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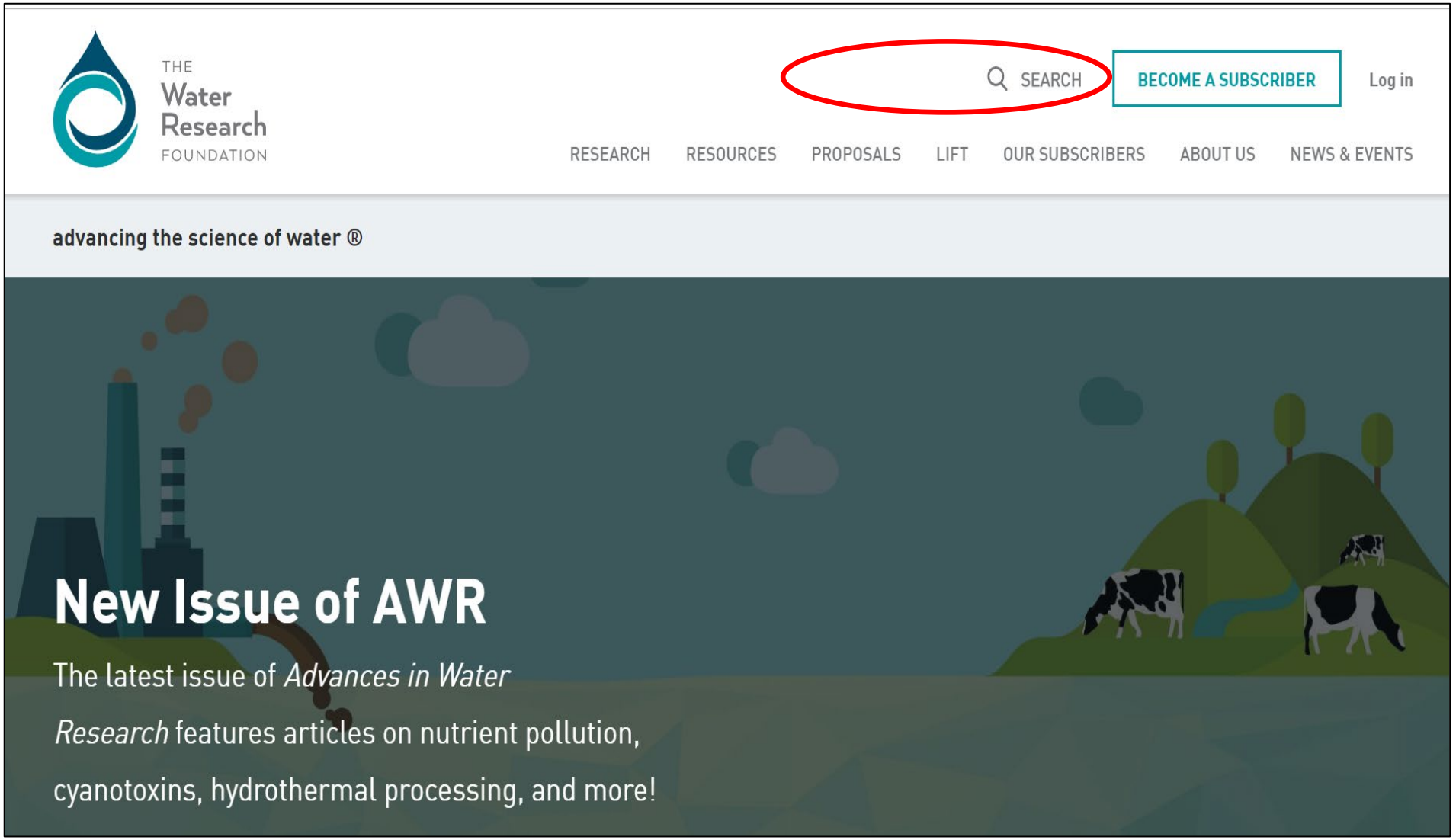
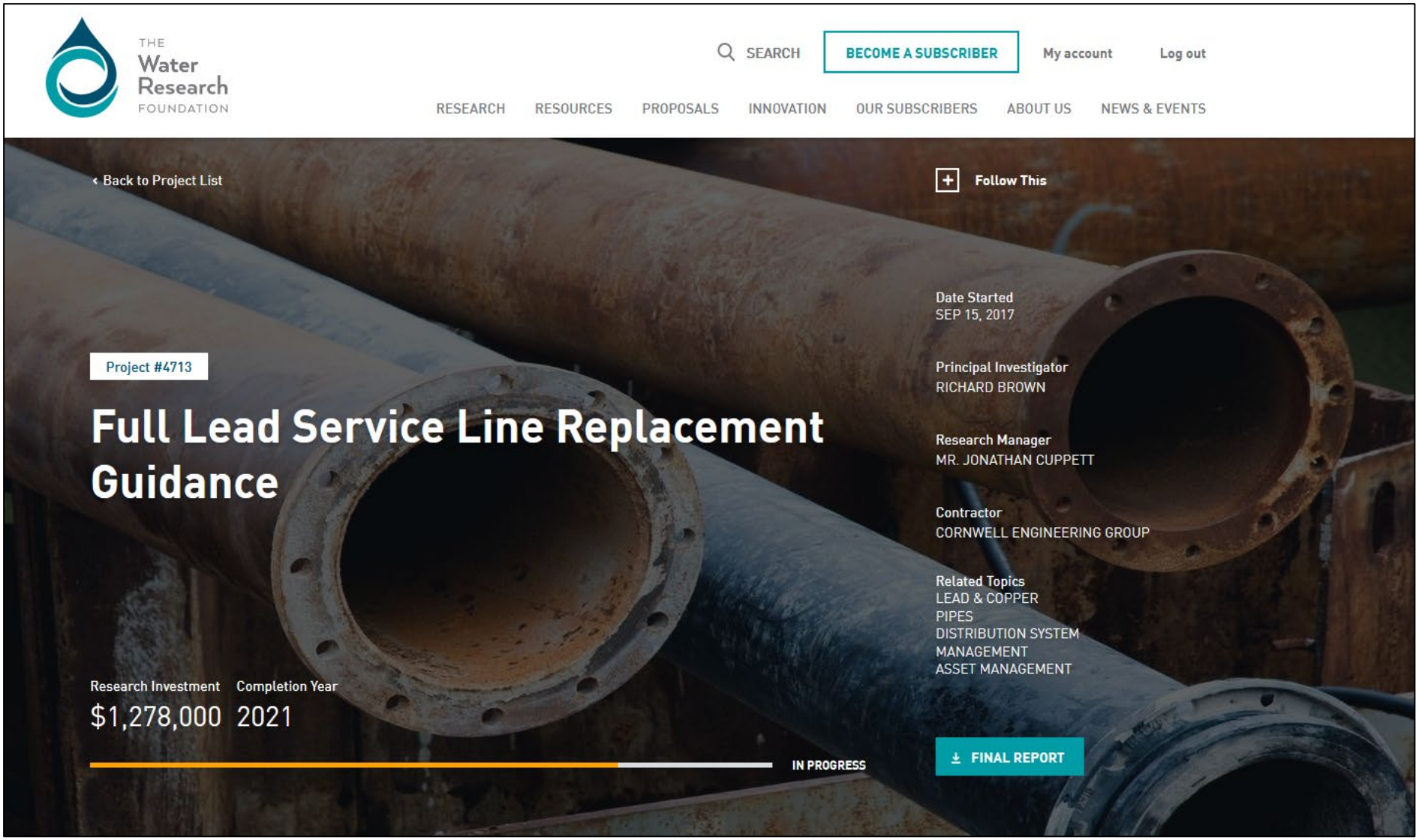
Full Lead Service Line Replacement Guidance - #4713

March 4, 2021

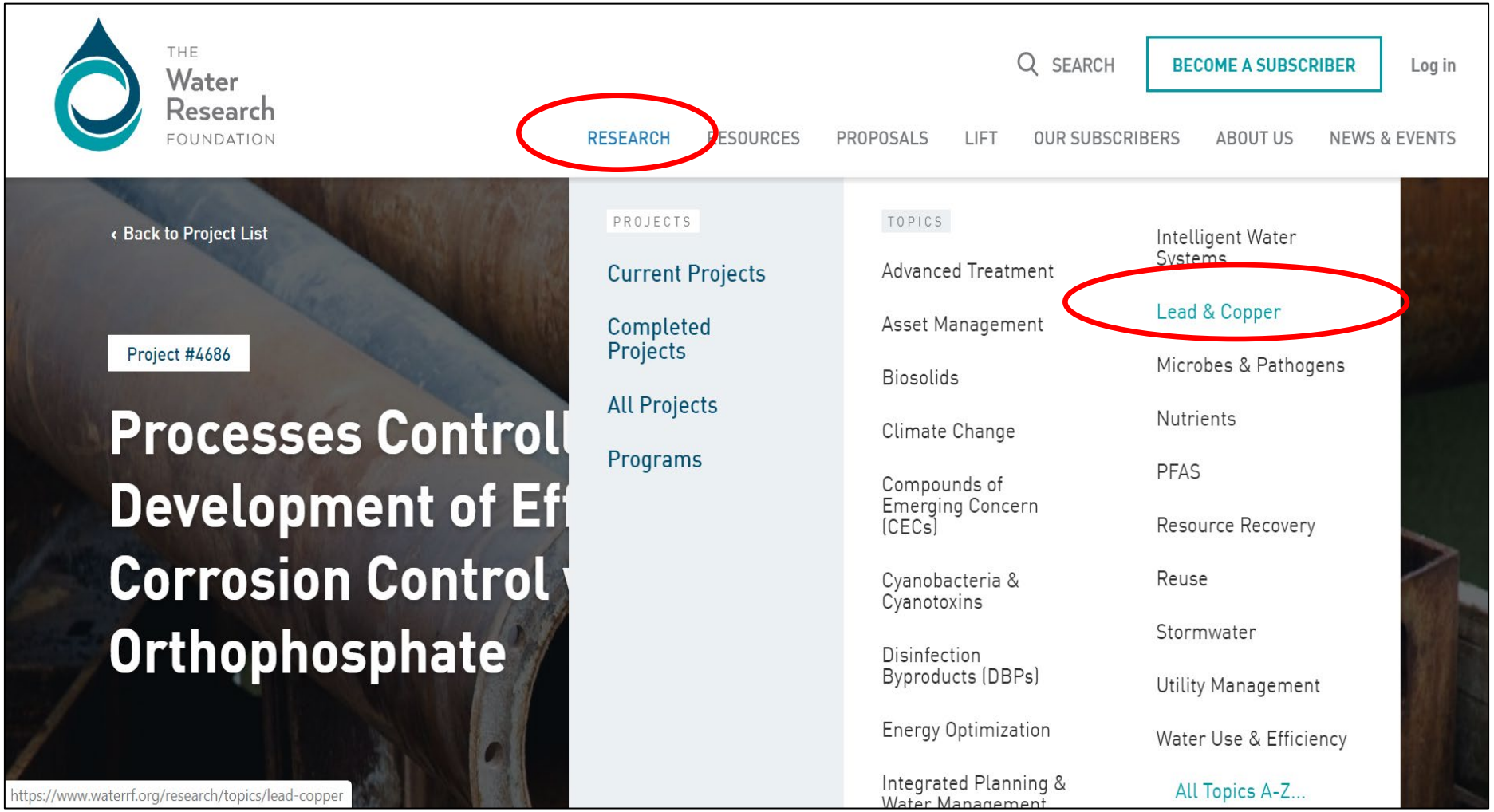
Report Access – waterrf.org



Project Page for 4713



Lead and Copper Research



WRF - Lead and Copper Overview

Lead & Copper

Lead and copper in service lines and household plumbing are the primary drinking water corrosion compounds of concern. Lead is a toxic metal that can be harmful to human health even at low exposure levels. Lead is persistent and can bioaccumulate in the body over time. Young children are particularly vulnerable to lead because the physical and behavioral effects of lead occur at lower exposure levels in children than in adults. A dose of lead that would have little effect on an adult can have a significant effect on a child. People who drink water containing copper in excess of 1.3 mg/L may experience short-term nausea, while long-term exposure can affect the liver and kidneys.

Lead is rarely found in source water and usually enters drinking water through corrosion of household plumbing. Lead at the tap can come from a variety of sources, including lead service lines, lead piping inside the home, lead-based solder, and brass components. The concentrations of lead and copper in water are regulated by the U.S. Environmental Protection Agency's Lead and Copper Rule.

In this topic
21 Projects · 1 Web Tool · 1 Case Study · 13 Webcasts

Related Topics
Water Quality · Corrosion · Pipes · Distribution System Management

TOPIC OVERVIEW (PDF)

Project #4686

Processes Controlling the Development of Effective Lead Corrosion Control with Orthophosphate

Research Investment: $74,881
Completion Year: 2019
COMPLETED

Project Highlights

This project provides new scientific insights into the addition of orthophosphate for corrosion control that will enable efficient application of phosphate to control both dissolved and total lead concentrations in water. Laboratory-scale experiments were performed for two scenarios to further...

Principal Investigator
DANIEL GIAMMAR

Research Manager
MR. JONATHAN DUPUIS

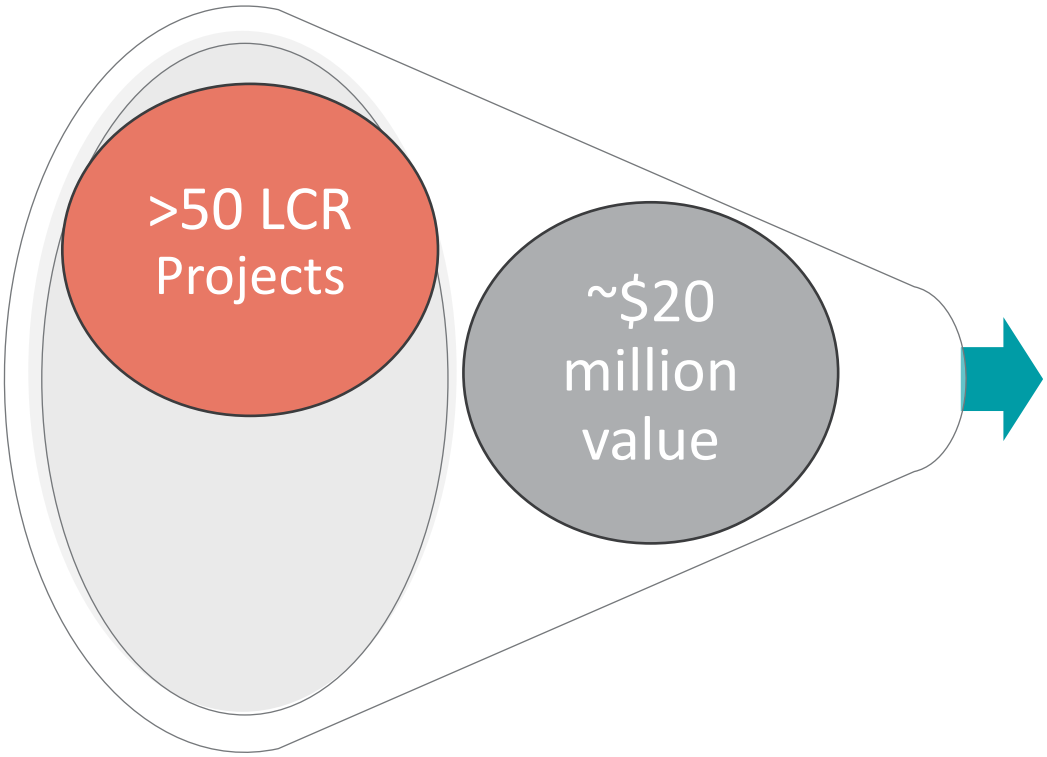
> View more details

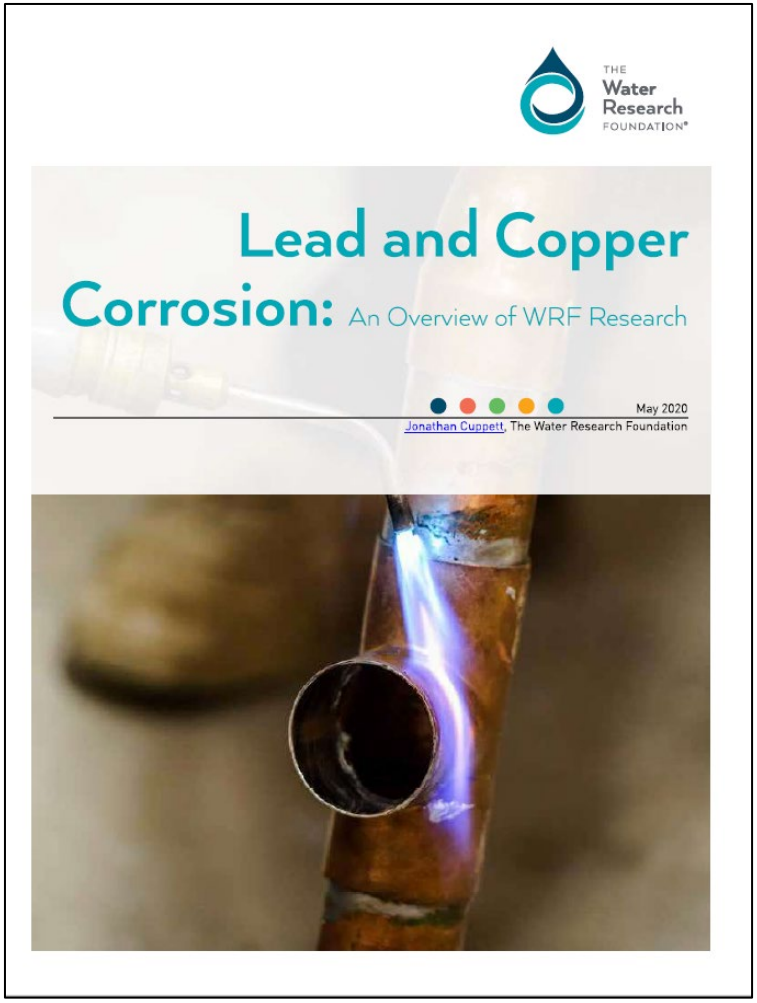
Lead and Copper Corrosion: An Overview of WRF Research

WRF has funded over 50 research projects related to lead and copper corrosion valued at more than $20 million. This state of the science document summarizes the objectives, general research approach, and major findings of this body of research, and offers a basic understanding of the issues surrounding distribution system corrosion and the Lead and Copper Rule (LCR).

DOWNLOAD THIS DOCUMENT

WRF Lead Research since late 1980's





Lead and Copper Management Research Area: Started 2016

1. #4713 - Full Lead Service Line Replacement Guidance
2. #4910 - Evaluating Key Factors that Affect the Accumulation and Release of Lead from Galvanized Pipes
3. #5032 - Analysis of Corrosion Control Treatment for Lead and Copper Control
4. #5081 - Guidance for using Pipe Loops to Inform Lead and Copper Corrosion Control Treatment Decisions

- Membership of 26 national organizations
- Replacement practices, preparing an inventory, communication resources, policies and more
- www.lslr-collaborative.org

LSLR COLLABORATIVE

AWWA Lead Resources

LEAD

Resources & Tools / Resource Topics / Inorganic Contaminants / Lead

AWWA Resources on Lead in Drinking Water

AWWA members protect consumers against lead in drinking water. The Association continues to prepare helpful communications, technical and public policy resources. Selected resources are available from this single hub. Here you will find insights on corrosion control and other lead management issues, the latest legislative and regulatory developments, and public outreach tools to help you speak with consumers and other key stakeholders. Both resources prepared by AWWA's members and others such as the USEPA are available.

Related Resources:

Inorganic Contaminants

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WRF 4713 FLSLR Guidance

WRF WEBCAST – MARCH 4, 2021

Richard Brown

Cornwell Engineering Group

WRF 4713

- Co-PIs
  - Richard Brown, David Cornwell, Baljit Sidhu – **Cornwell Engineering Group**
  - Maureen Schmelling – **DC Water**
  - Suzanne Chiavari – **American Water**
  - Rebecca Slabaugh - **Arcadis**
- Participating Water Systems
  - 12 – Field and Case Studies
  - 1 – Field Studies only
  - 4 – Case Studies only
  - 10 US + 3 Canadian (field studies)

WRF 4713 FLSLR Guidance

- Report
  - Field studies
  - Case studies
  - FLSLR Guidance Toolbox
    - Including example recommendations, procedures, infographics, etc.
- Webcast
  - Field Studies
  - Experiences from two PWS participants
  - Case Studies
  - Toolbox overview

Issues

- We know lead can be high after a PLSLR or a FLSLR
- Whole-house High Velocity Flushing (HVF) can reduce the lead levels after a disturbance
- High Velocity Flushing should not be confused with displacement flushing
- What are the procedures for HVF

HVF in the Lead and Copper Rule Revisions

- Requires HVF after PLSLR or FLSLR
- Also required after any time water is shut off to house†
  - Water main break
  - Meter replacement

† = if there is a known LSL or galvanized service line, or a service line with "unknown" status.

