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USEPA Regulatory Update

Lead and Copper Rule Revisions

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Overview

- History of LCR Revisions
- Updates on Science
  - Lead Health Effects
  - Sampling Site Selection
  - Sampling Protocol
  - Treatment
- Summary

Lead and Copper Rule Rulemaking History

History of LCR Revisions

- Original Lead and Copper Rule was promulgated in 1991
  - Many studies have been conducted since 1991 on LCR-related topics, including corrosion and corrosion control
  - Lessons learned from systems attempting to simultaneously comply with multiple NPDWRs
- Several revisions have been made to the rule since 1991
  - LCR Minor Revisions in 2000
  - LCR Short-term Revisions in 2007
- Significant issues left for LCR 'Long-term' revisions

LCR Long-Term Revisions (LCR-LTR)

- Potential Changes to Lead and Copper Rule
  - Sample site selection criteria (lead and copper)
  - Sampling procedures for lead and copper tap monitoring
  - Public education for lead and copper
  - Corrosion control treatment & process control
  - Lead service line replacement requirements
  - Remove/revise outdated requirements
  - Streamline rule requirements for systems
  - Other Issues

NDWAC Consultation

- National Drinking Water Advisory Council (NDWAC) Meetings
  - Optimal Corrosion Control Treatment (March 25-26. 2014)
  - Sample Site Selection (May 29-30, 2014)
  - Sampling Protocol (Sept 18-19, 2014)
  - Lead Service Line Replacement (Nov 12-13, 2014)

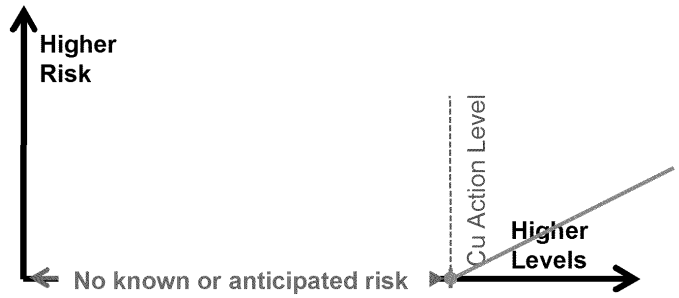
Updates on Science

Health Effects

What is the Pb 'Action Level'?

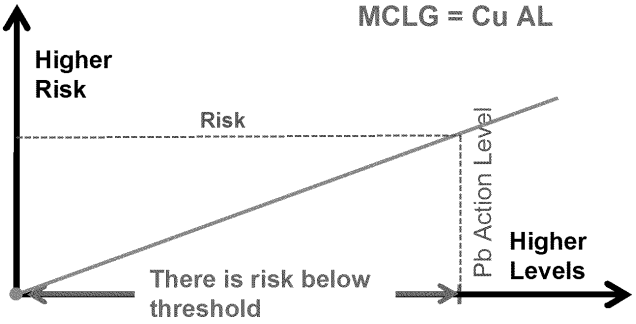
- **The Pb action level is NOT health-based**
  - It's not a threshold level that separates safe and unsafe Pb levels
  - EPA and CDC Risk Assessments:
    - There is no safe level of exposure to lead.
    - Infants, children and pregnant women should avoid all exposure to lead.
  - EPA's lead action level is a threshold value which requires public water systems to ***take action*** to reduce consumers lead exposure if lead levels exceed the lead 'action level' of 15 ppb.
    - Set at 15ug/L in 1991 based on EPA's understanding of the existing treatment capabilities and treatment costs at that time (i.e., achievable level)

Explaining The Risk



MCLG = Cu AL

When MCLG = specified value (not zero) = no known or anticipated adverse health effects occur below that value.



The Pb action level is above the health-based MCLG of zero, and so there is a risk from lead exposure below EPA's Pb action level.

MCLG for Pb = 0: No level without known or anticipated adverse health effects; Pb AL = 15 µg/L

Centers for Disease Control and Prevention (CDC) – on lead in DC water

"Controlling for age of housing, LSL was an independent risk factor for BLLs ≥10 mg/dL, and ≥5 mg/dL even during time periods when water levels met the US Environmental Protection Agency (EPA) action level of 15 parts per billion (ppb)."

- Childhood lead poisoning prevention programs should be made aware of the results of local public water system lead monitoring measurement under LCR and consider drinking water as a potential cause of increased BLLs, especially when other sources of lead exposure are not identified.
- When investigating cases of children with BLLs at or above the reference value established as the 97.5 percentile of the distribution of BLLs in U.S. children aged 1–5 years, drinking water should be considered as a source.

Low Lead Level Exposure Harms Children:

A Renewed Call for Primary Prevention (January 4, 2012)

Advisory Committee on Childhood Lead Poisoning Prevention (ACCLPP) ***of the Centers for Disease Control and Prevention***

- Reaffirmed there is no safe level of lead exposure.
- Recommended eliminating term 'blood lead level of concern' – replaced with 'reference value' (currently 5ug/dL) to emphasize that there is no safe level.
- Reaffirmed the best way to protect children is to prevent lead exposure in the first place.

