Diagnostic Sampling Tools for Lead in Drinking Water

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Deceptively Simple Citizen Question…

Q: Is my water safe to drink?

A: Here is a sample bottle and instructions for taking a regulatory monitoring protocol water sample.

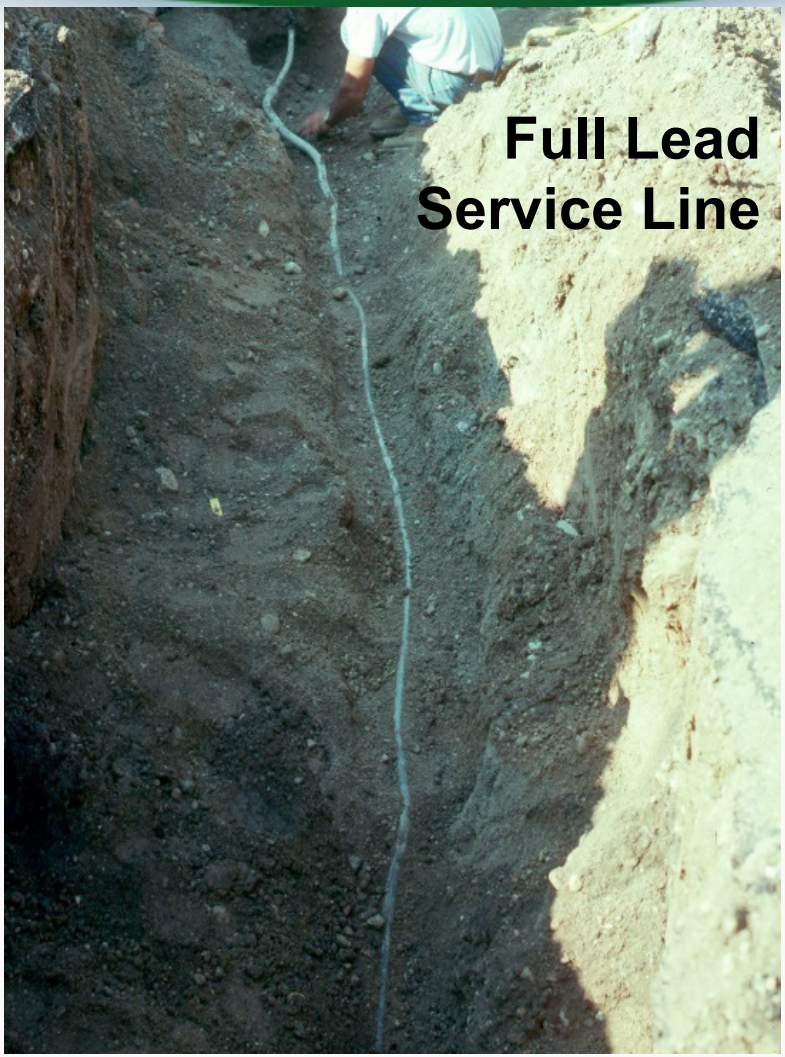
Why It's So Hard…..

Sampling is a TOOLBOX with Many Purposes

- Regulatory/Compliance/Treatment Sampling
- Exposure Assessment Sampling
- Diagnostic Sampling for Lead (or copper) Sources

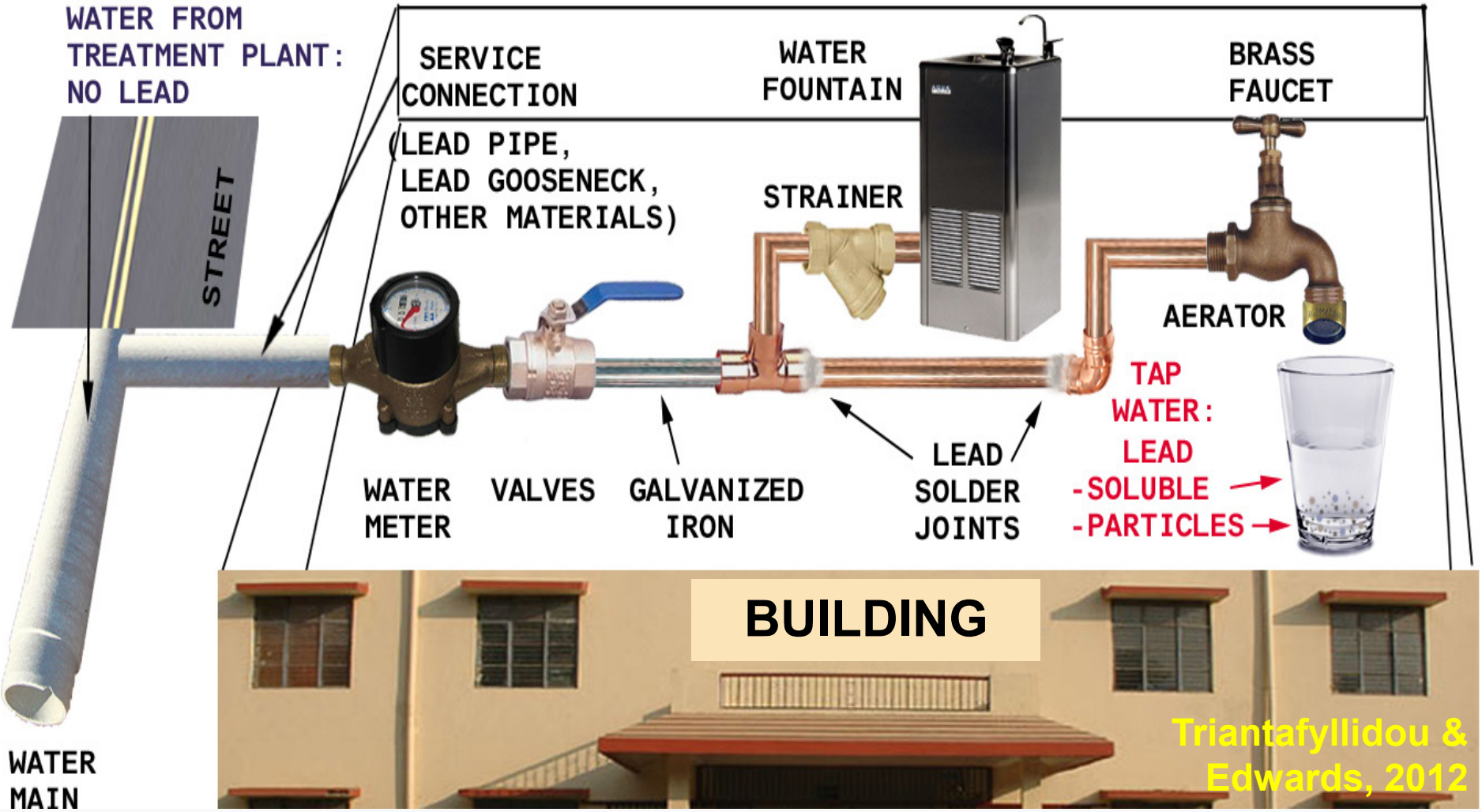
No single universally applicable sampling approach for lead in drinking water exists

There are many protocols, but each has a *specific use* in answering one or more of those many questions