Public education materials, filters, instructions, replacement media, etc. are also required

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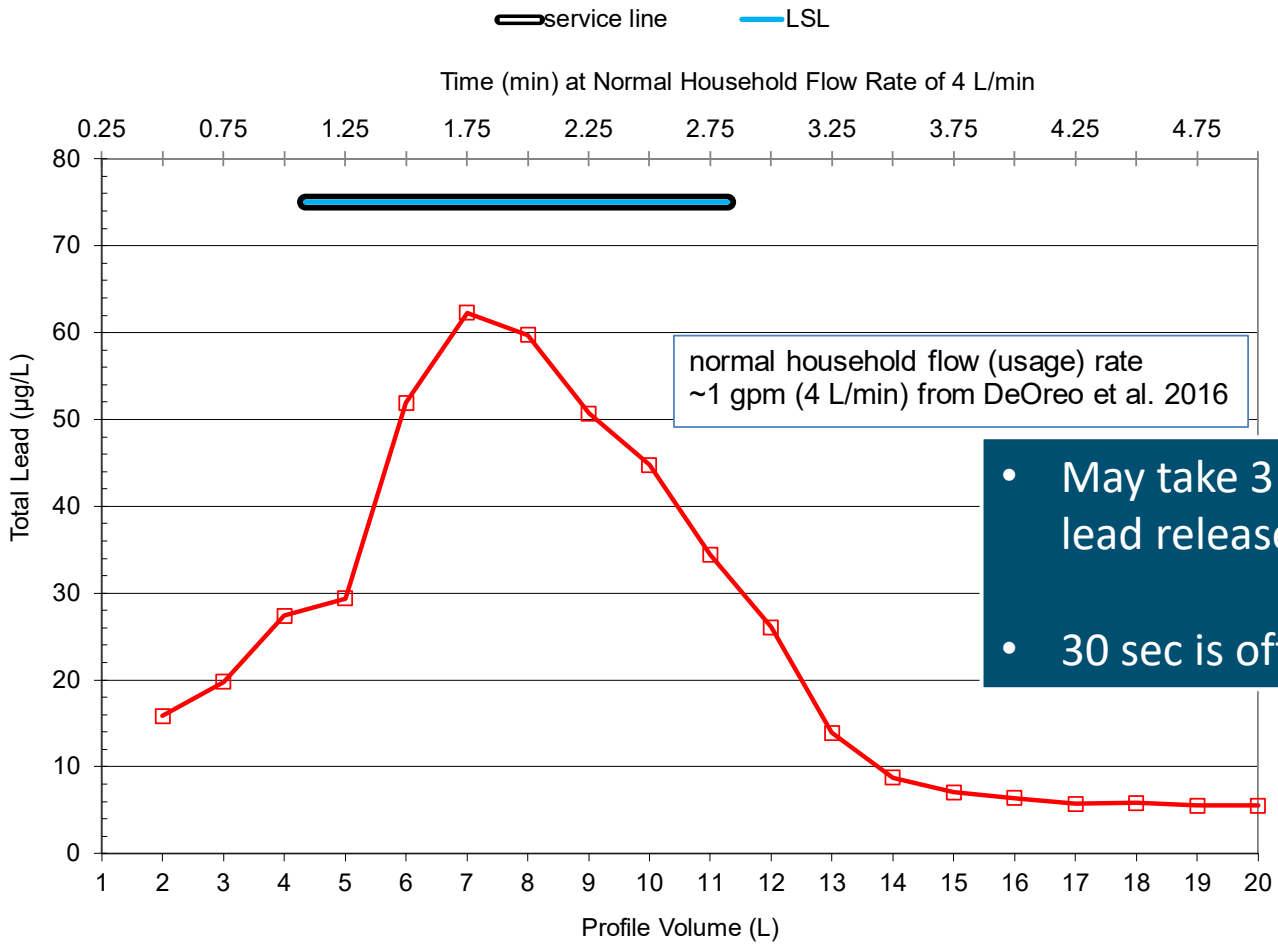
Displacement vs. HVF

What is a Displacement Flush

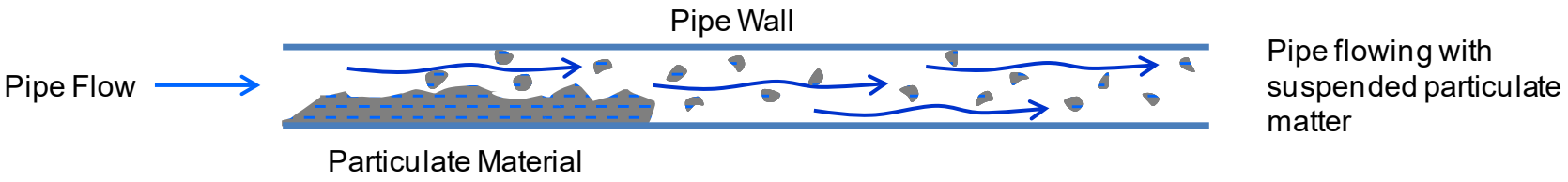
- Objective – replace water in house and service line with fresh water from water main in street



- May take 3 to 5 min to get past lead release from LSL
- 30 sec is often start of LSL lead

What is High Velocity Flushing

- Analogous to “unidirectional” flushing of dist. sys.
- Objective is to dislodge, and then remove particulate material from pipes, fittings, and other parts of plumbing
- In this case to remove loose particulate material between household taps and water main
- Remove aerator



Flushing/Sampling Flow

Which Faucets In Your House to Flush?

- All faucets inside your house that can flow to a drain without overflowing should be flushed. For example:

- Don’t perform HVF at:
  - Faucets where you can’t remove aerator (rusted)
  - Outdoor faucets
  - Filters that can not be bypassed

Debris to be removed

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Past HVF Studies by the Research Team

Past HVF Studies Leading Up to WRF 4713

- WITAF 306 – PLSLRs (2012 – 2013)
  - Compared “service line (SL) flush” alone versus SL flush with HVF
  - Total lead results were lower and dropped to <DL (~1 µg/L) more quickly after HVF than with SL flush alone
- WRF 4584 – PLSLRs and FLSLRs (2014 – 2017)
  - Removal of lead and other metals was measured during 30 min HVF (so HVF did remove lead remaining after PLSLR and FLSLR)
  - Total lead increased in profile samples after FLSLR prior to HVF, then decreased within 60 days (typically <4 µg/L)

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WRF 4713 Field Studies

HVF Grab Sample Results

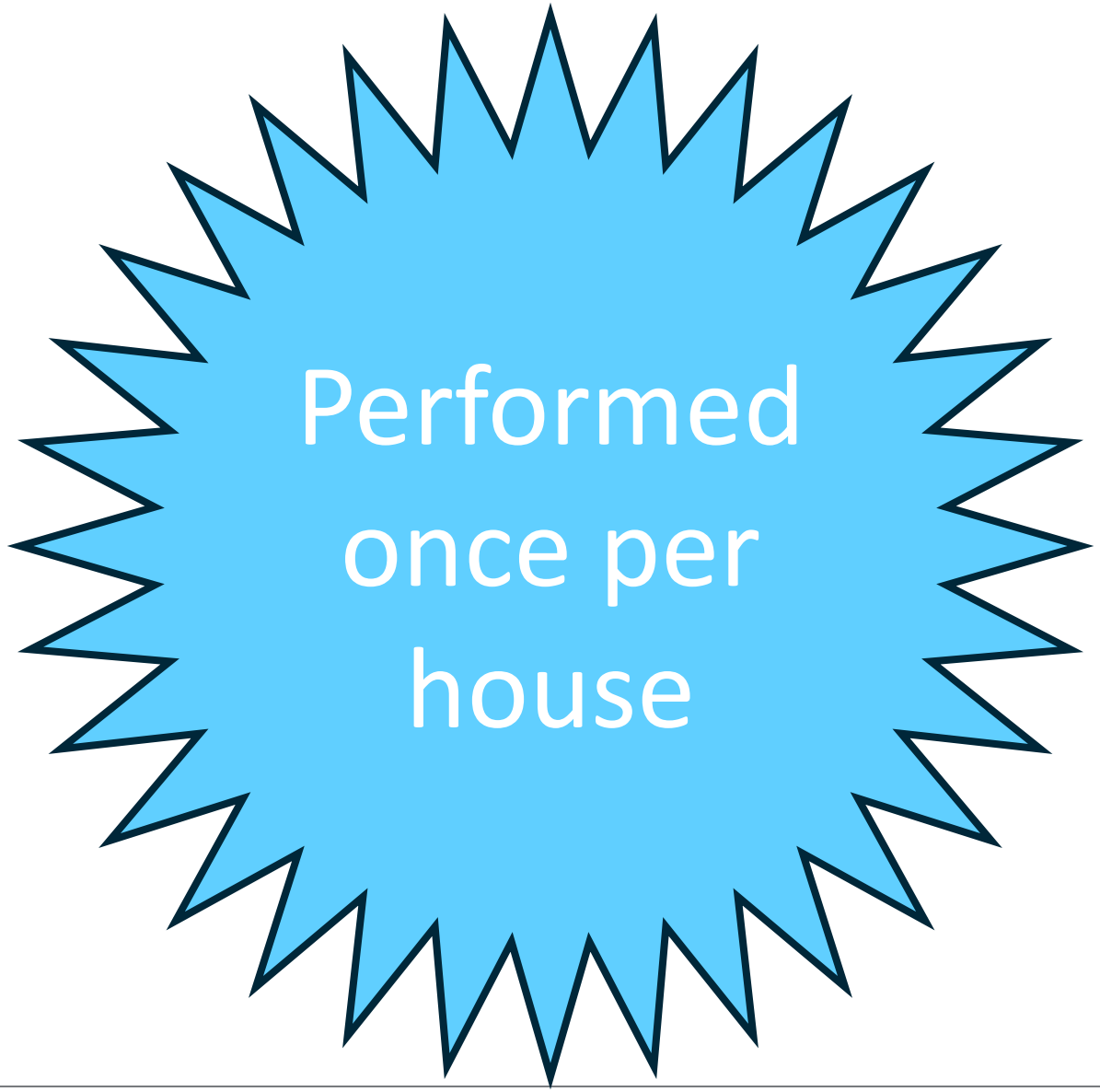
WRF 4713 Field Study Sequence

- Identify participants (**all single family homes**)
- Collect pre-LSLR samples
  - profile at all houses, some composite samples (~30)
- Conduct LSLR (with service line flush)
- Collect pre-HVF profile samples
- Conduct HVF
  - Typically PWS staff during each study
  - Collect grab samples 2, 4, 6, 8, 10, 20, 30 min (kitchen)
- Collect post-HVF profile samples
  - 1, 30, 60 day profile samples
  - 60 day composite samples (~30 houses)

Instructions on High Velocity Flushing

- **COLD** water
- Aerators and filters = removed or by-passed
- High-rate (“taps wide open”)

HVF in this project

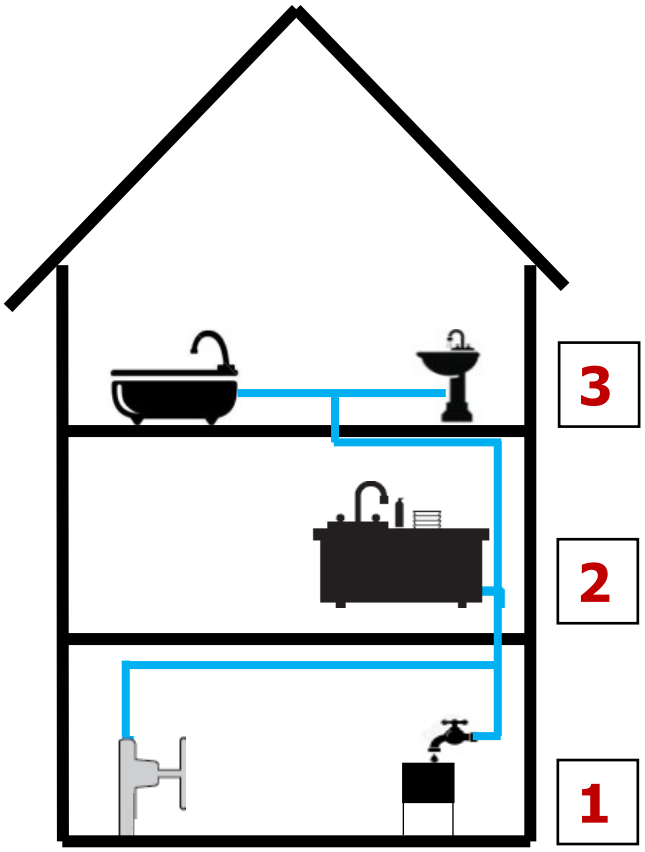


WRF 4713
Two types of HVF Evaluated

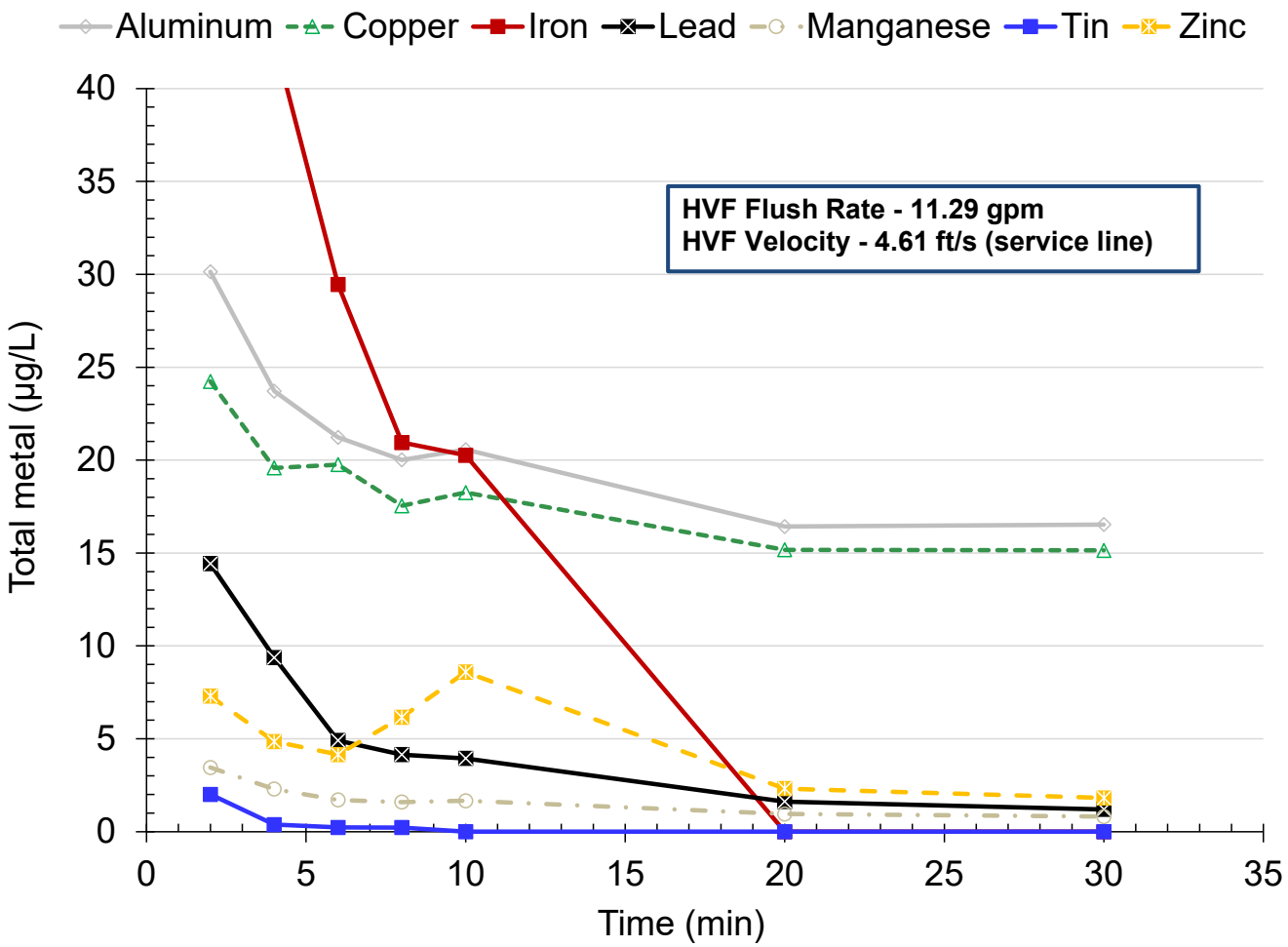
- "all taps at once" – **Method A** – AWWA Std. C810-17
  - All faucets, wide open, 30 min
  - Sample kitchen faucet (2, 4, 6, 8, 10, 20, 30 min)
- "one tap a time" – **Method B**
  - Flush each faucet, turn it off, move to next one
  - Sample kitchen faucet only

High Velocity Flush ("all taps" – Method A)

- Open all faucets in the house starting from lowest to highest level
- Leave faucets running at the highest rate possible for at least 30 minutes
- After 30 minutes, turn off all faucets in the same order they were turned on
- Replace aerators/screens at each faucet



Sampling during HVF - Kitchen



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WRF 4713 Field Studies

Profile Sampling Results

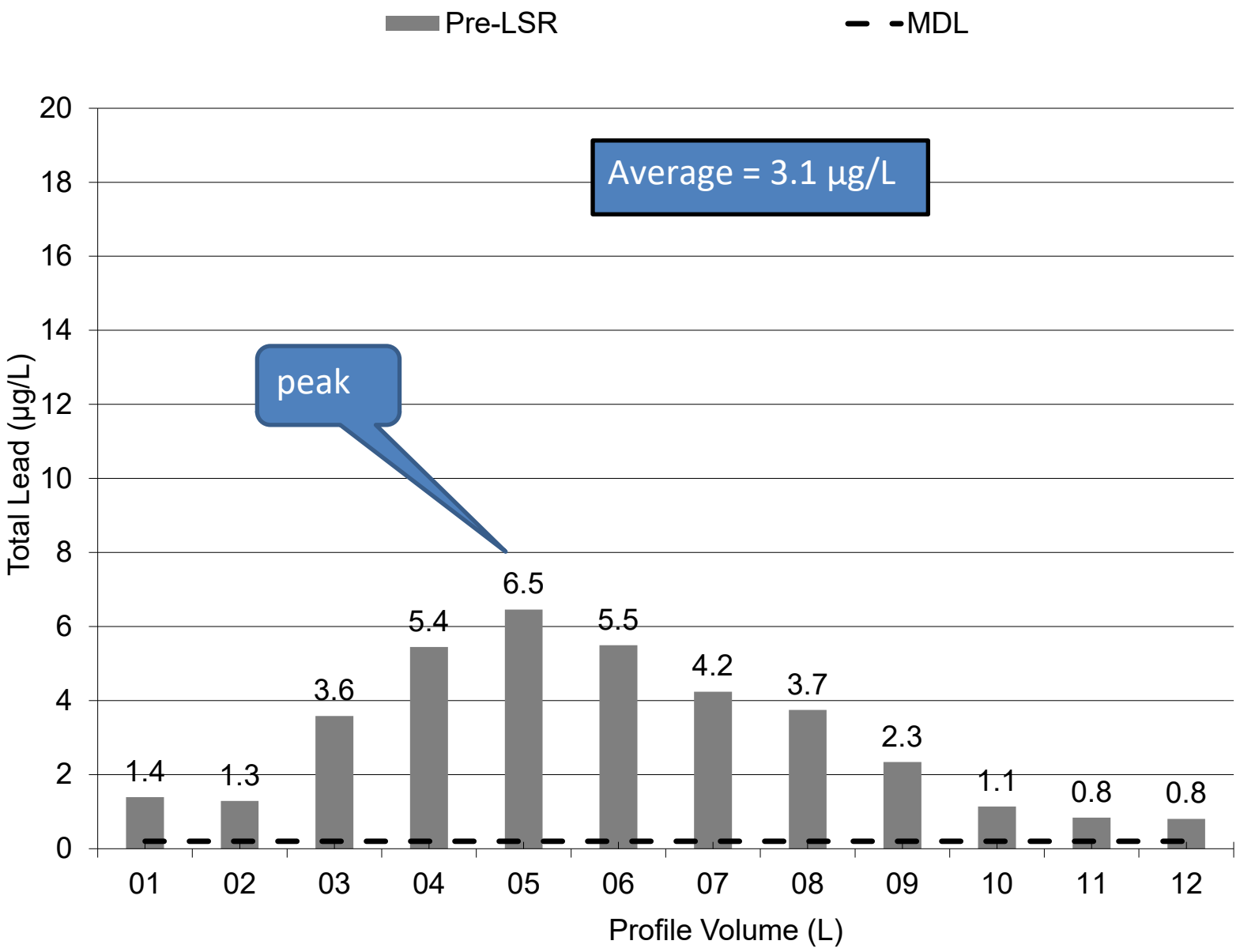
Setup Prior to Profile Sample Collection

Be prepared

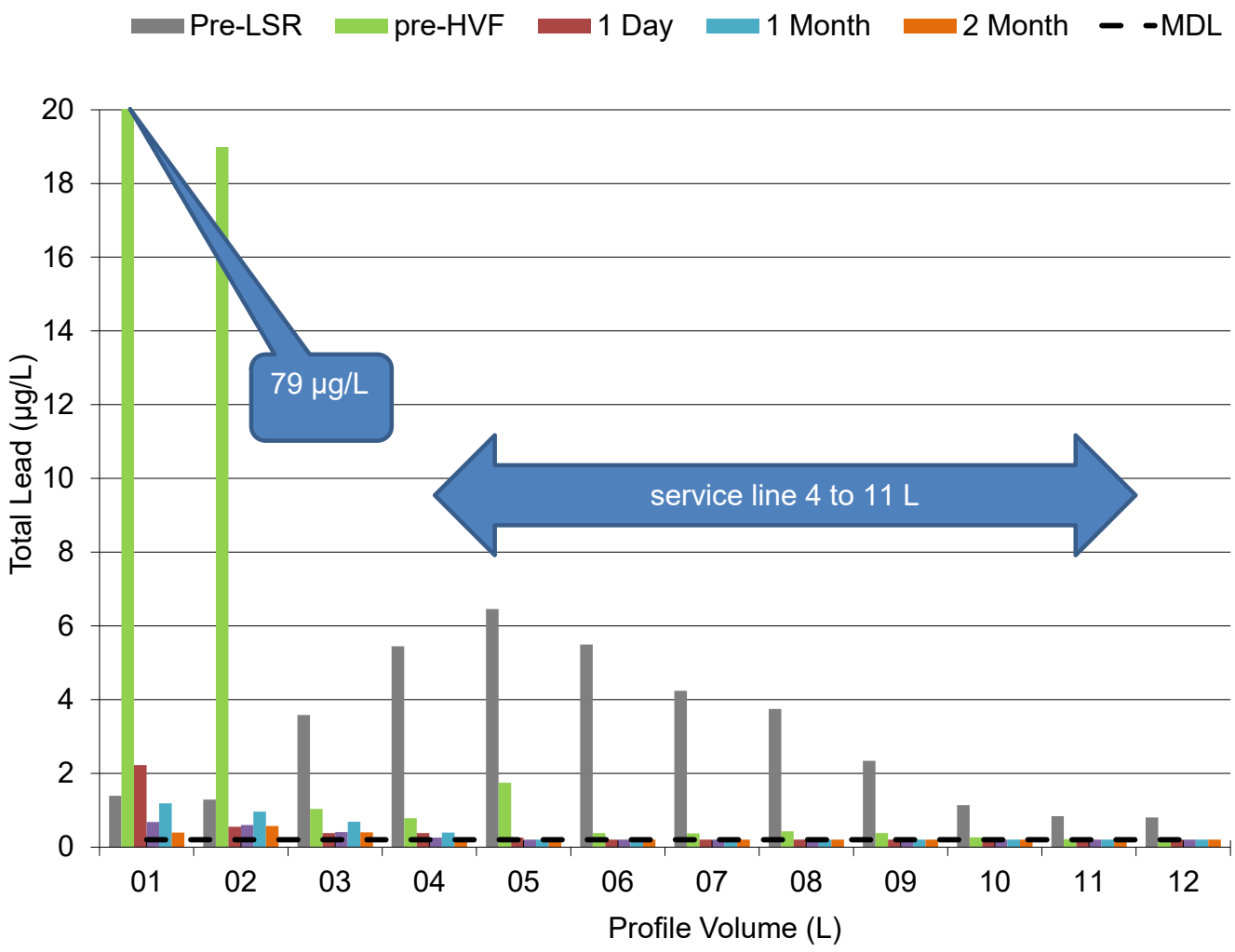
- It goes faster than you think
- Best results are two PEOPLE
  - ❑ one to collect
  - ❑ one to hand bottles
- Need lots of counter space
- In this study - >6 hr stagnation