"In January 2012, a committee of experts recommended that the CDC change its "blood lead level of concern." The recommendation was based on a growing number of scientific studies that show that even low blood lead levels can cause lifelong health effects."

http://www.cdc.gov/nceh/lead/acclpp/final_document_030712.pdf

Fetal Death and Reduced Birth Rates Associated with Exposure to Lead-Contaminated Drinking Water

- Fetal death rates (FDR) in Washington DC (1997-2004) peaked in 2001 when water lead levels (WLLs) were highest.
- FDR were minimized in 2004 after public health interventions were implemented to protect pregnant women.
- Birth rates in DC increased versus Baltimore City and versus the United States in 2004-2006, when consumers were protected from high WLLs.
- After public health protections were removed in 2006, DC FDR spiked in 2007-2009 versus 2004-2006 in a manner consistent with high WLL arising from partial lead service line replacements.

http://pubs.acs.org/doi/full/10.1021/es4034952

Fetal Death and Reduced Birth Rates Associated with Exposure to Lead-Contaminated Drinking Water

- DC FDR dropped to historically low levels in 2010-2011 after consumers were protected and the PSLR program was terminated.
- Re-evaluation of construction-related miscarriage cluster in the USA Today Building (1987-1988), demonstrates that high WLLs from disturbed plumbing were a possible cause. Overall results are consistent with prior research linking increased lead exposure to higher incidence of miscarriages and fetal death, even at blood lead elevations (≈ 5 ug/dL) once considered relatively low.

http://pubs.acs.org/doi/full/10.1021/es4034952

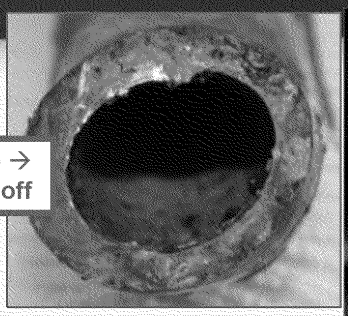
Lead & Element Percentages in Corrosion Byproduct Solids

Lead & Element Percentages in Important Corrosion Byproduct Solids							
Mineral Name	Formula	**% Pb**	%C	%O	%S	% P	%Cl
litharge, massicot	PbO	**97.80**	0.00	7.20	0.00	0.00	
plattnerite, scrutinyite	PbO_2	**86.60**	0.00	13.40	0.00	0.00	
Cerussite	$PbCO_3$	**77.50**	4.50	18.00	0.00	0.00	
Hydrocerussite	$Pb_3(CO_3)_2(OH)_2$	**80.10**	3.10	16.50	0.00	0.00	0.00
Plumbonacrite	$Pb_{10}(CO_3)_6(OH)_6O$	**81.30**	2.80	15.70	0.00	0.00	0.00
Anglesite	$PbSO_4$	**68.30**	0.00	21.10	10.60	0.00	0.00
Leadhillite, Susannite, MacPhersonite	$Pb_4(SO_4)(CO_3)_2(OH)_2$	**76.80**	2.20	17.80	3.00	0.00	0.00
Hydroxypyromorphite	$Pb_5(PO_4)_3OH$	**77.43**	0.00	15.55	0.00	6.95	0.00
Chloropyromorphite	$Pb_5(PO_4)_3Cl$	**76.38**	0.00	14.15	0.00	6.85	2.61
Tertiary Lead Orthophosphate	$Pb_3(PO_4)_2$	**76.60**	0.00	15.80	0.00	7.60	0.00
Lead(II) orthophosphate	$Pb_9(PO_4)_6$	**76.60**	0.00	15.80	0.00	7.60	0.00

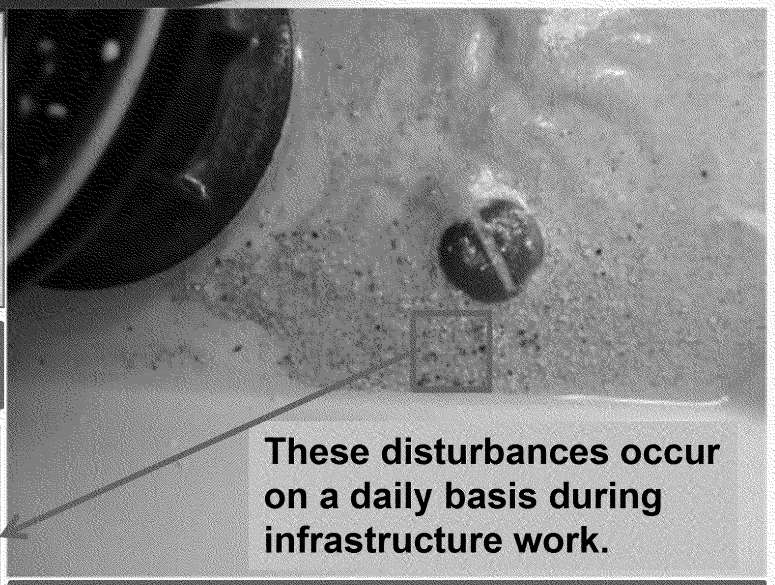
The federal definition of lead-based paint is 0.5 percent lead (0.5%).

Lead Service Line Disturbances

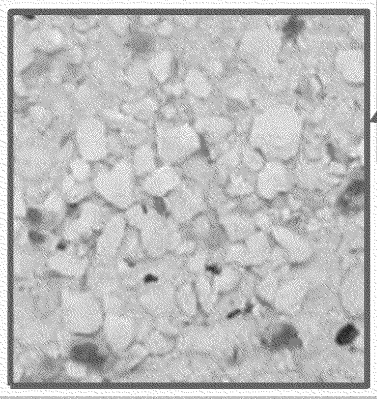
Partial LSL Replacement



LSL disturbance → Scale has fallen off



Physical LSL Disturbances Can Dislodge High-Pb Scale and Sediment



These disturbances occur on a daily basis during infrastructure work.

Sediment/Scale → Primarily Aluminum, Phosphorous & Calcium

- 330,000 µg/L Pb in particulate sample
- 125,000 µg/L Pb in suspended sample

Lead service line disturbances were found to be a common factor for the majority of sites with high lead levels. It is also possible that low water usage may play a role in sites with the highest lead levels.