Full Lead
Service Line

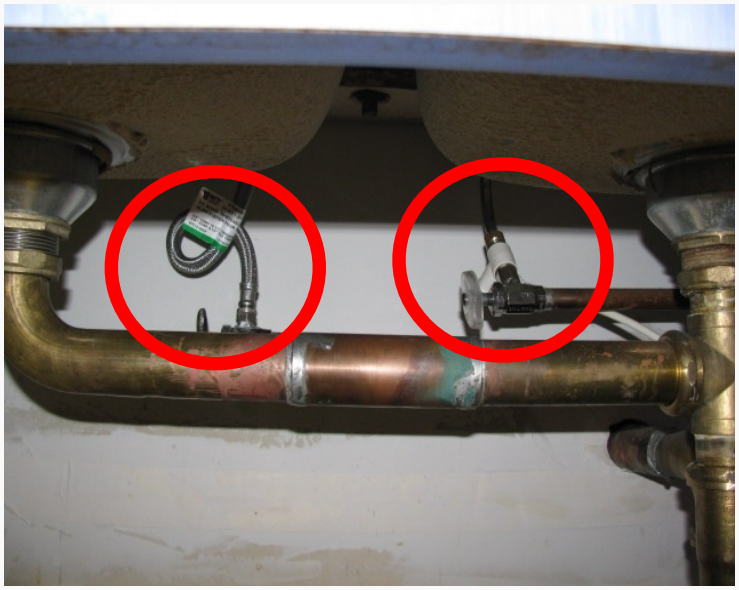

Partial Lead
Service Line


Lead gooseneck

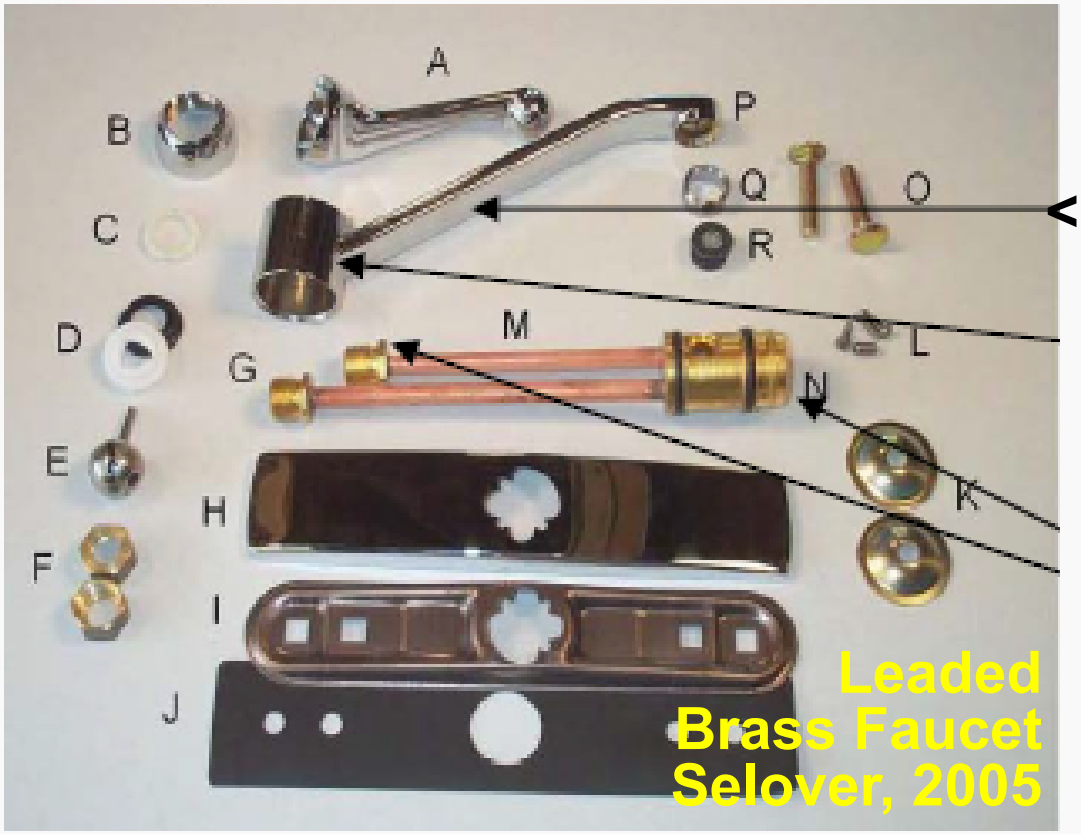


- Lead Service Lines (LSLs)
- Lead Goosenecks
- Leaded Solder
- Leaded Brass (valves, fittings, faucets, water fountains)
- Galvanized Pipe downstream of leaded plumbing

Lead sources may be small and hidden




Leaded
Solder


A
B
C
D
E
F
G
H
I
J
P
Q
R
O
M
L
N
K
<0.5%Pb
2% Pb
3% Pb
Leaded
Brass Faucet
Selover, 2005

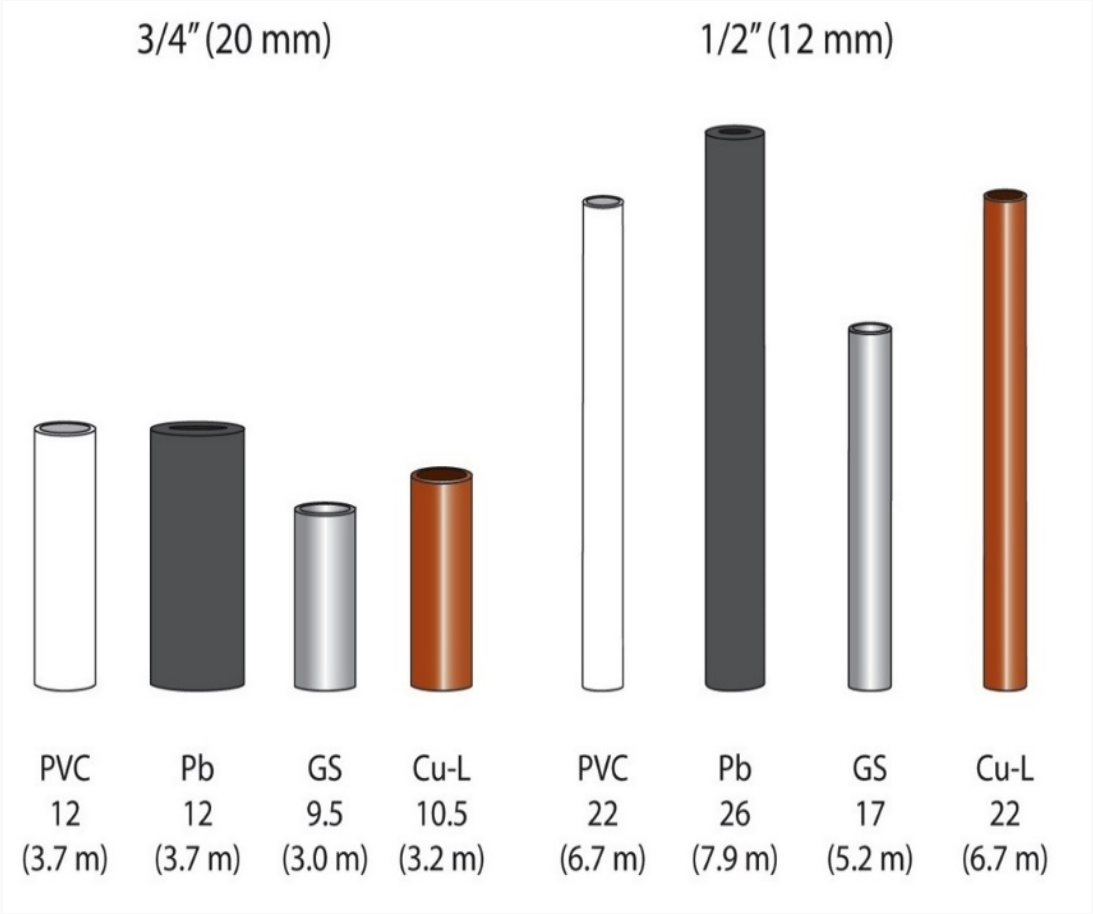
Diagnostic Sampling to Find Lead in Drinking Water

Prime Concept: Sample Volumes Represent Source Position in Plumbing

Wide-mouth bottles preferable to allow higher flow rate more typical of "normal" use