WRF 4713 profile samples

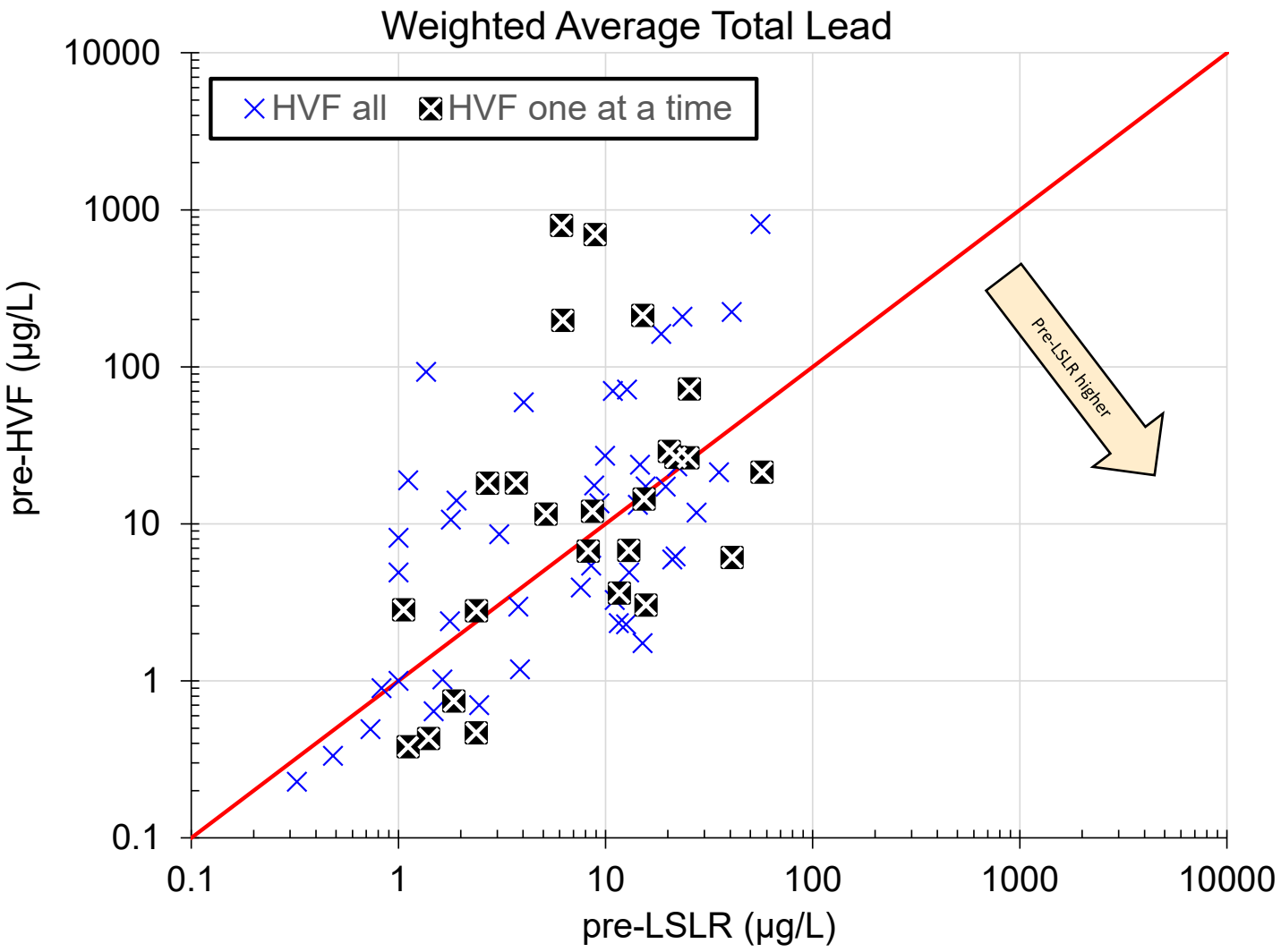
- Pre-LSLR
- Pre-HVF
- Post-HVF
  - ❑ 1 day
  - ❑ 30 day
  - ❑ 60 day
- Some PWS's voluntarily collected other profile samples (14, 90, 120 days)


Pre-LSR
MDL
Average = 3.1 µg/L
peak
Total Lead (µg/L)
20
18
16
14
12
10
8
6
4
2
0
1.4
1.3
3.6
5.4
6.5
5.5
4.2
3.7
2.3
1.1
0.8
0.8
01
02
03
04
05
06
07
08
09
10
11
12
Profile Volume (L)