Public Education / Risk Communication

- Residents with LSLs should be alerted to the risks posed by LSLs
- PWSs should not assure residents that the water is safe to drink when it is not
  - Not an accurate statement
  - Residents will not take measures to protect their families
- Notify residents of risks from particulate lead and scale/sediment release from LSL disturbances
- Thoroughly flush the lines following LSL disturbances and provide flushing and aerator cleaning instructions to residents when LSLs are disturbed

Sampling Site Selection

Sources of Lead in Drinking Water

- **Lead service lines**
  - **Largest single source of lead in distribution system where present**
  - **Millions installed in many systems throughout U.S. going back over 100 years ago**
  - **Very durable: 100+ yr old LSLs are still in service and have not degraded.**
- **Leaded brass (brass meters, faucets, valves, connectors, couples, etc.)**
  - Commonly found in most homes
  - Lead content and leaching potential varies significantly
  - Devices meeting 0.25% on wetted surface began to emerge with CA and VT legislation before 2011 SDWA Amendments.
  - Significance will decline over time as existing devices are replaced with 2014-compliant devices, but can still be a factor in the near term
- **Leaded solder**
  - Common in homes built prior to SDWA use prohibition in 1986
  - Significance continues to diminish with time

Lead Release Mechanisms

Water Quality Factors

- **Corrosive/Aggressive Water Quality**
  - Corrosive/Aggressive water can dissolve lead into the water and cause release of lead particles
- **Water Chemistry**
  - Iron and Manganese can sorb lead and transport it into home plumbing ('seeds' home plumbing with lead)
  - Natural Organic Matter (NOM) in source water can increase lead release
  - Chloride-to-Sulfate Mass Ratio can increase galvanic corrosion.
  - Chemistry of water varies and can change over time
    - Can affect the composition and stability of scales within LSLs and lead release

Lead Release Mechanisms
Physical and Chemical Disturbances

- **Physical and chemical disturbances of LSL scales can cause lead to dissolve into water and/or particulate lead release into the water**
  - Water chemistry changes can result in high lead release system-wide*
  - Physical disturbances to LSLs can release lead-bearing scale and sediment at individual sites*
- **Galvanic Corrosion**
  - Connection of copper pipe to lead pipe during partial LSL replacement can cause galvanic corrosion of lead
    - Chloride to sulfate mass ratio can impact severity of galvanic corrosion.

***where lead sources are present**

Lead Release: Other Factors

- **Variable Length of LSLs**
  - Can vary significantly within same system
  - Longer LSLs can contribute more lead
- **Current rule allows 50% LSL sites and 50% leaded-solder sites as Tier 1 sites**
  - Sites with LSLs yield much higher results overall than non-LSL sites
- **Water Usage Varies from Site to Site**
  - Low water use homes may perpetually have high lead
  - Homes become vacant and are subsequently re-occupied
  - Stagnation can affect protective scales within LSLs
- **Particulate Lead is released sporadically**
  - Can increase with higher flow rates

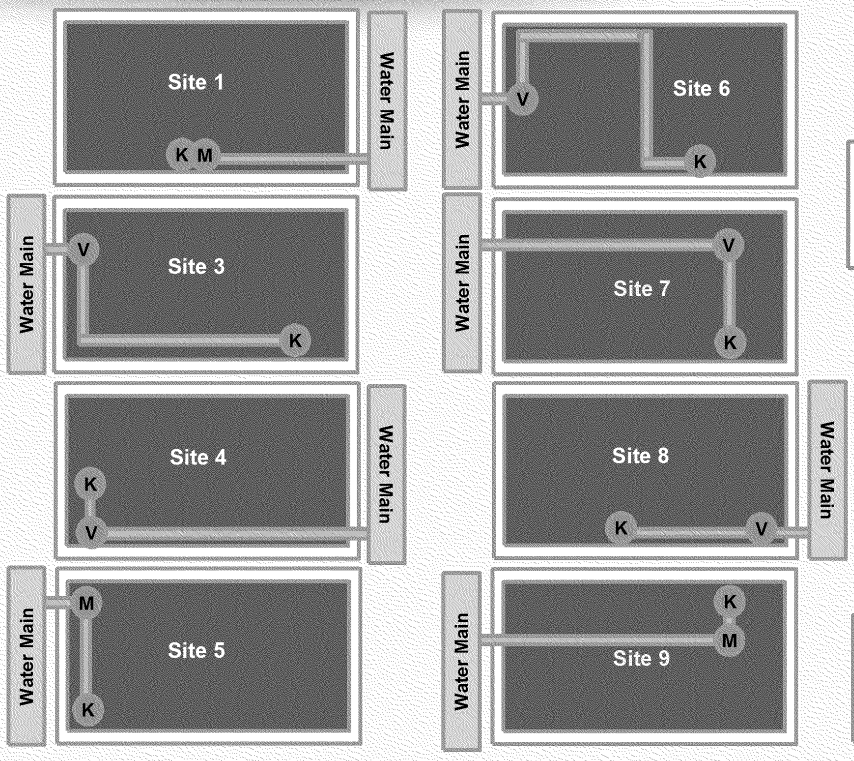
Distance Between Water Main and Homes Varies Significantly