=

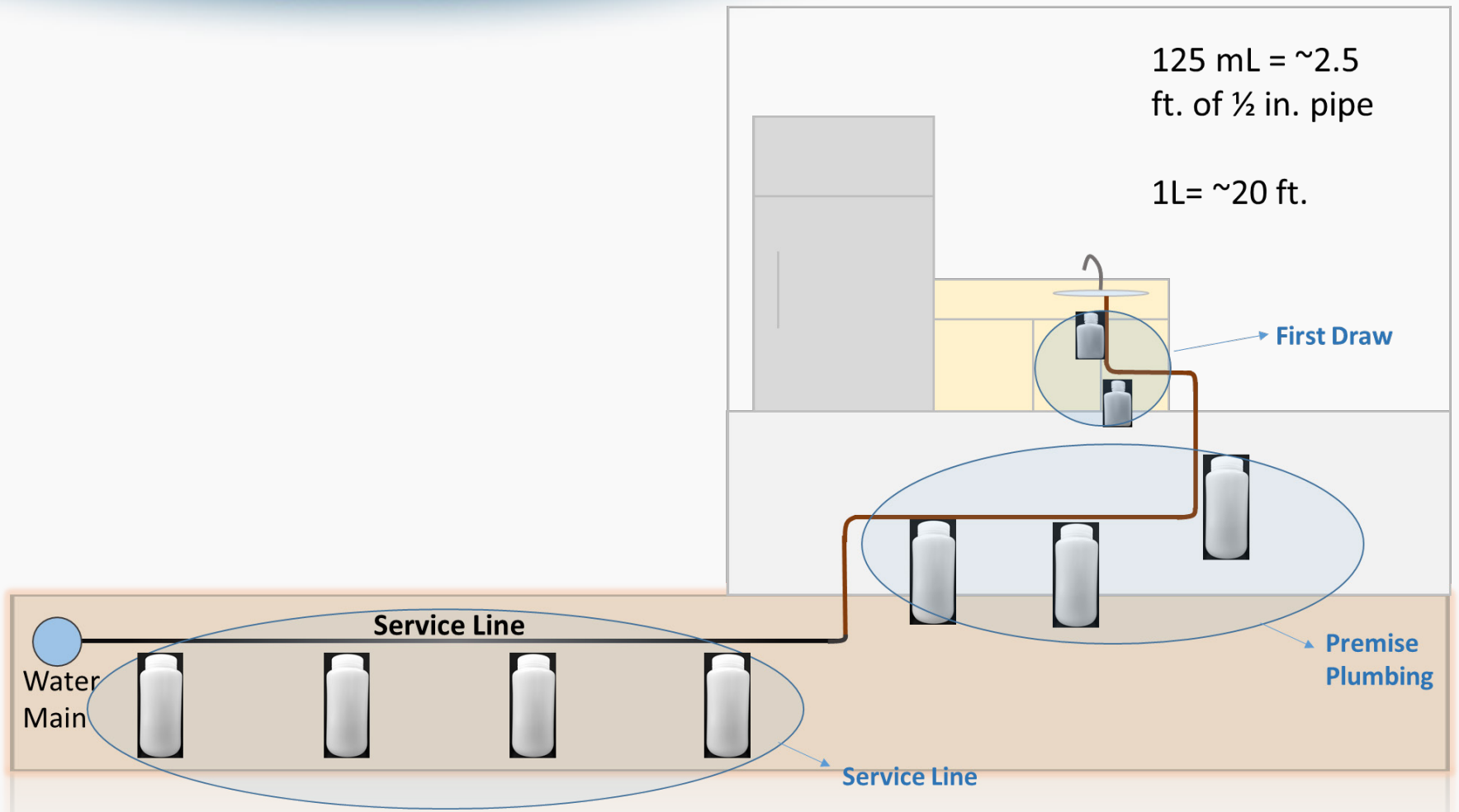
ID



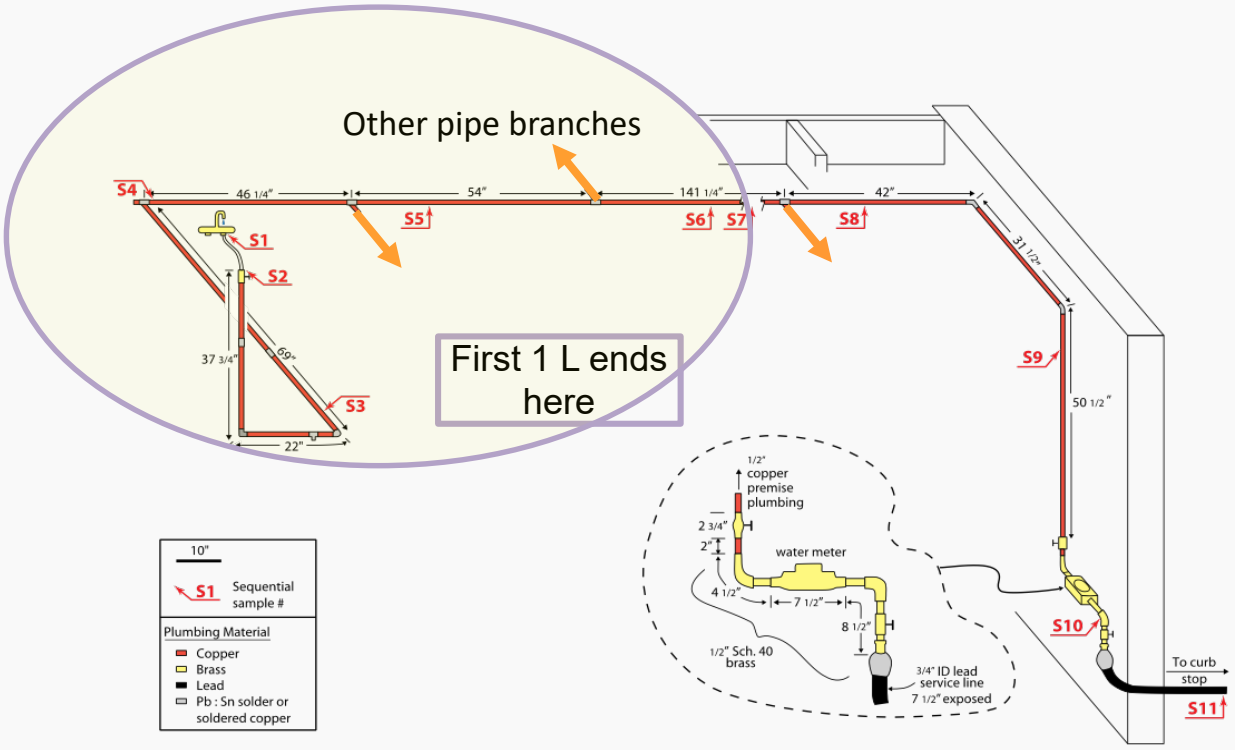
Feet

Sampling for Lead Sources
Where is the lead coming from?

- Sequential Sampling ("Profiling")
  - Map interior plumbing and approximate exterior route to main in terms of lengths, ID and visible materials
  - Allow water to sit motionless for 30 minutes to overnight
  - Take successive samples of variable volumes, as desired
  - Can somewhat differentiate bubbler, faucet, valve, tubing, inside-wall plumbing by different sample volumes
- Relate Pb and/or Zn, Cu, Fe, Cd, Ni in samples to plumbing volumes/distance from tap and location of leaded materials

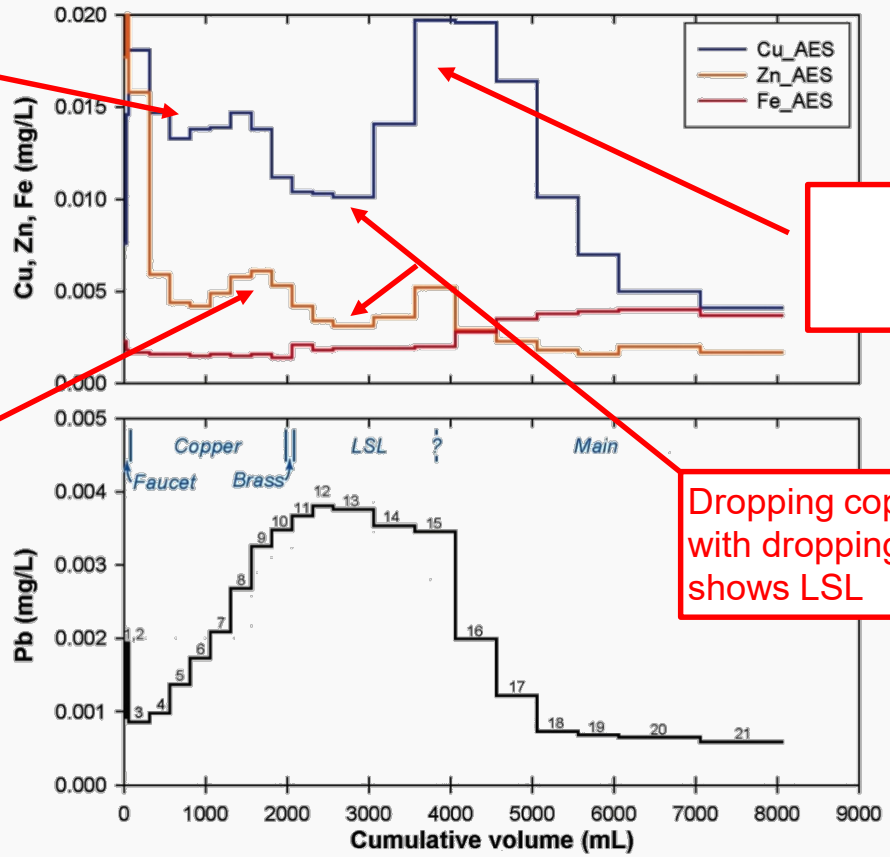

125 mL = ~2.5 ft. of ½ in. pipe
1L= ~20 ft.
First Draw
Service Line
Water Main
Premise Plumbing
Service Line