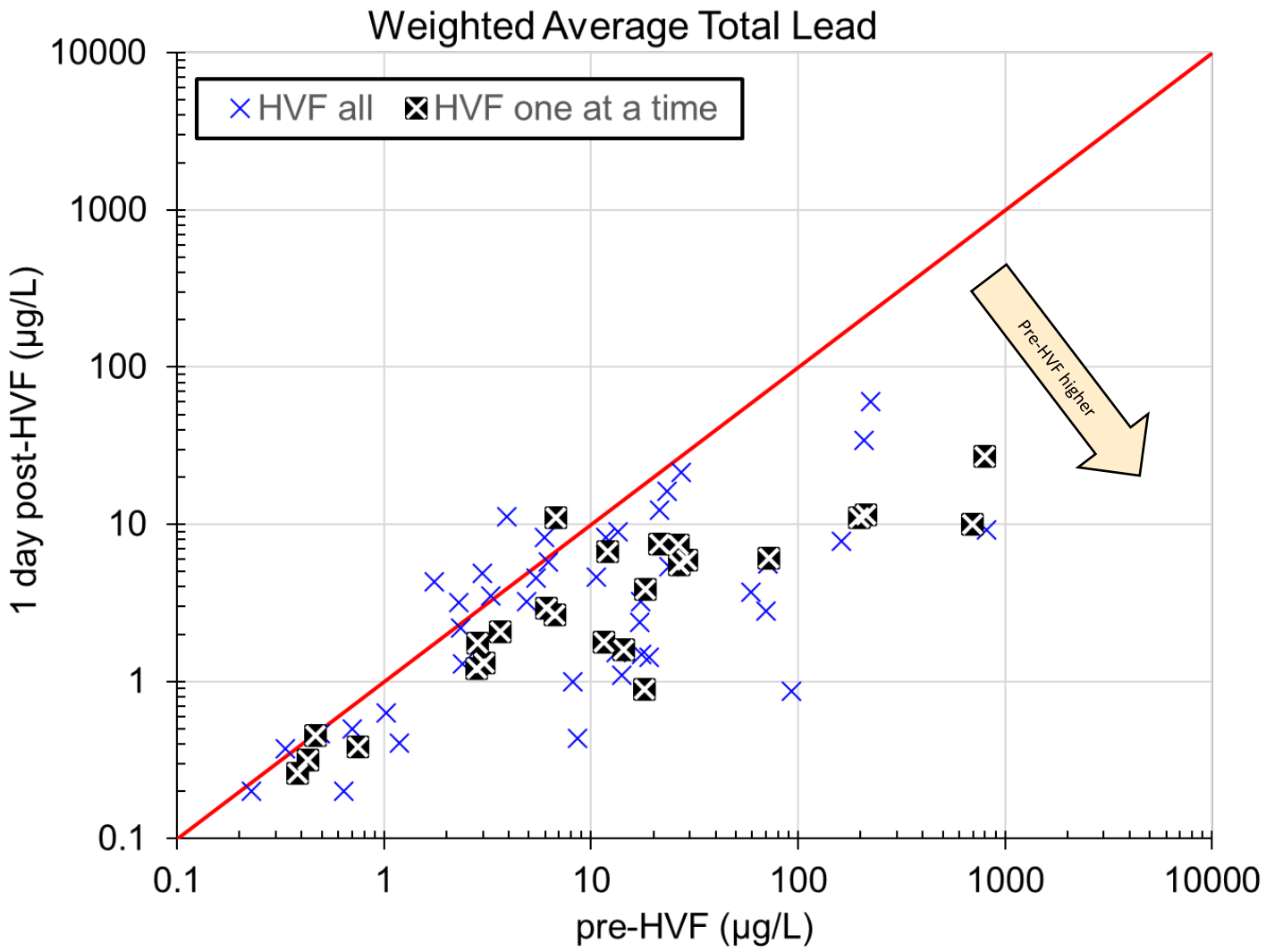
WRF 4713 profile



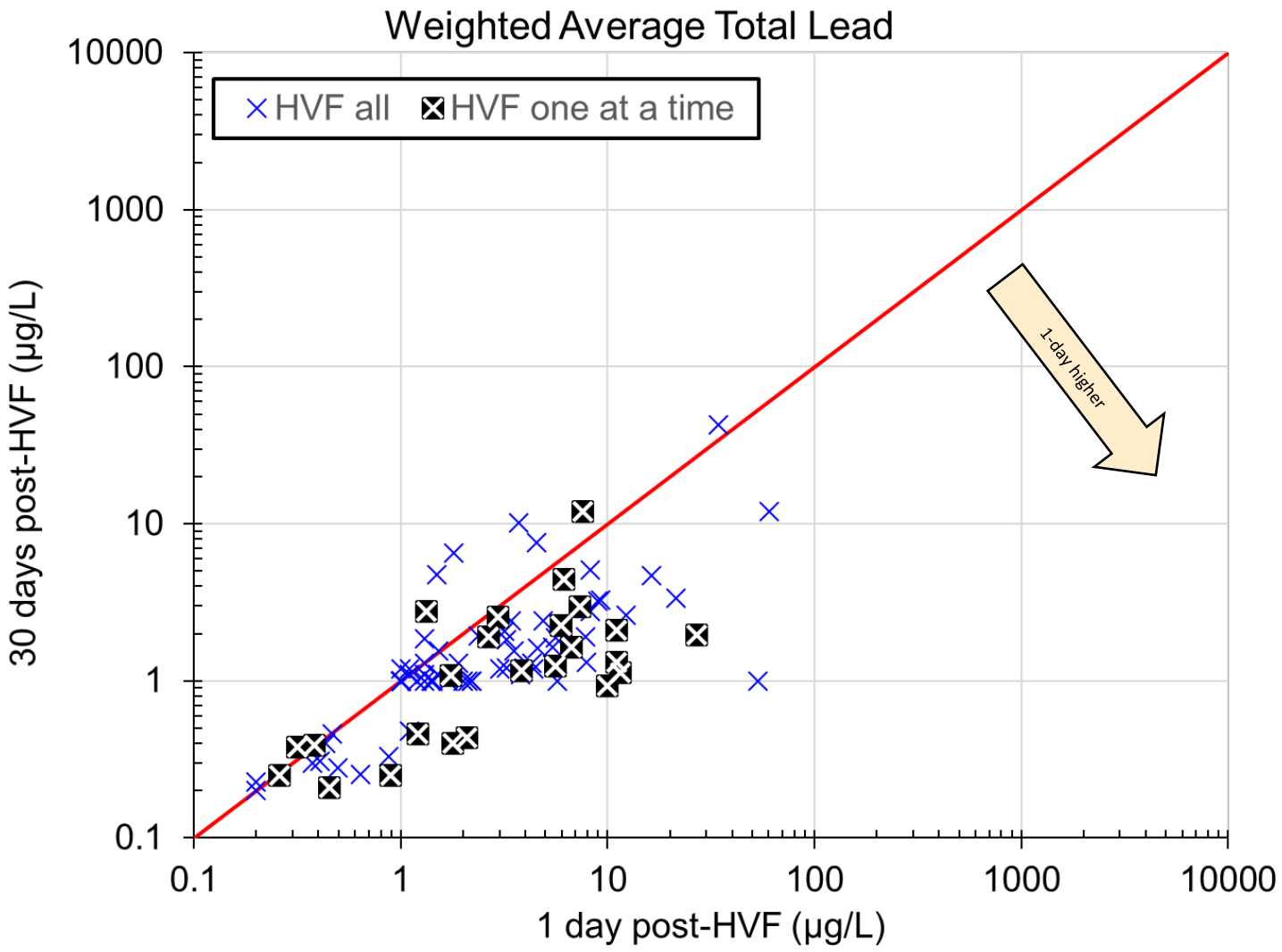
Average – Impact of FLSLR before HVF



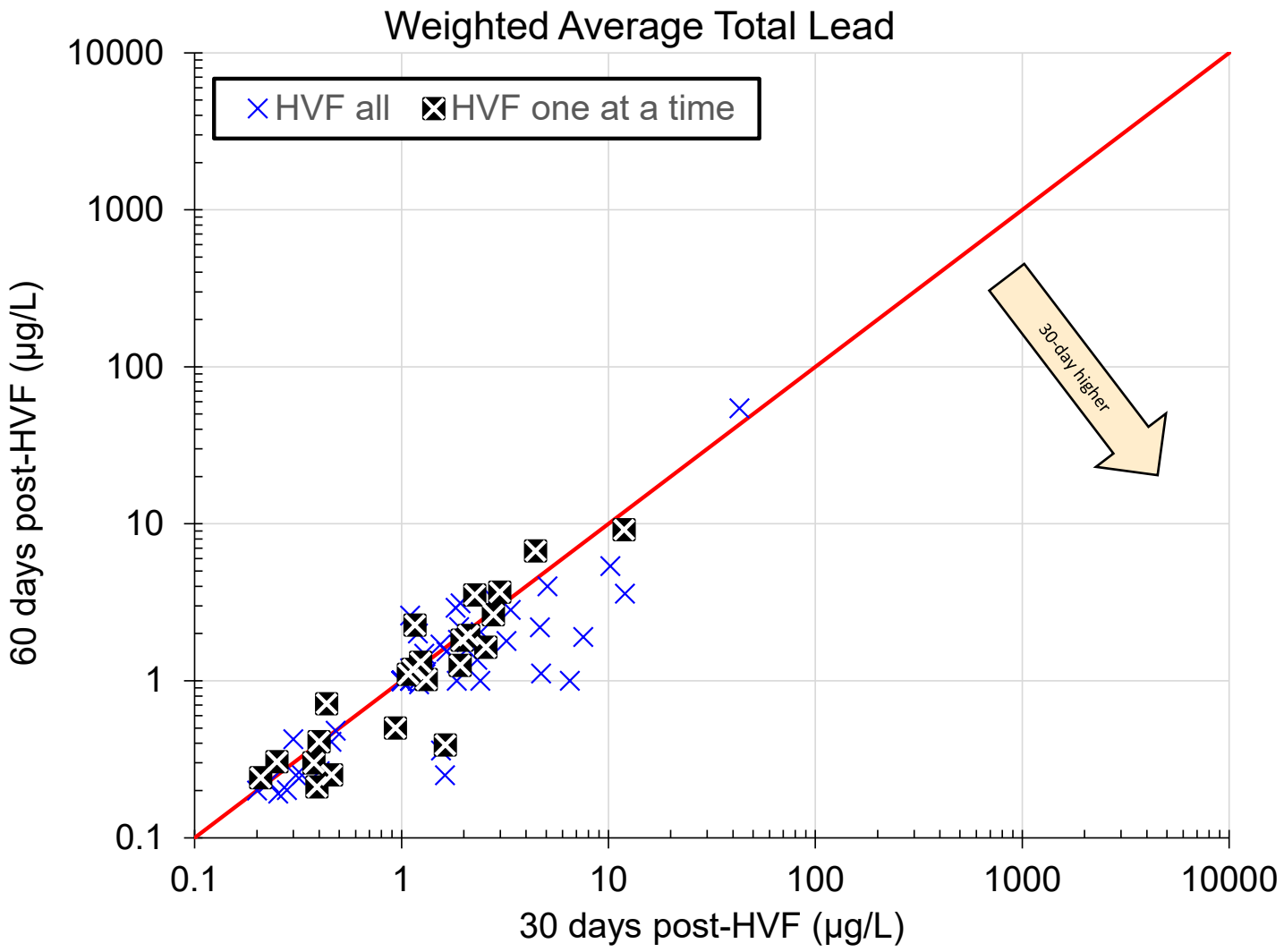
Average – Impact of 1 day post-HVF



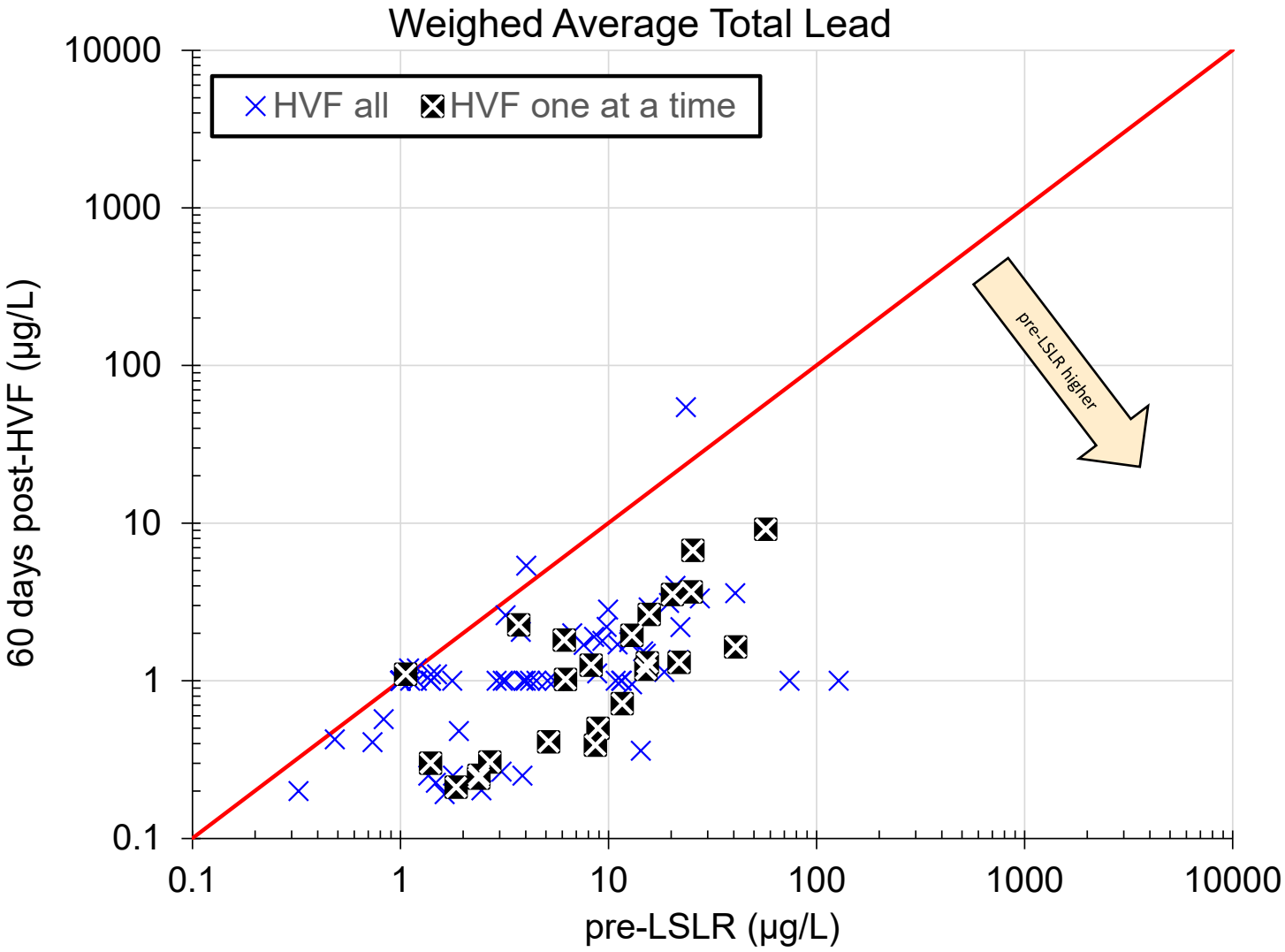
Average – Impact of 30 days post-HVF



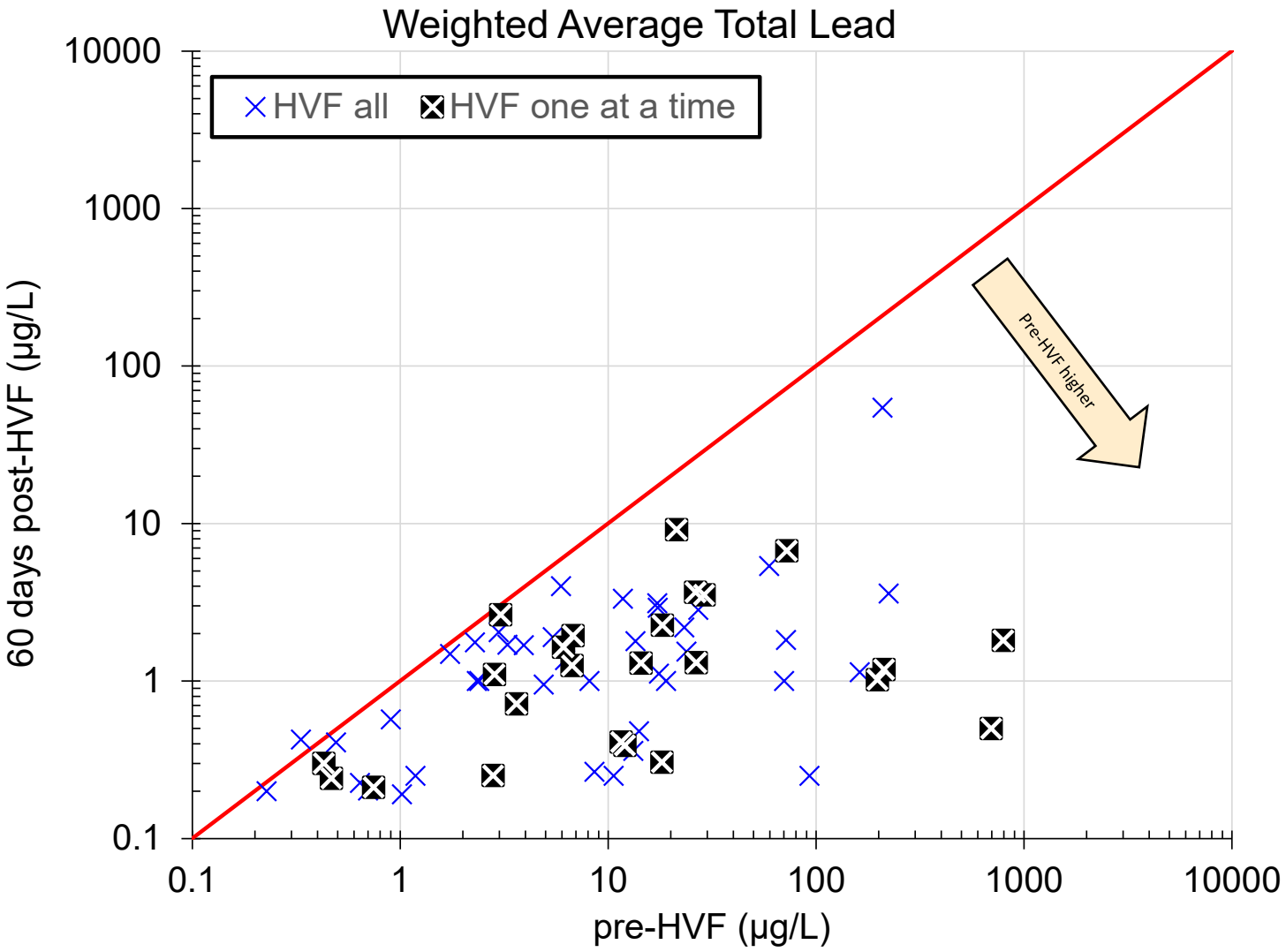
Average – Impact of 60 days post-HVF

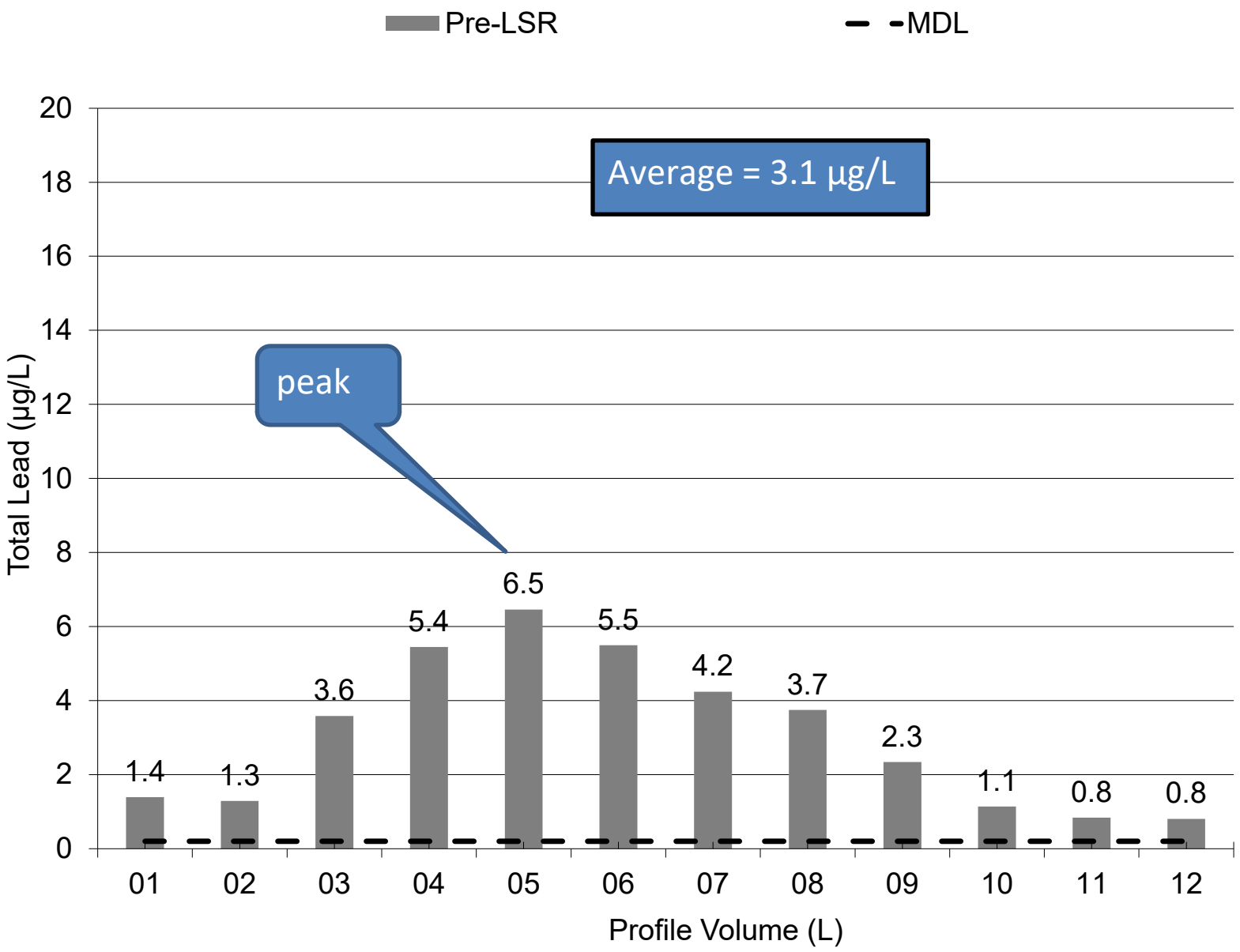


Average – Impact of FLSLR before HVF



Average – Impact of FLSLR before HVF

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Average = 3.1 µg/L
peak
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3.7
2.3
1.1
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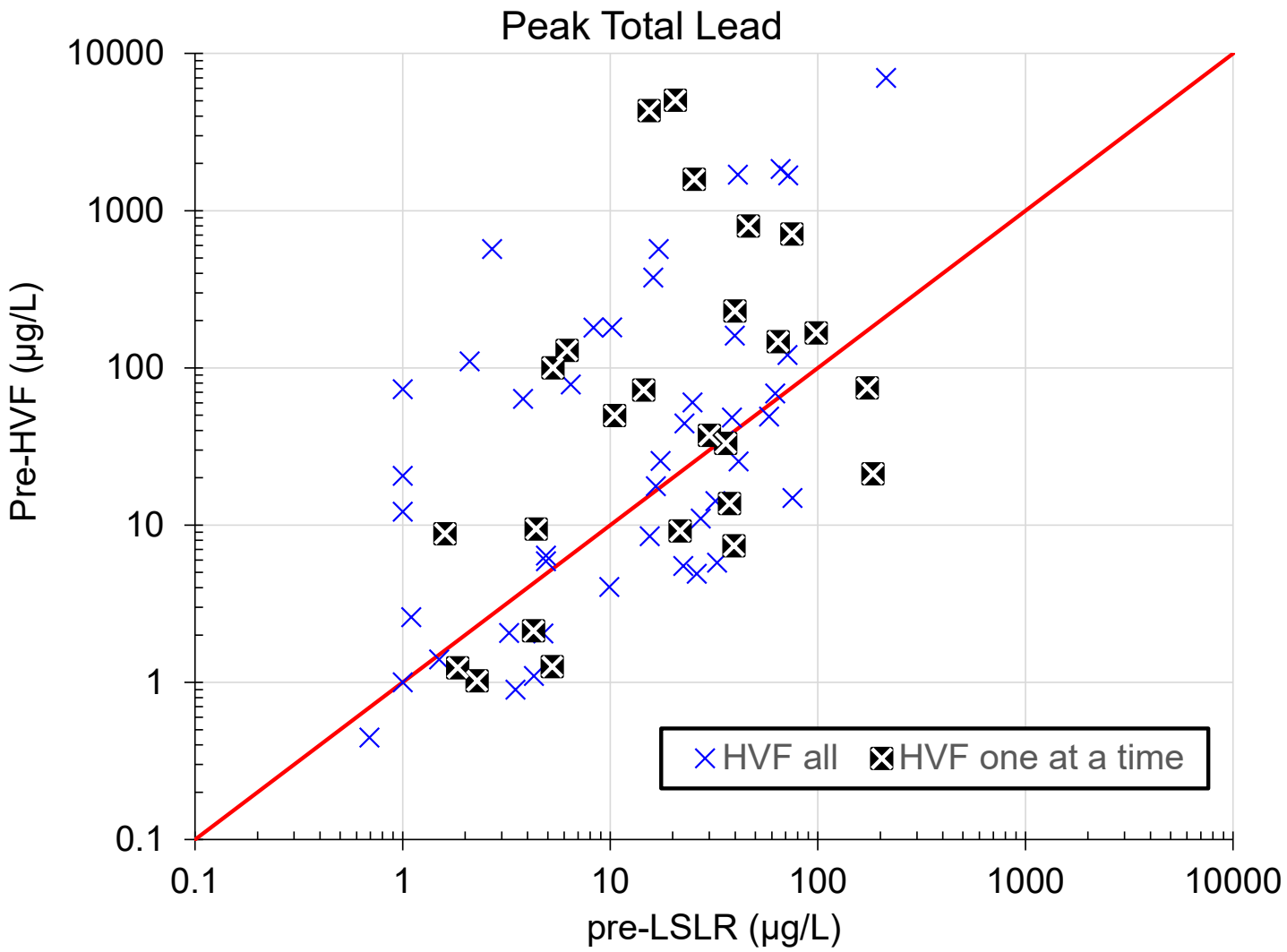
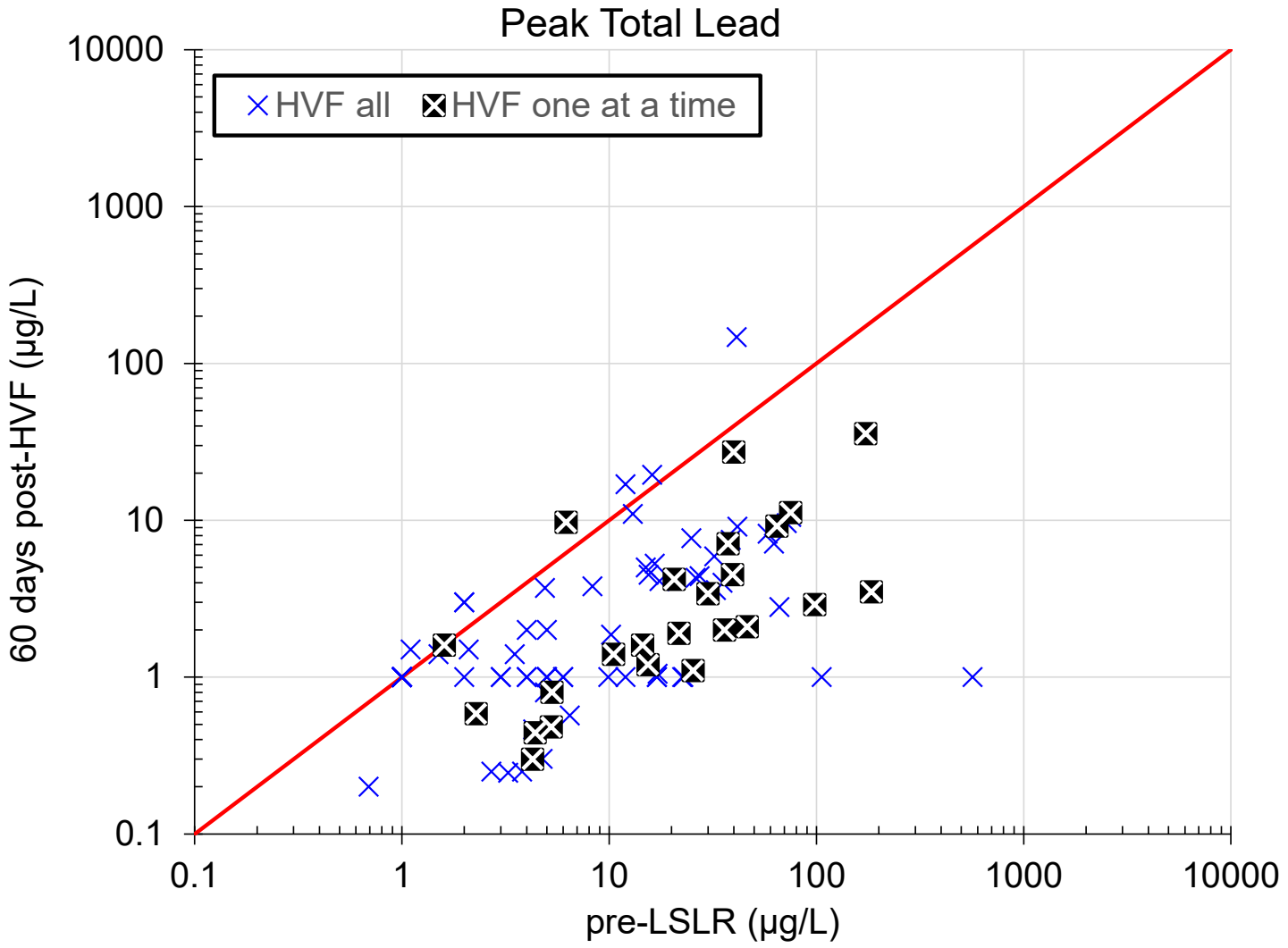
Profile Volume (L)

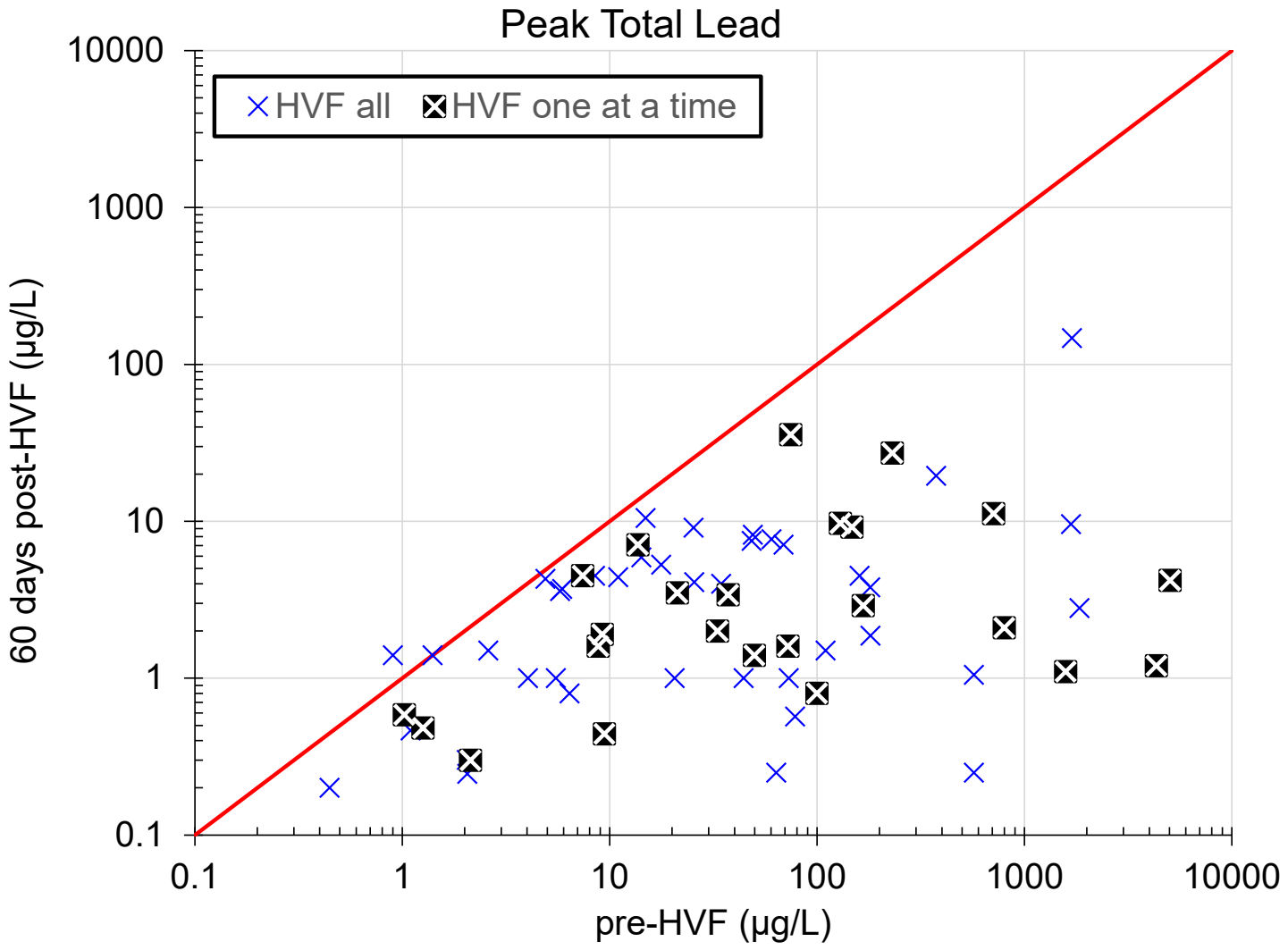
Peak – pre-LSLR vs. pre-HVF



Peak – pre-LSLR vs. 60 day



Peak – pre-HVF vs. 60 day



Improvement (Decrease) in Peak 60-Day Results Versus Pre-LSLR and Pre-HVF

Description	Peak total lead	
Pre-LSLR greater than 60 day data		
All data	76 of 94	81%
Pre-LSLR >10 µg of L	45 of 48	94%
Pre-LSLR ≤10 µg of L	31 of 46	67%
Pre-HVF greater than 60 day data		
All data	62 of 64	97%
Pre-HVF >10 µg of L	43 of 43	100%
Pre-HVF ≤10 µg of L	19 of 21	91%

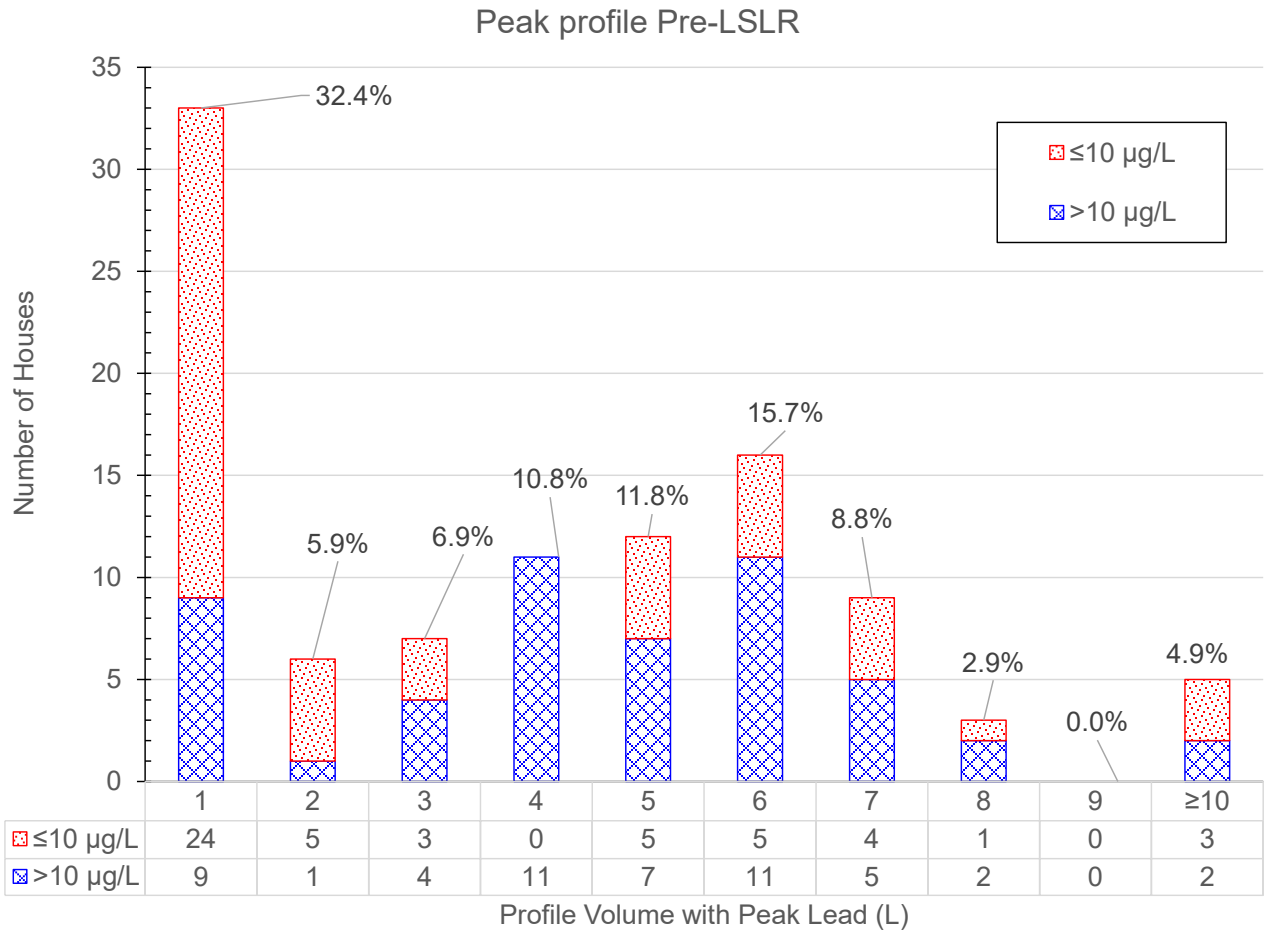
Mann-Whitney U Test Comparison - Profile Data

[α =0.05 (or 90% confidence interval)]

Comparison	Data Values	p-value	Is difference statistically significant?
Pre-LSLR vs. 60 day (paired)			
All data	94	<0.001	"Yes"
Method A (all taps)	70	<0.001	"Yes"
Method B (one at a time)	24	<0.001	"Yes"
Pre-HVF vs. 60 day (paired)			
All data	64	<0.001	"Yes"
Method A (all taps)	40	<0.001	"Yes"
Method B (one at a time)	24	<0.001	"Yes"
60 day vs. 60 day			
Method A vs Method B	70, 24	0.183	"No"

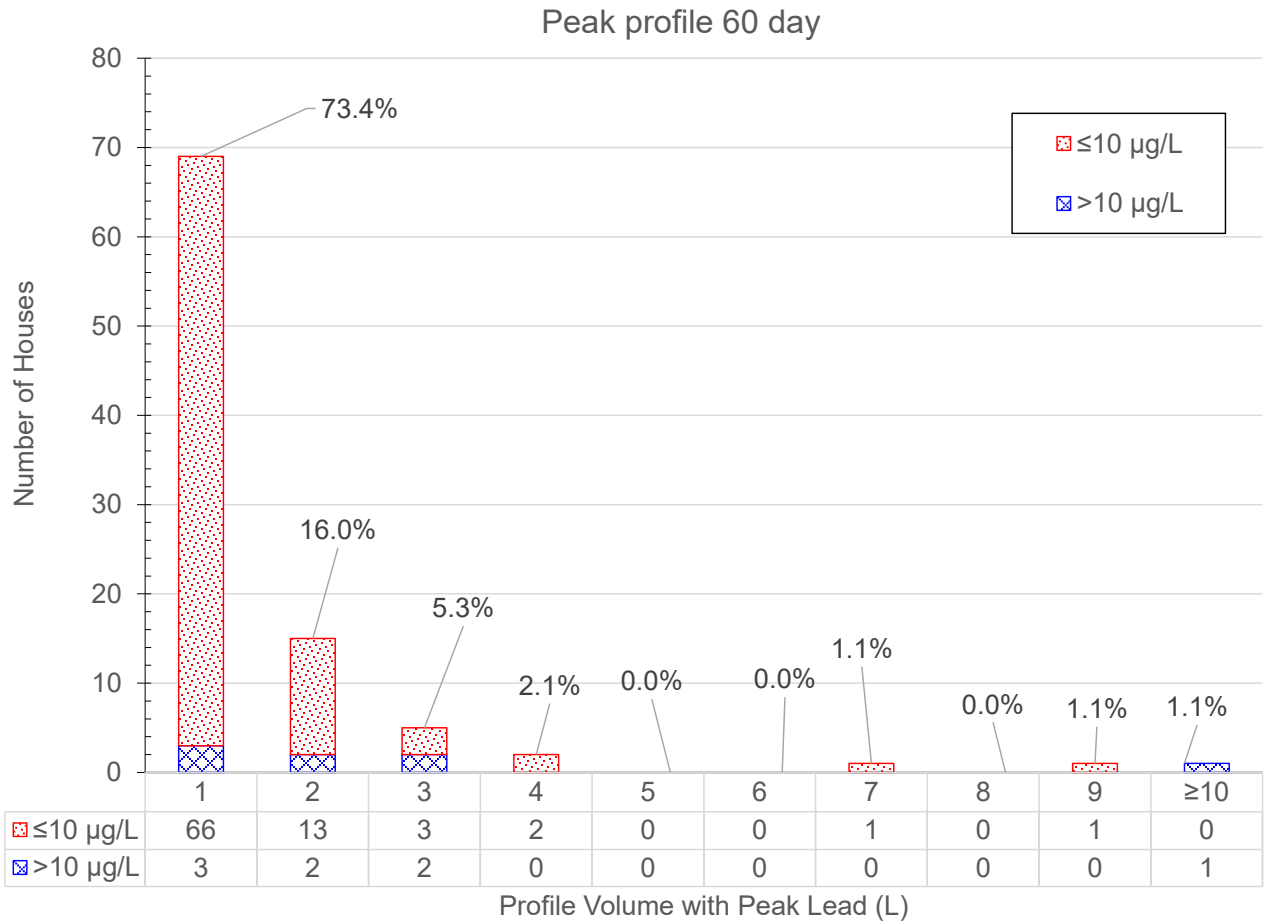
Shapiro-Wilks Normality test – "Not normal" for each evaluation