Major Variability Factors: Summary Table

Example of Realistic Site Characteristics within the Same Public Water System									
Higher Risk/Lead Release Factors									
Site	Recently re-occupied	Lower water use	Disturbed LSL	Partial LSL	Longer LSL	Warmer water temps	Fe/Mn in water	Aggressive water zone	
1	X	X		X		X	X		
2		X	X		X		X		
3			X		X			X	
4	X			X		X		X	
5		X			X		X	X	
…									
Lower Risk/Lead Release Factors									
Site	Continuously occupied	Higher water use	Undisturbed LSL	No LSL	No partial LSL	Shorter LSL	Colder water temps	No Fe/Mn in water	Non-aggressive water zone
6	X			X	X			X	
7	X		X		X	X	X	X	X
8	X	X		X			X	X	
9	X		X		X	X		X	X
10	X	X		X	X		X	X	
…									

Sampling Protocol

Distance Between Kitchen Taps and LSLs Varies Considerably

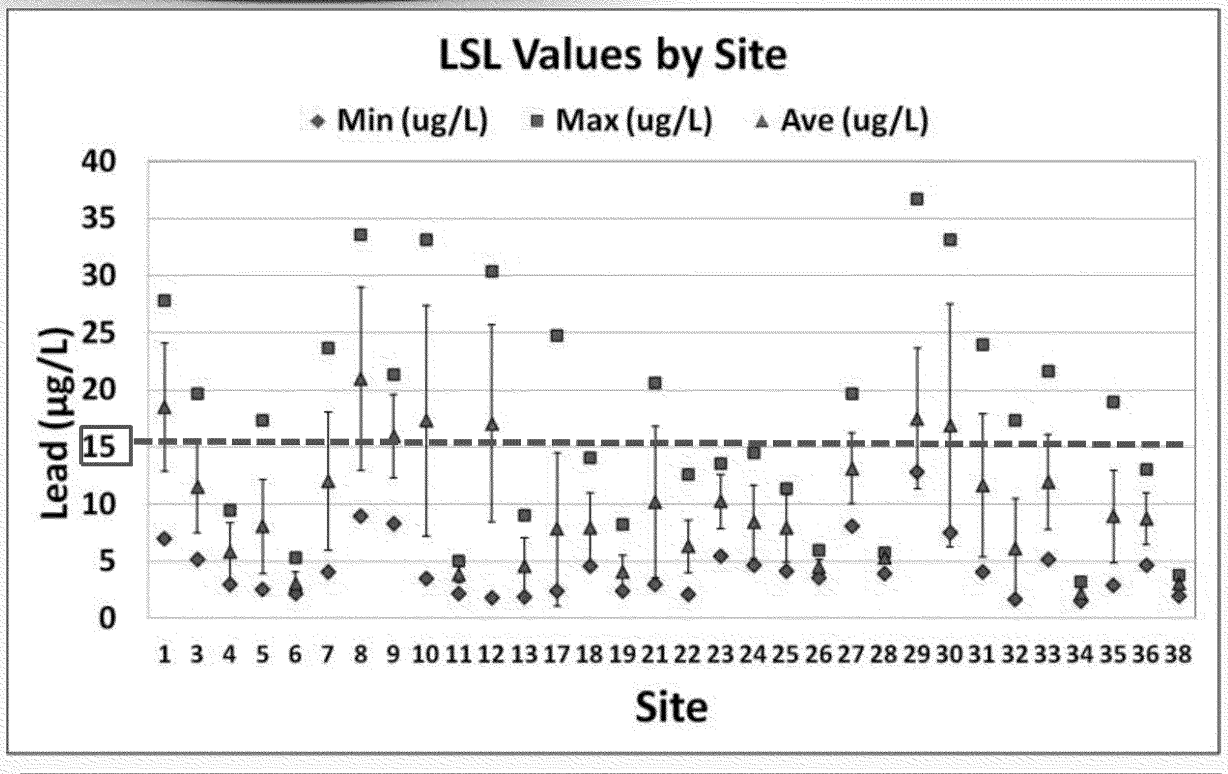


Plumbing configurations within each home varied significantly.

Some LSLs end just inside the front wall; Some continue beyond.

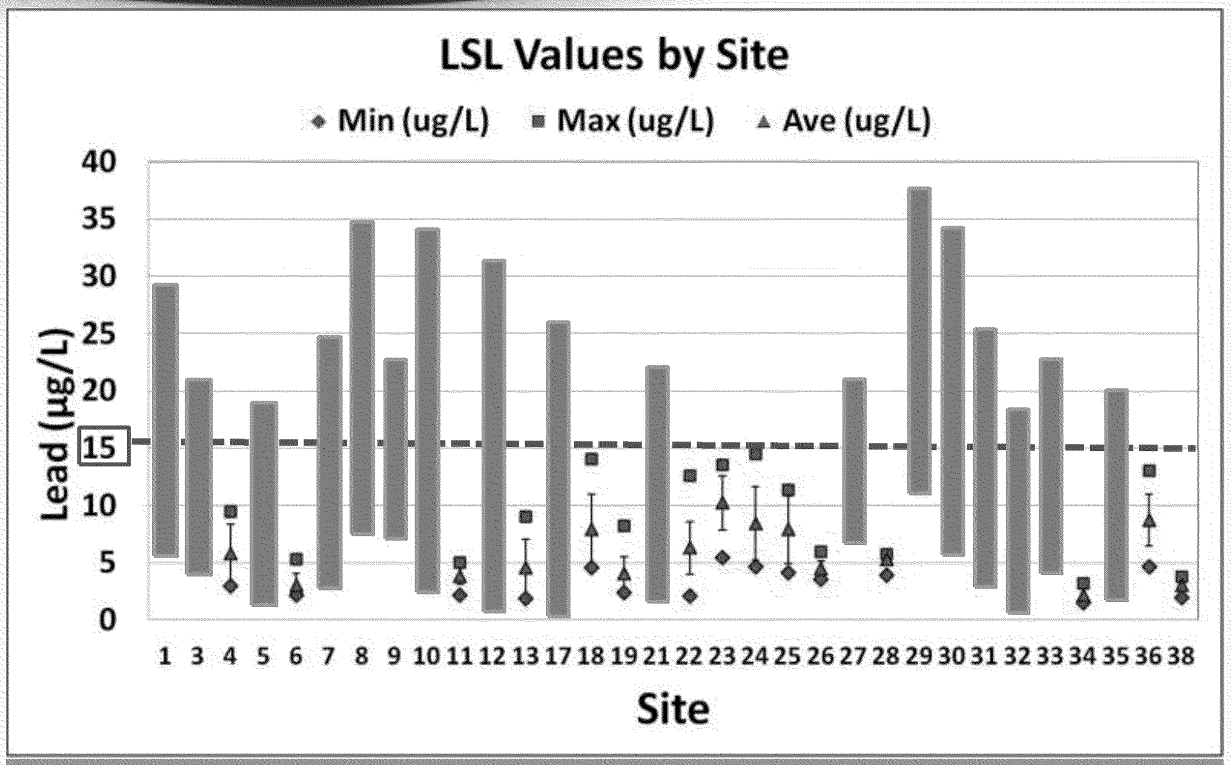
K Kitchen Tap Water M Water Meter V Shut-off Valve