LCR Sampling Misses the LSL



Including Cu, Zn and Fe is Very Useful

Consistent high Cu is interior piping



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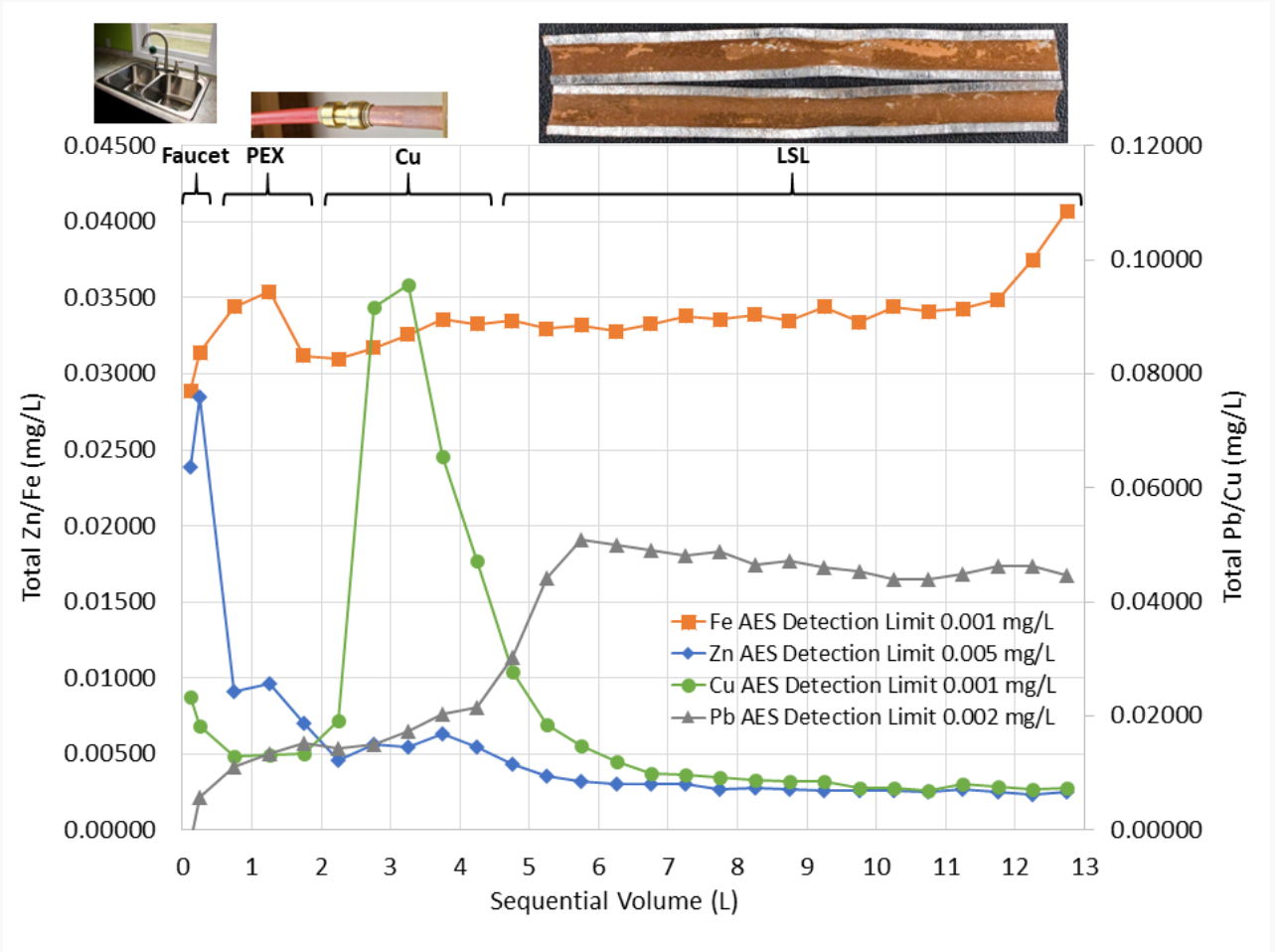
High Zn and Cu, associated with rising Pb is the meter area

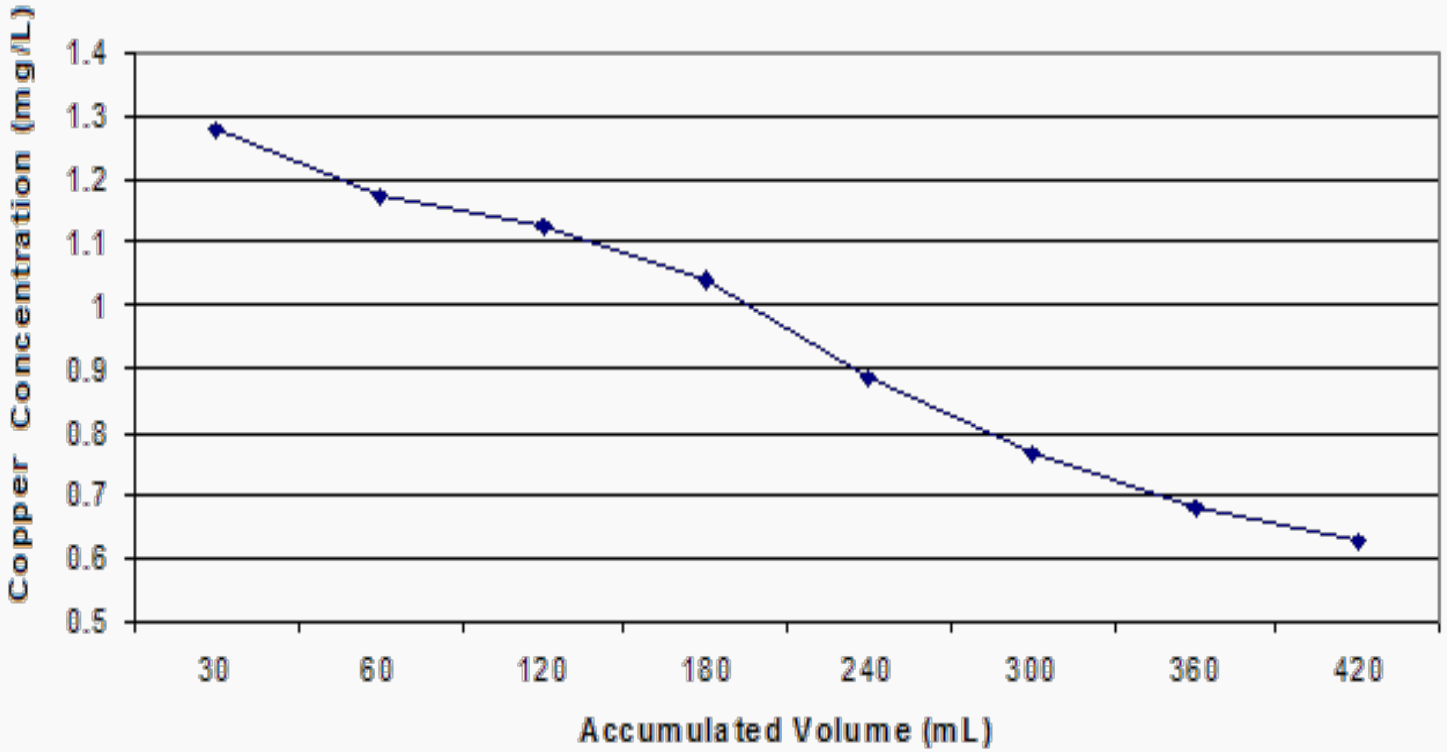
Dropping copper with dropping Zn shows LSL