Peak Total Lead Occurrence - Pre-LSLR



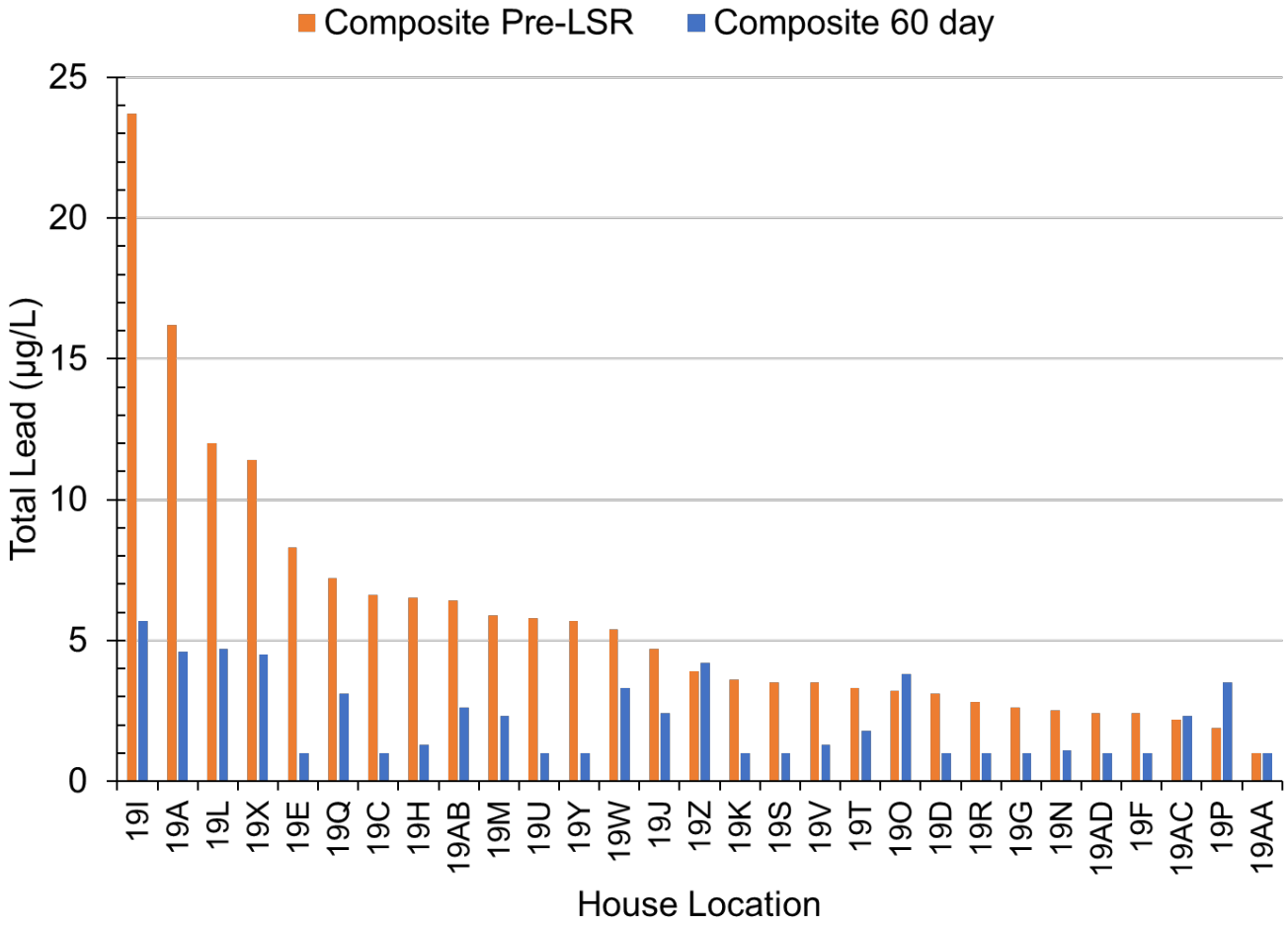
Profile Volume with Peak Lead (L)	1	2	3	4	5	6	7	8	9	≥10
≤10 µg/L	24	5	3	0	5	5	4	1	0	3
>10 µg/L	9	1	4	11	7	11	5	2	0	2

Peak Total Lead Occurrence - 60-day

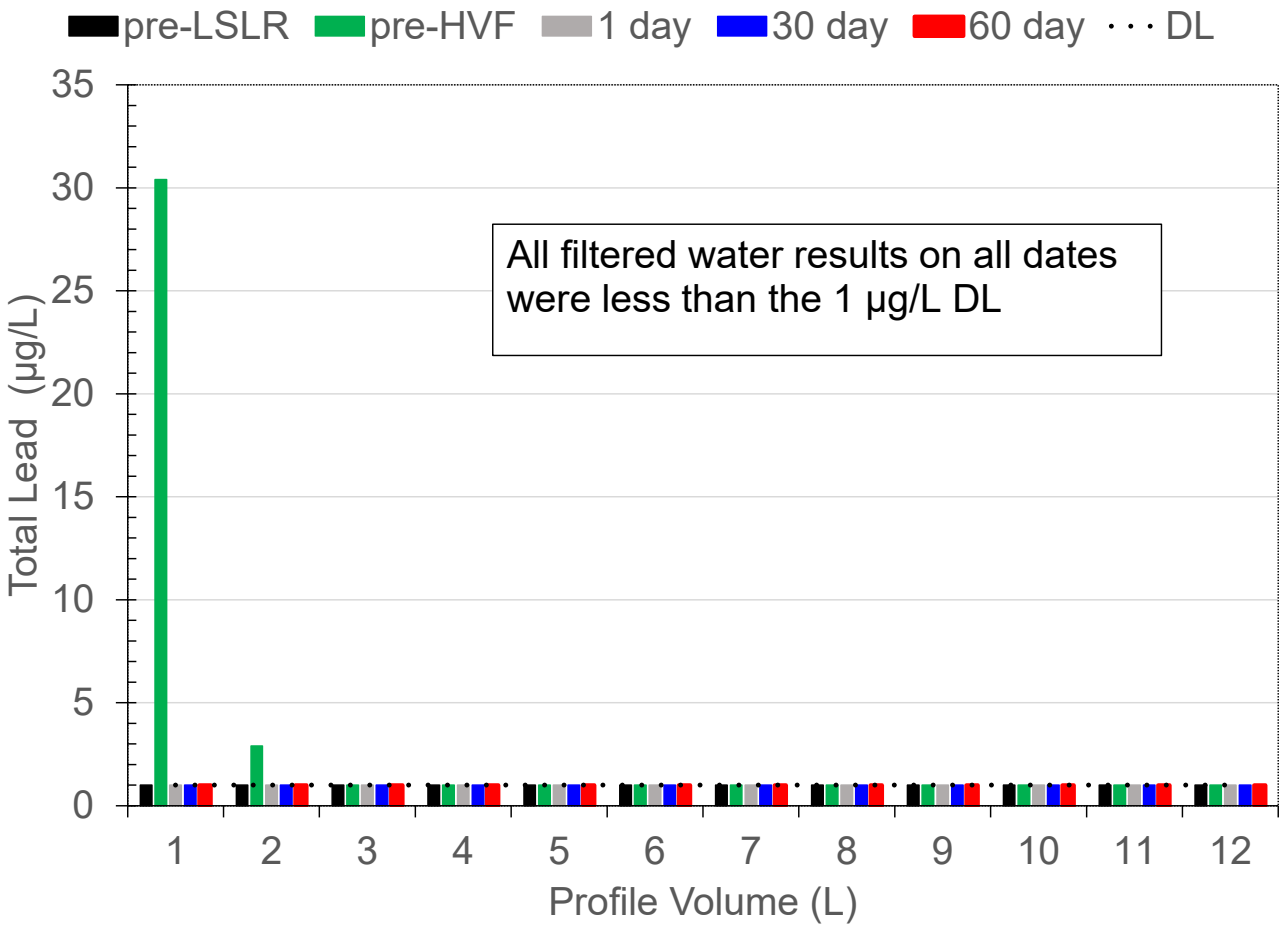


Profile Volume with Peak Lead (L)	1	2	3	4	5	6	7	8	9	≥10
≤10 µg/L	66	13	3	2	0	0	1	0	1	0
>10 µg/L	3	2	2	0	0	0	0	0	0	1

Composite Sample Results

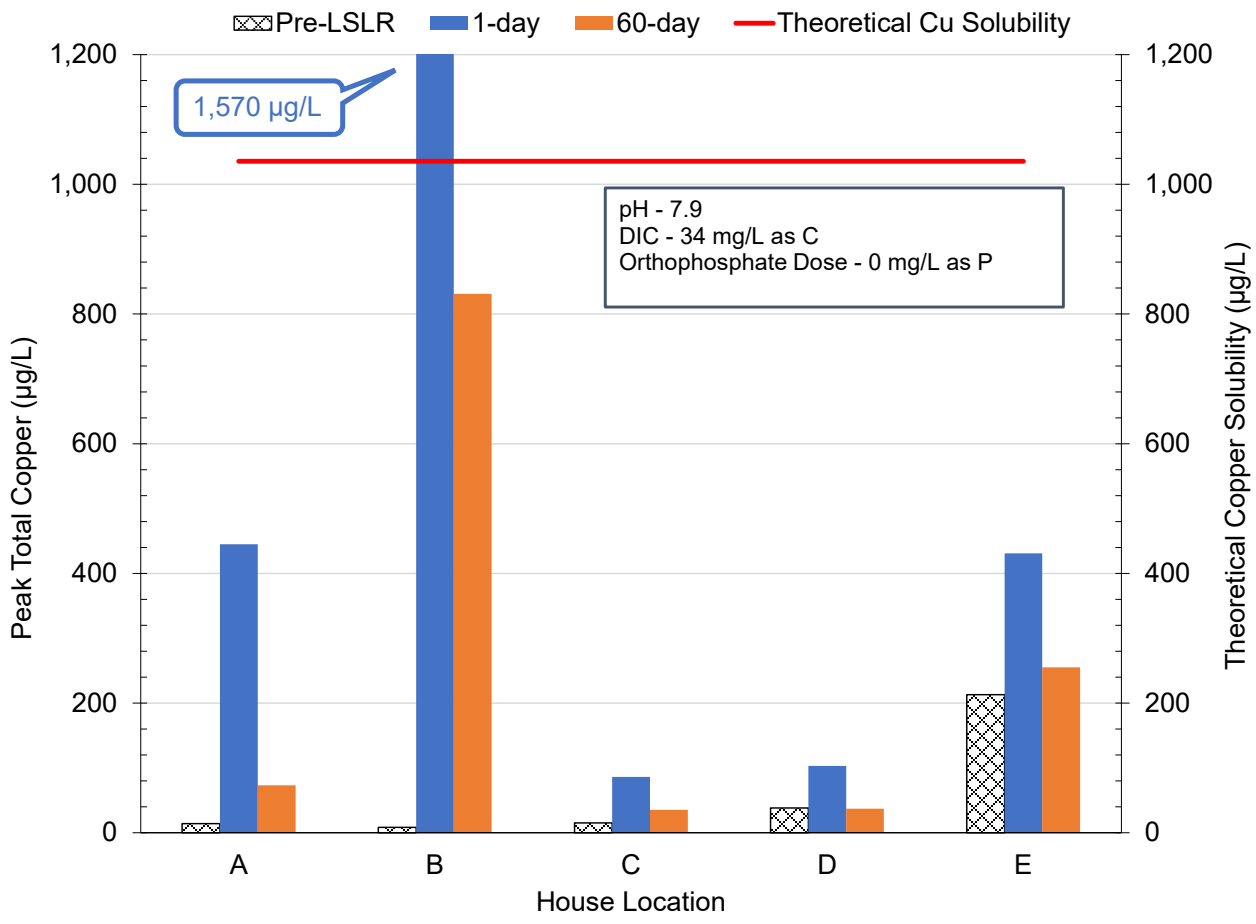


Galvanized Pipe with Lead Goosenecks



- 1 PWS
- 43 dates, 10 houses
- 512 samples
- 9 profile samples >DL
  - DL=1 µg/L
  - 6 are <2 µg/L
  - 7 were pre-HVF

Peak Measured Copper Versus Theoretical Copper Solubility (Lytle et al. 2018)



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WRF 4713 Field Studies

Conclusions and Recommendations

Field Study Summary

- HVF does remove materials either not removed by FLSLR or caused by FLSLR
  - WRF 4584 = same goes for PLSLR
- About 60% of houses had higher lead in pre-HVF than in pre-LSLR
- 1 day after HVF the total lead was lower than pre-HVF, 30 day was lower than 1 day, but 30 and 60 day were similar
- Results from Method A and B were similar
  - Mann-Whitney U Test, α=0.05
- LSLR combined with HVF can greatly “improve” peak total lead
  - But there still can be lead >10 µg/L (lead in premise plumbing)
- Presence of LSL does not necessarily always mean “high” lead
  - Peak total lead during pre-LSLR = 13% ≤ 1 µg/L, 20% ≤ 2µg/L
- New copper SL created elevated post-HVF copper

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Utility Experiences with FLSLR: EPCOR Water Canada

Jeff Charrois, PhD

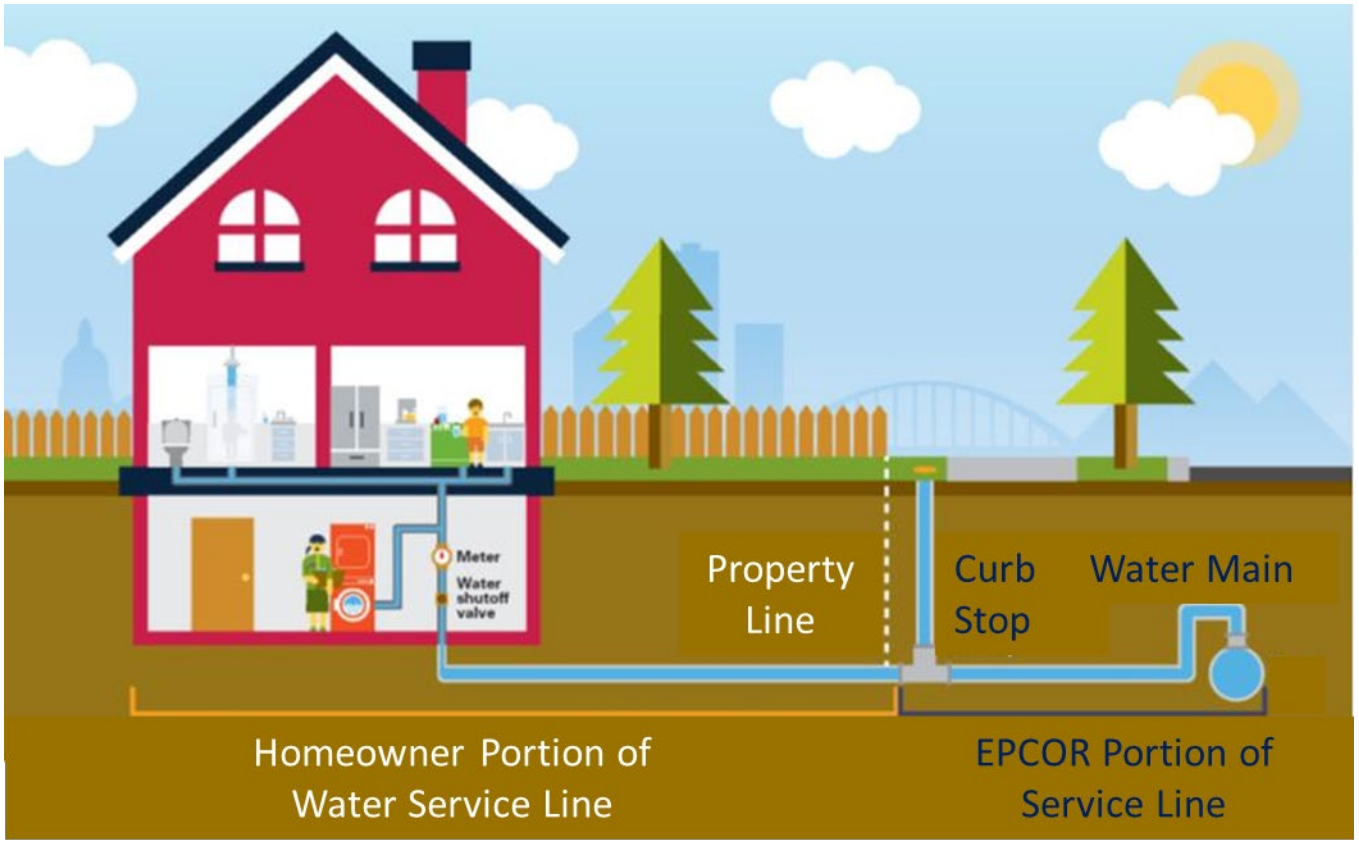
Senior Manager, Analytical Operations & Process Development

EPCOR

March 4, 2021

Lead Service Lines (LSLs) in Edmonton

- Approximately 4,450 homes have LSLs in Edmonton (1.6% of 270,000 total)
- LSLs were typically installed from 1910 – 1950 in single family residences
- Lead was not used for service lines for larger customers (schools, businesses)
- Shared ownership and responsibility for service line



Past EPCOR Lead Program

- EPCOR's lead program (since 2008) had focused on homes with LSLs and involved
  - annual notification
  - free lead testing
  - point-of-use filters, tips on maintaining water quality
  - utility LSL replacements
- EPCOR has been replacing utility-portion of LSLs since the 1970s
  - about 125 per year mainly due to repairs, water main renewal, and abandonments
  - Little emphasis on post-replacement flushing
- Any private-side LSL replacement was at owner's expense
  - about 40 per year, mostly due to infill construction

Alberta Government

AEP Guidance Document for Managing Lead in Municipal Drinking Water Systems in Alberta:

Phase 1 tools for utilities to plan, assess and implement lead management plans for 2020-2024

Aug 28, 2019

- New info on health effects
- MAC reduced from **10 µg/L to 5 µg/L**
  - ALARA goal
  - Compliance at the Tap

- Alberta Environment and Parks will require lead management plans from drinking water utilities in AB within 5 years.

Goals of EPCOR's Enhanced Lead Mitigation Strategy

Presented business case to City Council for a non-routine adjustment—Approved in July 2019

1. **Reduce public health risk due to exposure to lead in drinking water at the tap**
   - Minimize and eventually eliminate risk due to lead service lines
   - Minimize risk due to plumbing components
   - Protect all uses of drinking water in Edmonton and the 70 surrounding communities we serve
2. **Proactively meet the intent of Health Canada Guideline (5 µg/L)**
3. **Be prepared for Provincial regulation in 5 years**

Key Elements—Lead Mitigation Strategy

1. **Addition of a lead corrosion inhibitor to the Edmonton drinking water**
   - EPCOR will add orthophosphate to the treated drinking water to protect against lead release from all sources (LSLs and plumbing) throughout Edmonton and the region
2. **Elimination of Partial Lead Service Line Replacements / Utility Funding of Private Portion Replacements**
   - EPCOR will always replace the private portion of the LSL every time EPCOR initiates a replacement of the utility portion (emergency repairs or water main renewals)
3. **Accelerated Replacement of High Priority Lead Service Lines / Utility Funding of Private Portion Replacements**
   - EPCOR will replace any lead service lines (private and/or utility portion) where lead concentration at the tap is found to be greater than the new Health Canada MAC of 5 µg/L after orthophosphate addition

Need for High Velocity Flushing (HVF)

American Water Works Association

Dedicated to the World's Most Important Resource®

ANSI/AWWA C810-17
(First Edition)

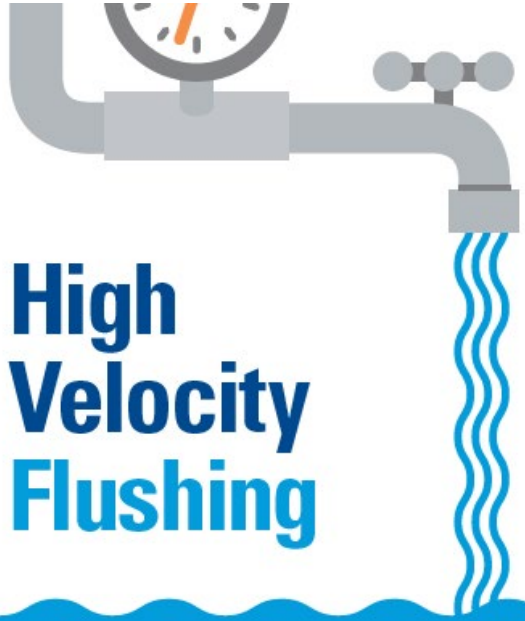
AWWA Standard

Replacement and Flushing of Lead Service Lines

Effective date: Nov. 1, 2017.
First edition approved by AWWA Board of Directors June 11, 2017.
This edition approved by AWWA Board of Directors June 11, 2017.
Approved by American National Standards Institute Sept. 1, 2017.

STANDARD Since 1881

ANSI



High Velocity Flushing

As a customer who has recently had a partial or full lead service line replacement, it is critical that you flush your drinking water pipes to ensure scale and displaced lead particles are removed.