Pb is Variable Across Sites



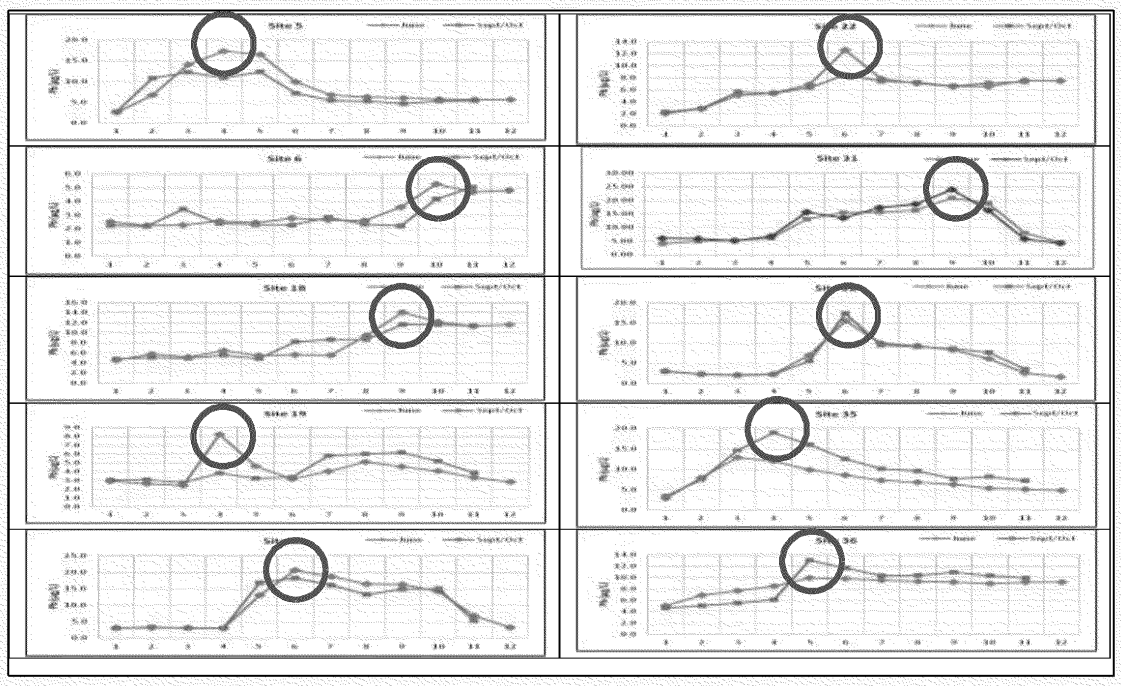
A PWS can meet or not meet the lead AL based on the sites that are selected for compliance sampling.

Pb is Variable Within Each Site



Even if the worst-case sites are chosen, a PWS can meet or exceed the lead action level based on the liter selected for the LSL sample (53% of sites in this study).

Peak Pb Occurs at Different Points



High lead levels in water can easily be missed

Using Same Liter at all Sites Misses Peak at Most/All Sites

June (28 Sites)												
If this liter is used across all sites	1st liter	2nd liter	3rd liter	4th liter	5th liter	6th liter	7th liter	8th liter	9th liter	10th liter	11th liter	12th liter
No. of sites that miss peak lead value	28	27	26	25	26	22	25	28	24	24	28	26
Percent of sites that miss peak lead value	100 %	96%	93%	89%	93%	79%	89%	100 %	86%	86%	100 %	93%

September / October (30 Sites)											
If this liter is used across all sites	1st liter	2nd liter	3rd liter	4th liter	5th liter	6th liter	7th liter	8th liter	9th liter	10th liter	11th liter
No. of sites that miss peak lead value	30	29	28	27	28	25	24	30	23	28	28
Percent of sites that miss peak lead value	100%	97%	93%	90%	93%	83%	80%	100%	77%	93%	93%