Other metals could be informative in some cases, like Cd and Ni

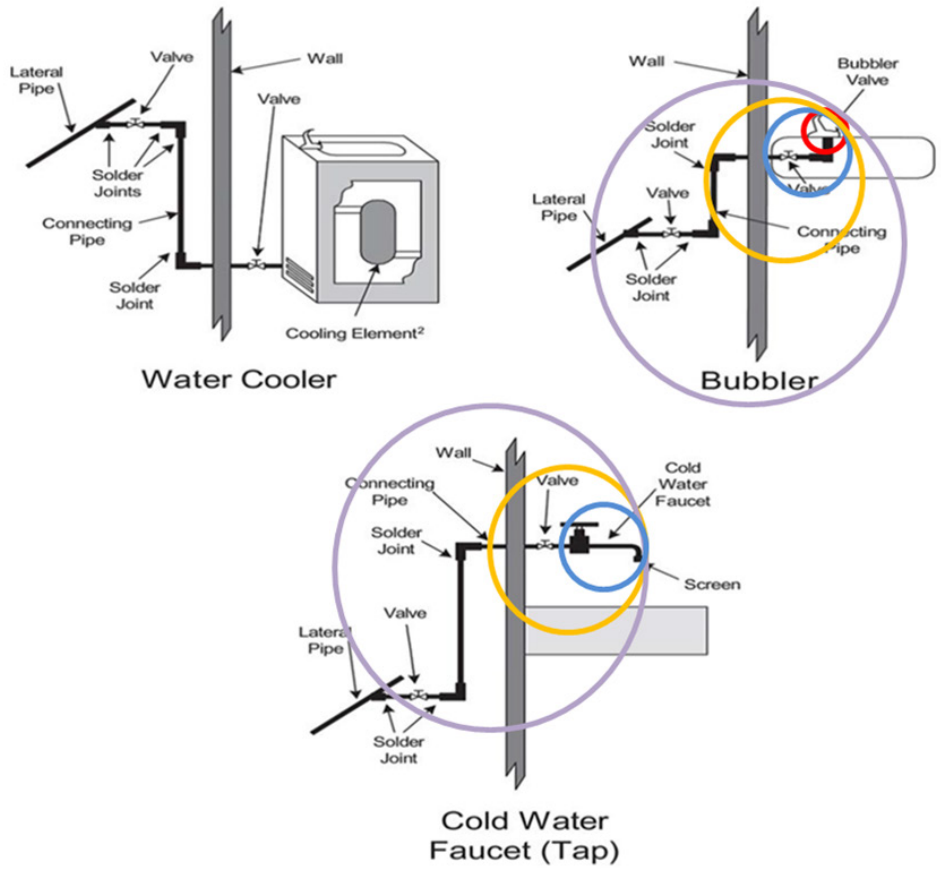
Multi-metal Source Identification



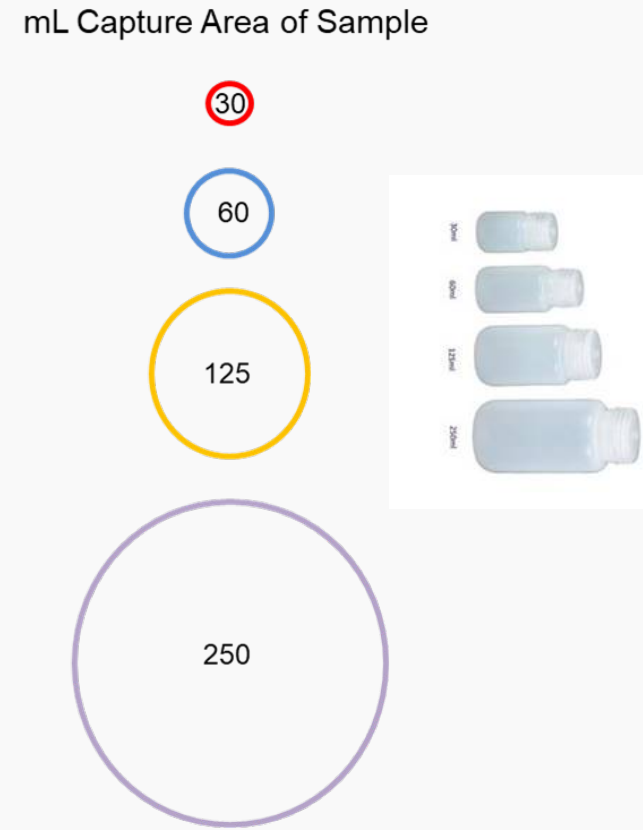
Effect of Renovation (New Cu) at Sink



Importance of Sample Volume in Detecting Pb Source



¹Valve locations are approximate and will vary, depending upon installation.
²Old cooling elements may be lead-lined. For more information on replacement of lead-lined cooling elements, see Appendix E of this document.



Caveats in Interpreting "Profiling" Data

- We often get lazy and plot data as a sequence of points and smoothly interpolate to connect them, *but that's not really an accurate representation*
- Each sample in a bottle represents average Pb over linear distance captured by that sample volume
- A given Pb level in an interval could be
  - One uniform source of Pb
  - Mix of multiple "point" or short sources
- Smaller sample volumes give better resolution and Pb source insight, but it's a tradeoff with other factors
  - Lower particulate release tendency
  - More dispersion from departure from plug flow

Potential Constraints of Sequential Sampling

- The farther the deviation from plug flow, the less accurate in finding exact location of specific sources
- The longer the distance of the tap from the source, and the more bends, the more mixing that will take place
- Lowering of peak Pb through dispersion
- Loss in resolution when sample volume > lead source size
- May displace precise peak positions relative to source locations
- Samples can be biased by water passing through leaded devices on the way to the bottle
- Accurately capturing particulate release highly depends on on-off protocol, flow rate and flow turbulence

Common Field Problems

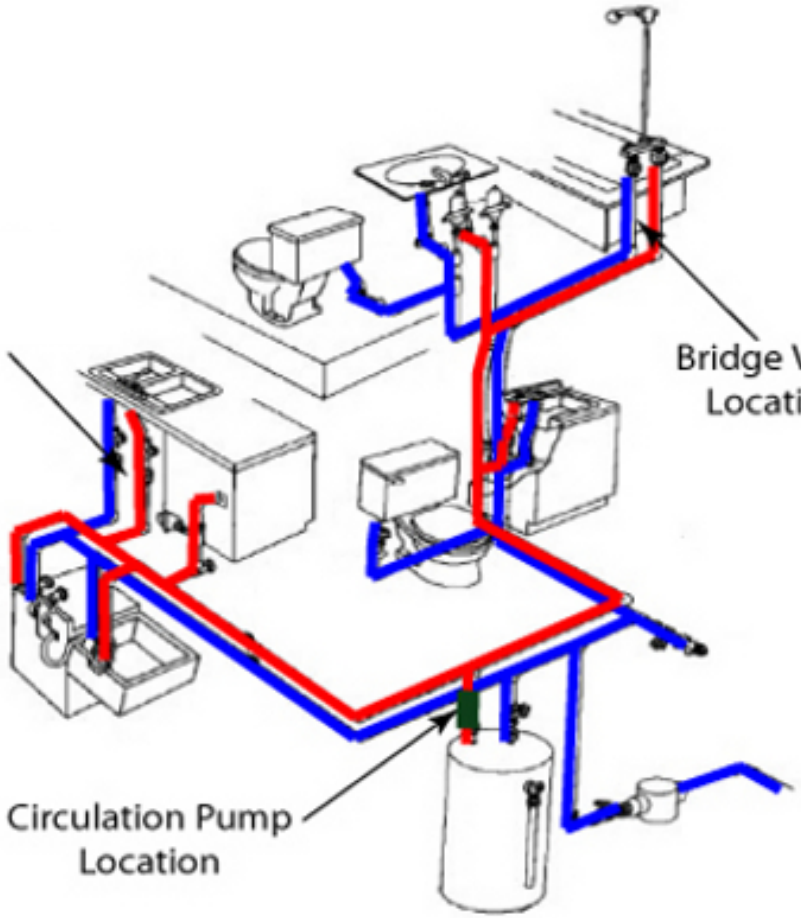
- Plumbing changes where you can't see it
  - Length of segment and number of bends and segments
  - Type of pipe or tubing
  - ID
  - Hidden devices, couplings, soldered joints
- Tuberculation/occlusion makes effective pipe ID smaller
- Residents use water and don't know or don't say
  - Toilet use
  - Icemakers or water dispensers
  - Furnace humidifiers
  - Lawn sprinkler systems