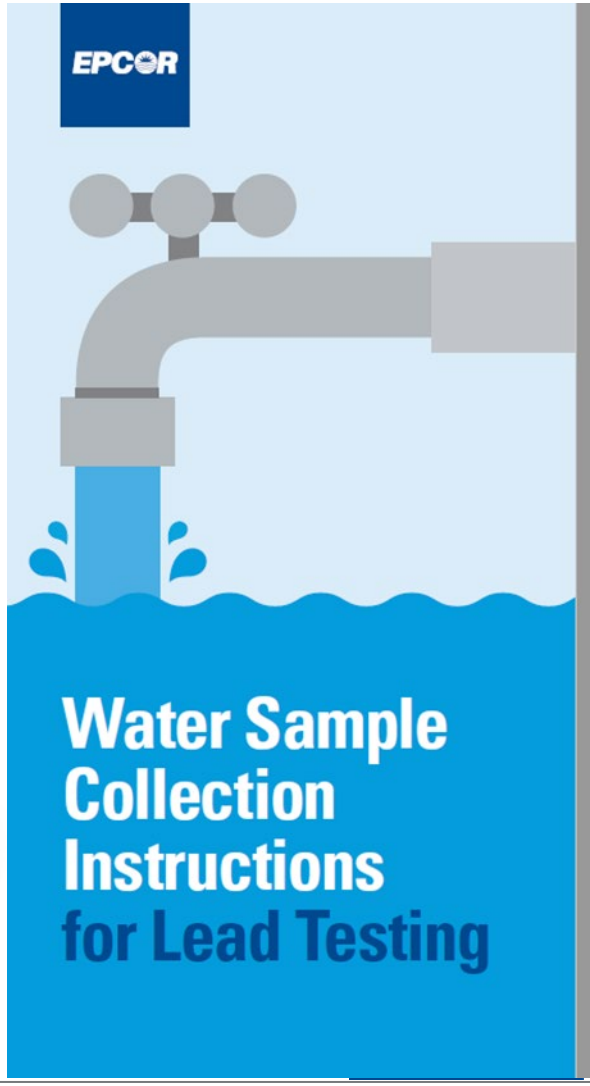
EPCOR

EPCOR's Care Package

- Use water quality kit until sampling confirms lead levels are down
- Coming in 2021 "How to home sample" video for customers

BOX CONTENTS

- ☐ Brita Pitcher
- ☐ Filter cartridge certified for lead removal
- ☐ Lead Brochure
- ☐ Health Canada one-pager
- ☐ High Velocity Flushing instructions

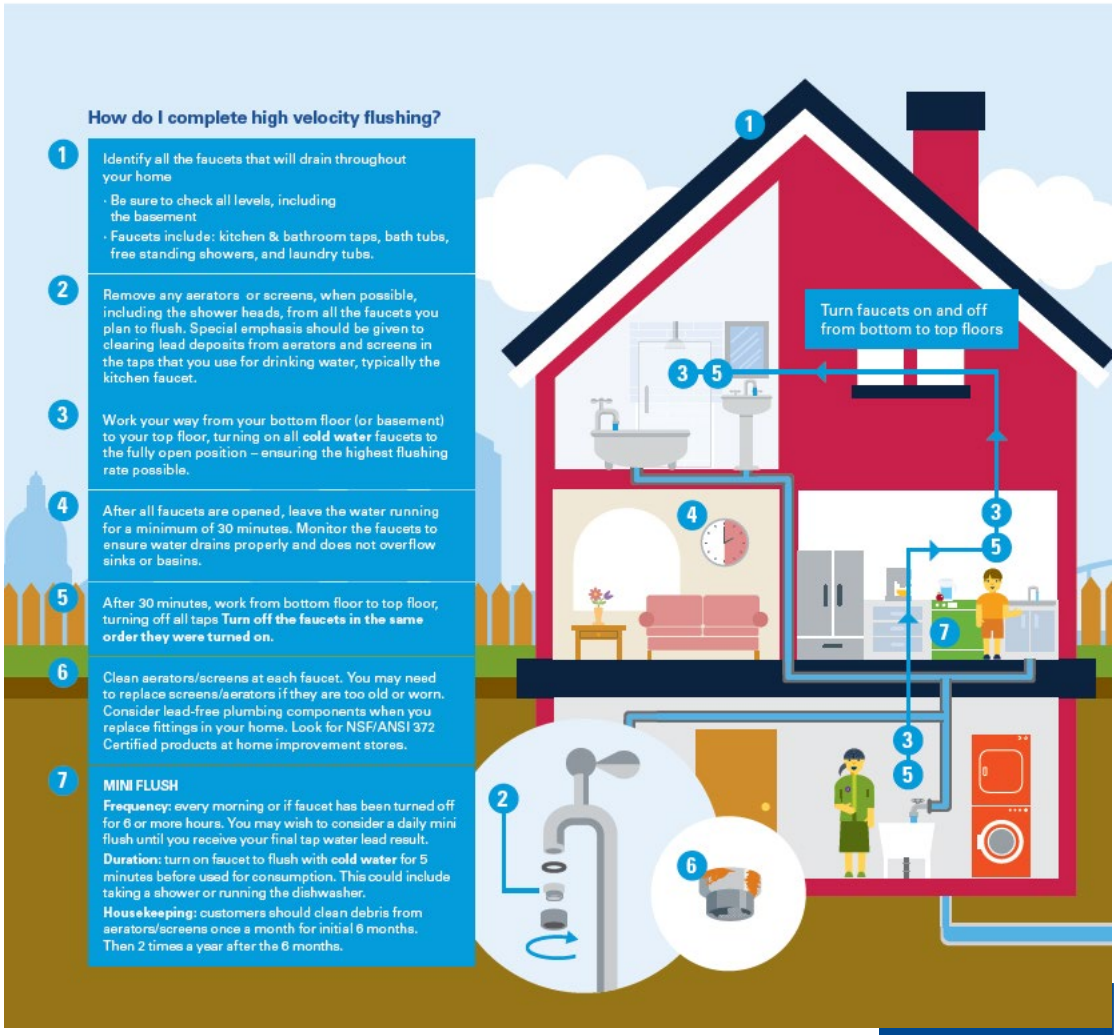


HVF Key Learnings

- Customer engagement takes time to do things right
  - A lot of coordination on-site required
  - Resident vs owner challenges
  - Fear of scams
- Post LSL replacement, lead concentrations can increase at the customers' tap
- **HVF is effective at removing particulate lead from premise plumbing and reducing lead at the tap**
- Possibly >6 months of working with customer (follow-up testing; additional flushing may be required)

Final Thoughts

- EPCOR's Enhanced Lead Mitigation Strategy is a comprehensive program that will enable EPCOR to be proactive and meet the Health Canada Guideline, **at the tap**, for drinking water quality by fully incorporating health, social, environmental and financial considerations



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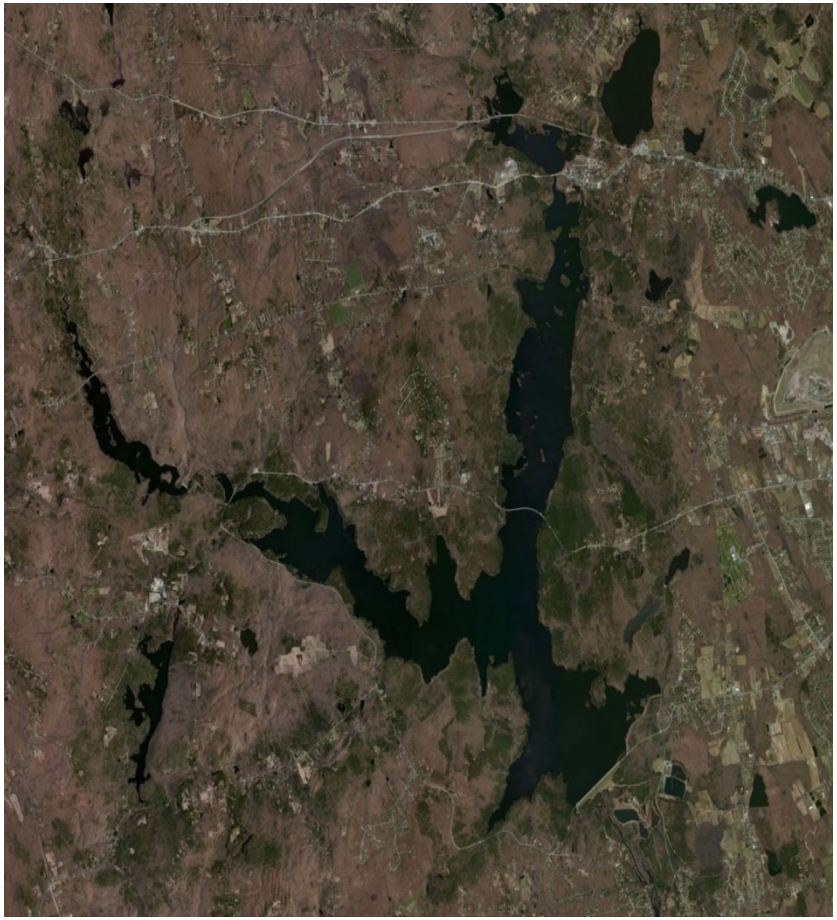
WRF 4713
Providence Water Case Study

WRF WEBCAST – MARCH 4, 2021

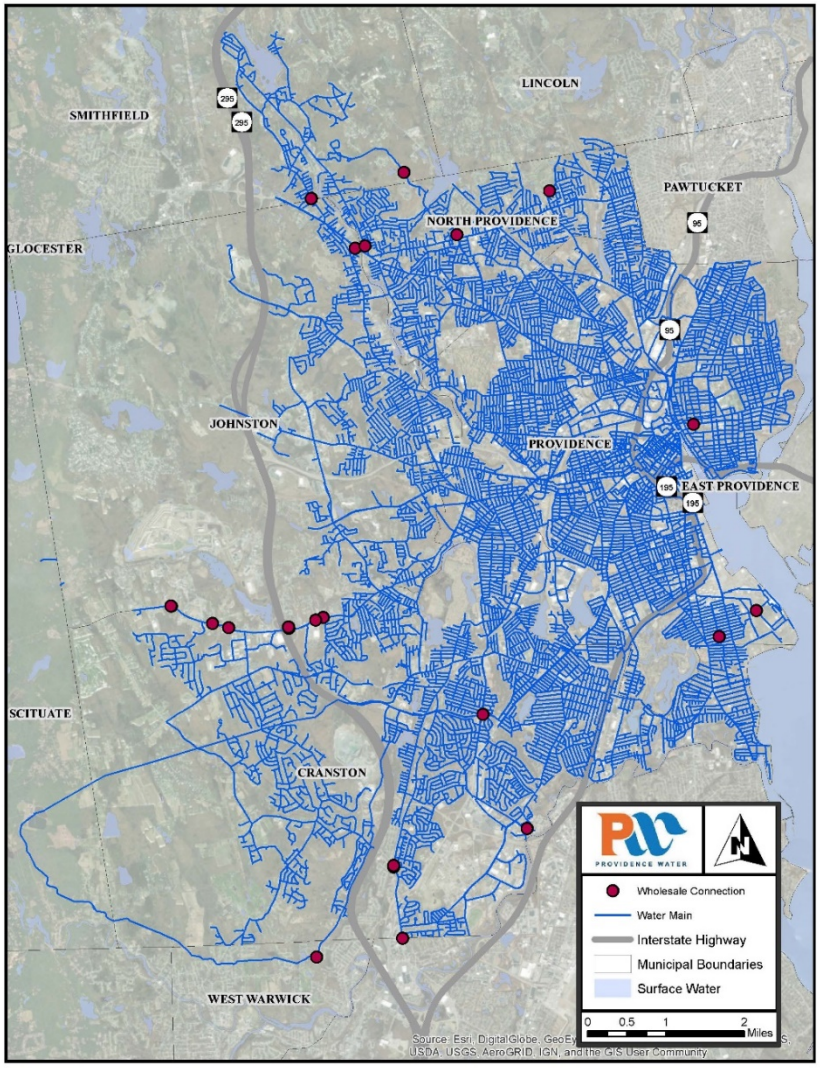
Kathy Mello
Providence Water

Providence Water- Source of Supply



Supply Source:	Scituate Reservoir & Five Tributary
Watershed Area:	93 Square Miles
Watershed Area Owned:	28 Square Miles
Storage Capacity:	40 Billion Gallons
Average Amount of Water Treated Per Day:	60 Million Gallons

Providence Water- System Overview



TRANSMISSION & DISTRIBUTION

Size of Pipes:	6 inches to 102 inches in diameter
Pipe Materials:	Cast Iron, Ductile Iron, Steel, Asbestos Cement and Concrete
Total Length of Pipe:	1,030 Miles
Storage Tanks & Total Volume:	6, 120 MG
Pumping Stations:	12
Pressure Zones:	10
Service Connections:	76,500
Valves:	14,500
Fire Hydrants:	6,300

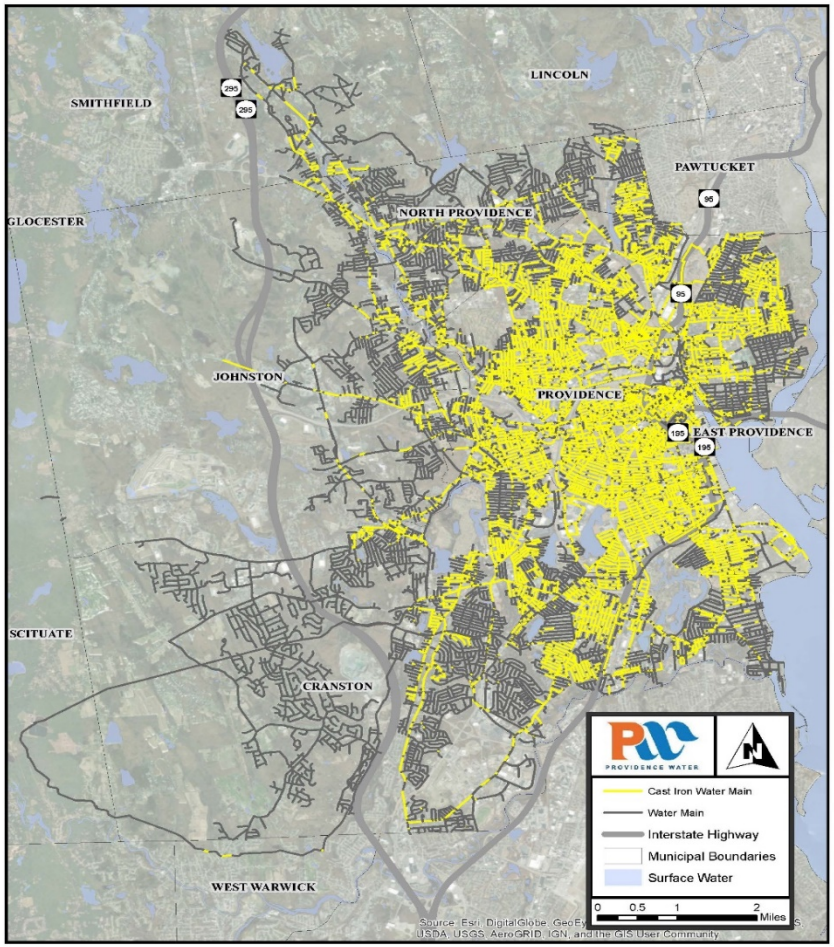
WHOLESALE CUSTOMERS

- Kent County Water
- Bristol County Water
- Greenville Water
- Smithfield
- East Providence
- Warwick
- Lincoln

RETAIL CUSTOMERS

- Cranston
- Providence
- North Providence
- Smithfield
- Johnston

Providence Water- Distribution



Unlined Cast-Iron Pipes: **470 Miles (50% of total piping)**

Approximate Total Services: **76,500**

Approximate Total Full LSLs: **10,400**

Approximate Total Private Side LSLs: **16,500**

PW's Approach to Reducing Lead

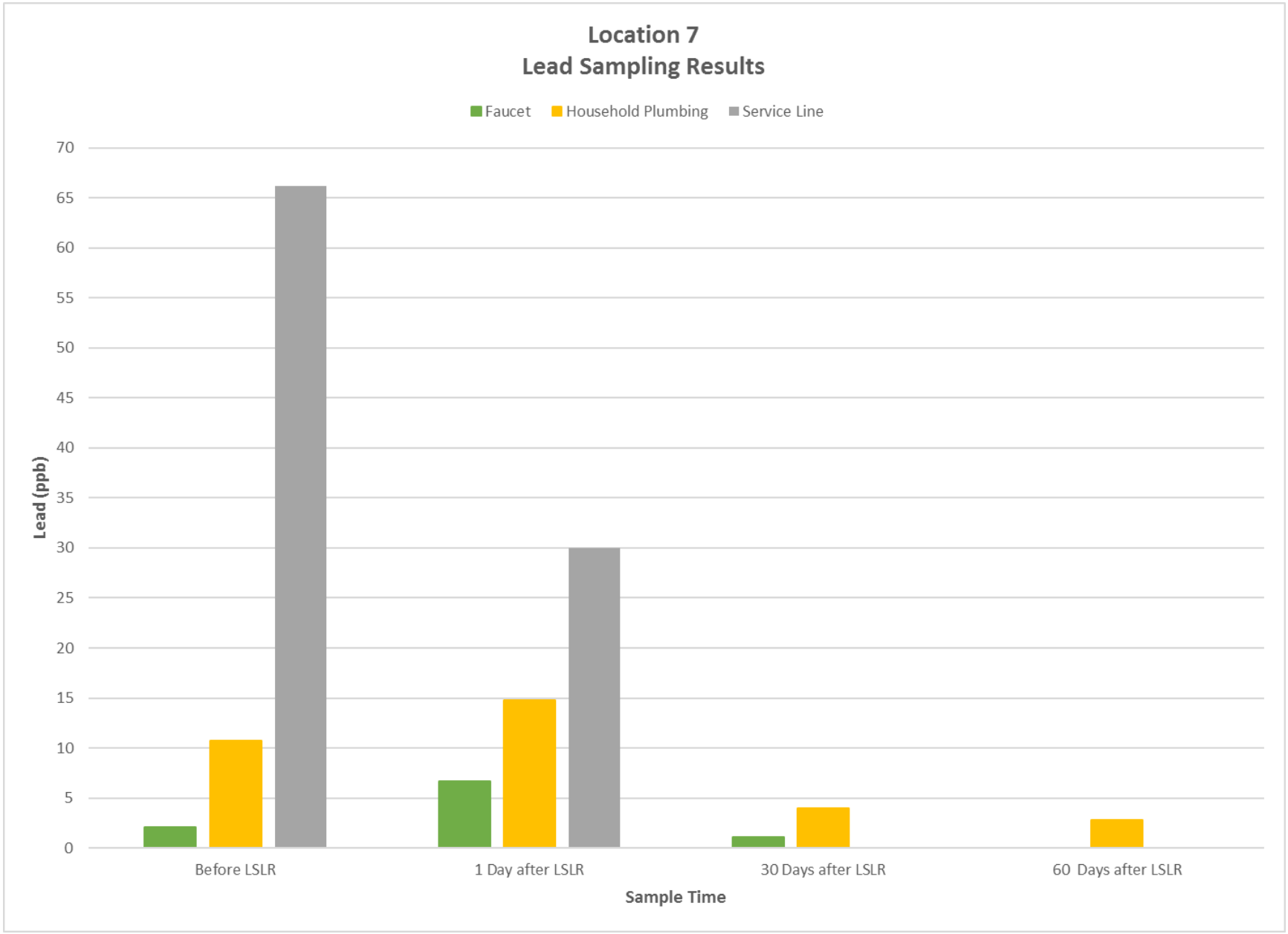
- Lead Service Line Replacements
- Water Main Rehabilitation
- Corrosion Control Treatment
- Public Education
- Unidirectional Flushing

PW's Current LSLR Practices

- Written notification (pre-construction)
- Post-construction premise plumbing flushing instructions
- NSF 53 Filter distribution
- Post-construction samples
- Follow-up communications

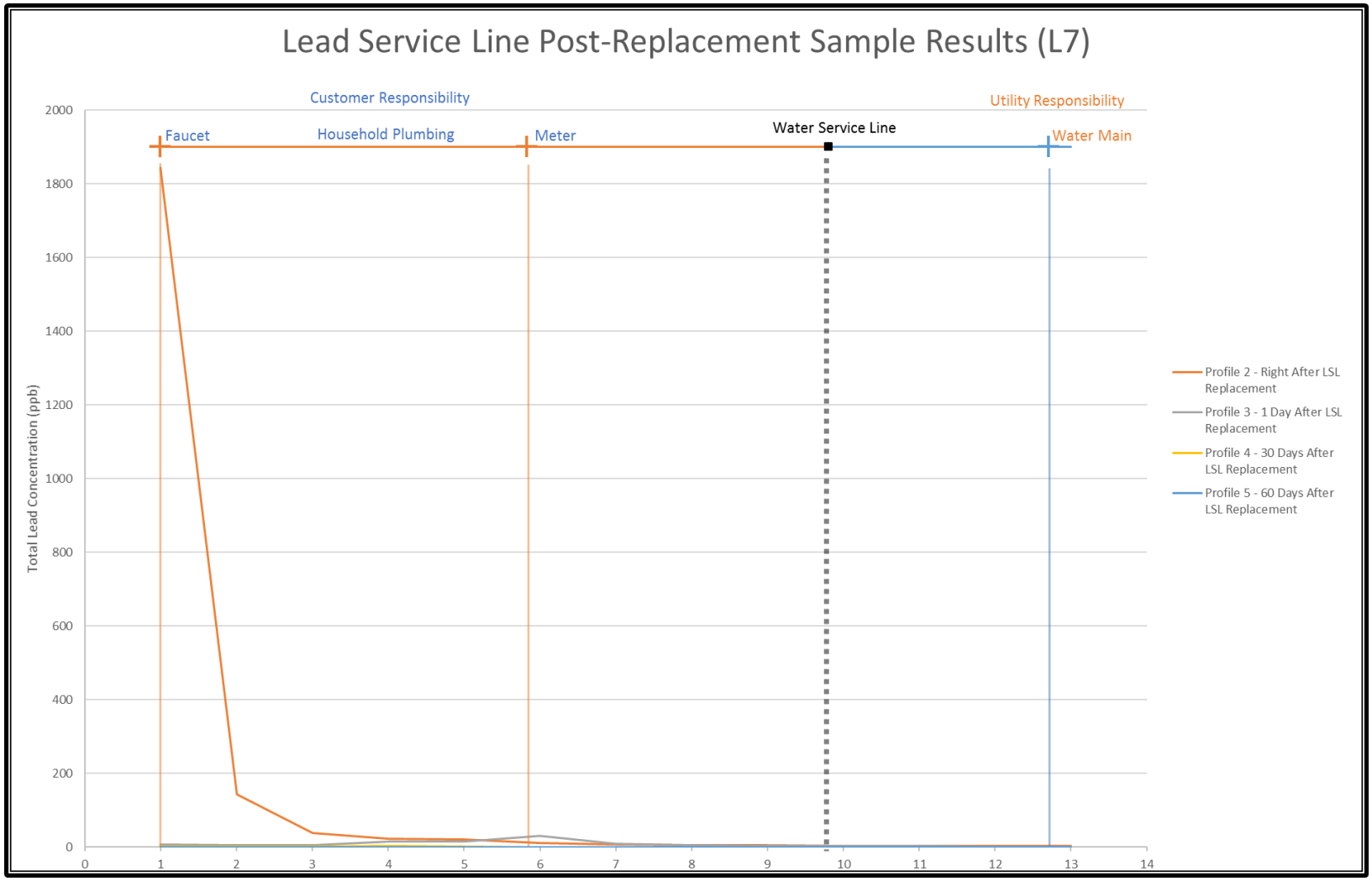
WRF 4713 – PW Challenges

- Customer participation
- Ambitious proposal
  - Preconstruction work
  - Full LSLR
- Pre HVF samples
- Follow-up communications with customers



WRF 4713 – PW Lessons Learned

Impact of HVF



WRF 4713 – PW Lessons Learned

- Orthophosphate versus pH/alkalinity passivation
- Additional metals sampling
- Composite sampling
- Identification of lead sources

Acknowledgements

- WRF
- Cornwell Engineering Group, Inc.
- Arcadis
- CDM Smith

THE Water Research FOUNDATION

Thank You

Comments or questions, please contact:

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THE Water Research FOUNDATION

WRF 4713: Full LSLR Guidance Case Studies

Rebecca Slabaugh, Arcadis

March 4, 2021

WRF 4713 Case Studies

Objective

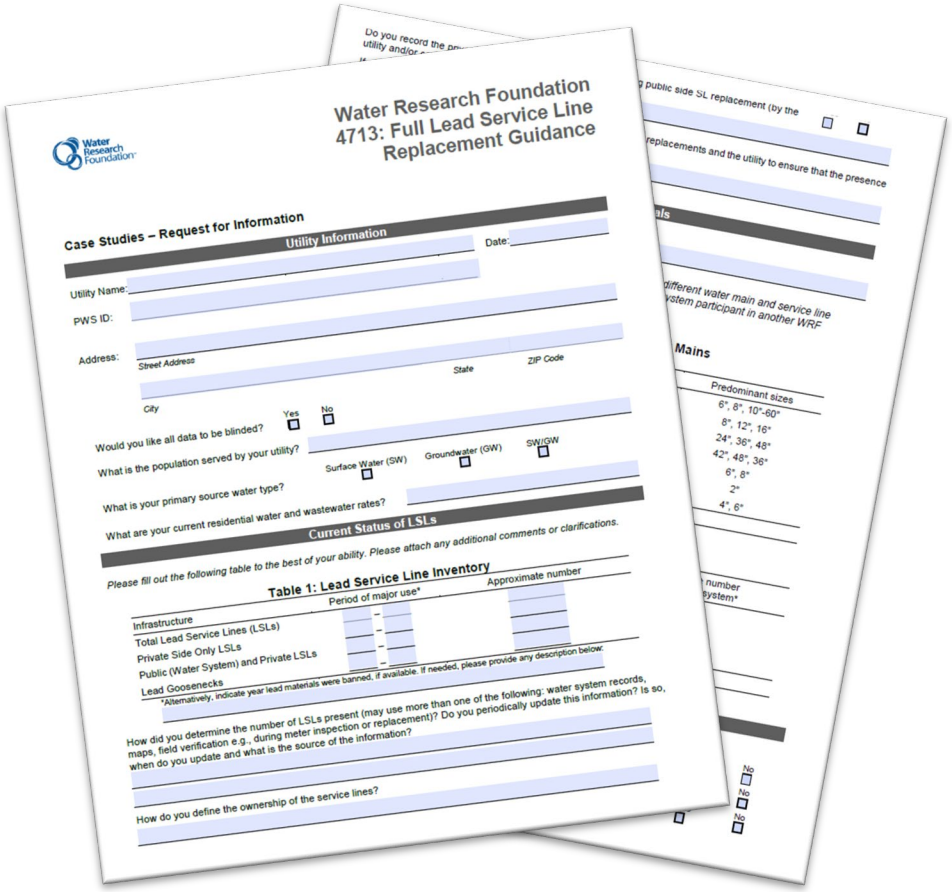
Identify trends and summarize protocols, successes, and challenges, amongst public water systems (PWSs) that have conducted full LSL replacements

Participating Systems

- **16 PWSs Participated**
  - 4 did not participate in field studies
- **System Characteristics**
  - Most surface water treatment (2 groundwater)
  - All except 2 practice corrosion control treatment (CCT)

Case Study Approach

- Initial Questionnaire
  - Background
  - Distribution System Materials
  - Water Quality
  - LSLR Program
    - Schedule and Goals
    - Funding and Financing
    - Utility Practices (Sampling, Flushing, Filters, Customer Coordination)
- Series of Follow-Up Calls


Water Research Foundation
4713: Full Lead Service Line Replacement Guidance

Case Studies – Request for Information

Utility Information

Utility Name: Date:

PWS ID:

Address: Street Address State ZIP Code

City

Would you like all data to be blinded? Yes No

What is the population served by your utility?