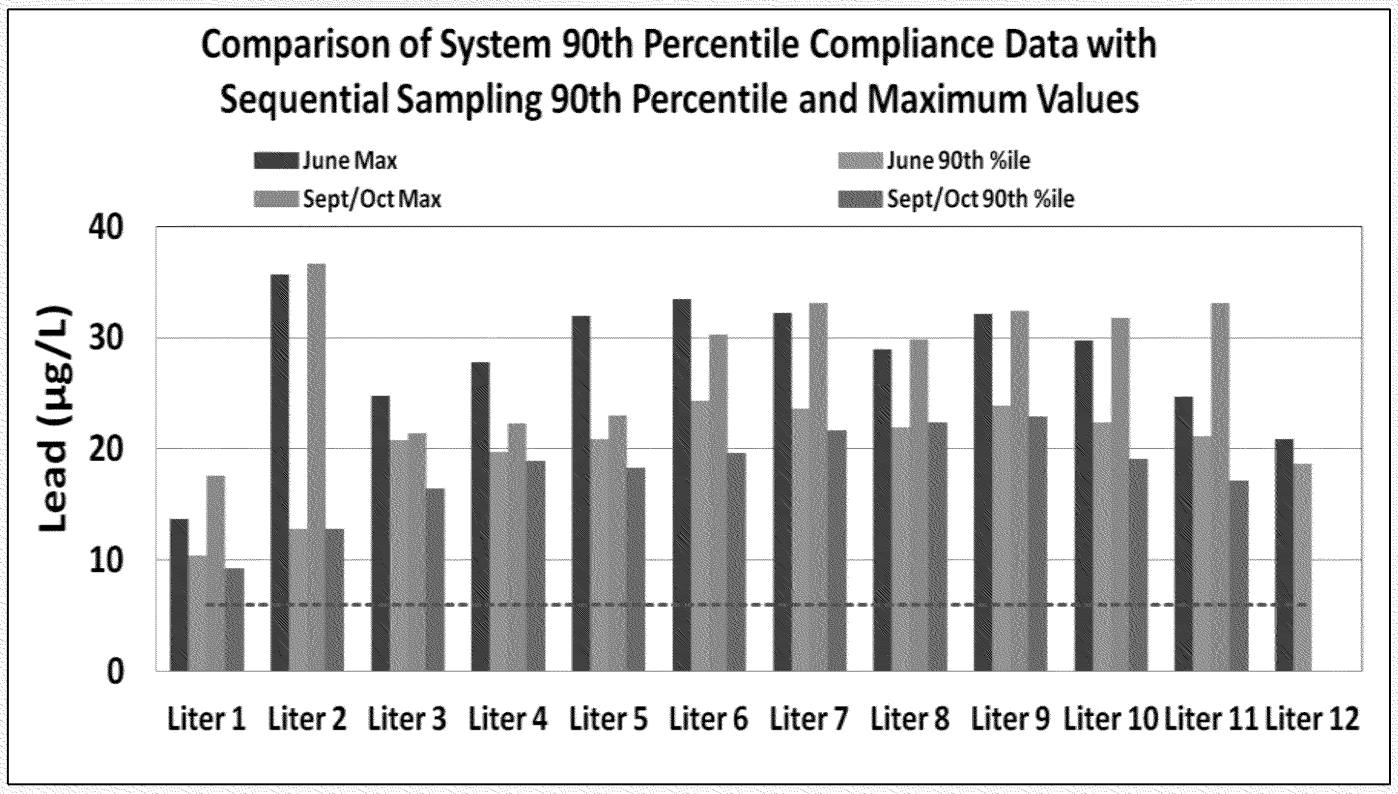
High lead levels in water can easily be missed

Treatment

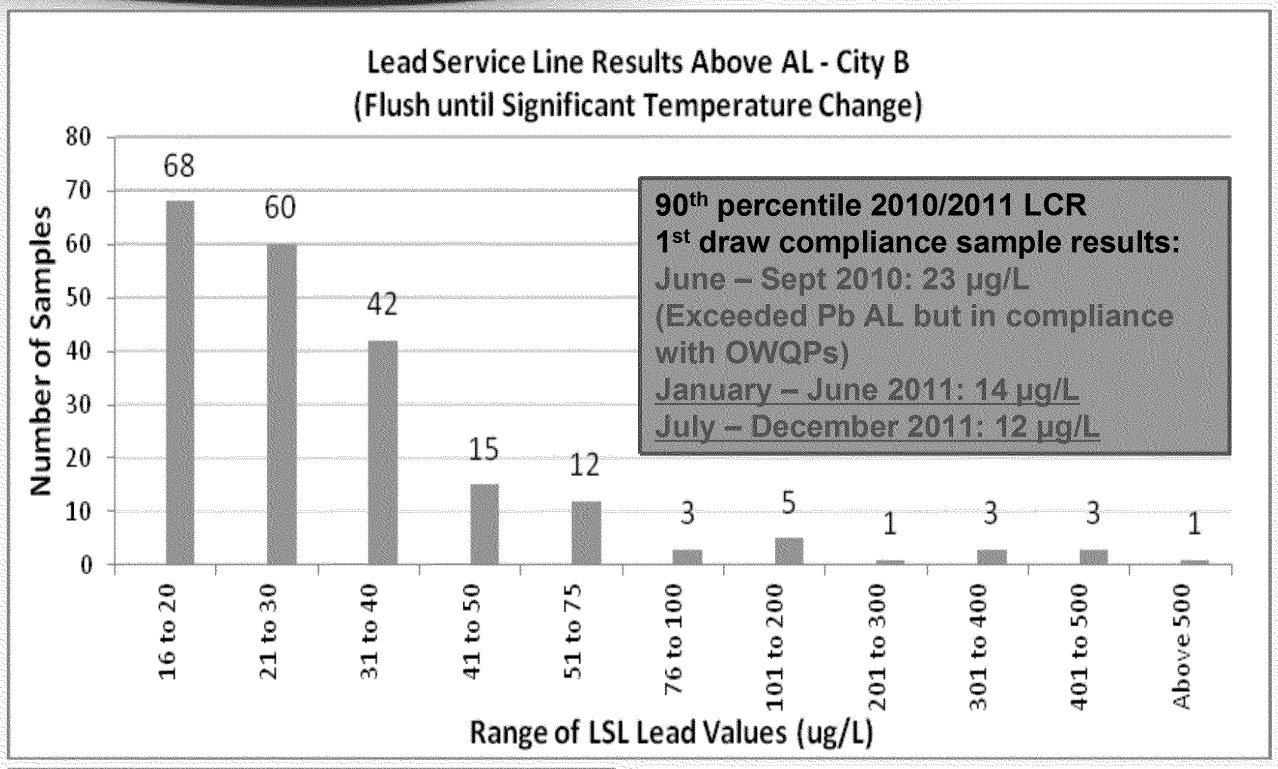
Optimal Water Quality Parameters Are Not Controlling Pb/Cu Levels