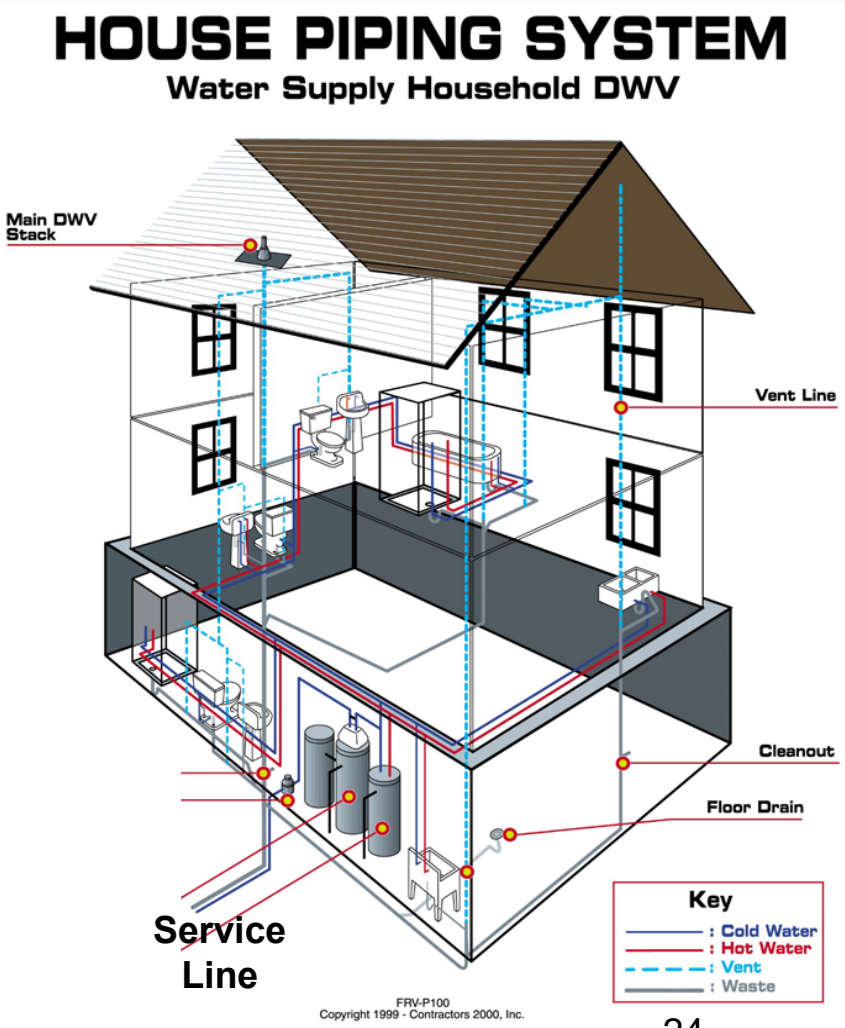
Exposure Assessment

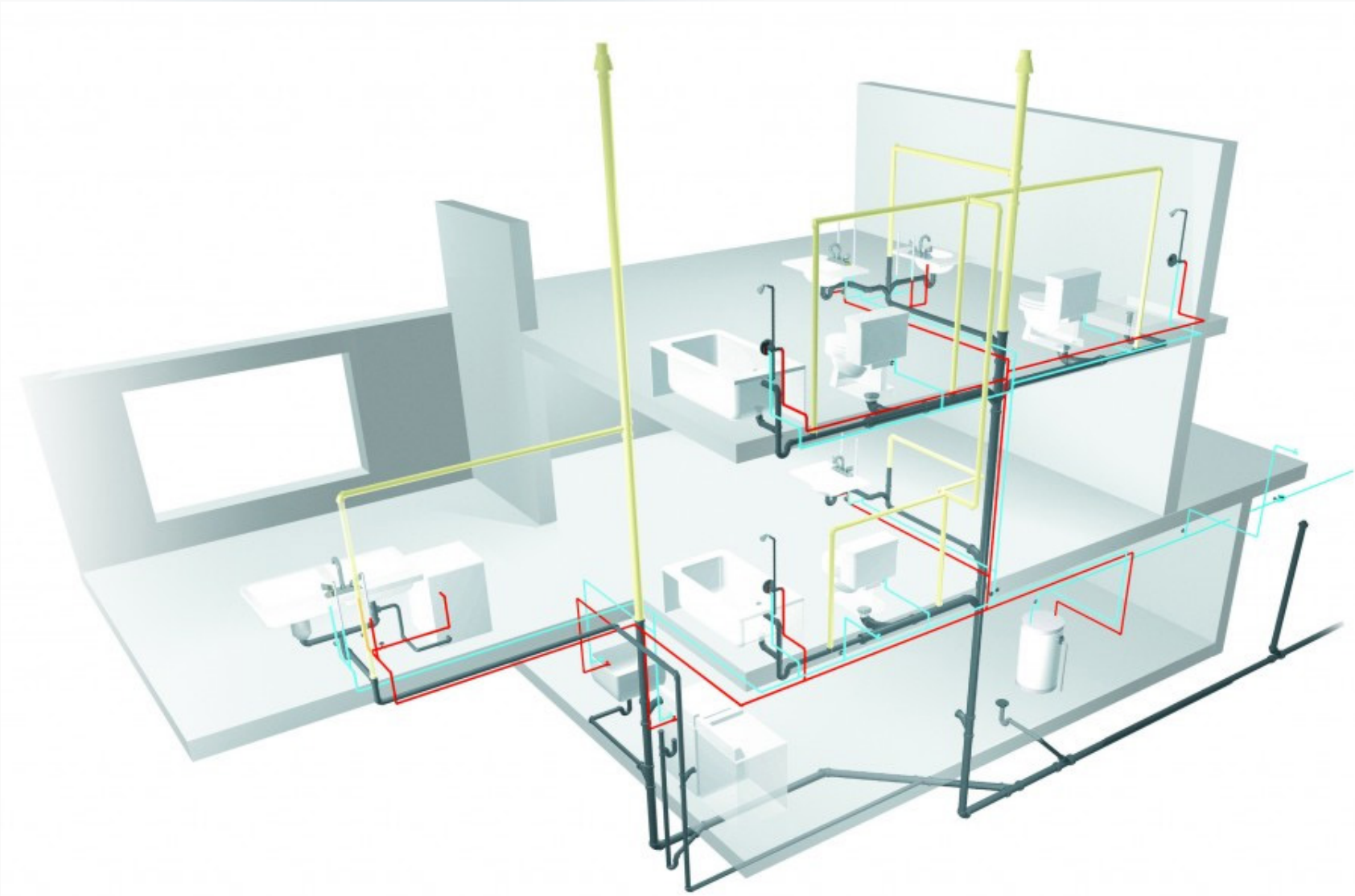
Exposure Assessment Varies with Scale

- Sampling strategy depends on exact *QUESTION*
  - Single residential dwelling
  - Individual within that dwelling
  - Community-wide estimation
    - Average risk
    - Risk of subset of housing, like with LSL, age range, etc.
- Almost no published papers have appropriate exposure sampling methodology

Let's pause and think about how plumbing is set up in real houses, and how the water travels through or stagnates in lead-containing sources.


Bridge Valve Location
Circulation Pump Location


HOUSE PIPING SYSTEM
Water Supply Household DWV
Main DWV Stack
Vent Line
Cleanout
Floor Drain
Service Line
Key
: Cold Water
: Hot Water
: Vent
: Waste
FRV-P100
Copyright 1999 - Contractors 2000, Inc.