What is your primary source water type? Surface Water (SW) Groundwater (GW) SW/GW

What are your current residential water and wastewater rates?

Current Status of LSLs

Please fill out the following table to the best of your ability. Please attach any additional comments or clarifications.

Table 1: Lead Service Line Inventory

Infrastructure	Period of major use*	Approximate number
Total Lead Service Lines (LSLs)	–	
Private Side Only LSLs	–	
Public (Water System) and Private LSLs	–	
Lead Goosenecks	–	

*Alternatively, indicate year lead materials were banned, if available. If needed, please provide any description below.

How did you determine the number of LSLs present (may use more than one of the following: water system records, maps, field verification e.g., during meter inspection or replacement)? Do you periodically update this information? If so, when do you update and what is the source of the information?

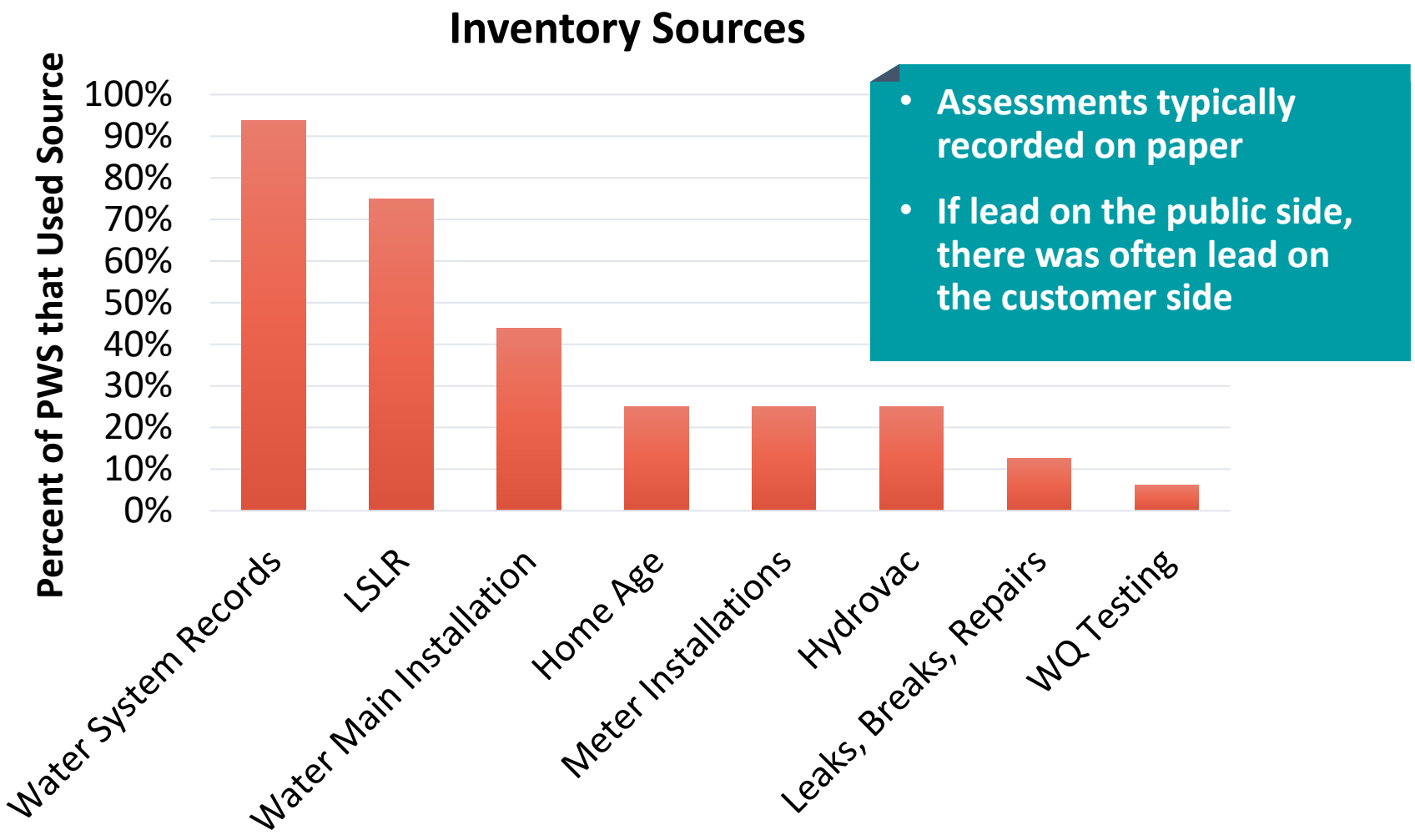
How do you define the ownership of the service lines?

Mains

Predominant sizes

6", 8", 10"-60"
8", 12", 16"
24", 36", 48"
42", 48", 36"
6", 8"
2"
4", 6"

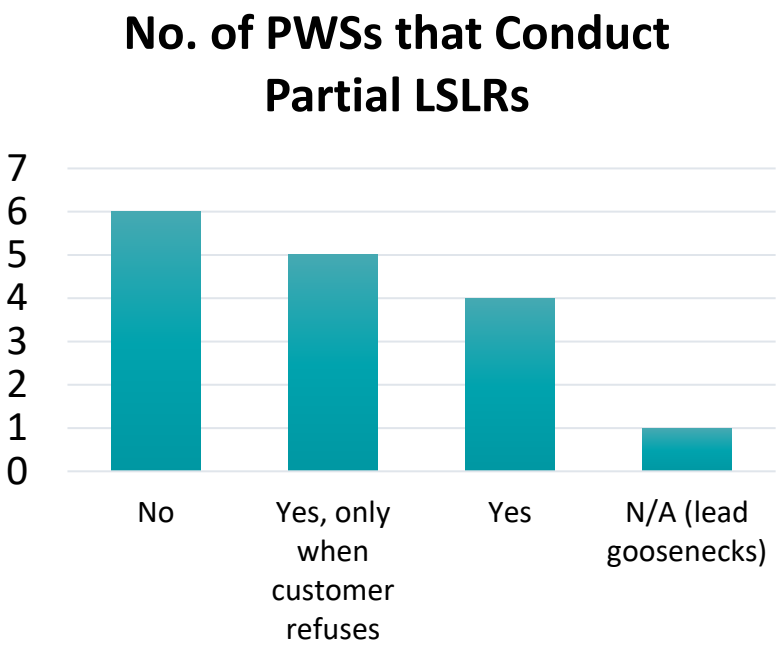
Service Line Materials Inventory



- Assessments typically recorded on paper
- If lead on the public side, there was often lead on the customer side

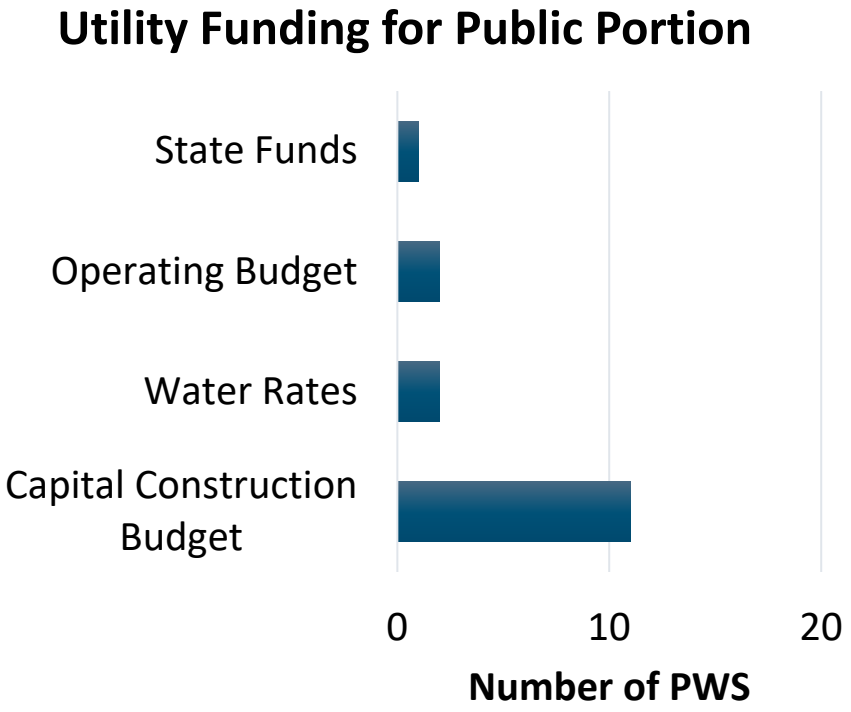
Lead Service Line Replacements

- Goals to replace all lead in the system range from 3 to 30 years
- Annual replacement goals 100 to 5,000 SLs/yr
- **Many utilities only replace during water main replacement or emergency repairs**

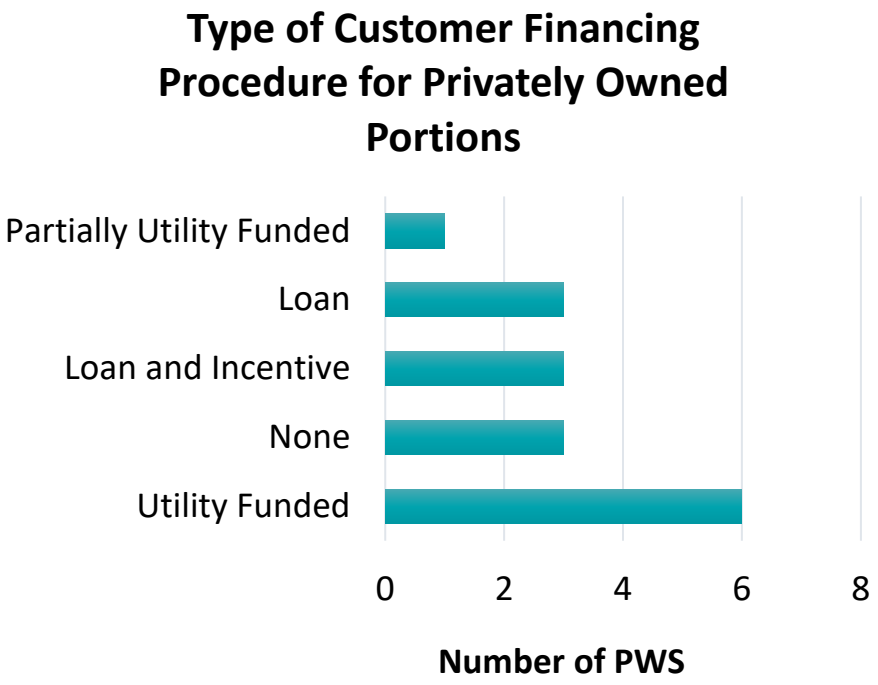


LSLR Utility Funding

- Replacement costs difficult to predict
- Costs varied by type:
  - **Partial**: $2,500 - $7,100
  - **Full**: $3,550 - $15,000
- Can include:
  - Materials
  - Street restoration
  - Construction/Labor
  - Sampling
  - Administrative
  - Other



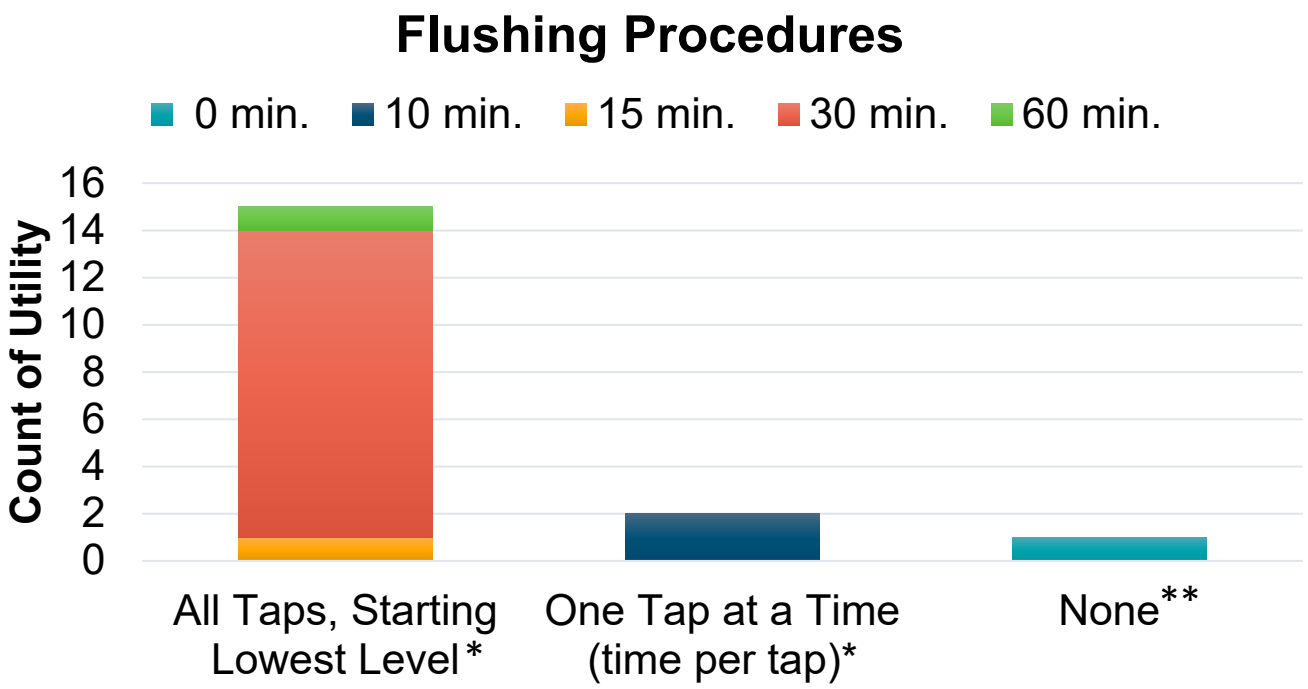
LSLR Customer Financing and Assistance



Loans	0% – 5% interest over 1 – 15 years
Incentives	$1000 – $2500

- Loans are sometimes offered only for low-income families and require an application
- Some loans have a cap for the total cost (e.g., $10,000)

Post LSLR Flushing Procedures

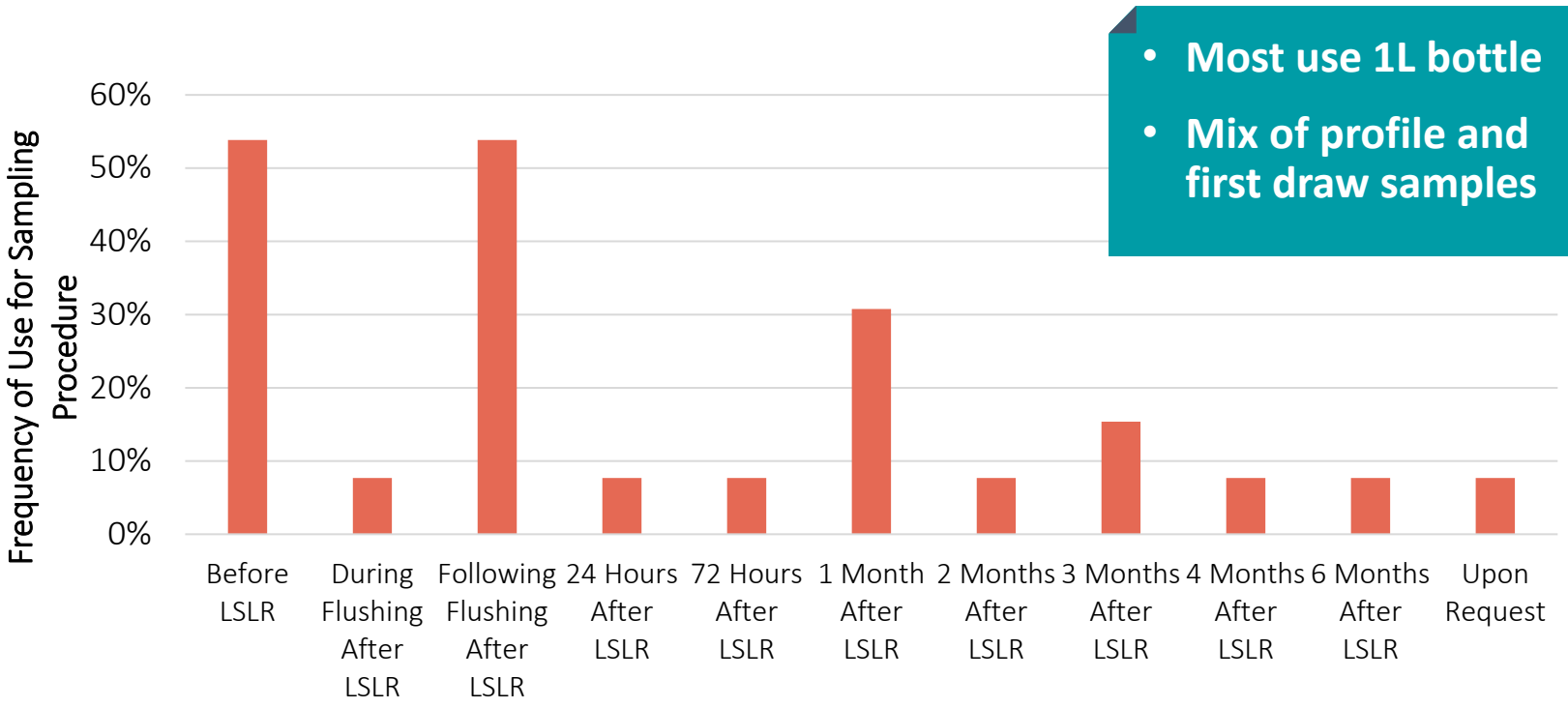


*Two utilities provide two separate sampling protocols: (1) all taps, starting lowest level and (2) one tap at a time.

**System that did not provide flushing instructions now provides flushing instructions following this study

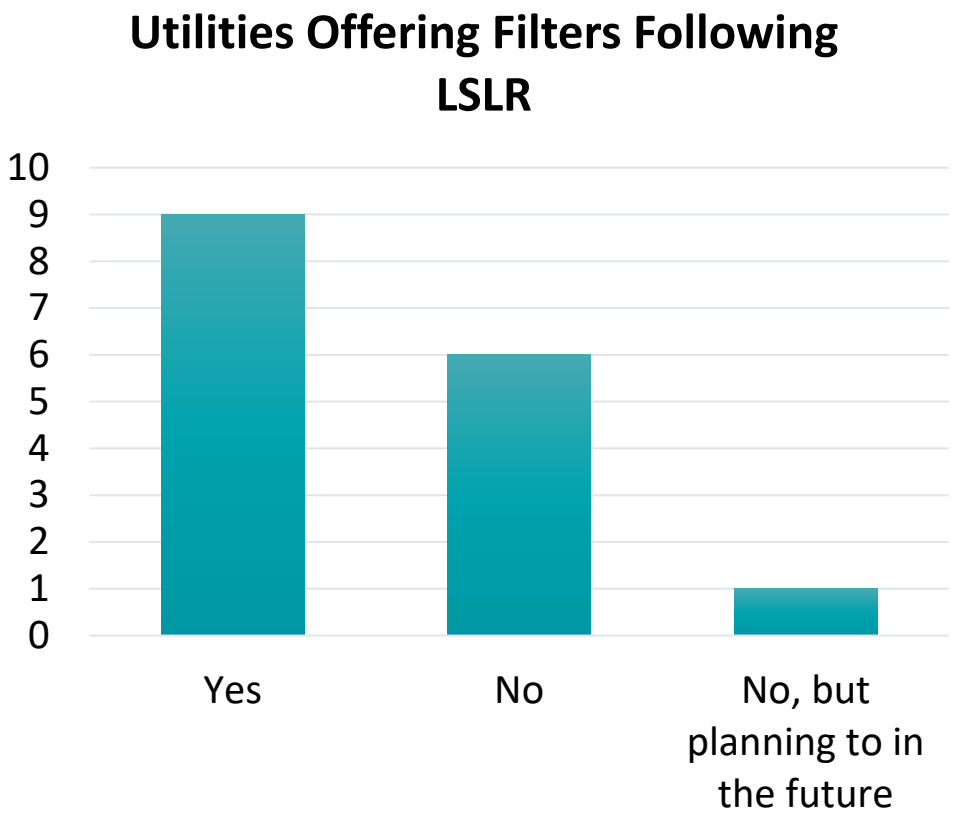
94% also provide additional flushing recommendations for daily use

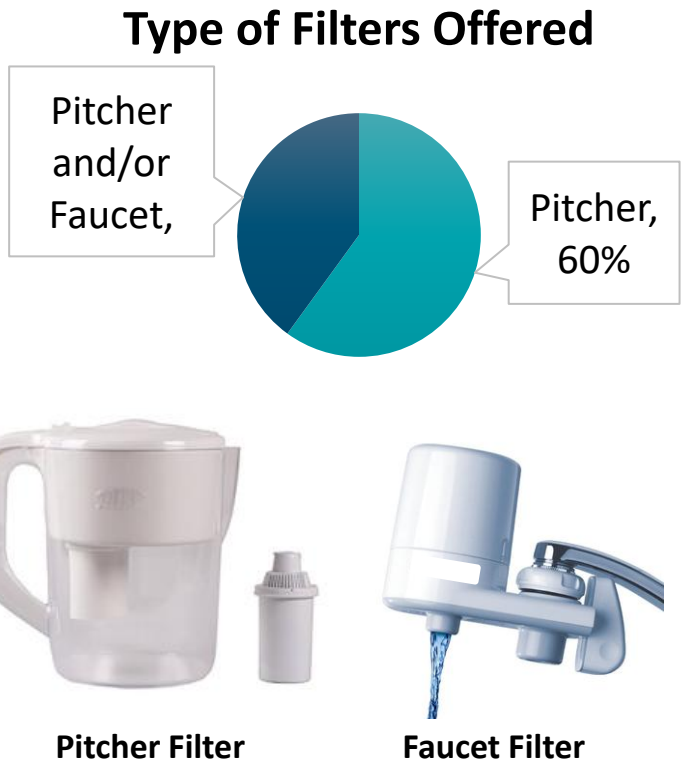
Post LSLR Sampling



- Most use 1L bottle
- Mix of profile and first draw samples

Home Water Filters





Home Water Filters (cont.)