- A PWS is in compliance with requirement to minimize Pb/Cu levels if they meet the OWQPs designated by the State.
- Since original LCR was promulgated:
  - Over 6,000 lead action level exceedances for CWSs in SDWIS/FED
  - Many more copper action level exceedances at CWSs and many more lead and copper action level exceedances at NTNCWSs
  - Most systems are in compliance with OWQPs.
    - Only 172 OWQP violations over same timeframe indicates that LCR's OWQP compliance framework is not effectively controlling lead levels.

Comparison of 90th Percentiles



Comparing 1st Draw to LSL Samples Using LCR Sample Protocols



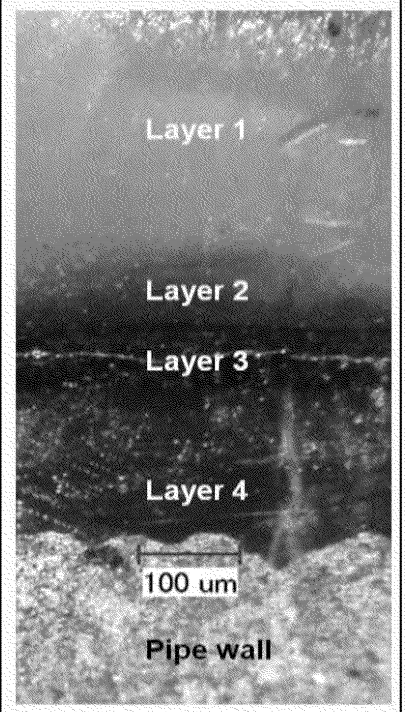
2011 LSL Sampling Results (1,975 Sites Sampled)
213 results (11%) above the lead AL, ranging from 16 µg/L to 580 µg/L.
85 results (4.3%) above twice the AL.

- **90th Percentile using all 1,975 LSL sample results: 16 µg/L**
- **No LSLs were required to be replaced (7 percent of LSLs tested under AL)**

Lead Service Line Scales

Lead Service Line (LSL) Scales

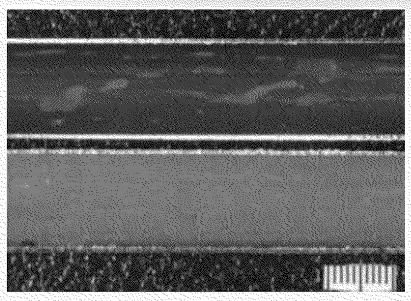
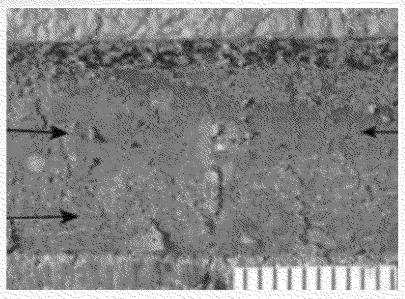
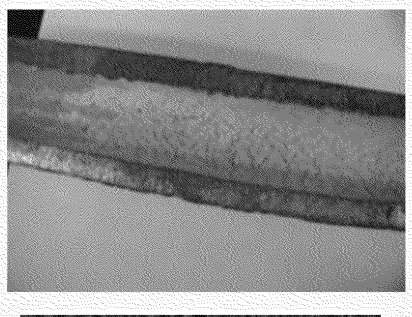
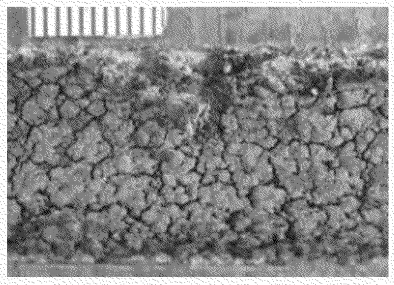
The composition, stability and solubility of LSL scales can and do vary considerably. It's important to know what is happening inside the LSLs: Unstable scales can result in high particulate release. Studies can inform, and common scientific principles can be used for treatment, but all systems are different, so CCT may not be working according to theory or as anticipated in a given system.