Service Line from Meter

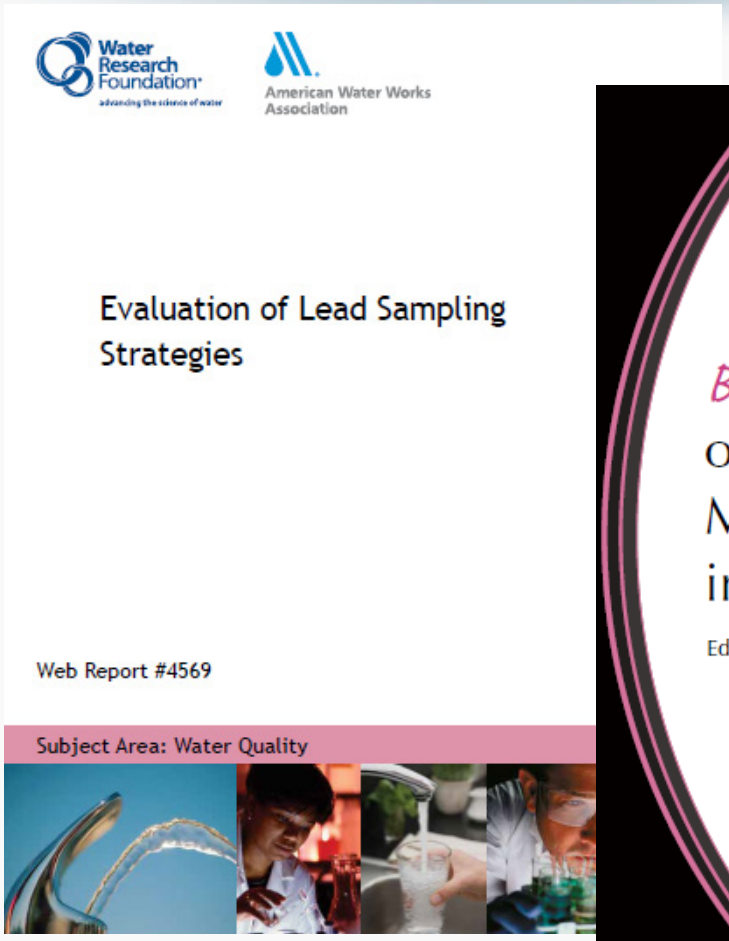
Short List of DW Exposure Variables

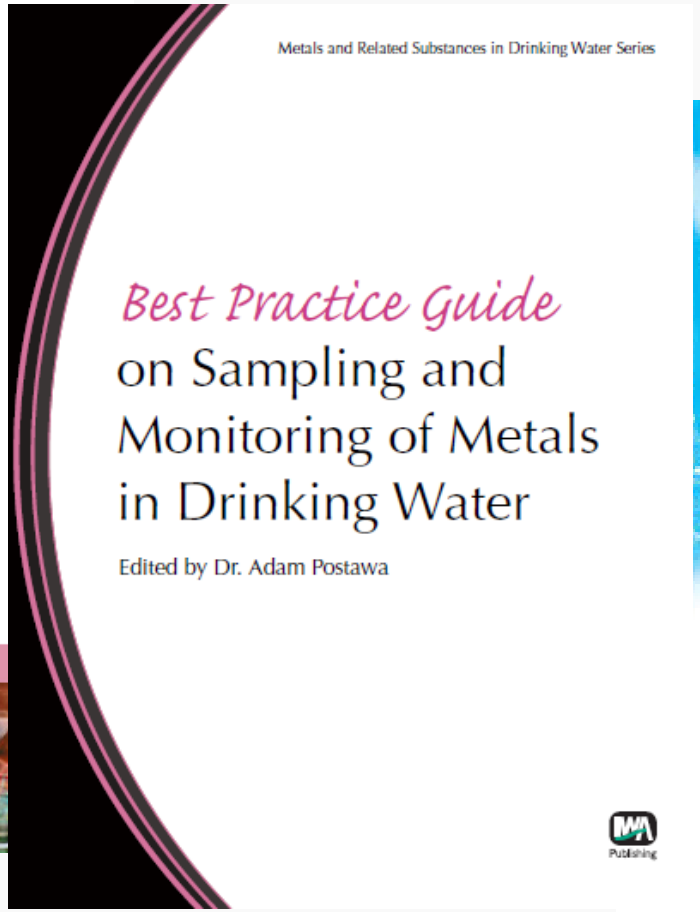
- When do you use your water each day?
- How many people use the water?
- Which faucet or outlet is used each time?
- Which activities are done, and in what order?
- What is the water pathway through the plumbing, each time a faucet or appliance is turned on?
- What kind of pipes are there, in what order are they arranged, how old and how long are they?
- How long did the water stand in *which part(s) of the* piping?
- How much does the pattern of use vary from day to day, week to week?
- Does the background water chemistry change during the day?
- Are school or work-related activities the same or different from the prior day/week/month?
- Are there visitors that change the water use pattern?
- Is work being done to the plumbing, to the water mains in the street, hydrant repairs, or other construction work that can physically disturb pipe scales?

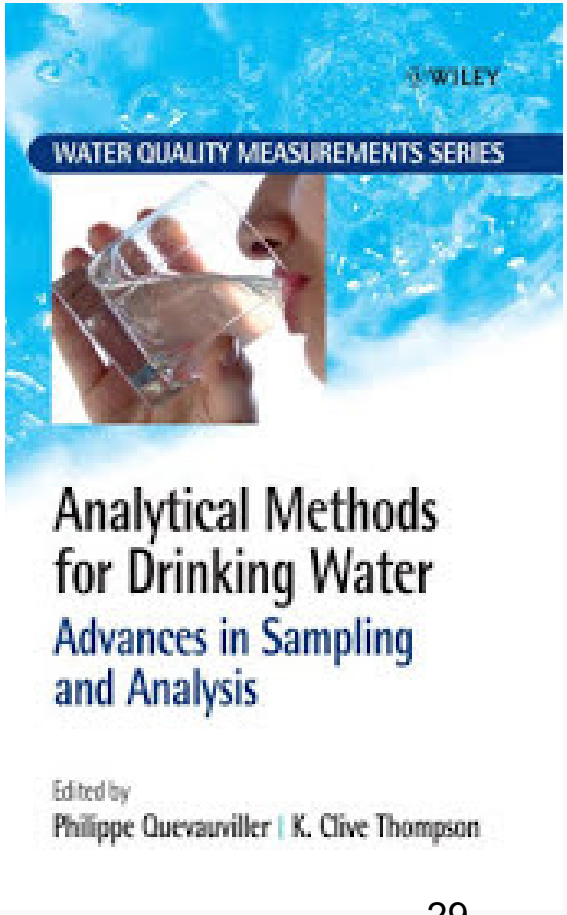
High-level Conclusions

- "Exposure" risk differs by individual in a house
- "Exposure" risk differs by cold water usage pattern in identically-configured houses
- Over days to weeks to months, "exposure" risk differs with cold water usage pattern changes in the same house, if activities differ
- Fraction of lead exposure from drinking water in an individual can be almost anything from 0 to nearly 100%, complicating correlations with BLLs

OK, so now what???


Water Research Foundation
advancing the science of water
American Water Works Association
Evaluation of Lead Sampling Strategies
Web Report #4569
Subject Area: Water Quality


Metals and Related Substances in Drinking Water Series
Best Practice Guide
on Sampling and Monitoring of Metals in Drinking Water
Edited by Dr. Adam Postawa
IWA Publishing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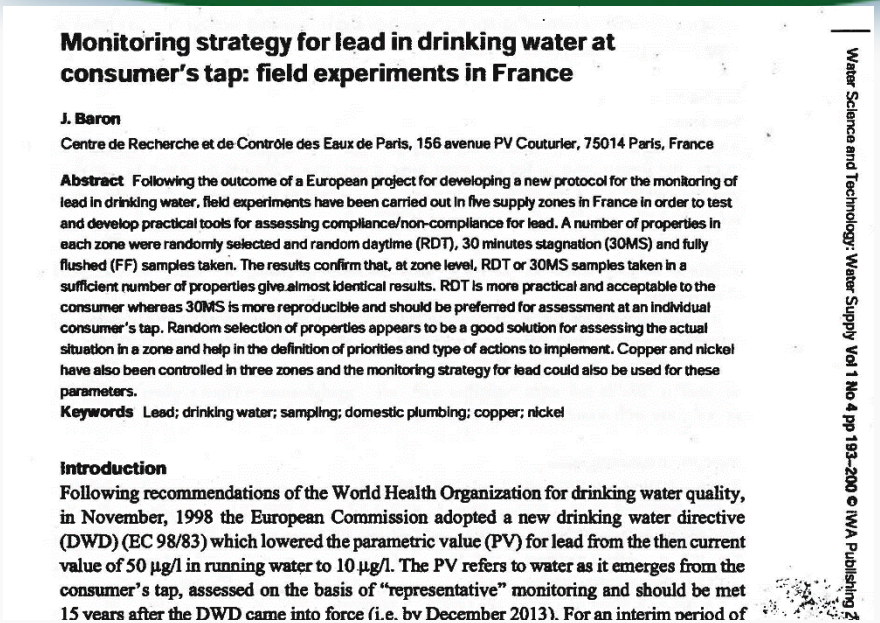

Monitoring strategy for lead in drinking water at consumer's tap: field experiments in France

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Abstract Following the outcome of a European project for developing a new protocol for the monitoring of lead in drinking water, field experiments have been carried out in five supply zones in France in order to test and develop practical tools for assessing compliance/non-compliance for lead. A number of properties in each zone were randomly selected and random daytime (RDT), 30 minutes stagnation (30MS) and fully flushed (FF) samples taken. The results confirm that, at zone level, RDT or 30MS samples taken in a sufficient number of properties give almost identical results. RDT is more practical and acceptable to the consumer whereas 30MS is more reproducible and should be preferred for assessment at an individual consumer's tap. Random selection of properties appears to be a good solution for assessing the actual situation in a zone and help in the definition of priorities and type of actions to implement. Copper and nickel have also been controlled in three zones and the monitoring strategy for lead could also be used for these parameters.