Filter Selection Considerations	Replacement Frequency	Costs
• NSF 53 Certification • In-house testing • Recommendation from other utilities • Cost • Availability	• 1 to 6 months depending on the make and manufacturer • Most rely on manufacturer instructions or TDS meter (where included)	• Pitcher: $12 to $50 • Faucet: $20 to $30 • Replacement Filters: $3 to $10 each

LSLR Customer Communication

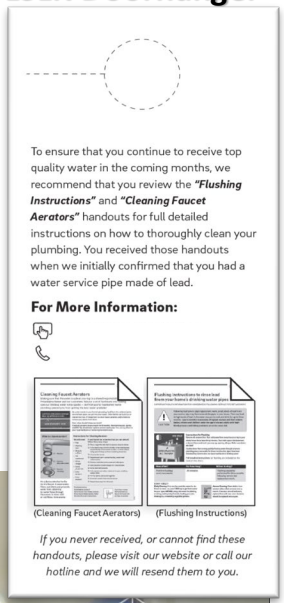
Notification of Work

- Letters
- Information Sheets
- Bill Stuffers
- Outreach Meetings
- Door-to-door
- Phone Calls (e.g., Staff, Robocalls)

Educational Materials

- Door Hanger
- Postcards
- Information Packet
- PWS Contact Information
- Website

LSLR Doorhanger



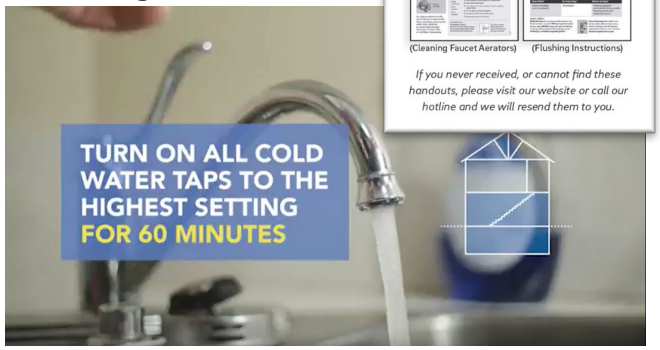
To ensure that you continue to receive top quality water in the coming months, we recommend that you review the ***"Flushing Instructions"*** and ***"Cleaning Faucet Aerators"*** handouts for full detailed instructions on how to thoroughly clean your plumbing. You received those handouts when we initially confirmed that you had a water service pipe made of lead.

For More Information:

(Cleaning Faucet Aerators) (Flushing Instructions)

If you never received, or cannot find these handouts, please visit our website or call our hotline and we will resend them to you.

Flushing Protocols



Customer Engagement and Participation

- Staff Training
- Common reasons customers did not participate
  - Unwilling/unable
  - Renters/vacant homes
  - Non-English speakers
- Did customers follow recommendations?
  - Many PWSs do not record information for customer questions/complaints on water sampling, filter use, and flushing
  - Anecdotal:
    - Customers are proactive and some had questions surrounding the flushing protocol
    - Some customers are not doing the full flush; concerns over wasting water

Key Conclusions

- ✓ Most participating PWSs developed initial LSL inventory **using historical water records**
- ✓ Most participating PWSs utilized capital funding for LSLR **and** offered customer financing options
  - ✓ **One PWS noted that since they cover the cost of the full replacement, they have about 99% participation in the program.**
- ✓ Most common post-LSLR flushing recommendation is a **whole house flush with all taps at once** with the aerator removed
- ✓ Wide variety in post-LSLR sampling – **both timing and procedure**

Lessons Learned

LSLR record keeping is key!

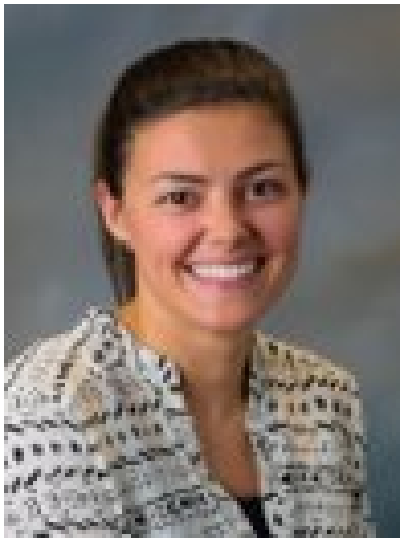
Customer participation in a LSLR program can be a challenge – provide incentives to increase the number of participants

Multiple methods of communication with the customer are more effective than a single method

LSLR programs should be reviewed annually and need to be flexible

Project Team

KAREN CASTELOES



VICTORIA NYSTROM

THE Water Research FOUNDATION

ARCADIS

Thank You

REBECCA SLABAUGH, PE

Drinking Water Practice Lead

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THE Water Research FOUNDATION

WRF 4713: Full Lead Service Line Replacement Guidance: Guidance Toolbox

March 4, 2021

FLSLR Toolbox Guidance

- The following slides summarize
  - Pre-LSLR activities
  - Post-LSLR activities
- See report for more details, guidance, and example materials

Pre-Replacement

- Developing an LSL Inventory
- LSLR Methods (see service line flush)
- Cost
  - PLSLR ($2,500-$7,100) and FLSLR ($3,500-$15,000)
- Funding (LSLR)
  - To enable and encourage customer participation
- Customer communication
  - Pb in drinking water
  - LSLR as part of Pb reduction strategy
  - Health impacts
  - Customer water use practices

Post-Replacement (1 of 3)

- Flushing
  - Service line flushing (as part of LSLR)
  - Whole-house HVF (see field studies)
  - Displacement flushing (before consuming)
- Post-LSLR monitoring
  - Conduct profile sampling 2-6 months (recommended)
  - Monitor for Copper (after replacement with Copper)
    - Copper scales develop over time (~ 6 months)
  - Supply filters certified for lead (LCRR)
    - Certified for copper too?

Post-Replacement (2 of 3)

- Customer communication and best practices
  - Communication/training of PWS staff
    - Procedures to conduct LSLR, HVF, sampling, etc.
      - Meet OSHA PPE and other requirements
    - Communication/interaction with customers
    - Train contractors too
  - Communication with customers
    - AWWA. 2005. “Strategies to Obtain Customer Acceptance of Complete Lead Service Line Replacement.”
    - AWWA. 2014. “Communicating About Lead Service Lines: A Guide for Water Systems ...”
    - AWWA. 2020b. “Public Communications Toolkit.”

Post-Replacement (3 of 3)

- Customer best practices
  - Identify and replace lead-containing plumbing (including galvanized iron, brass, etc.)
  - HVF to remove particulate Pb
  - Home water filters
    - ANSI/NSF Std 53 “certified for lead”
    - EPA does not require filters certified for copper
  - Water use
    - Our study did not find a link between low household water use and higher lead occurrence, but other systems have noted a correlation

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Example Materials

Example Materials – Appendix C

- SOP templates
  - "All Taps at Once" HVF Method
  - "One Tap at a Time" HVF Method
  - Sequential Profile Sampling
  - Composite Sampling
- Letter template = Letter to Customer after FLSLR
- Brochures (infographics)
  - "All Taps at Once" HVF Method
  - "One Tap at a Time" HVF Method
  - Daily Displacement Flush and Periodic Aerator Cleaning
  - LSL Replacement Notice Doorhanger
  - Doorhanger After LSL Not Detected

Example SOP

ALL TAPS AT ONCE METHOD (METHOD A)

Maximum Velocity at POE (Point of Entry); All taps open at same time

1. (Optional) - Collect profile sample after 6-hour or more water stagnation, prior to starting HVF.
2. Begin whole-house flush
   - 2.1. Start at lowest level of house
   - 2.2. Remove aerator from faucet (skip faucets where aerator cannot be removed).
   - 2.3. Open cold water supply to fully open position
     - 2.3.1. Feel water to ensure cold water supply only
     - 2.3.2. Watch to make sure sinks will drain
     - 2.3.3. Keep towels and other absorbent materials ready for water spray or spills
   - 2.4. Most important faucets to flush are kitchen faucet, laundry sink and bathtubs
     - 2.4.1. Can skip bathroom sink when bathtub in bathroom is flushed
     - 2.4.2. If the kitchen faucet has an extendable hose, extend the hose and flush back into the sink to remove U-bends that can collect particles
3. Once all taps are open, set a timer for 30 minutes
4. (Optional) - If feasible for the customer or water system staff, collect grab samples during HVF
   - 4.1. After 30 min timer set (step 3) Collect 1-liter grab samples at the following times after flush begins at kitchen faucet: 2 min, 4 min, 6 min, 8 min, 10 min, 20 min, and 30 min
   - 4.2. Analyze for total lead and total iron
5. (Optional) - If feasible for the customer or water system staff, measure flow rate from every faucet used to flush
   - 5.1. See General Instructions item 5.
6. After 30 minutes, turn off all faucets and re-install aerators
   - 6.1. Turn off in the same order they were turned on (i.e., basement sink/ lowest floor fist)
   - 6.2. Inspect aerators and screens and re-install if satisfactory, or replace with new ones if worn or damaged.

Example Brochure – Whole House HVF

CORNWELL ENGINEERING GROUP

WHOLE-HOUSE, HIGH VELOCITY FLUSHING
TO REMOVE LEAD PARTICLES

For City of XXXX

WHERE DOES LEAD COME FROM?

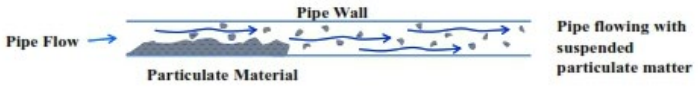
Lead in water can be dissolved or in particles

The lead in your tap water comes from the lead pipes that may be present from the street to your house or from faucets or indoor plumbing with lead.

When the street is disturbed by construction lead particles can come loose from the pipes. Some particles may still be present from the corrosion events and these need to be removed from your home plumbing.

WHY SHOULD YOU CONDUCT A FLUSH?

Lead particles can be released at random if they are in your pipes, but more particles can be released during construction that disturbs the lead lines



WHEN SHOULD "HIGH VELOCITY FLUSHING" BE DONE?

- When the City of XXXX informs you about a disturbance, or
- If you have had high lead results.

This type of flushing can dislodge (break loose) lead containing particles in pipes inside the house as well as in the service line between the house and the street.

CAUTION – SHORT TERM CONSEQUENCES

Research has shown flushing can produce long-term benefits, typically after 2 months, but prior to this the lead may actually be higher – see precautions described in "follow up."

WHICH FAUCETS IN YOUR HOUSE TO FLUSH?

All faucets inside your house that can flow to a drain without overflowing in your house should be flushed.

HOW OFTEN?

After you perform a flush, the City of XXXX or State staff will work with you to take lead samples. You will be advised if more flushing is needed.

PROCEDURE

ALL FILTERS IN THE HOME MUST BE REMOVED OR BY-PASSED

When possible, it is best to flush at times of the day when neighbors don't use a lot of water – so best to flush from mid-morning to dinner time or late at night

1. Find all the faucets that have good drains, including those in the basement and on all floors in your house.
2. Remove all in-home filters or by-pass them. You cannot flush through a filter.
3. Remove aerators and screens from all faucets or shower heads.
4. Be sure to include the laundry tub, the bathtub, or shower (shower head removed) as flushing points.
5. After all the aerators are removed, open the faucets in the basement or lowest floor in the house. Leave all faucets running at the highest rate possible –using COLD water only.
6. After faucets are all open on the lowest floor, open faucets on the next highest floor of the house. Continue until faucets are open on all floors, including tubs and showers (shower head removed).
7. After all faucets are opened, leave them ALL running for at least 30 minutes.
8. After 30 minutes, turn off the 1st faucet you opened (lowest floor), and continue to turn off other faucets in the same order you turned them on.
9. Re-install aerators/screens at each faucet – you may need to discard old screens/aerators and replace with new ones if too old or worn.

CAUTION – MESS FROM WATER SPRAY

Make sure the drain is open and clear so water can flow freely to drain

Make sure water can drain as fast as water is flowing from tap during flushing

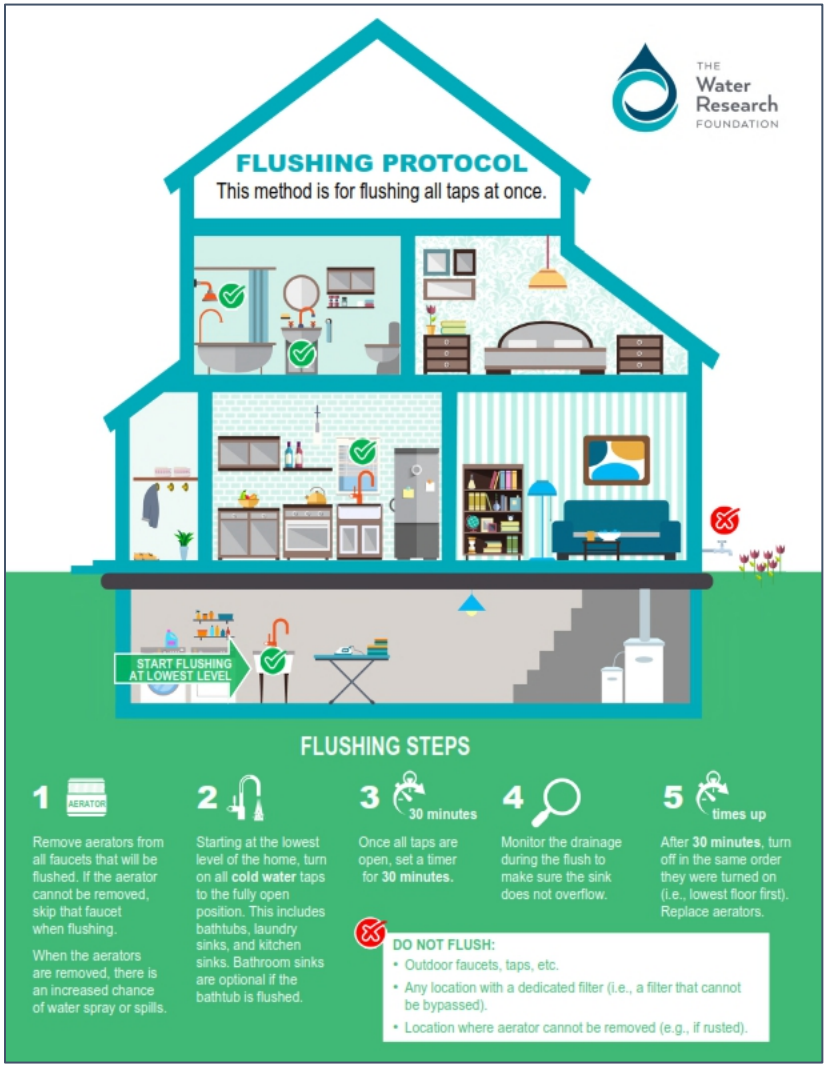
When faucet is open at high rate, especially since aerators/screens are removed, it can create a mess due to water spray. Take precautions to either contain or monitor the spray.

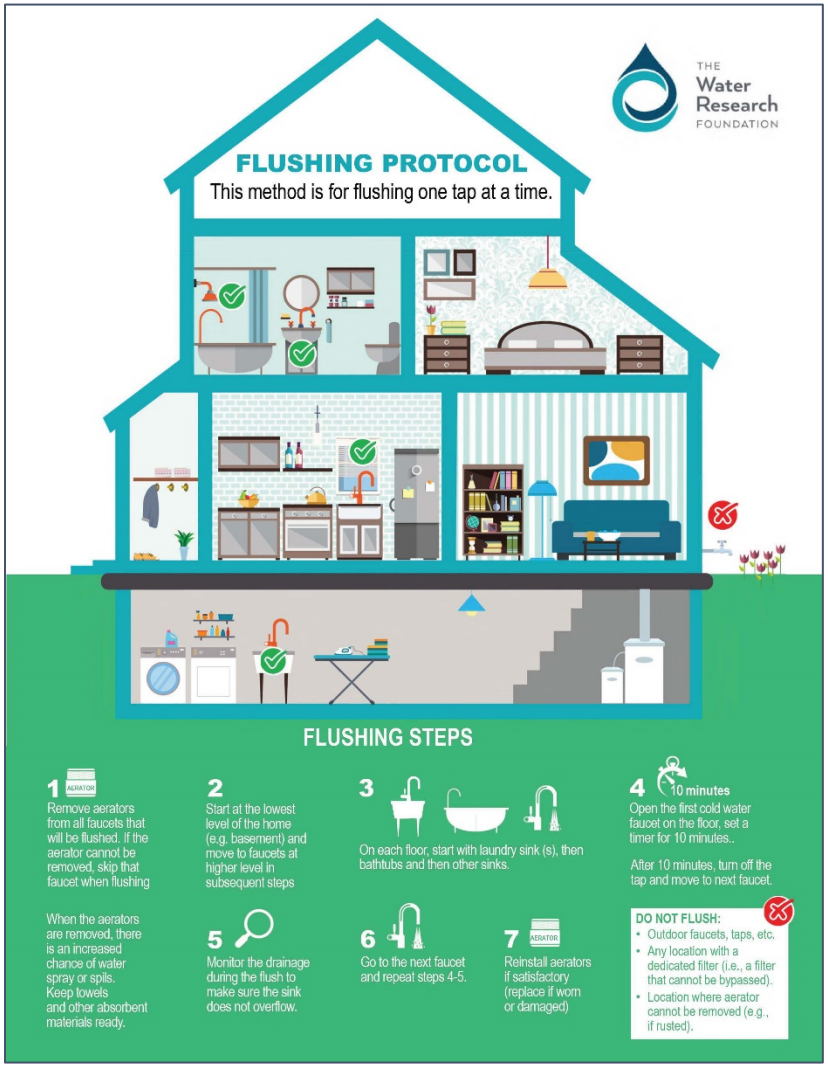
FOLLOW UP

(WHAT SHOULD I DO ON DAYS AFTER THE FLUSH?)

- Run tap water each morning for at least 5 min to displace water that has been sitting in pipes inside the house and in the service line. This could include taking a shower, running dishwasher, or running the faucet. Do this BEFORE using any water for drinking, cooking, infant formula, etc.
- Clean debris from aerators and screens, once a month for 6 months.
- After 6 months, clean debris from aerators/screens twice a year (for example, in April/October when daylight savings time changes).

“All Taps at Once’ and “One Tap at a Time” - Brochure





Example Notice

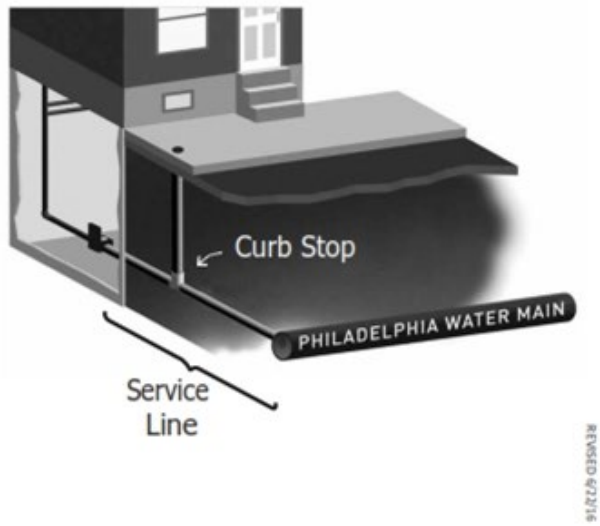
PWD –
“you do not have a lead service line”

Dear Water Customer,

We were able to inspect your service line, and based upon what we could see from our excavation, it was determined that **you do not have a lead line.** Your service line will be replaced to the curb stop.

Thank you.

PHILADELPHIA WATER



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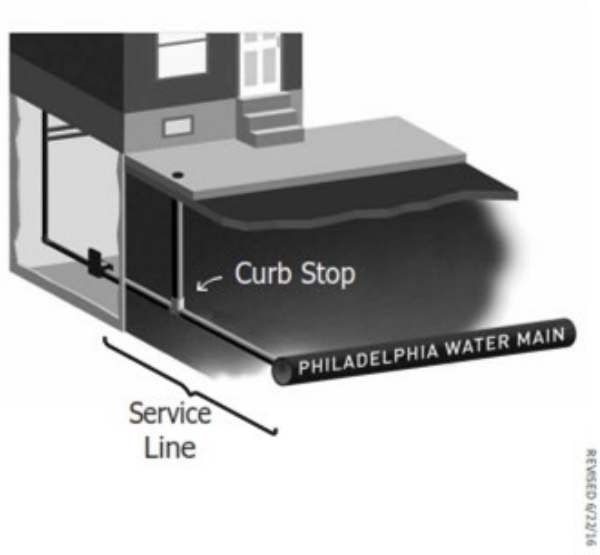
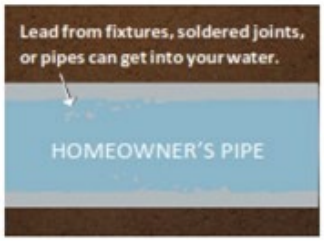


Example Notice

PWD – “Cleaning faucet aerators”

Cleaning faucet aerators

Don’t let poorly maintained home plumbing prevent you from getting the best water available!



As water stands in your home’s plumbing, lead from the soldered joints and old lead pipes can get into your water. Other debris can build up on the aerator, too. It’s important to clean faucet aerators and screens to remove any debris from them.

How often should I clean aerators?

It’s recommended you replace the aerator annually, and then clean the aerator twice a year. If the aerator appears to need frequent cleaning or becomes worn, the aerator may need to be replaced more often.

What is a faucet aerator?

It’s a device attached to the tip of a faucet. It saves water, filters out debris, and prevents water from splashing. As water flows through the screen, it mixes with air and flows more evenly.

Instructions for cleaning aerators

You will need:

- Rag
- Masking tape
- Wrench or Pliers
- Old toothbrush
- White vinegar
- Small plastic tub
- Extra aerators
- Extra washers

If your faucet has an aerator that you can take off, follow these easy steps:

- ❑ Place a rag in the sink drain in case you drop any pieces.
- ❑ If you need to use a wrench or pliers, wrap masking tape around the tips of the wrench or pliers, or on the aerator. Using tape will keep you from scratching the aerator.
- ❑ Unscrew the aerator.
- ❑ Separate each part—aerator housing, aerator and rubber washer.
- ❑ Remove small bits on the screen and other parts.
- ❑ Soak the parts in white vinegar for a few minutes.
- ❑ Scrub them with a brush.
- ❑ If the aerator and rubber washer are in poor condition, replace them.
- ❑ Put the aerator parts back together.
- ❑ Screw the aerator back onto the faucet.
- ❑ Repeat these steps for all faucets.

Troubleshooting

Can’t find the aerator?
Some faucets have hidden aerators. If you have a hidden aerator, follow the manufacturer’s instructions.

If you have a water filter attached to a faucet, the faucet will not have an aerator.

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Thank You

Comments or questions, please contact:

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For more information, visit

www.waterrf.org

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Questions?