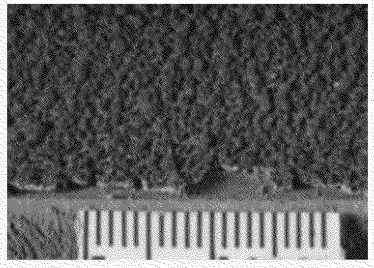
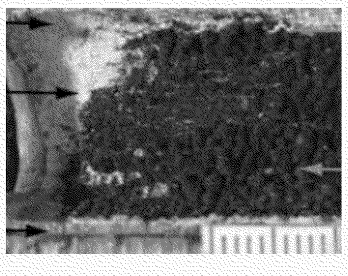
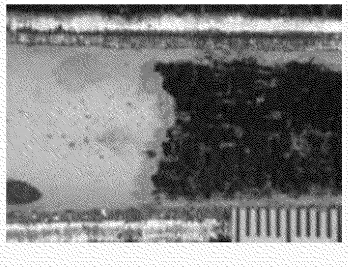


Magnified Scales View: Separated into layers by color and texture.

Photo: USEPA-ORD

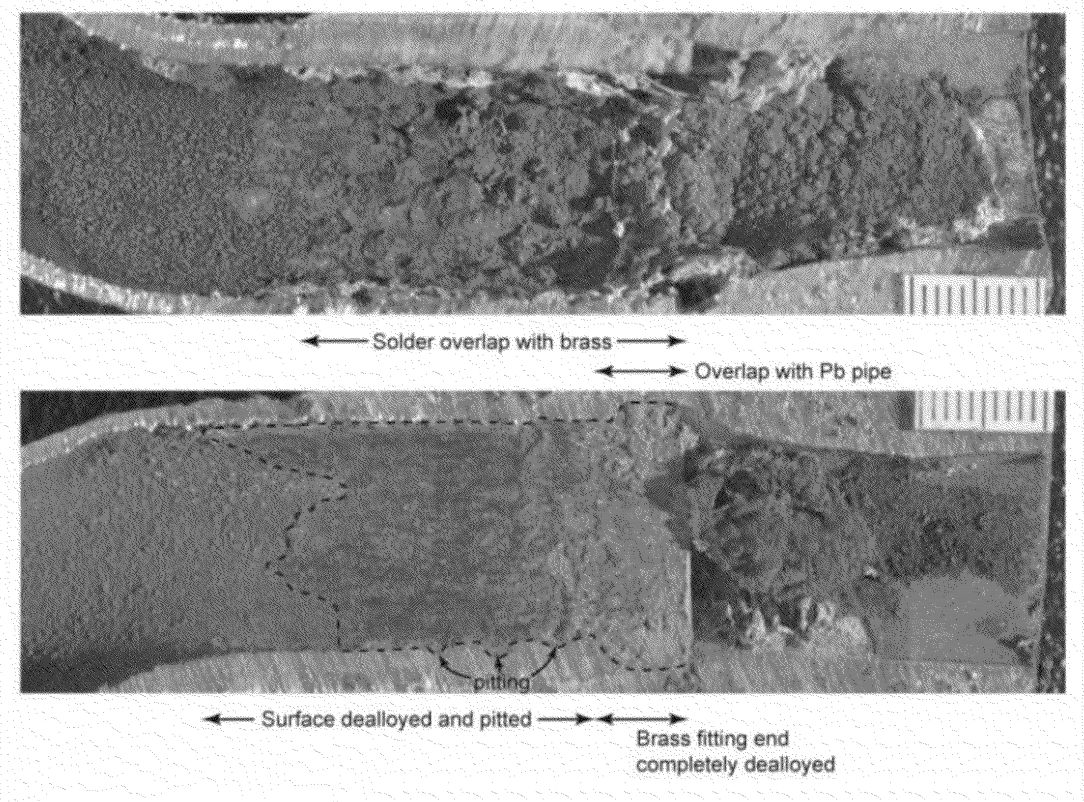
Lead Service Line Scales

Photos: USEPA-ORD

USEPA-ORD Study on Galvanic Corrosion Evidence



Connections between lead pipe and brass or copper in *some* water systems show boundaries where scale mineral transitions reflect pH conditions much lower than bulk water, consistent with expected impacts of CSMR or other factors increasing galvanic corrosion

Photos: USEPA-ORD

Summary

Is the Water Safe to Drink?

- Based on the health effects studies as well as data and studies in systems with LSLs, the answer is very likely 'no' for most homes with LSLs.
- **Physical LSL disturbances happen daily**
  - Water main repair/replacement; meter and shut-off valve repair, installation & replacement
  - Number of Partial LSLR from infrastructure work far exceeds LCR-required LSLR
- **Maintaining optimal treatment is important, but does not address all risk factors**
  - Homes with low water use; LSL Disturbances; Galvanic corrosion from partial LSLR; Re-occupied homes that were unoccupied for extended periods of time.

Is the Water Safe to Drink?

- **Water quality changes**
  - Can affect Pb levels system-wide or in specific areas
  - Water main material/condition can affect pH/Pb levels in some areas
- Scale/sediment released from LSL disturbances can be dangerous and should be flushed thoroughly out of home plumbing.
- Residents should be reminded that aerators should be cleaned regularly
- **Water usage varies and can change**
  - Varies from site to site and usage at any site can go from high to low, low to high, stay high or stay low.
  - Homes become vacant and are subsequently re-occupied

Additional Information

For more information on Chicago Lead Sampling Study:
http://www.epa.gov/Region5/water/chicagoserviceline/index.html

- **Chicago Lead in Drinking Water Study (download)**
- **Advice for Residents**
- **How do I know if I have a LSL**
- **What do LSLs look like**
- **Cleaning aerators**
- **Flushing instructions**
- **Collecting water samples**

Questions on LSL scales and analyses:

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schock.michael@epa.gov

Related Journal Article:

Del Toral, M. A., Porter, A., & Schock, M. R. (2013). Detection and Evaluation of Lead Release from Service Lines: A Field Study. *Environmental Science and Technology, 47(16),* 9300-9307. doi:10.1021/es4003636

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Questions

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