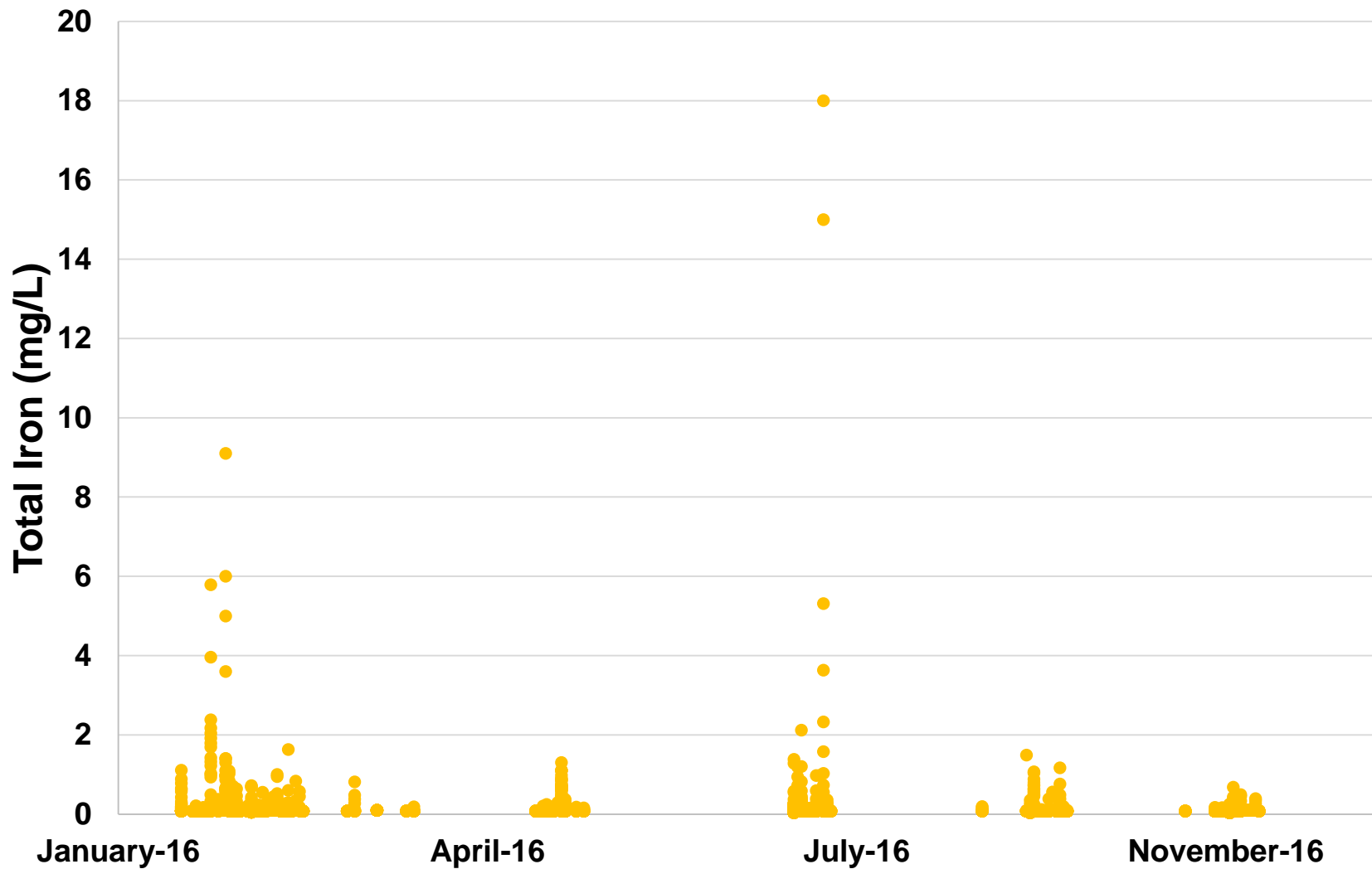
## Total Phosphorus





# Iron

## Total Iron





# Remaining Challenges

- Distribution system needs to be optimized
  - Oversized infrastructure
  - Low water use areas
- Removing all the lead pipes takes time
- Lead pipes and associated galvanized iron pipe, where present, are a continued source of lead



# Acknowledgments

- Field Sampling: Peggy Donnelly, Dean Maraldo, Thomas Mendez, Joan Rogers & WD Field Team
- Flint Support: Andrea Porter and Valerie Bosscher
- Lab: Central Regional Lab & Regional Labs
- Data: Brian Cooper, John Gulch and R5 IT Team