Keywords Lead; drinking water; sampling; domestic plumbing; copper; nickel

Introduction

Following recommendations of the World Health Organization for drinking water quality, in November, 1998 the European Commission adopted a new drinking water directive (DWD) (EC 98/83) which lowered the parametric value (PV) for lead from the then current value of 50 µg/l in running water to 10 µg/l. The PV refers to water as it emerges from the consumer's tap, assessed on the basis of "representative" monitoring and should be met 15 years after the DWD came into force (i.e. by December 2013). For an interim period of

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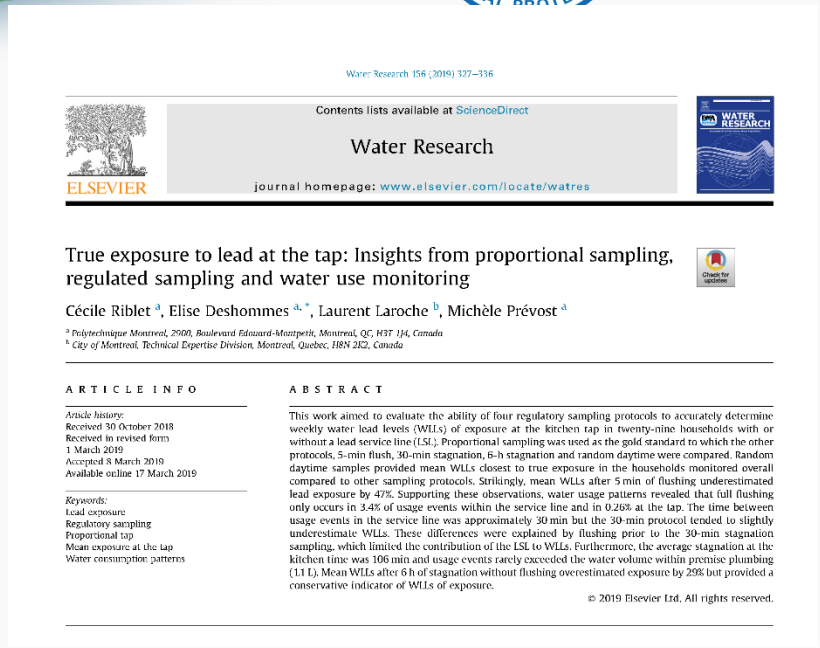

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Water Research

journal homepage: www.elsevier.com/locate/watres

True exposure to lead at the tap: Insights from proportional sampling, regulated sampling and water use monitoring

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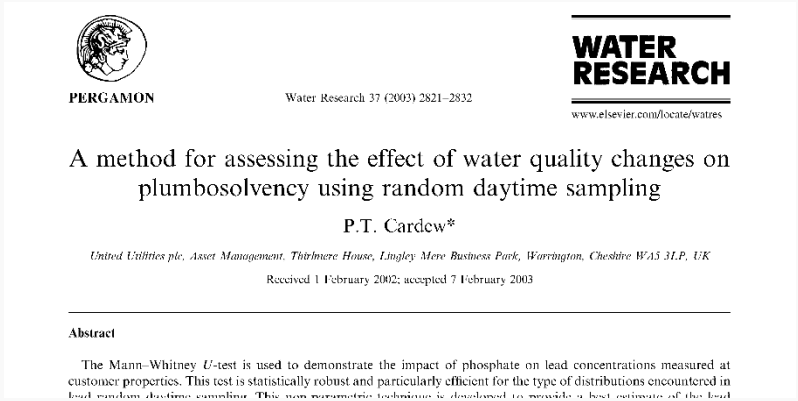
ABSTRACT

This work aimed to evaluate the ability of four regulatory sampling protocols to accurately determine weekly water lead levels (WLLs) of exposure at the kitchen tap in twenty-nine households with or without a lead service line (LSL). Proportional sampling was used as the gold standard to which the other protocols, 5-min flush, 30-min stagnation, 6-h stagnation and random daytime were compared. Random daytime samples provided mean WLLs closest to true exposure in the households monitored overall compared to other sampling protocols. Strikingly, mean WLLs after 5 min of flushing underestimated lead exposure by 47%. Supporting these observations, water usage patterns revealed that full flushing only occurs in 3.4% of usage events within the service line and in 0.26% at the tap. The time between usage events in the service line was approximately 30 min but the 30-min protocol tended to slightly underestimate WLLs. These differences were explained by flushing prior to the 30-min stagnation sampling, which limited the contribution of the LSL to WLLs. Furthermore, the average stagnation at the kitchen time was 106 min and usage events rarely exceeded the water volume within premise plumbing (1.1 L). Mean WLLs after 6 h of stagnation without flushing overestimated exposure by 29% but provided a conservative indicator of WLLs of exposure.



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Water Research 37 (2003) 2821–2832

WATER RESEARCH

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A method for assessing the effect of water quality changes on plumbosolvency using random daytime sampling

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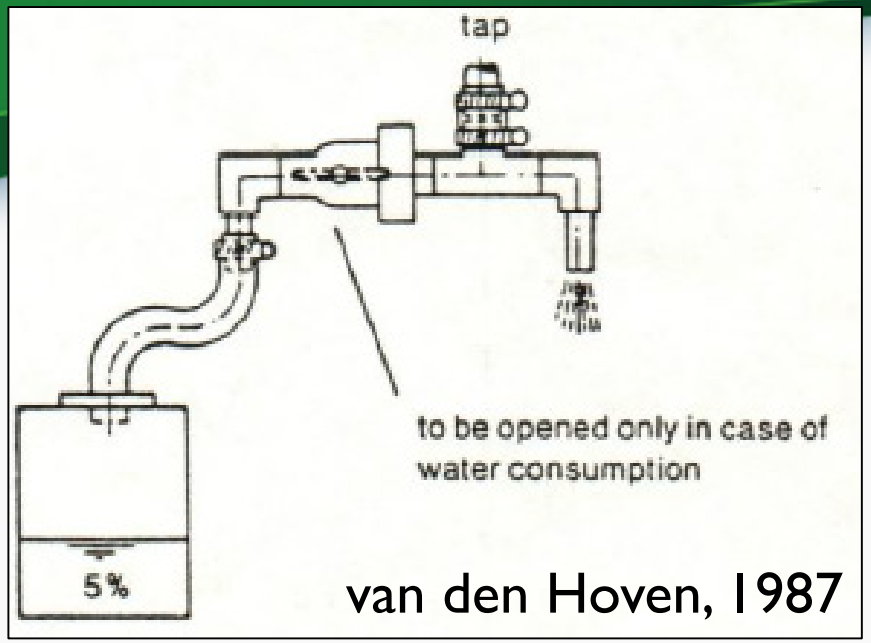
Received 1 February 2002; accepted 7 February 2003

Abstract

The Mann–Whitney *U*-test is used to demonstrate the impact of phosphate on lead concentrations measured at customer properties. This test is statistically robust and particularly efficient for the type of distributions encountered in

The "Gold Standard" : Side Stream (Proportional) Composite Sampler

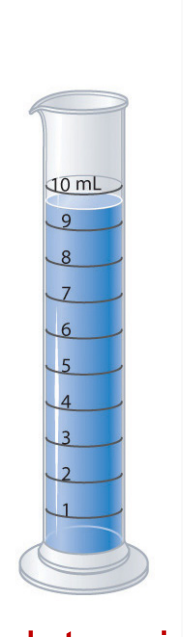
- Exposure reference method
- Device affixed to tap & consumer-operated
- Proportion of every draw meant for consumption routed into holding tank
- Collects lead under normal use conditions
- Capturing a range of flow rates, stagnation times, flow durations, and temperatures
- After one week the composite sample is analyzed for Pb (etc.)



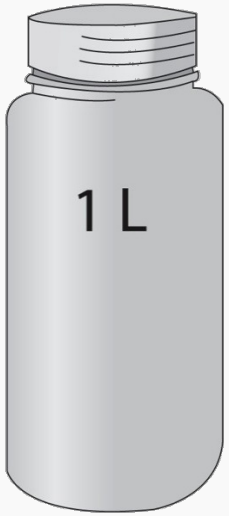
van den Hoven, 1987

Deshommes et al, 2017

"Manual Composite" Sampling



Take a pre-determined amount of water EACH time the water is drawn for drinking, beverage preparation or cooking.



Accumulate the water for a specific amount of time to get mass of lead per unit time.

Maximum Risk Alternative Question

- Profile sampling is appropriate
- Volumes need to be adjusted for configuration
- Make sure sufficient bottles are provided to fully trace water to mains
- Make sure “best case” is identified for fully-flushed case
  - Virtually nobody will do it each time but it identifies potential or limits
  - May help sell residents on full LSL replacement or POU filters

- Lead in water can be highly variable (spatially and temporally)
- Different sampling protocols will yield different lead concentrations and will sample different sources/forms of lead
- The efficacy of a given protocol in capturing water lead risks varies from building to building due to plumbing differences and other site variabilities
- Choosing the appropriate protocol for the sampling intent is crucial to producing meaningful data
- Understanding differences in sampling protocols is important when attempting to compare lead results from different studies

Contact Information & Disclaimer

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